Emissions of greenhouse gases in Iceland from 1990 to 2009

National Inventory Report 2011

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

ENVIRONMENT AGENCY OF ICELAND

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

UST-2011:05, May 2011

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 2011. 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 – 2009. The Standard Electronic Format (SEF) is not reported as Iceland has not transferred or acquired any Kyoto Protocol Units.

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

Environment Agency, Reykjavík, May 2011

TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

DEFENITION OF PREFIXES AND SYMPOLS USED IN THE INVENTORY

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

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

ABBREVIATIONS

AAU	Assigned Amount Units
AE	Anode Effect
AUI	Agricultural University of Iceland
BAT	Best Available Technology
BEP	Best Environmental Practice
BOD	Biological Oxygen Demand
C_2F_6	Hexafluoroethane
CER	Certified Emission Reduction
CF_4	Tetrafluoromethane
CFC	Chlorofluorocarbon
CH_4	Methane
CITL	Community Independent Transaction Log
CKD	Cement Kiln Dust
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2-eq	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
COPERT	Computer Programme to calculate Emissions from Road Transport
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 Scheme
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**
GPS	Global Positioning System
GRETA	Greenhouse gases Registry for Emissions Trading Arrangements
GWh	Gigawatt Hour
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbon
IEF	Implied Emission Factor
IFR	Icelandic Forest Research
IFS	Iceland Forest Service
IPCC	Intergovernmental Panel on Climate Change
ITL	International Transaction Log
IW	Industrial Waste
kha	Kilohectare
KP	Kyoto Protocol
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Mobile Air Conditioning
MCF	Methane Correction Factor
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
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
NO_x	Nitrogen Oxides
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
OX	Oxidation Factor
PFC	Perfluorocarbons
PFPB	Point Feed Prebake
QA/QC	Quality Assurance/Quality Control
RMU	Removal Unit
SCSI	Soil Conservation Service of Iceland
SEF	Standard Electronic Format
SF_6	Sulphur Hexafluoride
Si	Silicon
SiO	Silicon Monoxide
SiO_2	Quarts
SO_2	Sulphur Dioxide
SO_2-eq	Sulphur Dioxide Equivalents
t/t	Tonne per Tonne
TOW	Total Organics in Wastewater
UNFCCC	United Nations Framework Convention on Climate Change
WER	Without Energy Recovery

ES 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 LULUCF sector are compiled by the Agricultural University of Iceland. The national inventory and reporting system is continually being developed and improved.

Iceland is a party to the UNFCCC and acceded to the Kyoto Protocol on May 23rd, 2002. Earlier that year the government adopted a climate change policy that was formulated in close cooperation between several ministries. The aim of the policy is to curb emissions of greenhouse gases so they do not exceed the limits of Iceland's obligations under the Kyoto Protocol. A second objective is to increase the level of carbon sequestration resulting from afforestation and revegetation programs. In February 2007 a new climate change strategy was adopted by the Icelandic government. The strategy sets forth a long-term vision for the reduction of net emissions of greenhouse gases by 50-75% by the year 2050, using 1990 emissions figures as a baseline.

The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their greenhouse gas emissions during the 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 3,415 Gg of CO_2-equivalents. In 2009, total emissions were 4,618 Gg CO_2-equivalents. This is an increase of 35% over the time period.

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

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

	1990	2008	2009	Changes ´90-´09	Changes ´08-´09
CO_2	2,172	3,595	3,556	64%	-1%
CH_4	445	467	460	3%	-2%
N_2O	377	396	358	-5%	-10%
HFC 32	-	0.1	0.1	-	3%
HFC 125	-	23	30	-	30%
HFC 134a	-	15	17	-	10%
HFC 143a	-	28	39	-	38%
HFC 152a	-	0.0	0.0	-	-15%
CF_4	355	295	129	-64%	-56%
C_2F_6	65	54	24	-64%	-56%
SF_6	1	6	6	428%	-5%
Total	**3,415**	**4,880**	**4,618**	**35%**	**-5%**
CO_2 emissions fulfilling 14/CP.7*		**1,163**	**1,187**		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,717**	**3,424**		

*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 is the Energy sector, followed by Industrial Processes, then Agriculture, Waste, and Solvent and other Product Use (Table ES 2). From 1990 to 2009, the contribution of the Energy sector to the total emissions increased from 39.1% to 40%. The contribution of industrial processes decreased from 25% in 1990 to around 17 - 19% in the period 1992 to 1997. The contribution of industrial processes increased again after 1997 and was 40% in 2009 with an 8.2% decrease between 2008 and 2009.

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

	1990	2008	2009
Energy	1,783	2,092	2,033
Industrial processes	863	1,992	1,828
Emission fulfilling 14/CP.7		1,163	1,187
Solvent Use	14	9	6
Agriculture	575	566	539
LULUCF	1,103	718	681
Waste	180	221	212
Total without LULUCF	3,415	4,880	4,618
Total excluding emissions falling under 14/CP.7		3,717	3,431
Removals from KP 3.3 and 3.4		**295**	**336**

The distribution of the total greenhouse gas emissions over the UNFCCC sectors (including geothermal energy and excluding LULUCF) in 2009 is shown in Figure ES 1. Emissions from the Energy sector account for 40.0% (fuel combustion 36% and geothermal energy 4%) of the national total emissions, industrial processes account for 40% and agriculture for 12%. The Waste sector accounts for 5%, and Solvent and other Product Use for 0.1%.

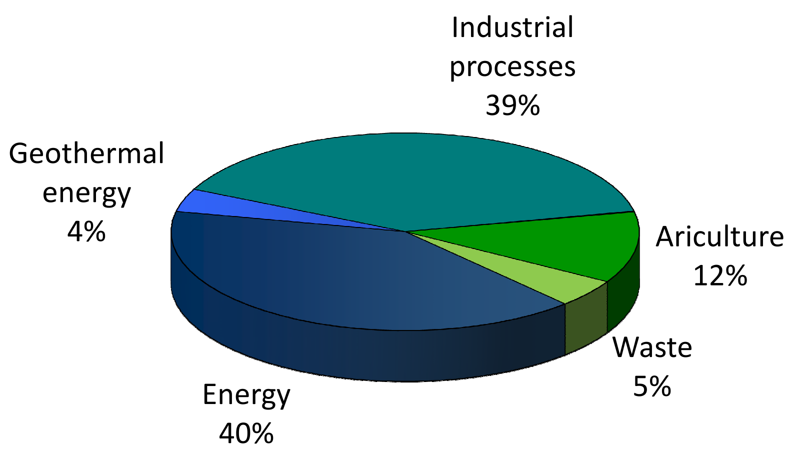

Figure ES 1: Emissions of greenhouse gases by UNFCCC sector in 2009.

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 4,880 Gg CO_2-equivalents for 2008 and 4,618 Gg CO_2-equivalents in 2009. Iceland's total emissions in 2009 were 35% above 1990 levels. Emissions that fall under the provision of Decision 14/CP.7 amounted to 1,163 Gg CO_2 in 2008 and 1,187 Gg CO_2 in 2009. 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 295 Gg in 2008 and 336 Gg CO_2-equivalents in 2009. 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

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, more than 80% of emissions from the Energy sector stem from mobile sources (transport, mobile machinery and fishing vessels). Third, emissions from the LULUCF sector are relatively high. Recent research has indicated that there are significant emissions of carbon dioxide from drained wetlands. These emissions can be attributed to drainage of wetlands in the latter half of the 20th Century, which had largely ceased by 1990. These emissions of CO_2 continue for a long time after drainage. The fourth distinctive feature is that individual sources of industrial process emissions have a significant proportional impact on emissions at the national level. Most noticeable are increased emissions from 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 one of scale. In small economies such as Iceland, a single project can dominate the changes in emissions from year to year. When the impact of such projects becomes several times larger than the combined effects of available greenhouse gas abatement measures, it becomes very difficult for the party involved to adopt quantified emissions limitations. It does not take a large source to strongly influence the total emissions from Iceland. A single aluminium plant can add more than 15% to the country's total greenhouse gas emissions. A plant of the same size would have negligible effect on emissions in most industrialized countries. Decision 14/CP.7 sets a threshold for significant proportional impact of single projects at 5% of total carbon dioxide emissions of a party in 1990. Projects exceeding this threshold shall be reported separately and carbon dioxide emissions from them shall not be included in national totals to the extent that they would cause the party to exceed its assigned amount. The total amount that can be reported separately under this decision is set at 1.6 million tonnes of carbon dioxide. The scope of Decision 14/CP.7 is explicitly limited to small economies, defined as economies emitting less than 0.05% of total Annex I carbon dioxide emissions in 1990. In addition to the criteria above, which relate to the fundamental problem of scale, additional criteria are included that relate to the nature of the project and the emission savings resulting from it. Only projects where renewable energy is used and where this use of renewable energy results in a reduction in greenhouse gas emissions per unit of production will be eligible. The use of best environmental practice (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 can not transfer assigned amount units to other Parties through international emissions trading.

The Government of Iceland notified the Conference of the Parties with a letter, dated October 17th 2002, of its intention to avail itself of the provisions of Decision 14/CP.7. Emissions that fall under Decision 14/CP.7 are not excluded from national totals in this report, as Iceland will undertake the accounting with respect to the Decision at the end of the commitment period. The 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 III.

The present report together with the associated Common Reporting Format tables (CRF) is Iceland's contribution to this round of reporting under the Convention, and covers emissions and removals in the period 1990-2009. The methodology used in calculating the emissions is according to the revised 1996 and 2006 IPCC Guidelines for National Greenhouse Gas Inventories as set out by the IPCC Good Practice Guidance and Good Practice Guidance for Land Use, Land-Use Change and Forestry. The Standard Electronic Format (SEF) is not reported as Iceland has not transferred or acquired any Kyoto Protocol Units.

The greenhouse gases included in the national inventory are the following: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Emissions of the precursors 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, carries the overall responsibility for the national inventory. EA compiles and maintains the greenhouse gas emission inventory, except for LULUCF which is compiled by the Agricultural University of Iceland (AUI). EA reports to the Convention. Figure 1.1 illustrates the flow of information and allocation of responsibilities.

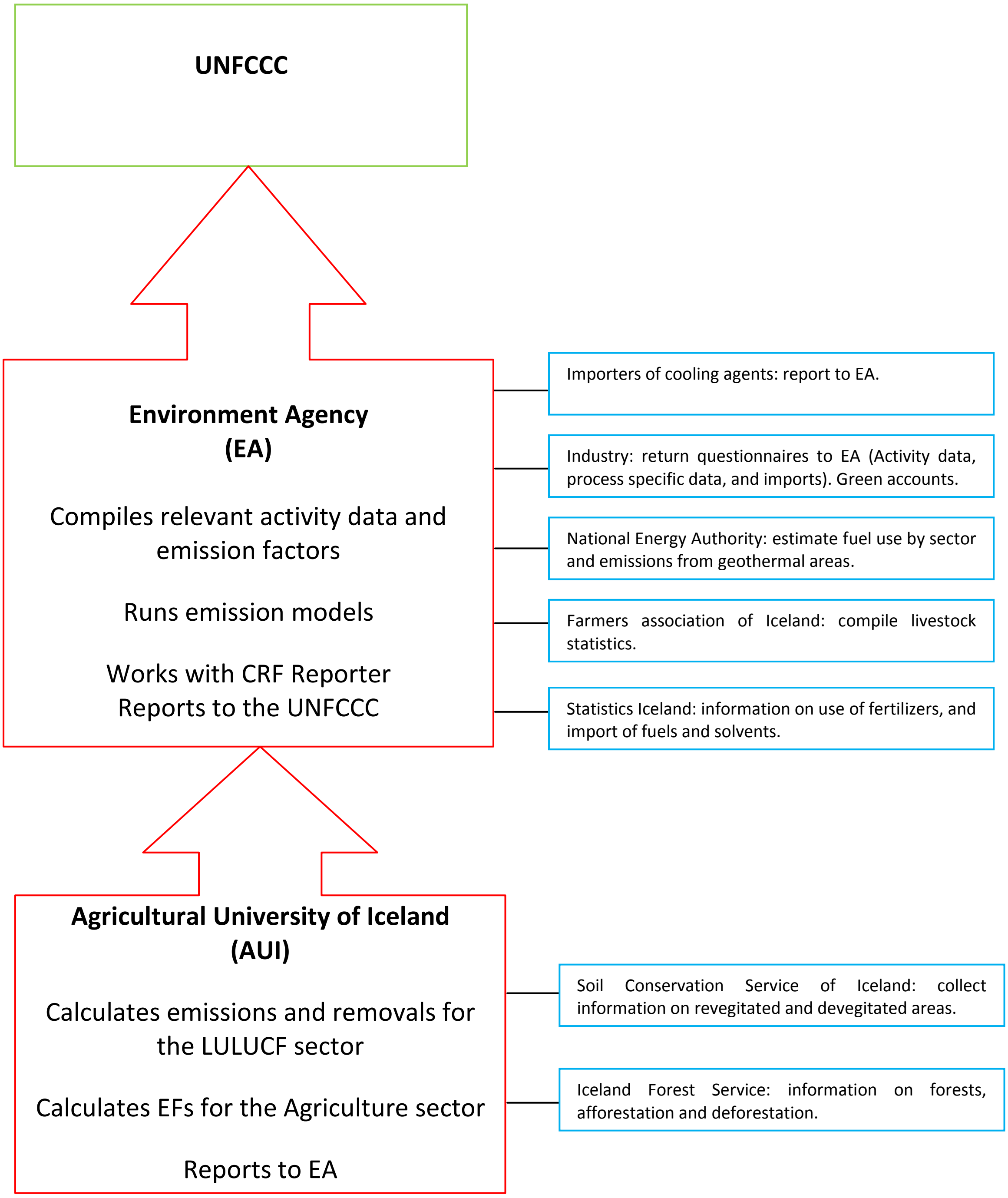

Figure 1.1: Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

A Coordinating Team was established in 2008 as a part of the national system. The team has representatives from the Ministry for the Environment, the EA and the AUI not directly involved in preparing the inventory. Its official roles are to review the emissions inventory before submission to UNFCCC, plan the inventory cycle and formulate proposals on further development and improvement of the national inventory system. During this inventory cycle the Coordinating Team held 6 meetings, thereof there were 3 meetings only with Coordinating Team members and 3 with the team members as well as major data providers. The work of the team has already led to improvement in cooperation between the different institutions involved with the inventory compilation, especially with regards to the LULUCF and Agriculture sectors. Some improvements proposed by the team are incorporated into this and the last years submissions.

1.2.2 Act No. 65 from 2007

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

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

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

1.2.1 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. The Farmers Association of Iceland (FAI), on the behalf of the Ministry of Agriculture, is responsible for assessing the size of the animal population each year. On request from the EA, the FAI assisted to come up with a method to account for young animals that are mostly excluded from national statistics on animal population. Statistics Iceland provides information on population, GDP, production of asphalt, imports of solvents and other products, the import of fertilizers and on the import and export of fuels. The EA collects various additional data directly. Annually an electronic questionnaire on imports, use of feedstock, and production and process specific information is sent out to industrial producers, in accordance with Regulation no. 244/2009. Green Accounts submitted under Regulation no. 851/2002 from the industry are also used. Importers of HFCs submit reports on their annual imports by type of HFCs to the EA. EA also estimates activity data with regard to waste. Emission factors are taken mainly from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC Good Practice Guidance, 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.

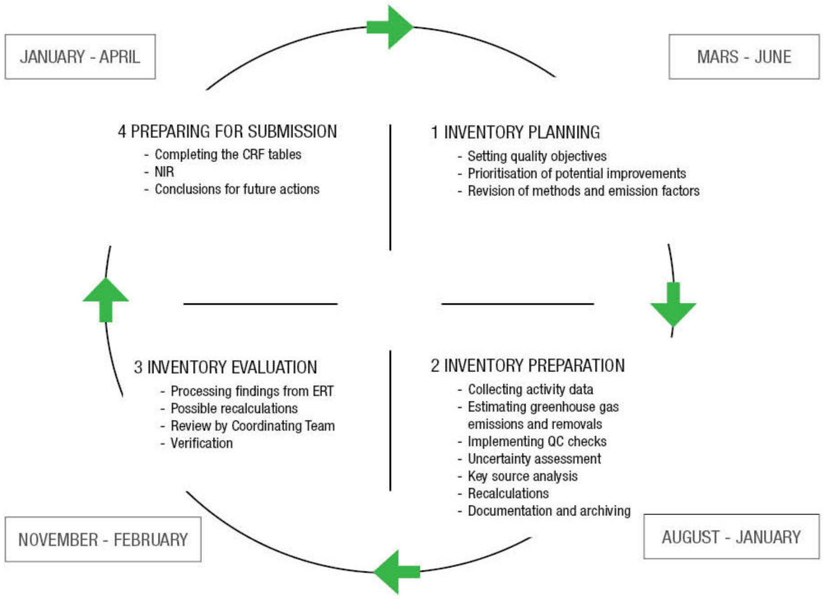

Figure 1.2: The annual inventory cycle.

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

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

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

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

1.4 Methodologies and Data Sources

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

The general emission model is based on the equation:

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

The model includes the greenhouse gases and in addition the precursors and indirect greenhouse gases 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 Key source Categories

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

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

Table 1.1: Icelandic emission inventory 2009 key source categories.

IPCC SOURCE CATEGORIES	Direct GHG	Key source		
		Level '90	Level '09	Trend
ENERGY SECTOR				
1.A.2: Manufacturing Industry And Construction	CO_2	ν	ν	ν
1.A.3b: Road Transport	CO_2	ν	ν	ν
1.A.3b: Road Transport	N_2O		ν	ν
1.A.3 (A,D): Non-Road Transport	CO_2	ν	ν	
1.A.4(A,B): Residential, Commercial, Institutional	CO_2	ν*		
1.A.4c: Fishing	CO_2	ν	ν	ν
1.B.2d Geothermal Energy Utilisation	CO_2	ν	ν	ν
INDUSTRIAL PROCESSES				
2.A: Mineral Industry	CO_2	ν	ν*	ν
2.C.2: Ferroalloys Production	CO_2	ν	ν	ν
2.C.3: Aluminium Production	CO_2	ν	ν	ν
2.C.3: Aluminium Production	PFC	ν	ν	ν
2.F Emissions From Substitutes For Ozone Depleting Substances	HFC		ν	ν
AGRICULTURE				
4.A.1 Enteric Fermentation, Cattle	CH_4	ν	ν	
4.A.3 Enteric Fermentation, Sheep	CH_4	ν	ν	ν
4.A.3 Enteric Fermentation, Other	CH_4		ν*	
4.B Manure Management	N_2O	ν*		
4.D.1 Direct N_2O Emissions From Agricultural Soils	N_2O	ν	ν	
4.D.2 Indirect N_2O Emissions From Nitrogen Used In Agriculture	N_2O	ν	ν	ν
LULUCF				
5.A Forest Land- Afforestation	CO_2		ν	ν
5.A Forest Land- Natural Birch Forest	CO_2		ν	
5.B.2.3 Wetlands converted to Cropland	CO_2	ν	ν	ν
5.C.2.3 Wetlands converted to Grassland	CO_2	ν	ν	ν
5.C.2.5 Other Converted Land to Grassland, Revegetation	CO_2	ν	ν	ν
5.G.5(II) Wetlands converted To Grassland	N_2O	ν	ν	
WASTE				
6.A Solid Waste Disposal Sites	CH_4	ν	ν	
6.C Emissions from Waste Incineration	CO_2			ν

*Key source excluding LULUCF.

1.6 Quality Assurance and Quality Control (QA/QC)

The objective of QA/QC activities in national greenhouse gas inventories is to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness. A QA/QC plan for the annual greenhouse gas inventory of Iceland has been prepared and can be found at http://www.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 (http://www.ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_manual.pdf). To further facilitate the QA/QC procedures all calculation sheets have been revised. They now include a brief description of the method used. They are also provided with colour codes for major activity data entries and emissions results to allow immediate visible recognition of outliers.

1.7 Uncertainty Evaluation

Uncertainty evaluation of the inventory was prepared for this round of reporting. The uncertainty estimate revealed that the total uncertainty of the Icelandic inventory (including LULUCF) is 6.8%. The results of the uncertainty estimate can be found in Annex II.

Uncertainty estimates are an essential element of a complete inventory and is 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 gasses are reviewed separately as CO_2-equivalents. The total base year´s and current year's emissions within a sector are used in the calculations as well as an uncertainty estimate value of the activity data and emission factors. This can be seen in the quantitative uncertainty table in Annex II.

1.8 General Assessment of the Completeness

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

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

In the case of temporal coverage, CRF tables are reported for the whole time series from 1990 to 2009.

With regard to sectoral coverage few sources are not estimated.

The main sources not estimated are:

- Emissions of CO_2 and CH_4 from distribution of oil products (1B2a v)
- The emissions/removals of some LULUCF components are not estimated (see Chapter 7). Most important are probably the emissions/removals of the subcategory "Other Grassland" and emissions due to biomass burning.

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

1.9 Planned and Implemented Improvements

Several improvements have been made in the LULUCF sector since last submission. The main changes include:

- Changes in carbon stock of dead organic matter of all subcategories of 5.A.2.- Land converted to Forest land were estimated.
- The carbon stock change of living biomass in 5.C.1-Natural birch forest is reported for the first time.
- A new subcategory of Grassland remaining grassland is introduced, i.e. Natural birch shrubland. Carbon stock changes for living biomass of this category were estimated.
- Emission of CO_2 from drained organic soil under 5.C.2.3-Wetland converted to grassland was revised and thereby responding to recommendations of the Expert Review Teams (ERT) reviewing the 2009 submission and reiterated by the ERT reviewing the 2010 submission.
- Emission of N_2O from drained organic soils of wetland converted to Grassland reported as 5.G. (5(II) - Wetland converted to Grassland Non-CO_2 emission, was revised adapting new country specific emission factor.
- The carbon stock changes for 5.C.2.5 Other land converted to Grassland (Revegetation) was revised. Both the activity area of Revegetation since 1990 and the emission/removal factors were revised.
- The emissions factors for reservoirs were revised. Reservoirs specific emission factors for four reservoirs are introduced.

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, in accordance with the formal agreement between EA and NEA.
- 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 HFC emission estimates regarding foam blowing agents.
- Move emission estimates of SF_6 to the Tier 2 methodology.
- Improvement of methodologies to estimate emissions from the Solvent and other Product Use sector
- Improvement of methodologies to estimate emissions from manure management in accordance with Icelandic livestock feeding situations
- Developing a time series for emission factors of enteric fermentation
- The division of land use into subcategories and improved time and spatial resolution of the land use information is an ongoing task of the AUI
- Ongoing new national forest inventory (NNFI) will further improve both estimates of Forest land area and Carbon stock changes.
- Similar effort as the NNFI regarding Revegetation began in 2007. The Revegetation inventory is expected to provide improved data on carbon stock changes and area of revegetated land in the next two years
- Effort in improving the area estimate for drained organic soils of Grassland and it's subdivision to soil classes is planned to start this summer
- Revising the annual protein intake in Iceland when estimating N_2O emissions from domestic wastewater

The following improvements are under consideration:

- Develop CS emission factors for fuels
- Develop verification procedures for various data
- Improvement of methodologies to estimate emissions from HFCs and SF_6
- Improvement of QA/QC for LULUCF
- Improvement of the time series for different land use categories and the estimate on past and present land use changes
- Revision of LULUCF emission/removal factors, in order to emphasize key sources and aim toward higher Tier levels
- Evaluation of LULUCF factors, not estimated in present submission and disaggregation of components presently reported as aggregated emission

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Emission Trends for Aggregated Greenhouse Gas Emissions

Total amounts of greenhouse gases emitted in Iceland during the period 1990-2009 are presented in the following tables, expressed in terms of contribution by gas and source.

Table 2.1 presents emission figures for greenhouse gases by sector in 1990, 2008, and 2009 expressed in CO_2-equivalents along with the percentage change indicated for both time periods 1990-2009 and 2008-2009. Table 2.2 presents emission figures for all greenhouse gases by gas in 1990, 2008, and 2009, expressed in CO_2-equivalents along with the percentage change indicated for both time periods 1990-2009 and 2008-2009. Empty cells indicate emissions not occurring.

Table 2.1: Emissions of greenhouse gases by sector in Iceland during the period 1990-2009 in Gg CO_2-equivalents.

	1990	2008	2009	Changes ´90-´09	Changes ´08-´09
Energy	1,783	2,092	2,033	14%	-3%
- Fuel combustion	1,717	1,907	1,858	8%	-3%
- Geothermal energy	67	185	175	163%	-6%
Industrial processes	863	1,992	1,828	112%	-8%
Solvent and other product use	14	9	6	-58%	-37%
Agriculture	575	566	539	-6%	-5%
LULUCF	1,103	718	681	-38%	-5%
Waste	180	221	212	18%	-4%
Total without LULUCF	**3,415**	**4,880**	**4,618**	**35%**	**-5%**
CO_2 emissions fulfilling 14/CP.7*		1,163	1,187		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,717**	**3,431**		

*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 1990-2009 (without LULUCF) in Gg CO_2-equivalents.

	1990	2008	2009	Changes ´90-´09	Changes ´08-´09
CO_2	2,172	3,595	3,556	64%	-1%
CH_4	445	467	460	3%	-2%
N_2O	377	396	358	-5%	-10%
HFC's	-	67	86	-	29%
PFC's	419	349	153	-64%	-56%
SF_6	1	6	6	428%	-5%
Total	**3,415**	**4,880**	**4,618**	**35%**	**-5%**
CO_2 emissions fulfilling 14/CP.7*		1,163	1,187		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,717**	**3,431**		

*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, the total emissions of greenhouse gases (excluding LULUCF) in Iceland were 3,415 Gg of CO_2-equivalents. In 2009 total emissions were 4,618 Gg CO_2-equivalents. This implies an increase of 35% over the time period. Total emissions show a decrease between 1990 and 1994, with an exception in 1993, and an increase until 2009. A sudden increase of 15% was seen between 2005 and 2006 followed by an increase of 8% in 2008 and a decrease of 5% in 2009.

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

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. In 2009, 817,281 tonnes of aluminium were produced in three aluminium plants. Parallel investments in increased power capacity were needed to accommodate for an nine fold increase in aluminium production. The size of these investments is large relative to the Icelandic economy.

The increase in GDP since 1990 explains further the general growth in emissions as well as the fact that the Icelandic population has grown by 24% from 1990 to 2009. This has resulted in higher emissions from most sources, but in particular from transport and the construction sector. Since 1990 emission from the transport sector have risen considerably, owing to the fact that a larger share of the population uses private cars for their daily travel. In 2008 and 2009 fuel prices rose significantly leading to lower emissions from the sector compared to the years before. The knock-off effect of the increased levels of economic growth until 2007 was an increase in construction, especially house building in the capital area. The construction of a large hydropower plant (Kárahnjúkar, building time from 2002 to 2007) led to further increase in emissions from the sector. The construction sector collapsed in autumn 2008. Emissions from fuel combustion in the transport and construction sector decreased in 2008 by 5% compared to 2007 and in 2009 by 2% compared to 2008, because of the economic crises.

The overall increasing trend of greenhouse gas emissions was until 2005 to some extent counteracted by decreased emissions of PFCs, caused by improved technology and process control in the aluminium industry. Increased emissions due to increased production capacity in the aluminium industry, since 2006, has led to a trend of overall increase in greenhouse gas emissions. In 2009 the total emissions from the aluminium sector was 10% lower than in 2008 due to less PFC emissions from the sector.

2.2 Emission Trends by Gas

As shown in Figure 2.1, the largest contributor by far to the total GHG emissions is CO_2 (77%), followed by CH_4 (10%), fluorinated gases (PFCs, HFCs, and SF_6, 5%) and N_2O (8%). In the year 2008, the changes in gas emissions compared to 1990 levels for CO_2, CH_4, N_2O, and fluorinated gasses were 65%, 5%, 5%, and 0%, respectively.

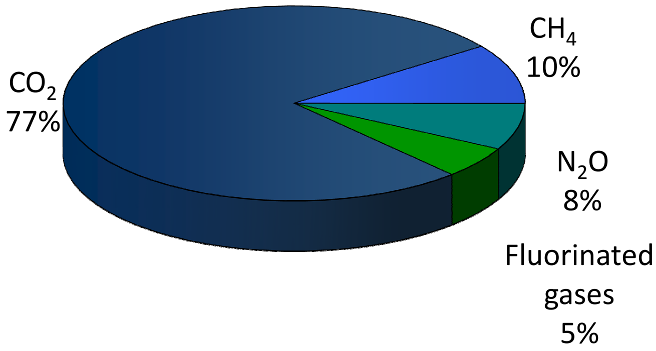

Figure 2.1: Distribution of emissions of greenhouse gases by gas in 2009.

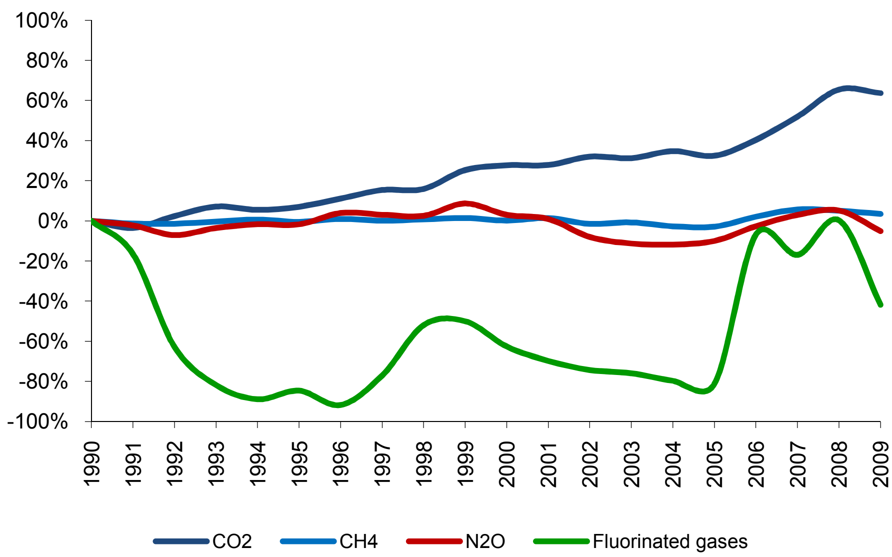

Figure 2.2: Percentage changes in emissions of GHG by gas 1990-2009, compared to 1990 levels.

Table 2.3: Emissions of greenhouse gases in Iceland during the period 1990-2009 (without LULUCF) in Gg CO_2-equivialents.

	1990	1995	2000	2005	2007	2008	2009
CO_2	2,172	2,326	2,775	2,877	3,301	3,595	3,556
CH_4	445	443	446	432	470	467	460
N_2O	377	371	388	339	388	396	358
HFC's	-	4	27	49	58	67	86
PFC's	420	59	127	26	281	349	153
SF_6	1	2	3	4	10	6	6
Total	**3,415**	**3,204**	**3,766**	**3,727**	**4,509**	**4,880**	**4,618**
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*						**3,717**	**3,431**

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

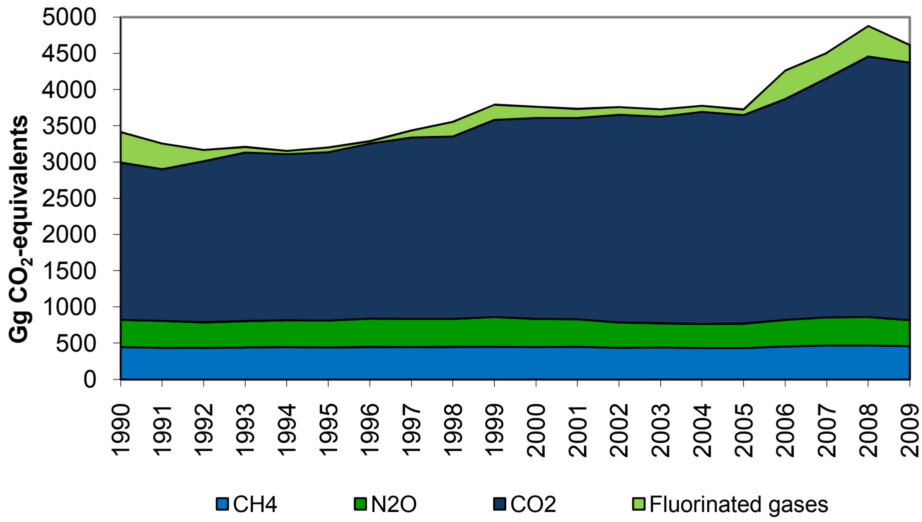

Figure 2.3: Emissions of greenhouse gases by gas, 1990-2009.

2.2.1 Carbon Dioxide (CO_2)

Industrial processes, road transport and fisheries are the three main sources of CO_2 emissions in Iceland. Since emissions from the electricity generation and space heating are low, as they are generated from renewable energy sources, emissions from stationary combustion are dominated by industrial sources. Thereof, the fishmeal industry is by far the largest user of fossil fuels. Emissions from mobile sources in the construction sector are also significant (though much lower 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, and emissions from non-road transport. Table 2.4 lists CO_2 emissions from each source category for the period 1990-2009. 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 2009 compared with 1990 levels.

Table 2.4: Emissions of CO_2 by sector 1990-2009 in Gg.

	1990	1995	2000	2005	2007	2008	2009
Fishing	656	772	720	626	565	517	597
Road vehicles	521	547	602	761	904	851	852
Stationary combustion, liquid fuels	243	229	214	179	162	112	112
Industrial processes	393	428	769	838	1,134	1,569	1,583
Construction	121	149	197	215	196	188	129
Geothermal	67	82	164	123	152	185	175
Other	172	120	109	135	188	172	107
Total CO_2 emissions	**2,172**	**2,326**	**2,775**	**2,877**	**3,301**	**3,595**	**3,556**

In 2009 the total CO_2 emissions in Iceland were 3,556 Gg. This implies an increase of 64% from 1990 levels and a decrease of about 1% from the preceding year. Emissions from industrial processes increased by 1% from 2008 to 2009 due to higher CO_2 emission from the aluminium industry, but partly counteracted by less emissions from the cement industry. Emissions from geothermal energy decreased by 6%. Emissions from road vehicles in 2008 were 5% below the emissions in 2007 but increased by 0.1% between 2008 and 2009. It is likely that the economic crisis had 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, thus can also be seen in decreased international aviation in 2008 and 2009 (Table 2.17). Emissions from stationary combustion of liquid fuels decreased by 0.4% from 2008 to 2009. Emissions from construction decreased by 31% and emissions from other sources decreased by 38% during the same time period.

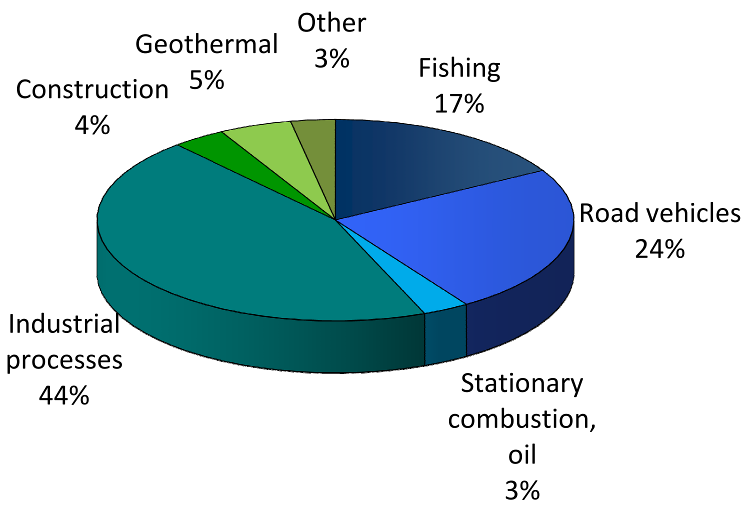

Figure 2.4: Distribution of CO_2 emissions by source in 2009.

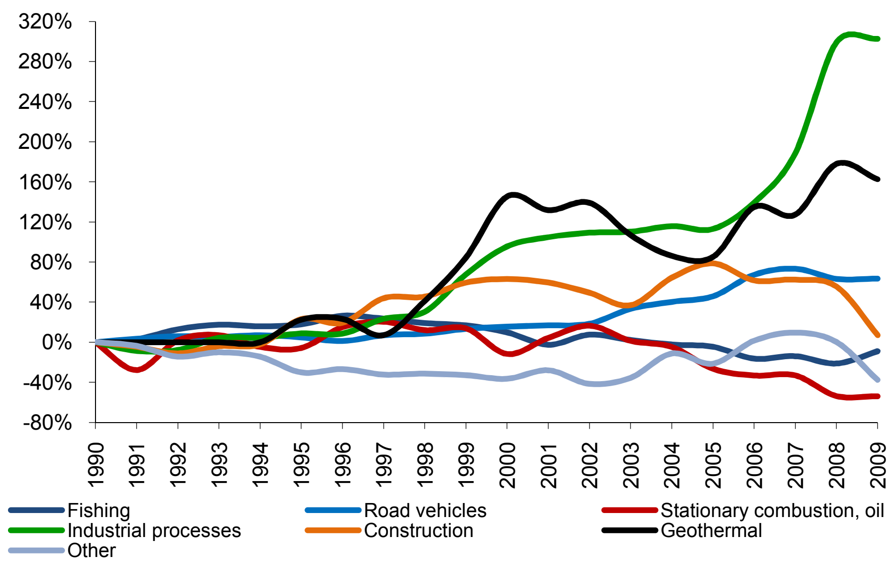

Figure 2.5: Percentage changes in emissions of CO_2 by major sources 1990-2009, compared to 1990 levels.

The increase in CO_2 emissions between 1990 and 2009 can be explained by increased emissions from industrial processes (303%), road transport (64%), geothermal energy utilisation (163%), and the construction sector (7%). Total emissions from the fishing sector declined by 9% during the same period.

The main driver behind increased emissions since 1990 has been the expansion of the metal production sector, the aluminium sector in particular. In 1990, 87,839 tonnes of aluminium were produced in one aluminium plant in Iceland. Three aluminium plants were in operation in 2009 producing 817,281 tonnes of aluminium.

CO_2 emissions from road transport have increased by 64% since 1990, owing to an increase in the number of cars per capita, more mileage driven and an increase in larger vehicles. Since 1990 the vehicle fleet in Iceland has increased by 78%. Also, the Icelandic population has grown by 24% from 1990 to 2009. Emissions from both domestic flights and navigation have declined since 1990.

Emissions from geothermal energy exploitation have increased by 163%. Electricity production using geothermal energy has increased from 283 GWh in 1990 to 4,553 in 2009, or 16-fold.

Emissions from fishing rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 the emissions decreased again reaching 1990 levels in 2001. Emissions increased again by 10% between 2001 and 2002, but in 2003 they dropped to 1990 levels. In 2009, the emissions were 9% below the 1990 levels but 15% above the 2008 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 2009, emissions from cement production were 52% lower than in 2008.

2.2.2 Methane (CH_4)

Agriculture and waste treatment were the main sources of methane emissions in 2009, with 55% and 44% of the total emissions respectively (Table 2.5 and Figure 2.6). The emissions from agriculture decreased by 12% between 1990 and 2009, whereas emissions from waste increased by 33%. Emissions from waste treatment increased from 1990 to 2001 due to a greater amount of waste generated and a higher ratio of landfilled waste in managed waste disposal sites instead of unmanaged sites before. The emissions from landfills decreased slightly from 2001 to 2005, due to increased methane recovery. The emissions rose by 5% from 2005 to 2009 (Figure 2.7). This increase is mainly due to failures in the methane capture system at the single landfill site where methane is collected, and also due to increased amount of landfilled waste disposed at managed waste disposal sites. A new methane recovery device has been taken into operation and should be fully functional in the end of 2009.

Table 2.5: Emissions of CH_4 by sector 1990-2009, CO_2-eqivalents.

	1990	1995	2000	2005	2007	2008	2009
Agriculture	287	265	256	243	249	252	254
Waste	153	173	185	185	217	212	203
Other	5	5	4	4	4	4	4
Total	**445**	**443**	**446**	**432**	**470**	**467**	**460**

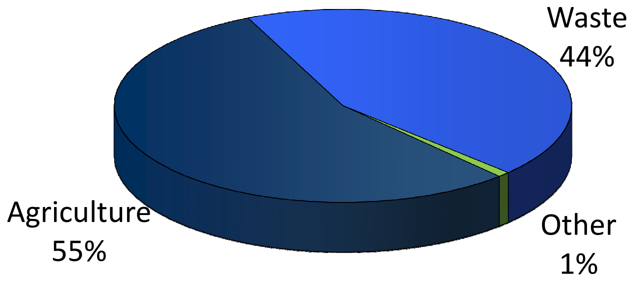

Figure 2.6: Distribution of CH_4 emissions by source in 2009.

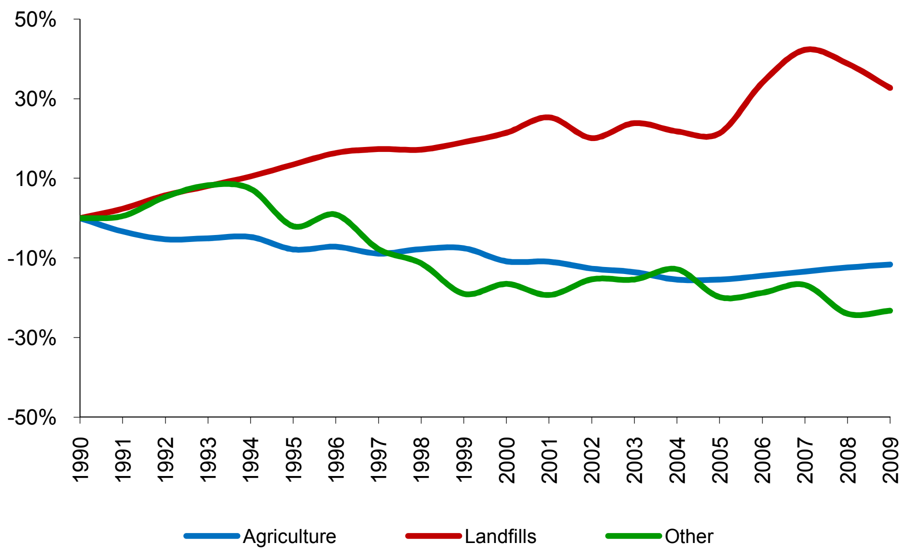

Figure 2.7: Percentage changes in emissions of CH_4 by major sources 1990-2009, compared to 1990 levels.

2.2.3 Nitrous Oxide (N_2O)

Agriculture accounts for around 80% of N_2O emissions in Iceland, as can be seen from Table 2.6 and Figure 2.8, with agricultural soils as the most prominent contributor. The second most important source of N_2O is road transport, which increased rapidly after the use of catalytic converters, but N_2O is a by-product of such converters when NO_x are converted to N_2. These catalytic converters became obligatory in all new vehicles in 1995.

Nitrous oxide emissions have decreased by 5% since 1990 and there was a slight increase in emissions from road transport. This increase was partially counteracted by the closure of a fertilizer production facility in 2001. Emissions from agriculture decreased after 1990 because of decrease in animal livestock, but increased again from 2006 to 2008 due to increased use of synthetic fertilizers. In 2009 prices raised leading to less use of synthetic fertilizers and therefore lower emissions (Figure 2.9).

Table 2.6: Emissions of N_2O by sector 1990- 2009 in CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Agriculture	288	277	296	256	302	315	286
Road traffic	5	12	29	38	41	39	39
Other	85	82	64	46	45	42	33
Total	**377**	**371**	**388**	**339**	**388**	**396**	**358**

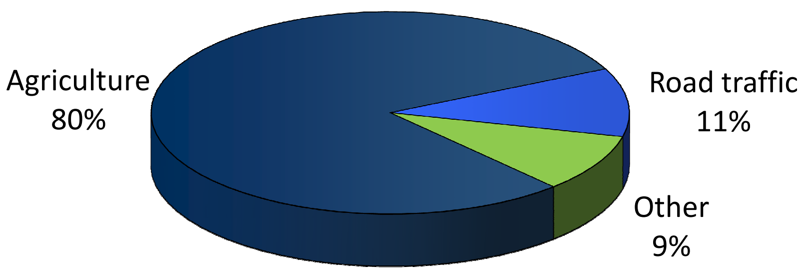

Figure 2.8: Distribution of N_2O emissions by source in 2009.

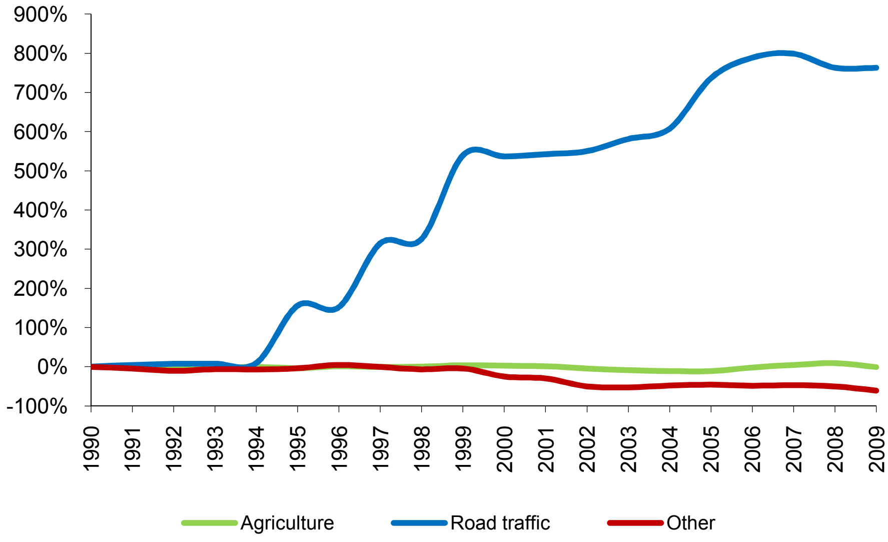

Figure 2.9: Changes in N_2O emission for major sources between 1990 and 2009.

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 129 and 24 Gg CO_2-equivalents respectively in 2009 (Table 2.7).

Total PFC emissions decreased by 64% in the period of 1990-2009. The emissions decreased steadily from 1990 to 1996 with the exception of 1995, as can be seen from Figure 2.10. PFC emissions per tonne of aluminium are generally high during start up and usually rise during expansion. The emissions therefore rose again due to the expansion of the Rio Tinto Alcan aluminium plant in 1997 and the establishment of the Century Aluminium plant in 1998. The emissions showed a steady downward trend between 1998 and 2005. The PFC reduction was achieved through improved technology and process control and led to a 98% decrease in the amount of PFC emitted per tonne of aluminium produced during the period of 1990 to 2005. The PFC emissions rose significantly in 2006 due to an expansion of the Century Aluminium facility. The extent of the increase can be explained by technical difficulties experienced during the expansion. PFC emissions per tonne of aluminium went down from 2007 to 2009 but still remained higher than in 2005 at the Century Aluminium plant, although not as high as in 2006. The Alcoa Fjarðarál aluminium plant was established in 2007 and reached full production capacity in 2008. The decline in PFC emissions in 2009 was achieved through improved process control at both Century Aluminium plant and Alcoa Fjarðarál, as the processes have become more stable after a period of start-up in both plants.

Table 2.7: Emissions of PFCs 1990-2009 in CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
CF_4	355	50	108	22	238	295	129
C_2F_6	65	9	20	4	43	54	24
Total	**420**	**59**	**127**	**26**	**281**	**349**	**153**

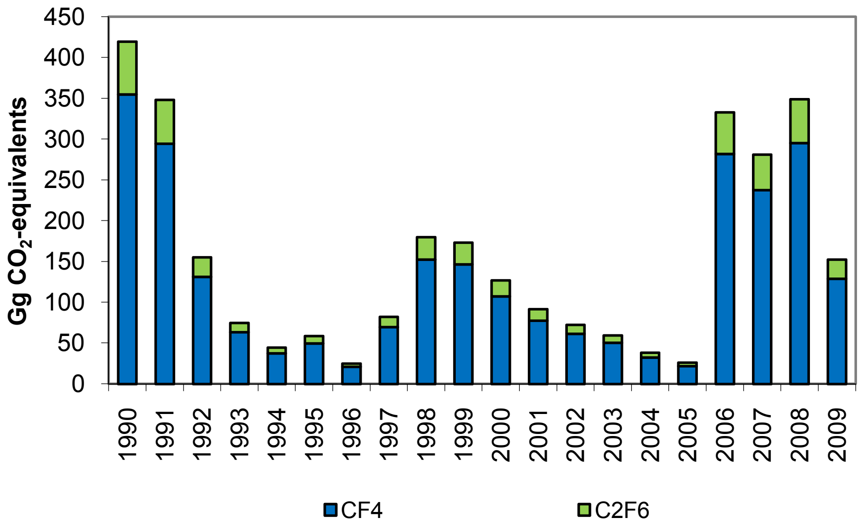

Figure 2.10 Emissions of PFCs from 1990 to 2009, Gg CO_2-equivalents.

2.2.5 Hydrofluorocarbons (HFCs)

The total actual emissions of HFCs, used as substitutes for ozone depleting substances, amounted to 85.8 Gg CO_2-equivalents in 2009 (Table 2.8). The imports of HFCs started in 1992 and have increased since then in response to the phase-out of chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs). Refrigeration is by far the largest source of HFCs emissions while air conditioning systems in cars are a minor source that has been gradually increasing.

Over the years the use of ozone depleting substances (ODS) in fishing boats has been decreasing due to a restriction of ODS import and therefore the use of substitutes (HFCs) have been increasing. Also, HFCs are used in the aluminium industry which production capacity has increased a nine fold since 1990. The openings of two large shopping centres in Iceland have further led to an increase in HFC usage (Figure 2.11).

Table 2.8: Emissions of HFCs 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
HFC 32	-	-	-	0.1	0.1	0.1	0.1
HFC 125	-	1.6	10.8	18.3	20.5	23.0	30.0
HFC 134a	-	1.1	4.5	10.1	14.1	15.2	16.7
HFC 143a	-	1.5	11.6	20.0	23.3	28.2	38.9
HFC 152a	-	-	0.1	0.1	0.1	0.0	0.0
Total	**-**	**4.2**	**27.0**	**48.5**	**58.1**	**66.5**	**85.8**

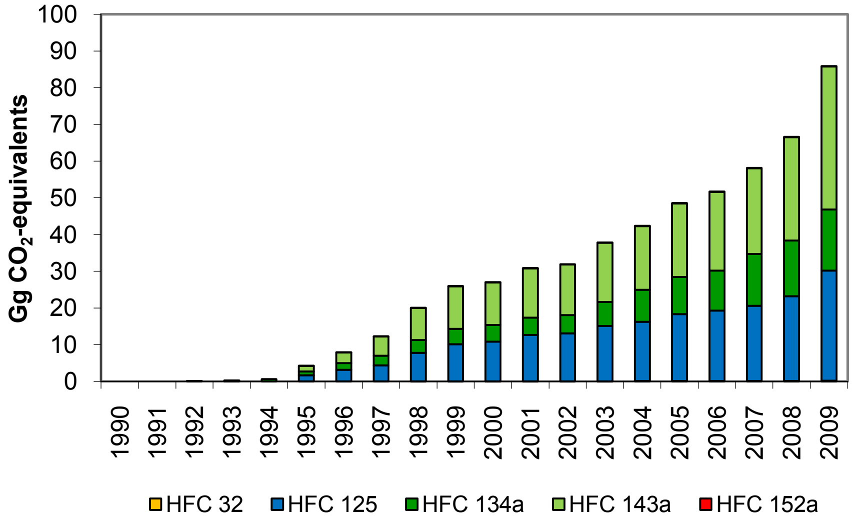

Figure 2.11: Actual emissions of HFCs 1990-2009, Gg CO_2-equivalents (HFC-32 and HFC-152 cannot be seen in figure due to proportionally low levels compared to other levels).

2.2.6 Sulphur Hexafluoride (SF_6)

The largest source of SF_6 emissions is leakage from electrical equipment. Total emissions in 2009 were 5.9 Gg CO_2-equivalents. Emissions have varied between 1 and 11 in the period 1990 and 2009. Peaks in emissions occur during power plant construction.

A large fluctuation is seen in SF_6 emission. This is due to the leakages that occur during the installation of new distribution systems and expansion of older systems. Emissions of 11 Gg CO_2-equivalents occurred in 1999 when two large power stations were built and enlarged (Sultartangi and Búrfell) (Figure 2.12). Average emission in 1990 to 2009 equal 3.9 Gg CO_2-equivalents.

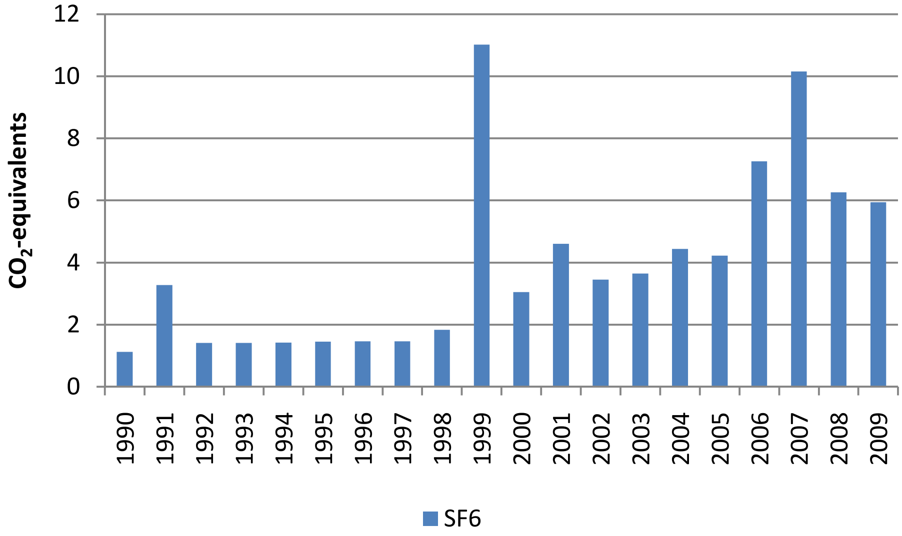

Figure 2.12: Emissions of SF_6 from 1990 to 2009 in Gg CO_2-equivalents.

The development of the Blanda power project began in 1984 and the first generating unit went online in the autumn of 1991. This can be seen as a peak in Figure 2.12. In the years after 1996 expansion took place in the metal production sector, which called for increased electricity production. The power plants at Blanda and Búrfell were expanded and new plants were constructed at Sultartangi and Vatnsfell in southern Iceland. In 2002 construction began on Kárahnjúkar hydropower project which was put into operation in 2007.

2.3 Emission Trends by Source

The Energy sector is the largest contributor of greenhouse gas emissions (without LULUCF) in Iceland, followed by Industrial Processes, Agriculture, Waste, and Solvent and other Product Use. The contribution of the Energy sector to the total net emissions decreased from 52% in 1990 to 44% in 2009. The contribution of Industrial Processes was 25% in 1990 and 40% in 2009 (Table 2.9, Figure 2.13, and Figure 2.15).

Table 2.9: Total emissions of GHG by sources in 1990- 2009 in CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Energy	1,783	1,919	2,053	2,102	2,234	2,092	2,033
- Fuel combustion	1,717	1,837	1,890	1,978	2,083	1,907	1,858
- Geothermal energy	67	82	164	123	152	185	175
Industrial processes	863	535	946	918	1,485	1,992	1,828
Solvent and other product use	14	14	15	16	13	9	6
Agriculture	575	542	552	498	551	566	539
LULUCF	1,103	1,056	931	809	747	718	681
Waste	180	194	201	194	226	221	212
Total without LULUCF	**3,415**	**3,204**	**3,766**	**3,727**	**4,509**	**4,880**	**4,618**

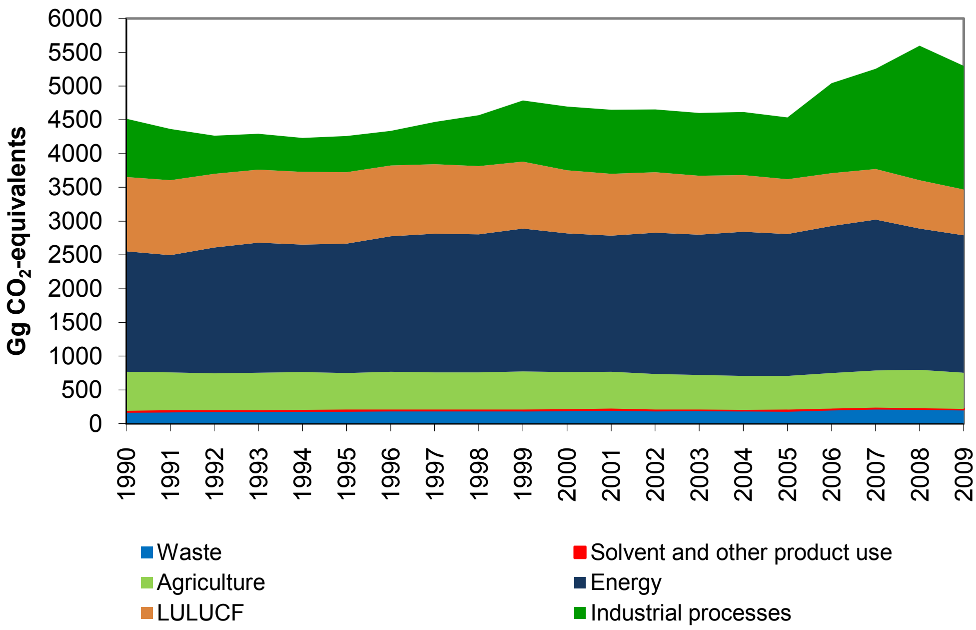

Figure 2.13: Emissions of GHG by sector from 1990 to 2009 in CO_2-equivalents.

The distribution of the total greenhouse gas emissions over the UNFCCC sectors (excluding LULUCF) in 2009 is shown in Figure 2.14.

Emissions from the Energy sector account for 44% (fuel combustion 40% and geothermal energy 4%) of the national total emissions without LULUCF, Industrial Processes account for 40%, and Agriculture for 12%. The Waste sector accounts for 5% and Solvent and other Product Use for 0.1%.

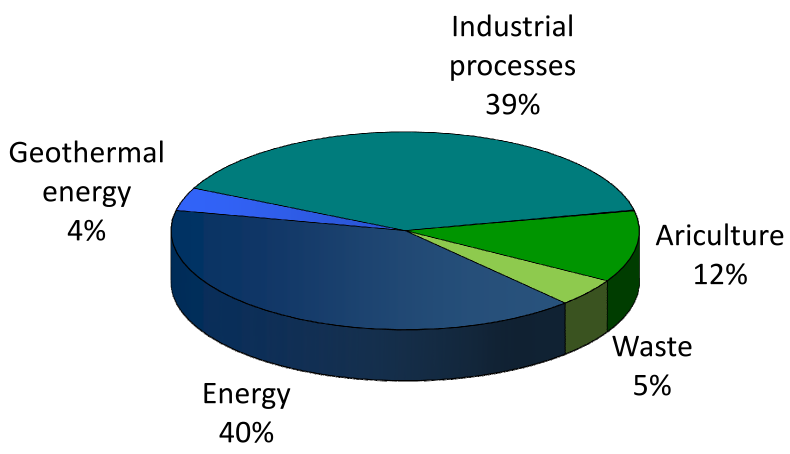

Figure 2.14: Emissions of greenhouse gases by UNFCCC sector in 2009.

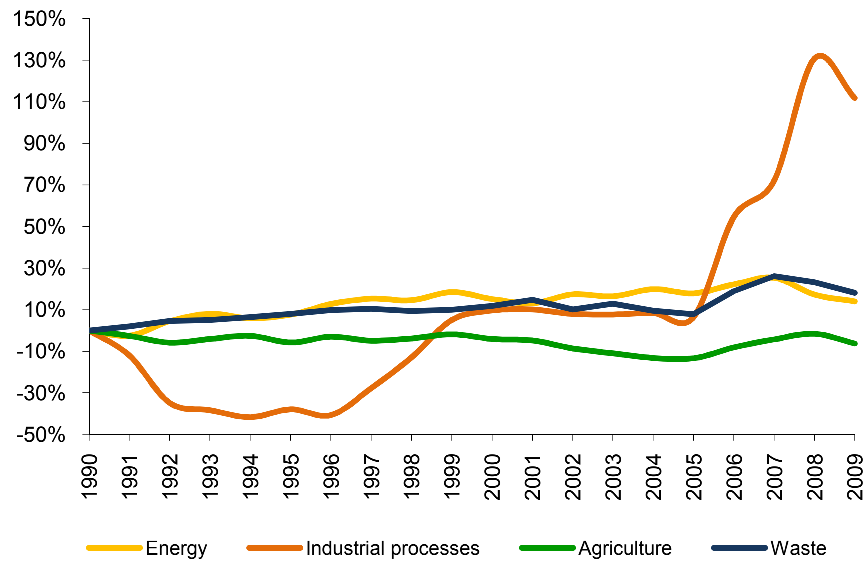

Figure 2.15: Percentage changes in emissions of total greenhouse gas emissions by UNFCCC source categories during the period 1990-2009, compared to 1990 levels.

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. In 2009 the consumption was about 745 GJ. However, the proportion of domestic renewable energy in the total energy budget is nearly 80%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy-intensive. The metal industry used around 79% of the total electricity produced in Iceland in 2009. 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 the signing of agreements on the building of an aluminium plant, and in 1979 a ferrosilicon plant began production. In the third phase, following the oil crisis of 1973-1974, efforts were made to use domestic sources of energy to replace oil, particularly for space heating and fishmeal production. Oil has almost disappeared as a source of energy for space heating in Iceland, and domestic energy has replaced oil in industry and in other fields where such replacement is feasible and economically viable.

Fuel Combustion

The total emissions of greenhouse gases from fuel combustion in the Energy sector over the period 1990 to 2009 are listed in Table 2.10. Emissions from fuel combustion in the Energy sector accounted for 40% of the total greenhouse gas emissions in Iceland in 2009. Figure 2.16 shows the distribution of emissions in 2009 by different source categories. The percentage change in the various source categories in the Energy sector between 1990 and 2009, compared with 1990, are illustrated in Figure 2.17.

Table 2.10: Total emissions of GHG from the fuel combustion in the Energy sector in 1990-2009, CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Energy industries	13	19	10	13	30	15	15
Manufacturing industry and constr.	377	379	450	454	426	367	262
Transport	621	628	674	849	1,029	974	947
- Road	561	561	633	800	946	892	893
- Other	92	67	41	49	83	82	57
Other sectors	706	810	756	663	598	551	634
- Fishing	662	780	728	633	571	523	603
- Residential/commercial	43	30	29	30	27	28	31
Total	**1,717**	**1,837**	**1,890**	**1,978**	**2,083**	**1,907**	**2,033**

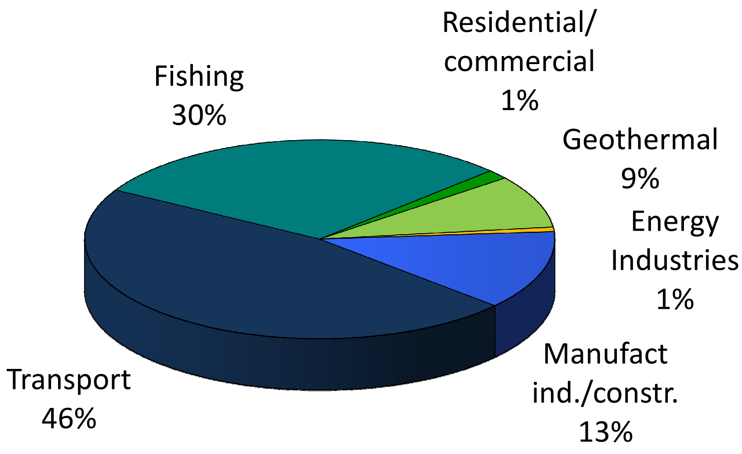

Figure 2.16: Greenhouse gas emissions in the fuel combustion sector 2009, distributed by source categories.

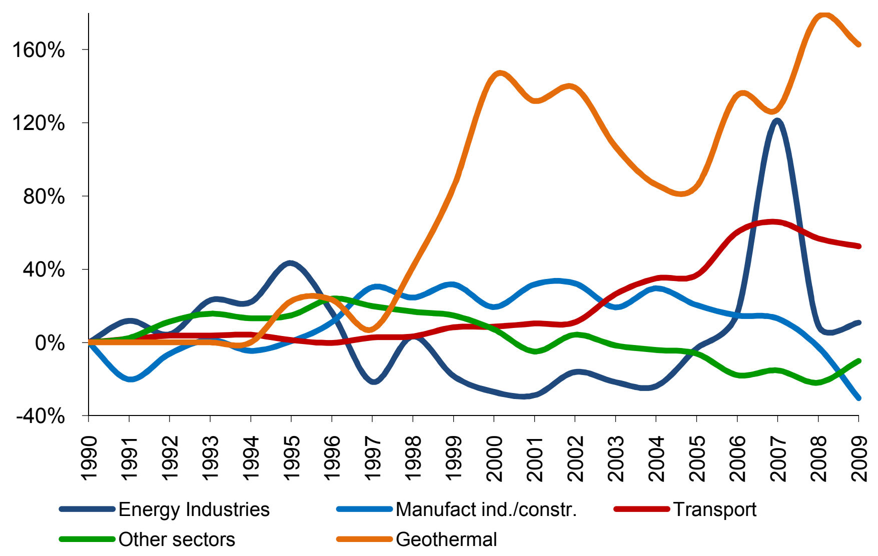

Figure 2.17: Percentage changes in emissions in various source categories of fuel combustion in the Energy sector during the period 1990-2009, compared to 1990.

Table 2.10 and Figure 2.17 show that emissions from transport have increased (by 52%) as emissions from other sector (dominated by fishing) have decreased (by 10%). Emissions from energy industries are back to 1990 levels and emissions from manufacturing industries and construction are 31% 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 low. Emissions from energy industries accounted for 0.7% of the sector's total and 0.3% of the total GHG emissions in Iceland in 2009. Electricity is produced with fuel combustion at 3 locations, which are located far from the distribution system. Some generation facilities have back up fuel combustion which they use if problems occur in the distribution system. Some district heating facilities that lack access to geothermal energy sources use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have back-up fuel combustion in case of an electricity shortage or problems in the distribution system. Emissions from the energy industries sector have generally decreased since 1990. In 1995 there were issues in the electricity distribution system that resulted in higher emissions that year. Unusual weather conditions during the winter of 1997/1998 led to unfavourable water conditions for the hydropower plants. This created a shortage of electricity which was met by burning oil for electricity and heat production. In 2007 a new aluminium plant was established. Because the Kárahnjúkar hydropower project was delayed, the aluminium plant was supplied for a while with electricity from the distribution system. This led to electricity shortages for the district heating systems and industry depending on curtailable energy, leading to increased fuel combustion and emissions.

Increased emissions from the manufacturing industries and construction source category over the period 1990 to 2007 are explained by the increased activity in the construction sector during the period. The knock-off effect of the increased levels of economic growth was increased activity in the construction sector. Emissions have risen, particularly in recent years (until 2007), related to the construction of Iceland's largest hydropower plant (Kárahnjúkar). The construction sector collapsed in fall 2008 due to the economic crises and the emissions from the sector decreased by 31% between 2008 and 2009. The fishmeal industry is the second most important source within manufacturing industries and construction. Emissions from fishmeal production decreased over the period due to replacement of oil with electricity as well as less production.

The fisheries dominate the Other sector. Emissions from fisheries rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in unusually distant fishing grounds. From 1996, the emissions decreased again reaching 1990 levels in 2001. Emissions increased again by 10% between 2001 and 2002. In 2003 emissions again reached the 1990 level. In 2009 emissions were 9% below the 1990 level and 15% above the 2008 level. Annual changes are inherent to the nature of fisheries.

Emissions from the Transport sector increased of 52% from 1990 to 2009. CO_2 emissions from road transport have increased by 64% since 1990, owing to an increase in the number of cars per capita, more mileage driven, and an increase in larger vehicles. Since 1990 the vehicle fleet in Iceland has increased by 78%. This has led to increased emissions from the Road Transport sector (64%). A trend has been observed in recent years in increasing size of passenger cars, which consume more fuel also, the Icelandic population has grown by 24% from 1990 to 2009. Fuel prices rose significantly in 2009 leading to lower emissions (3%) in 2009 than in 2008. 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. These emissions from domestic flights and navigation are expected to decline more but it is likely that the economic crisis had led to fewer air flights abroad and therefore more travel within Iceland during summer vacation.

Geothermal Energy

Emissions from geothermal energy utilization accounts for 4% of the total greenhouse gas emissions in Iceland in 2009. 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. Table 2.11 shows the emissions from geothermal energy from 1990 to 2009. Electricity production using geothermal power increased during this period from 283 to 4,553 GWh. The CO_2 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 2.11: Emissions from geothermal energy from 1990-2009 in CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Geothermal energy	67	82	164	123	152	185	175

2.3.2 Industrial Processes

Production of raw materials is the main source of industrial process related emissions for both CO_2 and other greenhouse gases such as N_2O and PFCs. The Industrial Process sector accounts for 40% of the national greenhouse gas emissions. As can be seen in Table 2.12 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.

Table 2.12: Emissions from industrial processes 1990-2009 in CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Mineral products	52	38	66	56	65	62	30
Chemical industry	49	43	19	-	-	-	-
Metal production	761	449	831	809	1,352	1,857	1,707
- **Ferroalloys**	205	239	358	374	391	340	342
- **Aluminium**							
○ Aluminium CO_2	137	151	346	409	680	1,168	1,212
○ Aluminium PFC	420	59	127	26	281	349	153
Consumption of HFCs and SF_6	1	6	30	53	68	73	92
Total	**863**	**535**	**946**	**918**	**1,485**	**1,992**	**1,828**
Emissions fulfilling 14/CP.7*						**1,171**	**1,195**

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

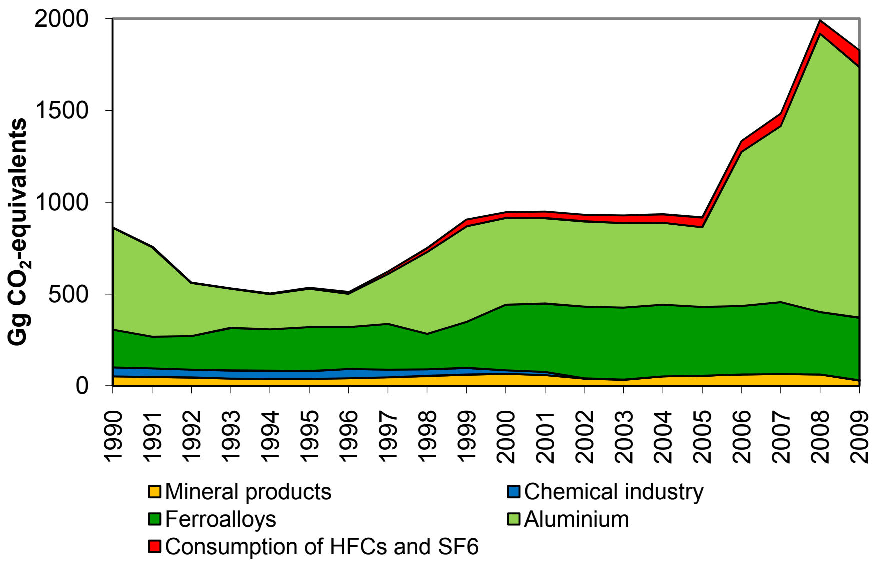

Figure 2.18 Total greenhouse gas emissions in the Industrial Process sector during the period from 1990-2009 in Gg CO_2-equivlalents.

The most significant category within the industrial processes sector is metal production, which accounted for 88% of the sector's emissions in 1990 and 93% in 2009. Aluminium production is the main source within the metal production category, accounting for 75% 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 2009 but still remained higher than in 2005, although not as high as in 2006. The Alcoa Fjarðaál aluminium plant was established in 2007 and reached full production capacity in 2008. PFC emissions per tonne of aluminium are generally high during start up and usually rise during expansion. PFC emission declined in 2009 through improved process technology at both Century Aluminium plant and Alcoa Fjarðarál. The amount of PFC emitted per tonne of aluminium was 0.19 tonnes of CO_2-equivalents in 2009. More discussion on PFC emissions from the three aluminium plants can be found in chapter 4.5.

Production of ferroalloys is another major source of emissions, accounting for 19% of industrial processes emissions in 2009. 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 and emissions have therefore increased considerably, or by 67% since 1990. Emissions in 2009 were 0.6% higher than in 2008.

Production of minerals accounted for 1.6% of the emissions in 2009. Cement production is the dominant contributor. Cement is produced in one plant in Iceland, emitting CO_2 derived from carbon in the shell sand used as the raw material in the process. Emissions from the cement industry reached a peak in 2000 but declined until 2003, partly because of cement imports. In 2004 to 2007 emissions increased again because of increased activity related to the construction of the Kárahnjúkar hydropower plant (built 2002 to 2007) although most of the cement used for the project was imported. Emissions in 2009 were 52% lower than in 2008.

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

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

The largest source of SF_6 emissions is leakages from electrical equipment. Emissions have varied between 1 to 11 Gg from 1990 to 2009, peaking in years when new power plants were built (Figure 2.12).

2.3.3 Solvent and other Product Use

The use of solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which are regarded as indirect greenhouse gases. The NMVOC compounds are oxidized to CO_2 in the atmosphere over time. Also included in this sector are emissions of N_2O, which occur because of its uses mainly for medical purposes, and also to a smaller extent for car racing. NMVOC emissions were 5.9 Gg CO_2-equivalents in total in 2009 (0.1% of the total GHG emissions), which is 77% below the 1990 level and 37% below the 2008 level. This is mainly due to a decrease in use of paint application which was 36% less in 2009 than in 2008. Also, there is a decrease in white spirit use in paint products and asphalt as well as N_2O use (classified under “other” in Table 2.13). This is believed to be due to the economic crisis which has among other led to a reduction in household construction among the public.

Table 2.13: Total greenhouse gas emissions from solvents and other product use in 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Paint application	3.6	3.3	5.2	4.0	4.4	5.1	3.3
Degreasing and dry cleaning	0.7	0.6	0.8	0.5	0.5	0.6	0.4
Other	9.7	10.1	8.9	11.6	7.6	3.6	2.2
Total	**13.9**	**14.1**	**14.9**	**16.2**	**12.5**	**9.3**	**5.9**

The dominant part of emission in the Solvent and other Product Use sector from 1990 to 2007 has been from the subcategory “Other”, where emissions from white spirit use are the main source followed by N_2O emissions from anaesthesia and other medical procedures (Figure 2.19). Emissions from that sub-category were much lower in 2008 and 2009.

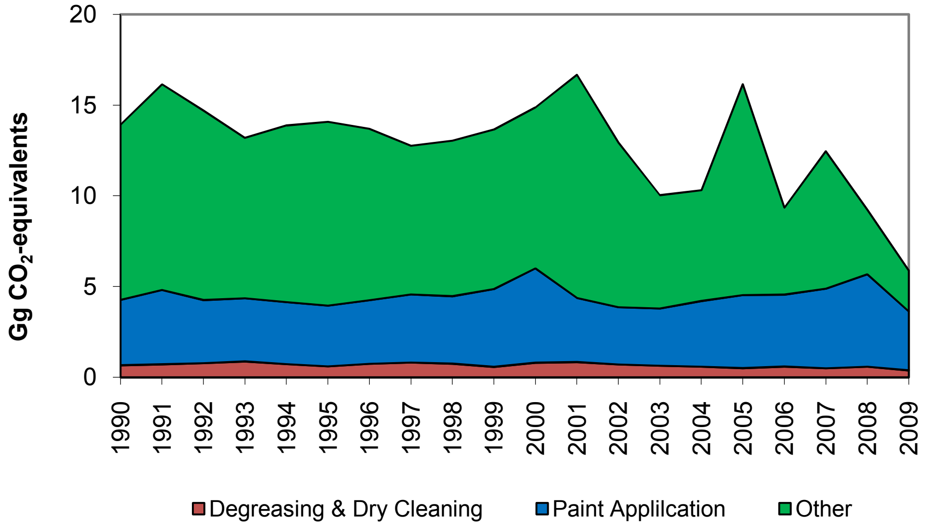

Figure 2.19: Indirect greenhouse gas emissions from solvents and other product use in the years 1990 to 2009.

2.3.4 Agriculture

Emissions from agriculture decreased from 1990 to 2005, as can be seen in Table 2.14 and Figure 2.21. This change was mainly due to a decreasing number in the livestock population. Emissions rose again from 2005 to 2008 due to increased use of synthetic fertilizers but in the year 2009 there was a drop in synthetic fertilizer use due to higher prices of fertilizer. There was a 12% decrease in emissions from enteric fermentation, an 8% decrease in emissions from manure management and a 0.2% increase in emissions from agricultural soils in the year 2009 compared to 1990 levels. When comparing 2009 levels to 2008 levels the total emissions from the Agricultural sector decreased by 5%, which is mainly due to a decrease in synthetic fertilizer use. Figure 2.20 shows that agricultural soils account for 48% of the total emissions from this sector, enteric fermentation accounts for 43% and manure management 9%.

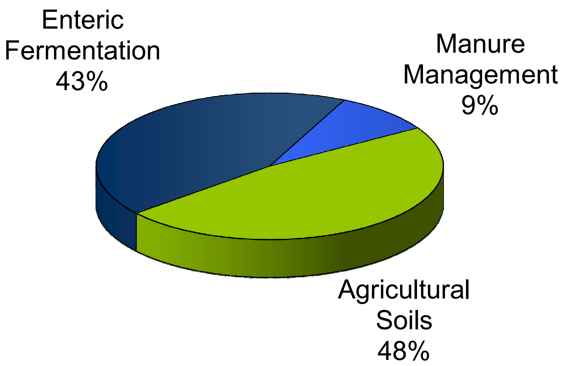

Figure 2.20: Greenhouse gas emissions in the agriculture sector 2009, distributed by source categories.

Table 2.14: Total greenhouse gas emissions from agriculture in 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Enteric fermentation	265	243	235	223	228	231	233
Manure management	54	51	50	47	49	49	50
Agricultural soils	256	248	267	228	274	287	257
Total	**575**	**542**	**552**	**498**	**551**	**566**	**539**

The largest sources of agricultural greenhouse gas emissions are nitrous oxide emissions from agricultural soils (48%) and methane from enteric fermentation (43%). Greenhouse gas emissions from the Agricultural sector accounted for 12% of the overall greenhouse gas emissions in 2009.

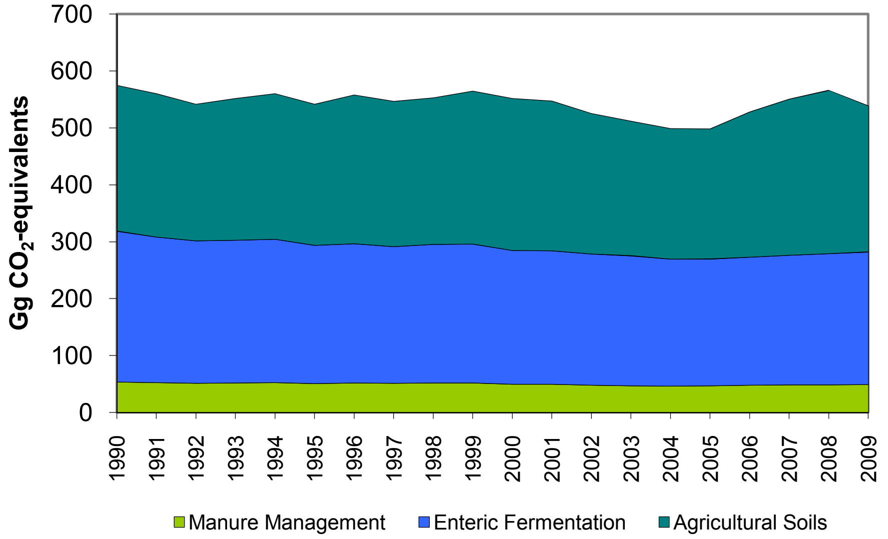

Figure 2.21: Total greenhouse gas emissions from agriculture 1990-2009 in Gg CO_2-equivalents.

2.3.5 LULUCF

Emissions from the LULUCF sector in Iceland are high compared to other sectors. A large part (62%) of the absolute value of emissions from the sector in 2009 were from cropland and grassland due to drainage of 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.

The time series in the LULUCF sector are incomplete. Trend analysis can therefore only be done provisionally. Time series are only available for few categories, i.e. Forest Land, Revegetation (Other land converted to Grassland), and Flooded land. The changes reported for other categories are due to adjustments in area resulting from the available time series. Net emissions (emissions – removals) in the sector have decreased over the time period, as can be seen in Table 2.15. This is explained by increased removals through forestry and revegetation as well as a small decline in emissions from drained wetlands, resulting from adjustment in area toward increased forest land. Increased removals in forestry and Revegetation are explained by the increased activity in those categories and changes in forest growth with stand age. The reason for decrease in emissions from drained wetland is that part of the previously drained area has been converted to Forest Land. The increase in emissions from Wetlands is due to increased emissions from hydropower reservoirs as new reservoirs were created during the time period.

Table 2.15: Emissions from the LULUCF sector from 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Forest Land	-24	-47	-114	-180	-217	-237	-258
- Afforestation	-24	-47	-80	-122	-145	-157	-169
- Natural birch forest	NE	NE	-34	-58	-72	-80	-89
Cropland	991	991	991	995	996	997	995
Grassland	59	24	-37	-100	-125	-136	-150
- Natural birch shrub land	NE	NE	-6	-10	-12	-13	-18
- Wetland converted to Grassland	310	309	308	308	308	308	307
- Revegetation	-250	-285	-339	-398	-421	-431	-439
Wetland	3	14	17	17	18	18	18
- Hydropower reservoirs	3	14	17	17	18	18	18
Settlement	NE,NO	NE,NO	NE,NO	0	0	NA,NE, NO	NA,NE, NO
Other emissions	74	74	74	77	75	76	76
- Wetland converted to Grassland (N_2O)	72	72	72	72	72	72	72
- Other emissions due to Revegetation	2	2	2	5	3	5	4
LULUCF Total	**1,103**	**1,056**	**931**	**809**	**747**	**718**	**681**

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

Iceland has elected revegetation as an activity under Article 3.4 of the Kyoto Protocol. Removals from revegetation amounted to 189 Gg (Net – Net accounting) in 2009. Removals from activities under Articles 3.3 (Afforestation and Reforestation) amounted to 147 Gg in 2009. Afforestation falling under Convention reporting amounted to 169 Gg. The difference, 22 Gg, was due to C-stock increase in older forests.

2.3.6 Waste

Emissions from the Waste sector accounted for 5% of the total GHG emissions in 2009. Emissions from the waste sector increased from 1990 to 2000. A minor decrease in emissions from the Waste sector occurred between 2000 and 2005, but emissions increased again in 2005 and 2007. The emissions from the sector were highest in 2007 when they were 27% above 1990 levels. There are a few reasons for this, increasing amounts of waste being landfilled instead of being incinerated, a larger proportion of waste being landfilled in managed waste disposal sites compared to unmanaged sites, and a failure in the methane recovery equipment at the single landfill site that recovers methane. This decrease in emissions can be seen in Table 2.16 and Figure 2.22.

Table 2.16: Total emissions from the Waste sector from 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Landfills	134	151	164	167	201	196	185
Wastewater handling	20	25	26	25	23	23	24
Waste incineration	26	17	10	1.2	1.0	1.0	0.9
Composting	-	0.4	0.4	0.9	1.8	1.8	2.3
Total	**180**	**194**	**201**	**194**	**226**	**221**	**212**

Solid Waste Disposal on Land

The total amount of emissions from landfilled waste increased by 38% from 1990 to 2009. The amount of greenhouse gases (CH_4) from landfills increased steadily from 1990 to 2000, as can be seen in Table 2.16 and Figure 2.22. Methane recovery started at the largest operating landfill site in 1997, and the amount recovered increased steadily until 2006 when methane recovery equipment failed partly due to technical problems. These problems led to continued failure in methane recovery in 2007 and 2008. Methane recovery was in better function in 2009 but significantly less methane was recovered than previous years due to the equipment failure. A decrease is seen in waste generation in 2008 and 2009 and in the GDP, which can be attributed to the financial crisis.

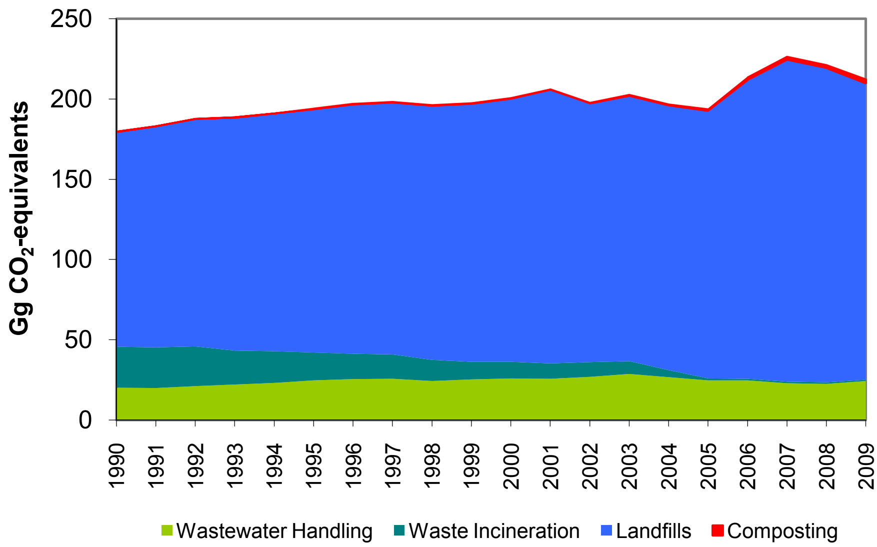

Figure 2.22: Emissions of greenhouse gases in the Waste sector 1990-2009 in Gg CO_2-equivalents.

Wastewater Handling

Fluctuations seen in wastewater emissions are mainly due to industrial wastewater where the fishing industry plays the main role. The CH_4 emissions from fishing industry alone were four to seven times larger than from the dairy industry and meat and poultry production combined, in the period from 1990 to 2009. After the restriction alleviation of the beer consumption in Iceland 1989 the beer industry has been steadily increasing with a 10% average increase between years. This has lead to the fact that the beer industry has become the second largest contributor of greenhouse gasses within the wastewater handling sector. Meat and poultry and dairy production has increased slowly since 1990, but a 1% decrease was seen between 2008 and 2009. Vegetable production has been somewhat stable from 1990 to 2005 with an increase from 2006 to 2009 despite a decrease between 2008 and 2009 of 4.5%. This can be seen in Figure 2.23.

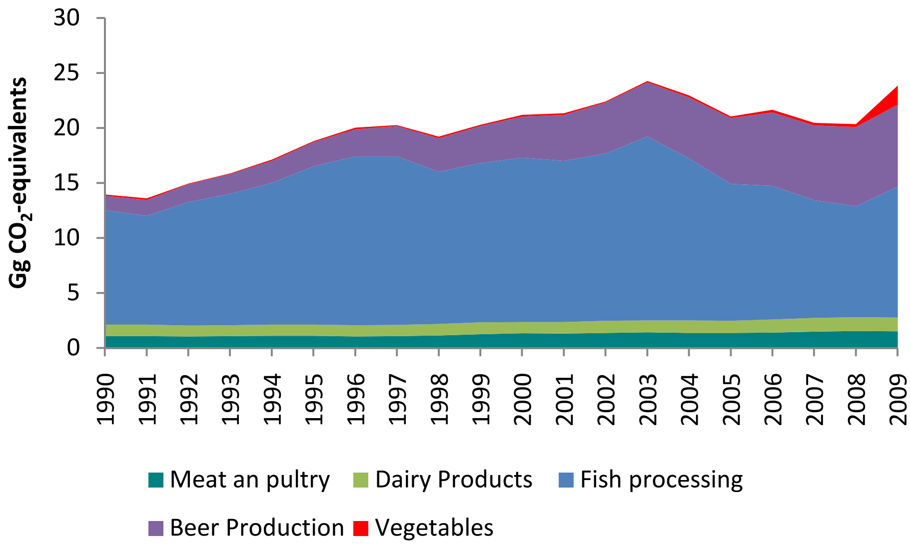

Figure 2.23: Methane emissions of industrial wastewater in Iceland 1990-2009 in Gg CO_2-equivalents.

Emissions from domestic wastewater are the minor factor in total wastewater emissions. Emissions from domestic wastewater handling have increased consistently since 1990 because the total number of inhabitants connected to wastewater facilities has increased in the time period. A small decrease is seen in domestic wastewater handling in 2007 when a municipality near Reykjavík which had a semi-anaerobic treatment was incorporated into Reykjavík's wastewater treatment which is an aerobic treatment. This led to a decrease in emissions from that municipality.

Waste Incineration

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

Composting

Emissions from composting have been steadily increasing since composting started in Iceland the year 1995 (Figure 2.24) and the year 2009 emissions from this category accounted for 1% of the total emissions from the Waste sector. Between 2008 and 2009 composting increased of 28% in Iceland. The public of Iceland is beginning to be more aware of this way of waste management and there is a increasing part of the population beginning to categorise their waste.

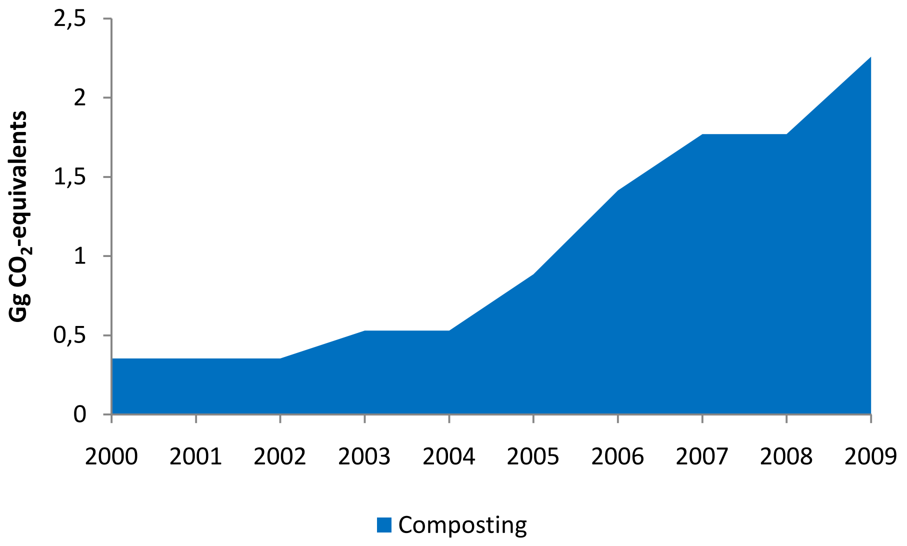

Figure 2.24: Emissions from composting in Iceland 1990-2009 in Gg CO_2-equivalents.

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 2.17.

In 2009, greenhouse gas emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 503 Gg CO_2-equivalents, which corresponds to about 11% of the total Icelandic greenhouse gas emissions. Greenhouse gas emissions from marine and aviation bunkers increased by around 57% from 1990 to 2009; with a 24% decrease between 2008 and 2009.

Looking at these two categories separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 67% from 1990 to 2009, while emissions from aircrafts increased by 52% during the same period. Between 2008 and 2009 emissions from marine bunkers decreased by 28% while emissions from aviation bunkers decreased by 52%. Foreign fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.17: Greenhouse gas emissions from international aviation and marine bunkers 1990-2009 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2007	2008	2009
Aviation	222	238	411	425	516	432	337
Marine	100	146	221	112	209	231	167
Total	**322**	**384**	**632**	**538**	**725**	**663**	**503**

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 (NO_x)

The main sources of nitrogen oxides in Iceland are fishing, transport, and the manufacturing industry and construction, as can be seen in Figure 2.25. The NO_x emissions from fishing rose from 1990 to 1996 when a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased, reaching the 1990 levels in 2001. Emissions in 2009 were 9% 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 23%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 64%. The rise in emissions from the manufacturing industries and construction are dominated by increased activity in the construction sector during the period. Total NO_x emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2002 and 2004 and then decreased again. Total NO_x emissions in 2009 were 13% below the 1990 level.

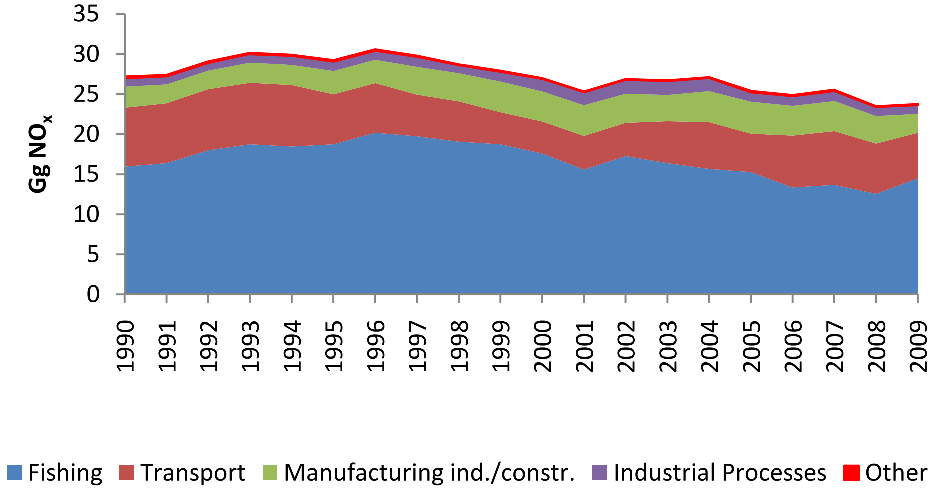

Figure 2.25: Emissions of NO_x by sector 1990-2009 in Gg.

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 2.26. Emissions from transport are dominated by road transport. These emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Emissions from solvent use have varied between 2 Gg and 4 Gg NMVOCs since 1990 with no obvious trend. The total emissions show a downward trend from 1994 to 2009. The emissions in 2009 were 58% below the 1990 level.

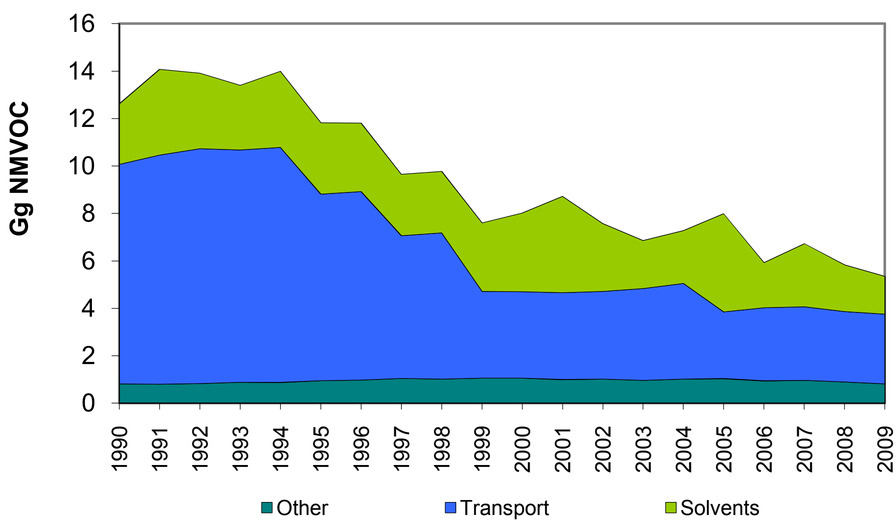

Figure 2.26: Emissions of NMVOC by sector 1990-2009 in Gg.

2.4.3 Carbon Monoxide (CO)

Transport is the most prominent contributor to CO emissions in Iceland, as can be seen in Figure 2.27. 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 2009 were 60% below the 1990 level.

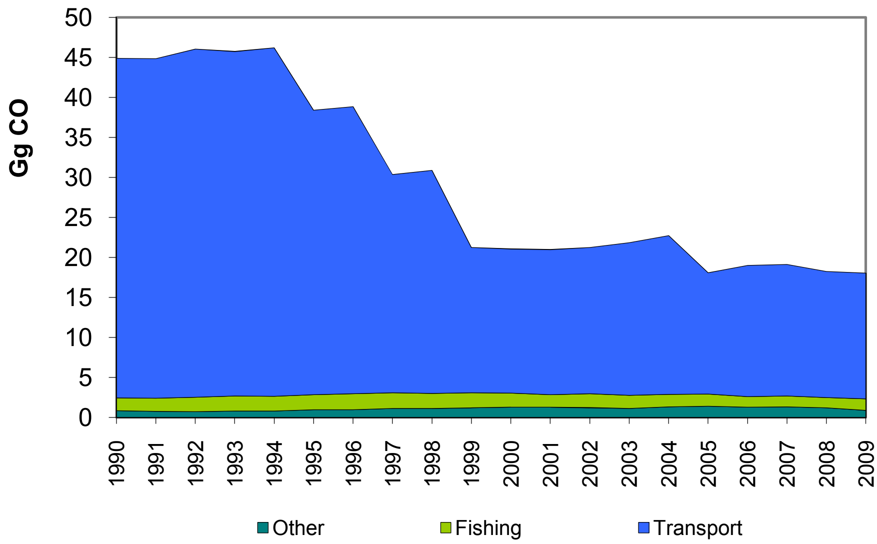

Figure 2.27: Emissions of CO by sector 1990-2009 in Gg.

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 386% since 1990 due to increased activity in this field. Other significant sources of sulphur dioxide in Iceland are industrial processes and manufacturing industry and construction, as can be seen in Figure 2.28. 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 2009 817,281 tonnes of aluminium were produced at three plants and 98,039 tonnes of ferroalloys were produced at one plant. This led to increased emissions of sulphur dioxide. The fishmeal industry is the main contributor to sulphur dioxide emissions from fuel combustion in the sector Manufacturing Industries and Construction. Emissions from the fishmeal industry increased from 1990 to 1997 but have declined since; the emissions were 58% below the 1990 level in 2009.

In 2009 total sulphur emissions in Iceland, calculated as SO_2, were in 275% above the 1990 level.

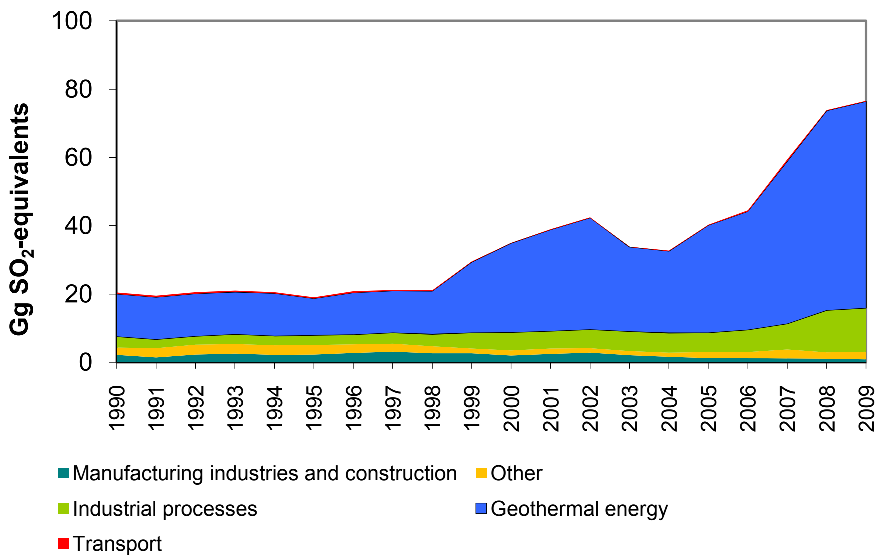

Figure 2.28: Emissions of S (sulphur) by sector 1990-2009 in Gg SO_2-equivalents.

3 ENERGY

3.1 Overview

The Energy sector in Iceland is unique in many ways. Iceland ranks 1st among OECD countries in the per capita consumption of primary energy. The consumption in 2009 was about 745 GJ. However, the proportion of domestic renewable energy in the total energy budget is about 80%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy-intensive. The metal industry used around 79% of the total electricity produced in Iceland in 2009. 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 44% (fuel combustion 40%, geothermal energy 4%) of the GHG emissions in Iceland. Energy related emissions increased by 14% from 1990 to 2009. From 2008 to 2009 the emissions from fuel combustion decreased by 3%, while emissions from geothermal energy decreased by 5%. Total emissions related to energy decreased by 3% from 2008 to 2009. Fisheries and road traffic are the sector’s largest single contributors. Combustion in manufacturing industries and construction is also an important source. No recalculations have been made in the Energy sector since last submission.

3.1.1 Methodology

Emissions from fuel combustion activities are estimated at the sectoral level based on the methodologies suggested by the IPCC Guidelines and the Good Practice Guidance. They are calculated by multiplying energy use by source and sector with pollutant specific emission factors. Activity data is provided by the National Energy Authority (NEA), which collects data from the oil companies on fuel sales by sector. The sales statistics for the manufacturing industry are given for the sector as a total. They do not specify the fuel consumption by the different industrial sources. This division is made by EA on basis of the reported fuel use by all major industrial plants 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. 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 2009 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 and trend
- Non-Road Transport – CO_2 (1A3a/d)
  - This is a key source in level and trend
- Road Transport – CO_2 and N_2O (1A3b)
  - This is a key source in level and trend
- Fishing – CO_2 (1A4c)
  - This is a key source in level and trend
- Geothermal Energy – CO_2 (1B2d)
  - This is a key source in level 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	N O T O C C U R R I N G									
- Manufacture of Solid Fuels	N O T O C C U R R I N G									
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	N O T O C C U R R I N G									
- 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	N O T O C C U R R I N G									
- Navigation	E	E	E	NA	NA	NA	E	E	E	E
- Other Transportation	N O T O C C U R R I N G									
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	N O T O C C U R R I N G									
Fugitive Emissions from Fuels										
- Solid Fuels	N O T O C C U R R I N G									
- Oil and Natural Gas	NE	NE	NE	NA	NA	NA	NE	NE	NE	NE
- Geothermal Energy	E	NA	NA	NA	NA	NA	NA	NA	NA	E
International Transport										
- Aviation	E	E	E	NA	NA	NA	E	E	E	E
- Marine	E	E	E	NA	NA	NA	E	E	E	E

3.1.4 Source Specific QA/QC Procedures

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

3.2 Energy Industries (1A1)

Energy Industries include emissions from electricity and heat production. Iceland has extensively utilised renewable energy sources for electricity and heat production, thus emissions from this sector are low. Emissions from Energy Industries accounted for 0.8% of the sectors total and 0.3% of the total GHG emissions in Iceland in 2009.

Activity data for the energy industries are provided by the NEA. The CO_2 emission factors reflect the average carbon content of fossil fuels. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and presented in Table 3.8 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 1-15 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.

3.2.1 Electricity Production

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2009 (Table 3.2) with hydropower as the main source of electricity. Electricity was produced with fuel combustion at a few locations that are located far from the distribution system. Some public electricity plants 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	2007	2008	2009
Hydropower	4,159	4,678	6,352	7,014	8,394	12,427	12,279
Geothermal	283	288	1,323	1,658	3,579	4,037	4,553
Fuel combustion	6	8	4	8	3	3	3
Total	**4,447**	**4,977**	**7,679**	**8,680**	**11,976**	**16,467**	**16,835**

Activity data

Activity data for electricity production with 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	2007	2008	2009
Gas/Diesel oil	1.3	1.5	1.1	2.0	1.1	0.5	0.8
Emissions	**4.1**	**4.9**	**3.4**	**6.3**	**3.5**	**1.7**	**2.4**

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 833 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 175 Gg of CO_2, in 2009. The resulting emissions of GHG per kWh amount to 1.5 g CO_2-equivalents/kWh for hydropower plants and to 38 g CO_2/kWh for geothermal energy. The weighted average GHG emissions from electricity production in Iceland in 2009 was thus 11.6 g/kWh.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from electricity production with fuels is 5% (with an activity data uncertainty of 1% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 1% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 1% 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 2009. Some district heating facilities, which lack access to geothermal energy sources, use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have back up fuel combustion in case of electricity shortages or problems in the distribution system. Three district heating stations burn waste to produce heat and are connected to the local distribution system. Emissions from these waste incineration plants are reported under Energy Industries. A description of the method to estimate greenhouse gas emissions is given in Chapter 8.

Activity Data

Activity data for heat production with fuel combustion and the resulting emissions are given in Table 3.5.

Table 3.5: Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equvalents) from heat production (NO: Not Occurring).

	1990	1995	2000	2005	2007	2008	2009
Residual fuel oil	3.0	3.1	0.1	0.2	4.5	0.1	0.1
Gas/Diesel oil	-	-	-	-	-	0.7	0.7
Solid waste	NO	4.7	6.0	6.0	12.0	10.3	8.0
Emissions (GHG)	**9.2**	**14.2**	**6.4**	**6.6**	**26.0**	**13.0**	**12.4**

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 3.6 along with sulphur content of the fuels.

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

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
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	24.95	0.98	0.96	0.17

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from electricity production with fuels is 5% (with an activity data uncertainty of 1% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 1% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 1% 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 13% of the Energy sector's total and 6% of total GHG emissions in Iceland in 2009. Mobile Combustion in the Construction sector accounts for 56% 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. Total use of different oil products is based on the NEAs annual sales statistics on fossil fuels. There is thus a given total, which the usage in the different sectors must sum up to. Fuel consumption in the fishmeal industry from 1990 to 2002 was estimated from production statistics, but the numbers for 2003 to 2009 are based on data provided by the industry (Green Accounts submitted under regulation 851/2007). All major industries, falling under law no. 65/2007 (metal and cement industries) report their fuel use to EA along with other relevant information for industrial processes. The difference between NEA sales statistics 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). 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	2007	2008	2009
Gas/Diesel oil	5.0	1.6	10.3	24.1	19.2	8.1	9.1
Residual fuel oil	55.9	56.2	46.2	25.0	22.8	20.5	17.6
LPG	0.5	0.4	0.9	0.9	1.5	1.9	1.6
Electrodes (residue)	0.8	0.3	1.5	-	0.5	0.5	0.4
Steam Coal	18.6	8.6	13.3	9.9	24.4	21.5	10.2
Petroleum coke	-	-	-	8.1	0.2	-	-
Waste oil	-	5.0	6.0	1.8	2.3	2.2	0.9
Total Emissions	**241**	**212**	**228**	**211**	**205**	**156**	**116**

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. 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 5% (with an activity data uncertainty of 2% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of e% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 2% 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 it happens that machinery tanks its fuel at a tank station, (thereby reported as road transport), as well as it happens that fuel that is sold to contractors, to be used on machinery, is used for road transport (but reported under construction). This is, however, very minimal and the deviation is believed to level out. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Activity data for fuel combustion 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	2007	2008	2009
Gas/Diesel oil	38	47	62	68	62	59	41
Emissions	**121**	**149**	**197**	**215**	**196**	**188**	**129**

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 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 5% (with an activity data uncertainty of 2% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of e% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 2% 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 47% of the sector's total and 20% of the total GHG emissions in Iceland in 2009. Road Transport accounts for 94% 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	2007	2008	2009
Gasoline	1.681	1.131	1.102	0.872	0.848	0.731	0.649
Jet kerosene	8.409	8.253	7.728	7.390	6.159	7.601	6.271
Emissions	**32**	**30**	**28**	**26**	**22**	**26**	**22**

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. The NEA estimates how the fuel consumption is divided between different vehicles groups, i.e. passenger cars, light duty vehicles, and heavy duty vehicles. The number of vehicles in each group comes from the Road Traffic Directorate.

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

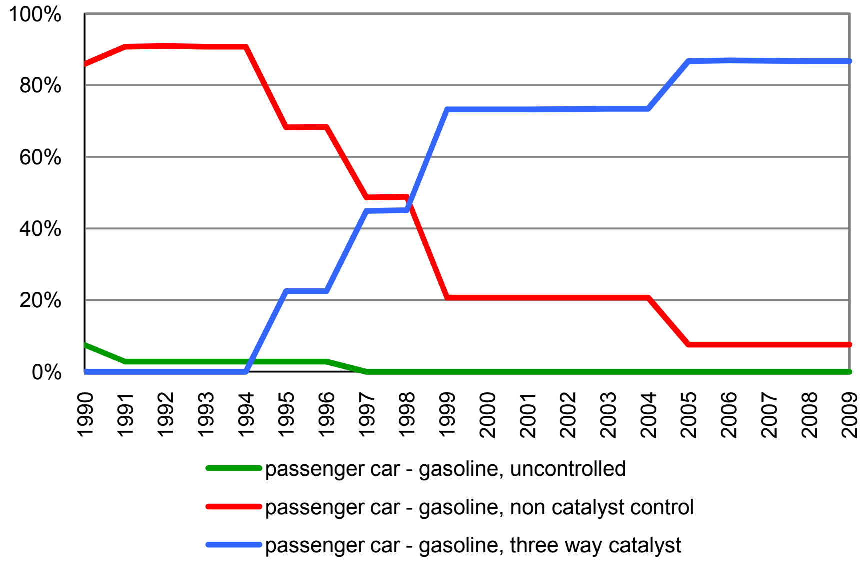

Figure 3.1: Passenger cars by emission control technology.

Emission Factors

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 3.13.

Table 3.13: 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
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

Planned improvements involve estimating emissions from road transport with the COPERT model.

3.4.3 National Navigation

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

Activity Data

Total use of residual fuel oil and gas/diesel oil for national navigation is based on NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion and the resulting emissions are given in Table 3.14.

Table 3.14: Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from national navigation.

	1990	1995	2000	2005	2007	2008	2009
Gas/Diesel oil	11.749	7.043	3.425	6.199	5.023	13.179	6.270
Residual fuel oil	7.170	4.755	0.542	0.881	14.374	4.192	3.709
Emissions	**59**	**37**	**13**	**22**	**60**	**55**	**31**

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 3.15.

Table 3.15: 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.

3.5 International Bunker Fuels

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

Emissions are calculated by multiplying energy use with pollutant specific emission factors. Activity data is provided by the NEA, which collects data on fuel sales by sector. These data distinguish between national and international usage. In Iceland there is one main airport for international flights, 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 retail supplier divides fuel use between international navigation (including foreign fishing vessels) and national navigation based on identification numbers which differ between Icelandic and foreign companies. The emission factors for marine bunkers are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.15 above.

3.6 Other Sectors (1A4)

Sector 1A4 consists of fuel use for commercial, institutional, and residential heating as well as fuel use in agriculture, forestry, and fishing. Since Iceland relies largely on its renewable energy sources, fuel use for residential, commercial, and institutional heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants. Commercial fuel combustion includes the heating of swimming pools, but only a few swimming pools in the country are heated with oil. Emissions from the fishing sector are high, since the fishing fleet is large. Emissions from fuel use in agriculture and forestry are included elsewhere; mainly in the Construction sector as well as in the Residential sector. Emissions from the Other sector accounted for 31% of the Energy sector’s total and for 14% of total GHG emissions in Iceland 2009. Fishing accounted for 95% of the Other sector’s total.

3.6.1 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. Activity data for fuel combustion in the Commercial/Institutional sector and the resulting emissions are given in Table 3.16.

Table 3.16: Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the commercial/institutional sector.

	1990	1995	2000	2005	2007	2008	2009
Gas/Diesel oil	1,8	1,6	1,6	1,0	0,3	0,8	0,3
Waste oil	3,3	-	-	-	-	-	-
LPG	0,3	0,3	0,5	0,5	0,5	0,1	0,1
Solid waste	-	0,5	0,6	11,5	13,3	12,1	9,8
Emissions	**12,3**	**6,5**	**7,0**	**16,3**	**16,7**	**15,2**	**7,0**

Activity data for fuel combustion in the Residential sector and the resulting emissions are given in Table 3.17. As can be seen in the table the use of kerosene has increased substantially the last two years. Kerosene is used in summerhouses, but also to some extent, in the Commercial sector for heating of commercial buildings. The usage has been very low over the years and therefore the kerosene utilisation has all been allocated to the Residential sector. The increase in usage in the years 2008 and 2009 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 3.17: Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the residential sector.

	1990	1995	2000	2005	2007	2008	2009
Gas/Diesel oil	8.8	6.9	6.0	3.2	2.1	2.2	2.1
LPG	0.4	0.5	0.7	0.9	1.1	1.1	1.5
Kerosene	0.5	0.2	0.1	0.2	0.2	0.8	4.0
Emissions	**31.0**	**23.9**	**21.8**	**13.6**	**10.5**	**12.8**	**23.9**

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. Emissions from waste incineration with recovery, where the energy is used for snow melting or swimming pools are reported here. A description of the method for calculating GHG is provided in Chapter 8. The IEF for the sector shows fluctuations over the time series. From 1994 onwards waste has been incinerated to produce heat (swimming pools, snow melting). 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.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from Commercial/Institutional and Residential sector 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.

3.6.2 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 3.18.

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

	1990	1995	2000	2005	2007	2008	2009
Gas/Diesel oil	174.9	191.3	211.1	171.7	129.1	127.7	144.7
Residual fuel oil	32.4	53.4	16.0	26.3	50.3	36.3	44.6
Emissions	**655.5**	**771.8**	**720.0**	**626.4**	**565.0**	**517.3**	**597.2**

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 3.14 above.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO2 emissions from fishing is 6% (with an activity data uncertainty of 2% and emission factor uncertainty of 5%), for CH4 emissions it is 100% (with an activity data uncertainty of 2% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 2% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.7 Cross-Cutting Issues

3.7.1 Sectoral versus Reference Approach

Formal agreement has been made between the EA and the National Energy Authority (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. EA is in the process to make a new agreement with the NEA to further clarify the cooperation between the two agencies as well as to clarify the role of NEA in the inventory process and to obtain better data to use for the reference approach as well as better data for the fuel split for the sectoral approach.

3.7.2 Feedstock and Non-Energy Use of Fuels

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

Iceland uses a carbon storage factor of 1 for bitumen and 0.5 for lubricants for the Non-Energy Use in the Reference Approach, CRF Table 1(A)d.

3.8 Geothermal Energy (1B2)

3.8.1 Overview

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (27% of the total electricity production in 2009). 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.

3.8.2 Key Source Analysis

The key source analysis performed for 2009 has revealed that geothermal energy is a key source in terms of both level and trend, as indicated in Table 1.1.

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

Table 3.19 shows the electricity production with geothermal energy and the total CO_2 and sulphur emissions (calculated as SO_2). Large quantities of sulphur are emitted from geothermal power plants in the form of hydrogen sulphide (H_2S).

Table 3.19: Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2007	2008	2009
Electricity production (GWh)	283	288	1323	1658	3579	4037	4553
Carbon dioxide emissions (Gg)	67	82	163	123	152	185	175
Sulphur emissions (as SO_2, Gg)	12	11	26	32	48	58	61

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%). 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 equipments. The Industrial Process sector accounted for 39% of the GHG emissions in Iceland in 2009. By 2009, emissions from the industrial processes sector were 112% above the 1990 level. This is mainly due to the expansion of energy intensive industry. The dominant category within the Industrial Process sector is metal production, which accounted for 93% of the sector's emissions in 2009. Figure 4.1 shows the location of major industrial plants in Iceland.

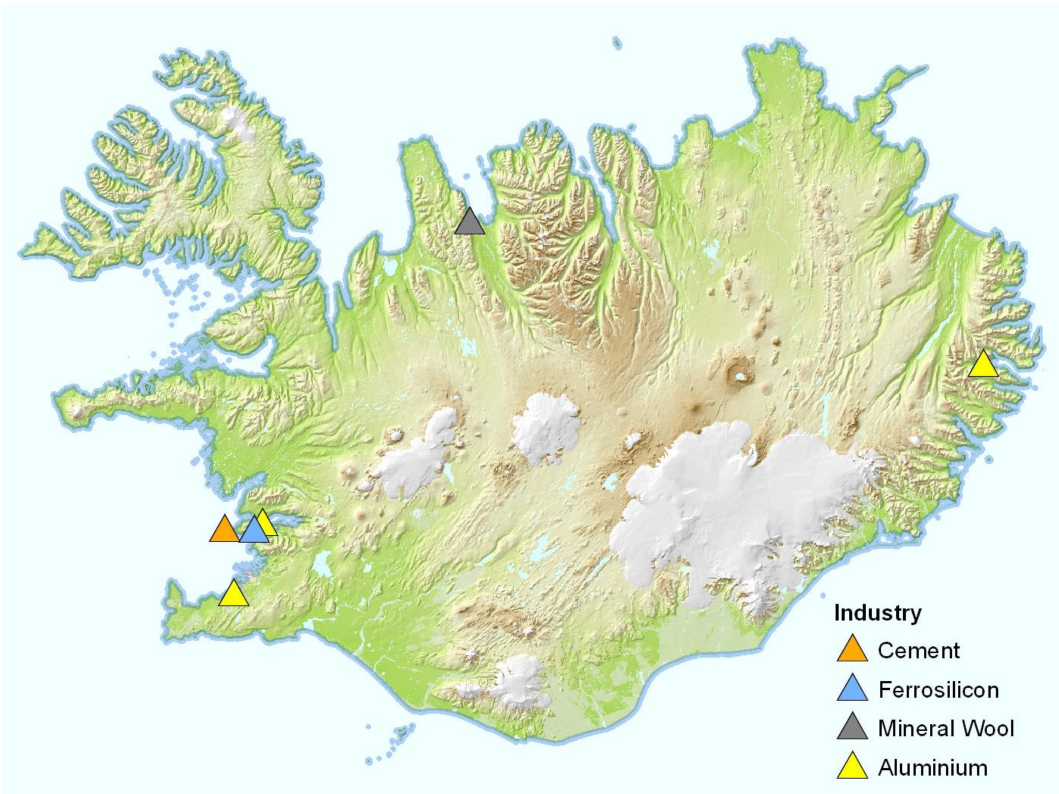

Figure 4.1: Location of major industrial sites in Iceland.

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 2009. Total CO_2 emissions from these projects amounted to 1,187 Gg and total emissions savings from the projects are 10,101 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.

Some minor recalculations were done for the Industrial Processes sector for this submission. Activity data for the year 2008 in the Mineral Wool Production were corrected, leading to minor reduction in emissions. Activity data for HFC were revised leading to minor changes in emissions and further emission estimates for SF_6 were also revised.

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 2009 has revealed, as indicated in Table 1.1 and in terms of total level and/or trend uncertainty the key sources that in the Industrial Processes Sector are the following:

- Emissions from Mineral industry – CO_2 (2A)
  - This is a key source in level and trend
- Emissions from Ferroalloys – CO_2 (2C2)
  - This is a key source in level and trend
- Emissions from Aluminium Production – CO_2 and PFCs (2C3)
  - This is a key source in level and trend
- Emissions from Substitutes for Ozone Depleting Substances – HFCs (2F)
  - This is a key source in level 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**
Lime Production	NOT OCCURRING									
Limestone and Dolomite Use	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soda Ash Production and Use	NOT OCCURRING									
Asphalt Roofing	NOT OCCURRING									
Road Paving with Asphalt	NE	NE	NE	NA	NA	NA	E	E	E	E
Other (Mineral Wool Production)	E	NE	NE	NA	NA	NA	NE	E	NE	E
Chemical Industry										
Ammonia Production	NOT OCCURRING									
Nitric Acid Production	NOT OCCURRING									
Adipic Acid Production	NOT OCCURRING									
Carbide Production	NOT OCCURRING									
Other (Silicium Production – until 2004)*	E	NE	NE	NA	NA	NA	E	NE	NE	NE
Other (Fertilizer Production – until 2001)*	NA	NE	E	NA	NA	NA	E	NE	NE	NE
Metal Production										
Iron and Steel Production	NOT OCCURRING									
Ferroalloys Production	E	E	NA	NA	NA	NA	E	E	E	E
Aluminium Production	E	NE	NE	NA	E	NA	NE	NE	NE	E
SF_6 used in aluminium/magnesium foundries	NOT OCCURRING									
Other	NOT OCCURRING									
Other Production										
Pulp and Paper	NOT OCCURRING									
Food and Drink	NE	NA	NA	NA	NA	NA	NA	NA	NE	NA
Production of HFCs and SF_6	NOT OCCURRING									
Consumption of HFCs and SF_6	NA	NA	NA	E	NO	E	NA	NA	NA	NA
Other	NOT OCCURRING									

*Fertilizer production was terminated in 2001 and Silicium production was terminated in 2004.
**SO_2 emissions from cement production are reported under the Energy sector, based on measurements.

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.

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

Where,
M_{cl} = Clinker production
EF_{cl} = Clinker emission factor; $EF_{cl} = 0.785 \bullet$ 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 for 2003-2009. Historical clinker production data has been calculated as 85% of cement production, which was the average proportion for 2003- 2005.

Table 4.2: Clinker production and CO_2 emissions from cement production from 1990-2009.

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

Emission Factors

It has been estimated by the cement production plant that the CaO content of the clinker was 63% for all years from 1990 to 2006, 64% in 2007 and 63.9% in 2008 and 2009. The corrected emission factor for CO_2 is thus 0.495 from 1990-2006, 0.501 in 2007 and 0.502 in 2008 and 2009. 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.

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 SO_2, NO_x, CO, and NMVOC are taken from Table 2.4, IPCC Guidelines Reference Manual.

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. Minor recalculations were done as activity data for the year 2008 were corrected. The resulting emissions in 2008 were thus 1.01 Gg instead of 1.39 Gg.

4.3 Chemical Industry (2B5)

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

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

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

4.4 Metal Production

4.4.1 Ferroalloys (2C2)

Ferrosilicon (FeSi, 75% Si) is produced at one plant, Elkem Iceland at Grundartangi. The raw material used is quartz (SiO_2). The quartz is reduced to Si and CO using reducing agents. The waste gas CO and some SiO 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. The carbon materials used are coal, coke, and wood. Electric (submerged) arc furnaces with Soederberg electrodes are used. The furnaces are semi-covered. Emissions of CO_2 originate from the use of coal and coke as reducing agents, as well as from the consumption of electrodes. Emissions are calculated according to the Tier 1 method based on the consumption of reducing agents and electrodes and emission factors from the IPCC Guidelines.

Activity Data

The consumption of reducing agents and electrodes are collected from Elkem Iceland by EA through an electronic reporting form. Activity data for raw materials 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	2007	2008	2009
Coking coal	45	52	88	87	97	87	88
Coke oven coke	25	30	36	43	40	32	31
Wood coal	-	-	-	2.1	0.8	0.2	0.2
Waste wood	17	8	16	16	18	14	16
Limestone	-	-	0.5	1.6	0.4	1.1	3.1
Production	63	71	108	111	114	96	98
Emissions	204	239	357	373	390	339	341

Emission Factors

Standard emission factors are used for CO_2, based on the carbon content of the reducing agents and electrodes. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 4.4. Values for NCV are from the Good Practice Guidance. Emission factors for CH_4, NO_x, and NMVOC are taken from Tables 1.7, 1.9, and 1.11 in the IPCC Guidelines Reference Manual. Emissions of SO_2 are calculated from the sulphur content of the reducing agents and electrodes. The emission factor for CO comes from Table 2.16 in the Reference Manual of the 1996 IPCC Guidelines.

Table 4.4: Emission factors for CO_2 from production of ferroalloys.

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

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 11% (with an activity data uncertainty of 5% and emission factor uncertainty of 10%). 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.

Planned Improvements

Iceland will join the EU ETS for industry from 2013 onwards. In relation to that and to further improve the methodology to estimate emissions from the ferroalloys industry a meeting is planned with the ferrosilicon plant in near future.

4.4.2 Aluminium Production (2C3)

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

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

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

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 1990-2009.

Year	Aluminium production [kt]	CO_2 emissions [Gg]	AE Anode Effect [min/cell day]	PFC emissions [Gg CO_2-eq]	CO_2 [t/t Al]	PFC [t CO_2-eq/t Al]
1990	87.839	136.5	4.44	419.6	1.55	4.78
1991	89.217	139.3	3.63	348.3	1.56	3.90
1992	90.045	134.2	1.60	155.3	1.49	1.72
1993	94.152	139.0	0.74	74.9	1.48	0.80
1994	98.595	148.0	0.42	44.6	1.50	0.45
1995	100.198	150.7	0.55	58.84	1.50	0.59
1996	103.362	157.0	0.23	25.2	1.52	0.24
1997	123.562	188.9	0.62	82.4	1.53	0.67
1998	173.869	265.5	1.18	180.1	1.53	1.04
1999	222.014	347.2	0.63	173.2	1.56	0.78
2000	226.362	345.5	0.51	127.2	1.53	0.56
2001	244.148	373.9	0.35	91.7	1.53	0.38
2002	264.107	392.6	0.25	72.5	1.49	0.27
2003	266.611	401.6	0.21	59.8	1.51	0.22
2004	271.384	407.3	0.14	38.6	1.50	0.14
2005	272.488	408.7	0.08	26.1	1.50	0.10
2006	326.270	506.9	0.86	333.2	1.55	1.02
2007	455.761	679.8	0.46	281.3	1.49	0.62
2008	781.151	1167.9	0.33	349.0	1.50	0.45
2009	817.281	1212.1	0.17	152.7	1.48	0.19

Emission Factors

The standard emission factors used for CO_2 are based on the carbon content of the electrodes. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 4.6. The default coefficients for the calculation of PFC emissions come from the IPCC Good Practice Guidance for Centre Worked Prebaked Technology (0.14 for CF_4 and 0.018 for C_2F_6). For high performing facilities that emit very small amounts of PFCs, the Tier 3 method will likely not provide a significant improvement in the overall facility GHG inventory in comparison with the Tier 2 Method. Consequently, it is good practice to identify these facilities prior to selecting methods in the interest of prioritising resources. The status of a facility as a high performing facility should be assessed annually because economic factors, such as the restarts of production lines after a period of inactivity, or, process factors, such as periods of power curtailments might cause temporary increases in anode effect frequency. In addition, over time, facilities that might not at first meet the requirements for high performers may become high performing facilities through implementation of new technology or improved work practices.

Table 4.6: Emission factors CO_2 from aluminium production.

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t input]
Electrodes	31.35	31.42	0.98	3.54

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from aluminium production is 10% (with an activity data uncertainty of 1% and emission factor uncertainty of 10%). 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 9% for CF_4 (with an activity data uncertainty of 5% and emission factor uncertainty of 7%) and 23% for C_2F_6 (with an activity data uncertainty of 5% and emission factor uncertainty of 22%).

QA/QC Procedures

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

4.5 Information on Decision 14/CP.7

Decision 14/CP.7 allows Iceland to report certain industrial process carbon dioxide emissions separately and not include them in national totals to the extent they would cause Iceland to exceed its assigned amount. The total amount that can be reported separately under this decision is set at 1.6 million tonnes of carbon dioxide per year. Only parties where the total carbon dioxide emissions were less than 0.05% of the total carbon dioxide emissions of Annex I Parties in 1990 calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 can avail themselves of this Decision. The total carbon dioxide emissions in Iceland in 1990 amounted to 2172 Gg and the total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg (FCCC/CP/1997/7/Add.1). Iceland's CO_2 emissions were thus less than 0.016% 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 2,172 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. 108.6 Gg, shall be reported separately and shall not be included in national totals to the extent that it would cause Iceland to exceed its assigned amount.

Four projects fulfilled the provisions of Decision 14/CP.7 in 2009, 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 1,187 Gg and total emissions savings from the projects are 10,101 Gg. Table 4.7 provides summary information for these projects.

Table 4.7: Information on project falling under decision 14/CP.7.

	Project CO_2 [Gg]	**Project CO_2 % CO_2'90**	**Total PFC [Gg CO_2-eq/t]**	**Project IEF CO_2 t/t**	**Total IEF PFC t CO_2-eq/t**	**Project Electricity [GWh]**	**Emission savings [Gg CO_2-eq]**
Rio Tinto Alcan	132.7	6.1	3.4	1.47	0.02	1,382	1,302
Alcoa	523.3	24.1	44.8	1.50	0.13	4,838	4,559
Century Aluminium	410.6	18.9	104.6	1.48	0.38	4,176	3,935
Elkem	120.4	5.5	NA*	3.40	NA*	323	304
Total	**1,187.0**	-	**152.7**	-	-	**1,0719**	**10,101**

*NA: Not Applicable.

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 0.017% 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 11.6 g/kWh in 2009.

For calculation of the resulting emission savings by using renewable energy, a comparison is made with a coal fired power plant. According to the International

Aluminium Institute[1] the major part of the electrical power used in primary aluminium production in 2009, excluding hydropower and nuclear energy, is coal. It can therefore be assumed that if the aluminium would not be produced in Iceland using renewable energy, it would be produced with coal energy.

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

The Allowance Allocation Committee has allocated emissions allowances to four production plants, operating in 2009, based on Decision 14/CP.7. Those are:

1. expansion of the Rio Tinto Alcan Aluminium plant at Straumsvík,
2. expansion of the Elkem Iceland Ferrosilicon plant at Grundartangi,
3. establishment of the Century Aluminium plant at Grundartangi, and
4. 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 108.6 Gg.
3. How renewable energy is used, resulting in reduction in greenhouse gas emissions per unit of production and the resulting emission savings.
4. How 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 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

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

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 2009 189,533 tonnes of aluminium were produced compared to 100,198 tonnes in 1995. In 2009 the production increase resulting from this project amounted to 89,355 tonnes of aluminium (71,130 tonnes in potline 3 and 18,205 tonnes in potlines 1 and 2). The resulting emissions from the production of 89,355 tonnes of aluminium are 133 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. In 2009 118,403 tonnes of aluminium were produced in potlines 1 and 2 leading to emissions of 172 Gg of CO_2. In potline 3 71,130 tonnes of aluminium were produced, leading to emissions of 106 Gg of CO_2.

3. In 2009 the plant used 2,932 GWh of electricity, thereof 1,382 GWh were used for producing the 89,355 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 11.6 g CO_2/kWh. Total CO_2 emissions from the electricity used for the project amounts to 16 Gg. Typical emissions from a coal powered power plant amount to 954 g CO_2/kWh[2]. The emissions from electricity use in the project would therefore have equalled 1,318 Gg had the energy been from coal and not from renewable sources. The resulting emissions savings are 1,302 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

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

quality management system and an OHSAS 18001 occupational health and safety management system.

5. Total process emissions from production of 189,533 tonnes of aluminium at Rio Tinto Alcan were 282 Gg CO_2-equivalents in 2009, 278 Gg of CO_2 from electrodes consumption and 3.4 Gg CO_2-equivalents of PFCs due to anode effects. Besides that 11.8 Gg were emitted from fuel combustion. The resulting IEF are 1.47 tonnes CO_2 per tonne of aluminium and 0.02 tonnes of PFC in CO_2-equivalents per tonne of aluminium. For comparison, the median value of PFC emissions in 2009 for prebake plants worldwide was 0.34 CO_2-equivalents per tonne of aluminium[3]. The IEF for fuel use is 0.06 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. 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 204 Gg of CO_2. In 2009 98,039 tonnes were produced (29,932 tonnes in furnace 1; 32,710 tonnes in furnace 2; and 35,397 tonnes in furnace 3) leading to emissions of 341 Gg of CO_2. The production falling under Decision 14/CP.7 is thus 35,397 tonnes of ferrosilicon (all production in furnace 3; the production increase since 1990 is less than the production in furnace 3 due to reconstruction of furnace 1 in 2009). This production leads to emissions of 120 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. In 2009 29,932 tonnes were produced in furnace 1 leading to emissions of 105 Gg of CO_2; 32,710 tonnes were produced in furnace 2 leading to emissions of 115 Gg of CO_2 and 35,397 tonnes were produced in furnace 3 leading to emissions of 120 Gg of CO_2.

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

3. In 2009 the plant used 894 GWh of electricity, thereof 323 GWh were used for the production increase since 1990 (35,397 tonnes of ferrosilicon). All the electricity used for the production comes from renewable sources. The average CO_2 emissions from producing this electricity are 11.6 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 4 Gg. Had the energy been from a coal powered power plant the emissions would amount to 954 g/kWh. The resulting emissions from electricity use in the project would in this case have amounted to 308 Gg CO_2. Emissions savings from using renewable energy for the project are 304 Gg CO_2.

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

5. Total process emissions from production of 98,039 tonnes of ferrosilicon at Elkem Iceland in 2009 were 341 Gg CO_2-equivalents. The resulting IEF are 3.48 tonnes CO_2 per tonne of ferrosilicon. Besides that 1.1 Gg CO_2 were emitted from fuel combustion. The IEF for fuel use is 0.01 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 2009 the Century Aluminium plant produced 278,244 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 411 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2009 the plant used 4,176 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 11.6 g/kWh. The resulting total CO_2 emissions from the electricity use are 48 Gg. Had the energy been from a coal powered power plant the emissions would have amounted to approximately 954 g/kWh, resulting in emissions from electricity use in the project equivalent to 3,984 Gg. Emissions savings from using renewable energy equal 3,935 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 has reported that they are preparing implementation of an environmental management system according to ISO 14001.

5. Total process emissions from production of 278,244 tonnes of aluminium at Century Aluminium in 2009 were 515 Gg CO_2-equivalents, 411 Gg of CO_2 from electrodes consumption and 105 Gg CO_2-equivalents of PFCs due to anode effect. Besides that 1.9 Gg were emitted from fuel combustion. The resulting IEF are 1.48 tonnes CO_2 per tonne of aluminium and 0.38 tonnes of PFC in CO_2-equivalents per tonne of aluminium. The IEF for fuel use is 0.007 t CO_2-equivalents per tonne of aluminium.

Establishment of the Alcoa Fjarðaál Aluminium plant at Reyðarfjörður

1. The Alcoa Fjarðaál Aluminium plant at Reyðarfjörður was established in 2007. In 2008 the plant reached full production capacity, 346,000 tonnes of aluminium per year. Since then, small capacity increase has occurred. In 2009 349,504 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 2009 the Alcoa Aluminium plant produced 349,504 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 523 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2009 the plant used 4,838 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 11.6 g/kWh. The resulting total CO_2 emissions from the electricity use are 56 Gg. Had the energy been from coal powered power plant the emissions would amount to approximately 954 g/kWh, resulting in emissions from electricity use in the project equivalent to 4,615 Gg. Emissions savings from using renewable energy equal 4,559 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 is preparing implementation of an environmental management system according to ISO 14001. Further, two audits have been performed in accordance with Alcoa´s Self Assessment Tool (ASAT). If the provisions of ASAT are met, all requirements of ISO 14001 should be met.

5. Total process emissions from production of 349,504 tonnes of aluminium at Alcoa Fjarðaál in 2009 were 568 Gg CO_2-equivalents, 523 Gg of CO_2 from consumption of electrodes and 45 Gg CO_2-equivalents of PFCs due to anode effect. Besides that, 2.1 Gg were emitted from fuel combustion. The resulting IEF are 1.50 tonnes CO_2 per tonne of aluminium and 0.13 tonnes of PFC in CO_2-equivalents per tonne of aluminium. 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. Emissions from this sector have not been estimated. The emissions are mainly NMVOCs.

4.7 Consumption of Halocarbons and SF_6 (2F)

In the following sections a brief description is provided for the activities for which emissions of Hydrofluorcarbons (HFCs), Perfluorcarbons (PFCs) and Sulphur Hexafluoride (SF_6) are estimated.

4.7.1 Emissions of HFCs

HFCs are used as substitutes for the ozone depleting substances (CFCs, halons and HCFCs) which are being phased out by the Montreal Protocol. In Iceland the F-gases have been regulated since 1998. HFCs are banned for certain uses and the use of HFCs in surgeries have phased out over the last decades. HFCs are imported in bulk for use in stationary and mobile air-conditioning systems, and in imported equipment such as refrigerators, cars, and metered dose inhalers. HFCs are banned in other aerosols, solvents, and fire extinguishers.

The HFCs used in Iceland are HFC-32, HFC-125, HFC-134a, HFC-143a, and HFC-152a. The bulk import of HFCs started in 1992 and increased until 1998. Annual imports stayed between 30 and 70 Gg CO_2-equivalents in following years until the year 2006, but an increase is seen from 2007 to 2009 (Figure 4.2). No import of HFC-152a took place in 2008 and 2009. It is assumed that the import of cars with MAC (Mobile Air-Conditioning systems) started in 1995. Since then, there has been a rapid increase in private cars with MAC, and from the year 2005 around 50% of all new private cars, all busses, and about 60% of larger trucks are considered to have MAC. The use of HFCs in some applications, specifically rigid foam (typically closed-cell foam), refrigeration and fire suppression, can lead to the development of long-lived banks of HFCs.

Sufficient data are available to calculate actual emissions in most applications. The total HFC import in 2009 was 189 Gg CO_2-equivalents, emissions were 86 Gg CO_2-equivalents and HFCs stored in banks was 544 Gg CO_2-equivalents (Figure 4.2). In 2009 the actual emissions of HFCs were about 1.9% of national total greenhouse gas emissions (without LULUCF). This source category is a key source in both level and trend.

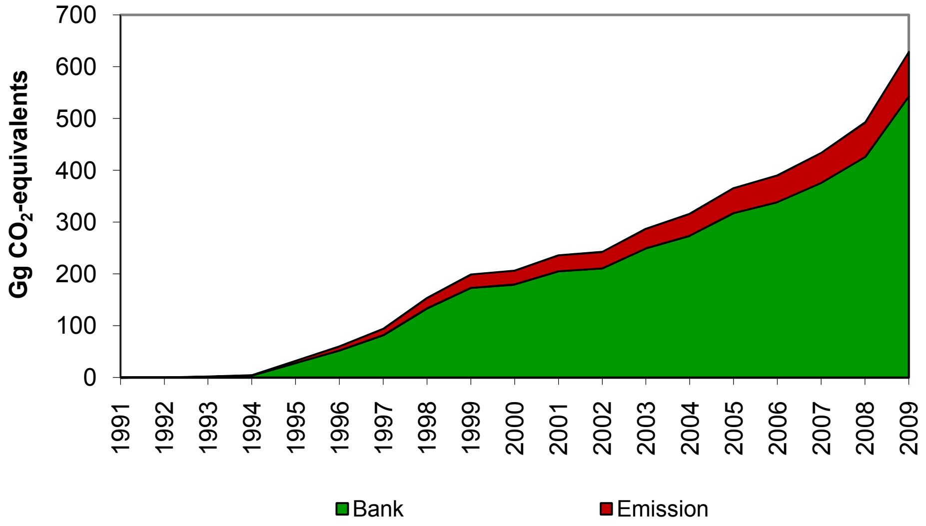

Figure 4.2: HFC emissions and HFCs accumulated in banks in CO_2-equivalents.

Methodology

Emissions of HFCs (Consumption of Halocarbons and SF_6, sector) are calculated using the Tier 2b methodology which takes into account the import, export, and destruction of chemicals in bulk and in equipment with time lag.

Activity Data

Data on imported and exported bulk are reported directly to the EA of Iceland each year. Data on imported cars are gathered from the Road Traffic Directorate and data on imported dose inhalers are gathered from The Icelandic Medicines Control Agency. Data on HFCs in refrigeration equipment is estimated from import statistics, based on land of origin and type of refrigerator. Other use of HFCs is prohibited in Iceland such as in fire extinguishers, as solvents etc. HFCs were exported to Denmark for disposal since there were no facilities for environmentally safe disposal of HFCs in Iceland in the year 2009.

Importers are required to report the type and amount of imported HFCs in order to release the chemicals from the customs agency. It is assumed that 95% of imported HFC-134a is used as refill in refrigeration equipment and 5% for air conditioning in vehicles. Other chemicals imported in bulk are assumed to be used in refrigeration equipment. Estimates of HFCs emissions from cars and imported equipment (i.e. refrigerators) are based on data on imported cars and refrigerators, combined with expert estimates based on surveys performed by EA. Estimates of HFCs emissions from dose inhalers are based on data on imported inhalers. The average lifetime of equipments is reported in Table 4.8.

Table 4.8: Assumed average equipment lifetime.

Equipment	Assumed lifetime (years)
Refrigeration systems	15
MAC	12
Dose inhalers	2

Uncertainty

The activity data are obtained from official data and are considered reliable. The exact number of cars with MAC systems is not available; approximation is used in accordance with a survey performed by the EA. The level of proper disposal of HFCs in used refrigerators, refrigeration systems, and MAC systems in cars is uncertain. Uncertainty varies between HFC types. The uncertainty is greatest for HFC-134a due to its widespread application in products that are imported and exported for disposal. Uncertainties that arise due to imperfect measurement and assessment are a significant issue for emission estimates from MAC (HFC-134a) and emissions estimates from commercial refrigerants (HFC-134a). The estimate of quantitative uncertainty has revealed that the uncertainty of HFC emissions is 100% (with an emission factor uncertainty of 100%). This can be seen in the quantitative uncertainty table in Annex II.

Recalculations

Emissions of HFCs were revised for the 2011 submission as the EA received new export data on HFC-134a for disposal from 2001 to 2008. This revision led to a decrease of 1% in HFC emission in years 2001-2005 and an increase of 1% – 2% in the years 2007 and 2008.

Planned Improvements

Still there are some uncertainties as HFCs in foam blowing agents have not been assessed. This will be taken into consideration and will presumably be improved before next submission.

4.7.2 Emissions of SF_6

Sulphur hexafluoride (SF_6) is mainly used for insulation and current interruptions in equipment used in the transmission and distribution of electricity. SF_6 is used to a minor extent in research particle accelerators in universities of Iceland. There is no SF_6 production in Iceland and consumption of SF_6 is mainly for insulation in electrical distribution systems.

Methodology

Emissions of SF_6 are calculated using the Tier 1 methodology which takes into account manufacturing emissions (none in Iceland), equipment installation emissions, as well as use and disposal emissions. The equation is as follows:

SF_6 Emission from Insulation in the Electrical Distribution System

$$SF_6 Emissions = Installation + Use + Disposal$$

Where,
SF_6 Emissions = Total emissions of SF_6
Installation = Total installation emissions
Use = Total use emission
Disposal = Total disposal emissions

The IPCC default emission factor of 6% is used for installation emissions (Table 8.2, 2006 IPCC Guidelines). The results showed an installed accumulated amount of approximately 21,100 kg SF_6. This is probably a slight underestimate as there might be some data missing. One of the larger power stations (Blanda) has been registering leakage since 2006. Leakage is usually negligible, but taking into account exceptional leakage, an annual leakage rate of 0.8% was used, as input data in this inventory. There are no data on retired equipment.

SF_6 emission from university particle accelerators was estimated by use of import data dating back to 1993 as suggested in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

University and Research Particle Accelerator SF_6 Emissions

$$Total\ SF_6\ Emissions = Total\ Use\ Emissions$$

On average, 49 kg of SF_6 have been imported each year for these purposes. The IPCC default emission factor of 7% is used for use emissions (Table 8.2, 2006 IPCC Guidelines).

Activity data

Actual emissions of SF_6 have been estimated through questionnaires addressed to power companies asking for the installed amounts of SF_6 in operating equipment, and the replaced amounts of SF_6 during service. Data on SF_6 use dates back to 1974. Information on the import of SF_6 chemicals used for the electricity transmission system is obtained from the Icelandic transmission system operator (TSO) named Icegrid (Landsnet hf.). The data on SF_6 import for universities are obtained from Statistics Iceland.

Uncertainty

The activity data on SF_6 import for universities are considered reliable. The electricity transmission system agency Icegrid, updates their data every year but due to less reliable registering of SF_6 in earlier times, there are some uncertainties regarding old transmission systems. Also, one large power station (Blanda) has been registering leakage since it was detected in 2006. It is however not known when the leakage started. An estimated annual leakage rate of 0.8% was used as input data in this inventory. The estimate of quantitative uncertainty has revealed that the uncertainty of SF_6 emissions is 100% (with an emission factor uncertainty of 100%). This can be seen in the quantitative uncertainty table in Annex II.

Recalculation

Emissions of SF_6 were revised as the EA received new data on electricity transmission system insulation for the years 1974, 1977, 1989, 2003-2006, and 2008. This revision leads to an increase in SF_6 emission over the period 1990 to 2008 with the highest increase in the period of 2003 to 2005.

Planned Improvements

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

5 SOLVENT AND OTHER PRODUCT USE

5.1 Overview

This chapter describes emissions from solvents and other products used in Iceland. NMVOCs are not considered direct greenhouse gases but once they are emitted in the atmosphere they will oxidize to CO_2 over a period of time. They are therefore considered as indirect greenhouse gasses. 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 are important sources of evaporation of NMVOCs and are defined as paint application (includes paints, lacquers, thinners and related materials) (3A), degreasing and dry cleaning (substances for printing, metal degreasing, and variety of industrial applications as well as household use) (3B), chemical products, manufacture and processing (3C), and other (3D) according to UNFCCC classification (Table 5.1). Emissions of indirect CO_2, N_2O, and NMVOCs emissions from chemical products, manufacturing, and processing (3C) are included in the 3D category under the subcategory called “other”. This can be seen in Table 5.1. Emissions of N_2O in this sector are mainly due to anaesthesia procedures and other medical purposes. Other emissions come from minor uses of N_2O such as car racing. This is included in the Icelandic inventory as well as emissions of NMVOC in CO_2-equivalents from paint application, degreasing and dry cleaning as well as other (white spirit, toluene, xylene, naphthalene etc.). The emissions from this sector are often called “area” sources because they occur in large numbers of small dispersed applications, rather than from large centralized industrial processes (point sources).

Indirect CO_2 emissions from solvents and N_2O from anaesthesia account for approximately 0.1% of the total greenhouse gas emissions in Iceland in 2009.

5.1.1 Methodology

NMVOC emissions estimates are characterized by high uncertainty even though the contribution of this source is considered quite significant on a global scale. The methodology used here is a consumption-based estimate which is recommended by the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The completeness of the sector can be seen in Table 5.1.

Table 5.1: Solvent and other Product Use – completeness (E: estimated, NE: not estimated, NA: not applicable, IE: included elswhere).

	Indirect Greenhouse Gasses		
Solvent and other product use	**CO_2**	**NMVOC**	**N_2O**
Paint application (3A)	E	E	NA
Degreasing and dry cleaning (3B)	E	E	NA
Chemical Products, manufacturing and processing (3C)	IE	IE	NA
Other (3D)			
- Use of N_2O for anaesthesia	NA	NA	E
- Fire extinguishers	NA	NA	NE
- N_2O from aerosol cans	NA	NA	NE
- Other us of N_2O	NA	NA	E
- Other (white spirit, toluene, xylen, etc.)	E	E	NA

The Revised 1996 IPCC Guidelines do not provide methodologies for the calculation of emissions of N_2O from Solvent and other Product Use (anaesthesia). Therefore, the total amount of N_2O used in medical purposes is converted to CO_2-equivalents with the GWP of 310 as indicated by 1996 IPCC Guidelines.

Estimates of NMVOC emissions are based on data on imports of solvents combined with expert estimates based on surveys. The NMVOC emissions will over a period of time oxidize to CO_2 in the atmosphere and this conversion has been estimated with the following equation:

Emissions from NMVOCs in CO_2-Equivalents

$$CO_2\ Equivalents = 0.85\ \cdot NMVOC_t \cdot 44/12$$

Where,
0.85 = Carbon content fraction of the NMVOCs
$NMVOC_t$ = Total NMVOC emissions in the year t
44/12 = Conversion factor

5.1.1 Key Source Analysis

The key source analysis performed for 2009 has revealed, as indicated in Table 1.1 and in terms of total level and/or trend uncertainty that the Solvent and other Product Use is not a key source neither in level nor trend.

5.1.2 Activity Data

Data on total consumption (i.e. sales) of the solvents, paints, etc. used in these applications are obtained from the division of External trade of goods at Statistic Iceland. Other data on production of industrial gas (CO_2) for various industries are collected directly by the Environment Agency of Iceland from AGA (Ísaga), located in Iceland. AGA is the main contributor of industrial gasses in Iceland. Also, N_2O data for medical purposes from AGA are collected. It is assumed that once these products are sold to end users, they are applied within a short period of time and therefore emissions occur relatively rapidly after purchase.

5.1.3 Emission Factors

Emission factors (EF) are based on the likely ultimate release of NMVOCs to the atmosphere per unit of product consumed. These EFs can then be applied to total consumption (sales) for the specific solvent or paint product. EF for N_2O is 1, i.e. sale/consumption of N_2O in Iceland equals emissions. For NMVOC the same emission factor was used between subcategories.

5.1.4 Recalculations

During data and calculating revision some changes were made within the sector. Import data on degreasing and dry cleaning products (3B) were updated which lead to a slight increase in CO_2 and NMVOC emissions for the years 2007 and 2008.

5.1.5 Uncertainties

When using a consumed-based methodology as recommended by the 1996 IPCC Guidelines only an approximation of the activities associated with the manufacture of all products within this subcategory is made and therefore there is a degree of uncertainty in the emission estimates. The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions is 50% (with an activity data uncertainty of 5% and emission factor uncertainty of 50%) as well as for N_2O emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 50%). This can be seen in the quantitative uncertainty table in Annex II.

5.1.6 Improvements

There are some improvement measures intended within this sector which mainly includes more comprehensive data collection and methodology revision. The EA specialists have started a project on updating the methodology for the solvent balance within the "Consumption-based" method to increase the quality of these emission estimates. The project has no sound results at the moment and it is not timely to state when the updated solvent balance is sufficiently adequate for reporting.

6 AGRICULTURE

6.1 Overview

Icelanders are self-sufficient in all major livestock products, such as meat, milk, and eggs. Traditional livestock production is grassland-based and most are native breeds, i.e. dairy cattle, sheep, horses, and goats, which all are of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is all pork and poultry production. There is not much arable crop production in Iceland, due to the cold climate and subsequently short growing season. Cropland in Iceland consists mainly of cultivated hayfields, but potatoes and barley are grown on limited acreage. The agriculture sector accounted for 12% of total greenhouse gas emissions in 2009. Emissions were 4% below 1990 levels.

6.1.1 Methodology

The calculation of greenhouse gas emissions from agriculture is based on the methodologies suggested by the 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. The methodology for calculating methane from enteric fermentation is in accordance with the Tier 2 method for cattle and sheep and Tier 1 method for other livestock. For estimating CH_4 emissions from manure management Tier 1 methodology was used. And finally, the methodology for calculating N_2O from agricultural soil is in accordance with the Tier 1b method of the 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

6.1.2 Key Source Analysis

As indicated in Table 1.1, the key source analysis performed for 2009 has revealed that in terms of total level and/or trend uncertainty the key sources in the agriculture sector are as follows and can be seen in Table 6.1:

- Emissions from Enteric Fermentation, Cattle – CH_4 (4A1)
  - This is a key source in level
- Emissions from Enteric Fermentation, Sheep – CH_4 (4A3)
  - This is a key source in level and trend
- Emissions from Enteric Fermentation, Other – CH_4 (4A4-4A9)
  - This is a key source in level
- Direct Emissions from Agricultural Soils – N_2O (4D1)
  - This is a key source in level
- Indirect Emissions from Agricultural Soils – N_2O (4D2)
  - This is a key source in level and trend

Table 6.1: Agriculture – completeness (E: estimated, NE: not estimated, NA: not applicable, NO: not occurring).

	Greenhouse gases		
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)			
- Direct Emissions	NA	NE	E
- Animal Production	NA	NE	E
- Indirect Emissions	NA	NE	E
- Other	Not Applicable		
Prescribed burning of Savannas (4E)	Not Occurring		
Field burning of Agricultural Residues (4F)	Not Occurring		
Other (4G)	Not Occurring		

6.1.1 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.

6.1.2 Source Specific QA/QC Procedures

The quality control include general methods such as accuracy checks on data acquisition and calculations and the use of approved and standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting as further elaborated in the QA/QC manual. To further facilitate the QA/QC procedures all calculation sheets have been revised. They are now provided with colour codes for major activity data entries and emissions results to allow immediate visible recognition of outliers. No source specific QA/QC procedures have been developed yet for the Agricultural sector.

6.1.3 Activity Data

The Farmers Association of Iceland (FAI) is, on behalf of the Icelandic Food and Veterinary Authority, in charge of recording the size of all farm animal population every year, namely the annual livestock census. These numbers are reported to Statistics Iceland that publishes them officially. On request from the Environment Agency of Iceland (EA), the FAI assisted EA in coming up with a method to account for young animals, but those are mostly excluded from national statistics on animal populations. The animal population data from Statistics Iceland can be seen in Table 6.2 and the revised animal population can be seen in Table 6.3.

Revision of Animal Population

In 2004 EA specialists in cooperation with FAI specialist came up with a method to account for young animal in the animal population statistics. The method is based on the newest available data at that time (year 2002) and the data was used to approximate the relative proportion of young animals. This method is used to revise animal populations of sheep, horses, swine, and poultry.

Data received from FAI on cattle population includes numbers for dairy cattle (high and low producing) as well as non-dairy cattle (mature and young cattle). These data are considered somewhat reliable. However, EA and FAI specialists took cognisance of that the data on non-dairy cattle did not take into account the average lifetime of young cattle and reported the total population every year. Therefore, EA specialist, along with FAI specialist determined to revise the population of young cattle with regard to the average lifetime. Consequently, the revised total population of cattle is slightly lower than reported from FAI.

Data received from FAI on sheep population includes numbers for mature ewes and other ewes but did not include population data for young sheep. EA and FAI specialist concluded that this needed to be revised. Therefore, when recalculating the population of sheep, it was concluded that around 700.000 lambs are born each year and only around 20% of them are included in official statistic numbers. The average lifetime of a lambs are 4 months and therefore 187.000 lambs were added to the 2002 population which accounts of a little less than 40% increase in the official population total each year.

When recalculating the total population of goats it was concluded by specialists that on average each doe (female goat) has one offspring with the average lifetime of a half a year. This adds to a 50% increase of the official total goat population each year.

When revaluating the official horse population, EA and FAI specialists took into account that around 7.000 foals were born in 2002 and each foal has the average lifetime of 5 months. Therefore, 2.900 foals were added to the 2002 population which is around a 4% increase in the total population each year.

When the total population of swine was revised, the EA and FAI specialists presumed that each sow had on average 17 piglets from 1995 onwards (average 15 piglets/year 1990 to 1994) with the average lifetime of 6 months which was not included in the official population numbers (FAI, 2009). The boars are included in the swine population.

The total poultry population was collected on the basis of poultry consumption and import is negligible due to very strict rules and regulations on import of raw meat and there is no export of poultry (FAI, 2009). The increase in the official poultry population is due to the fact that poultry breeding is not included in those numbers. The average lifetime of a cultivated chick is two months and according to Icelandic Agricultural Statistics (2009) the consumption of poultry is in the top two of all meat consumption in Iceland and was the relatively highest in the Nordic Countries the year 2006.

Table 6.2: Animal population data from Statistics Iceland.

	1990	1995	2000	2005	2008	2009
Cattle, total	74,899	73,199	72,135	65,979	72,012	73498
- Dairy cattle	32,246	30,428	27,066	24,538	26,211	26,489
- Non-dairy cattle	42,643	42,771	45,069	41,441	45,801	47,009
Sheep	548,508	458,341	465,777	454,950	457,861	469,429
Goats	345	350	416	439	563	655
Horses	71,693	78,202	739,95	74,820	77,502	77,158
Swine	3,116	3,726	3,862	3,982	4,265	3,818
Poultry	214,936	164,402	178,093	166,119	168,515	199,958
Mink	42,000	29,941	36,593	35,935	33,806	39,065
Foxes	4,800	7,308	4,132	774	5	3

Table 6.3: Revised animal population data table.

	1990	1995	2000	2005	2008	2009
Cattle, total	**64,844**	**66,262**	**64,729**	**58,172**	**63,575**	**63,482**
Dairy cattle	32,249	31,165	28,015	25,893	27,825	28,057
- High producing	32,249	30,428	27,066	24,538	26,211	26,489
- Low producing	-	737	949	1,355	1,614	1,568
Non-dairy cattle	32,595	35,097	36,714	32,279	35,750	35,425
- Other mature	22,536	28,160	26,208	21,961	24,870	25,408
- Young cattle	10,059	6,937	10,506	10,318	10,880	10,017
Sheep, total	**735,520**	**615,638**	**619,929**	**595,289**	**597,444**	**605,031**
- Mature ewes	445,635	372,222	373,194	360,375	361,485	366,228
- Other mature	13,277	12,376	12,091	11,227	11,583	11,483
- Young sheep	276,608	231,040	231,644	223,687	224,376	227,320
Goats	**518**	**525**	**624**	**659**	**845**	**983**
Horses	**74,961**	**81,384**	**76,667**	**77,303**	**80,656**	**80,298**
Swine, total	**29,645**	**31,130**	**32,267**	**33,269**	**35,634**	**31,899**
- Swine	3,135	3,726	3,862	2,982	4,265	3,818
- Pigs	26,510	27,404	28,405	29,287	31,369	28,081
Poultry	**771,585**	**590,069**	**693,061**	**596,232**	**604,832**	**717,686**
Mink	**42,000**	**29,941**	**36,593**	**35,935**	**33,806**	**39,065**
Foxes	**4,800**	**7,308**	**4,132**	**774**	**5**	**3**

6.1.4 Planned Improvements

There are some intended revisions and improvements of N_{ex} from livestock feed intake as well as of the CH_4 enteric fermentation time series.

6.2 Enteric Fermentation (4A)

The production of CH_4 by enteric fermentation in animals varies with digestive systems and feed intake. Ruminants such as cattle and sheep produce the largest amount of methane. However, enteric fermentation in pseudo-ruminants (e.g. horses) and monogastric animals (e.g. pigs) is also significant. The methodology for calculating methane from Enteric Fermentation is in accordance with the Tier 2 method for cattle and sheep and Tier 1 method for other livestock. Both the population levels (Table 6.3) and emission factors (Table 6.4) by type of animal are used to calculate the emissions.

6.2.1 Activity Data

The activity data for estimating total emissions from livestock enteric fermentation can be seen in Table 6.3. For the 2011 submission FAI assisted EA to divide cattle and sheep into the subcategories necessary to estimate emissions with Tier 2 method and 2011 estimations were conducted in accordance to these specialist evaluations. The revised animal population in Iceland can be seen in Table 6.3.

6.2.2 Emission Factors

Country-specific emission factors for cattle and sheep were calculated by the Agricultural University of Iceland (AUI) from feed intake according to the Tier 2 method and the equations are mentioned below.

Dairy Cows

Gross energy intake for dairy cows (high producing and low producing) is calculated with the following equations from the Good Practice Guidance: 4.1, 4.2a, 4.5a, 4,8, 4.9, and 4.11. Equation 4.3 – Net energy for growth, is not appropriate for mature cows and equation 4.4 – Net energy due to weight loss, is not appropriate as feeding aims for similar weight at the end of the lactation as in the beginning, so there should be no weight loss over the lactation.

Mature Cattle

Gross energy intake for other mature cattle is calculated with the following equations from the Good Practice Guidance: 4.1, 4.2a, 4.3a, 4.9, 4.10, and 4.11.

Young Cattle

Gross energy intake for young cattle is calculated with the following equations from the Good Practice Guidance: 4.1, 4.3a, 4.9, 4.10, and 4.11. Equation 4.2a – Net energy for activity, is not included as young calves are mostly kept indoors.

Milk Productivity

The milk productivity is 5.358 litres averaged over 2009 for high producing dairy cows and 2.000 litres for low producing cows.

Mature Ewes

Gross energy intake for mature ewes is calculated with the following equations from the Good Practice Guidance: 4.1, 4.2b, 4.5c, 4.7, 4.8, 4.9, 4.10, and 4.11. Equation 4.3 – Net energy for growth, is not appropriate for mature ewes.

Other Mature Sheep

Gross energy intake for other mature sheep is calculated with the following equations from the Good Practice Guidance: 4.1, 4.2b, 4.7, 4.9, 4.10, and 4.11.

Young Sheep

Gross energy intake for young sheep is calculated with the following equations from the Good Practice Guidance: 4.1, 4.2b, 4.3b, 4.7, 4.9, 4.10, and 4.11.

When calculating country specific emission factors for cattle and sheep the following equation was used from the IPCC Good Practice Guidance (eq. 4.14):

Emission Factor Development

$$EF = \frac{\left(GE \cdot Y_m \cdot 365 \frac{days}{yr}\right)}{55.65 \frac{MJ}{kg} CH_4}$$

Where;
EF = Emission factor, kg CH_4/head/yr
GE = Gross energy intake, MJ/head/yr
Y_m = Methane conversion rate which is the fraction of gross energy in feed converted to methane.

Other emission factors for other livestock species are taken from the 1996 IPCC Guidelines, except for fur animals which were taken from Norway’s NIR 2007. They are presented in Table 6.4.

Table 6.4: Emission factors (EF) for CH_4 from enteric fermentation (kg CH_4/head/year).

	kg CH_4/head/yr	Source of EF
Dairy cattle		
- High producing	83.87	Country specific
- Low producing	53.33	Country specific
- Other mature cattle	37.64	Country specific
- Young cattle	8.98	Country specific
Sheep		
- Mature ewes	13.17	Country specific
- Other mature sheep	9.76	Country specific
- Young sheep	5.63	Country specific
Goats	5	Table 4.3, IPCC '96 GL
Horses	18	Table 4.3, IPCC '96 GL
Swine	1.5	Table 4.3, IPCC '96 GL
Fur animals (minks and foxes)	0.1	Revised NIR 2007, Norway

The equation used to estimate the total CH_4 emissions from livestock enteric fermentation is according to the 1996 IPCC Guidelines and is as follows:

Total Emissions from Livestock Enteric Fermentation

$$Total\ CH_{4\ \mathrm{Enteric}} = \sum_i E_{\mathrm{i}}$$

Where:
Total $CH_{4Enteric}$ = Total methane emissions from enteric fermentation, Gg $CH_4 yr^{-1}$
E_i = Emission factor for the i^{th} livestock categories and subcategories.

6.2.3 Uncertainties

Some emission factors used for calculating methane emissions from livestock enteric fermentation are not country specific. The emission factor for horses are default values in the 1996 IPCC Guidelines and may therefore be a slight overestimate due to the fact that the domestic livestock of horses are generally smaller than in other European countries. Other default emission factors may perhaps not accurately represent Iceland livestock characteristics. The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from Enteric Fermentation for cattle, sheep, and other livestock animals is 28% (with an activity data uncertainty of 20% and emission factor uncertainty of 20%). This can be seen in the quantitative uncertainty table in Annex II.

6.2.4 Planned Improvements

The activity data and emission factors are constantly under revision for each submission. Before next submission, the emission factors will be continued to be reviewed for Enteric Fermentation.

6.3 Manure Management (4B)

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

6.3.1 Activity Data

The activity data for estimating total methane and nitrous oxide emissions from Manure Management can be seen in Table 6.3 which describes the livestock population in Iceland. Also, the ratio of manure management systems in Iceland can be seen in Table 6.5.

Table 6.5: Ratio of manure management systems in Iceland from 1990 to 2009.

	1990	1995	2000	2005	2009
Cattle:					
- Liquid	46%	49%	53%	53%	53%
- Solid	20%	17%	13%	13%	13%
- Pasture	34%	34%	34%	34%	34%
Sheep and goats:					
- Liquid	17%	17%	17%	17%	17%
- Solid	41%	41%	41%	41%	41%
- Pasture	42%	42%	42%	42%	42%
Horses:					
- Liquid	17%	17%	17%	17%	17%
- Solid	83%	83%	83%	83%	83%
Swine:					
- Liquid	90%	95%	100%	100%	100%
- Solid	10%	5%	0%	0%	0%
Poultry:					
- Solid	100%	100%	100%	100%	100%
Fur animals:					
- Liquid	10%	10%	10%	10%	10%
- Solid	90%	90%	90%	90%	90%

6.3.2 Methane Emissions

CH_4 emissions from Manure Management were estimated according to the 1996 IPCC Guidelines Tier 1 methodology. Population levels for each kind of animal, and the relevant emission factors were used to calculate the emissions.

The equation used to estimate total methane emissions from manure management is according to the 1996 IPCC Guidelines and is as follows:

CH_4 Emissions from Manure Management

$$CH_{4\text{Manure}} = \sum_{(T)} \left(\frac{EF_{(\text{T})} \cdot N_T}{10^6} \right)$$

Where:
$CH_{4Manure}$ = CH_4 emissions from manure management, for a defined population, Gg $CH_4 yr^{-1}$
$EF_{(T)}$ = Emission factor for the defined livestock population, kg CH_4 head^{-1} yr^{-1}
$N_{(T)}$ = Livestock population
T = Animal species index.

Emission Factors

Emission factors for CH_4 are taken from the 1996 IPCC Guidelines, except for those for fur animals which are not included in the 1996 IPCC Guidelines and taken from Norway's NIR 2007. They are presented in Table 6.6, but are likely to be overstated, as domestic livestock breeds of cows, horses and sheep are generally smaller than in other European countries.

Table 6.6: Emission factors for CH_4 from manure management.

	kg CH_4 per head per year	Source of EF
Cattle		
- Dairy	14	Table 4.6, IPCC '96 GL
- Non-dairy	6	Table 4.6, IPCC '96 GL
Sheep	0.19	Table 4.5, IPCC '96 GL
Goats	0.12	Table 4.5, IPCC '96 GL
Horses	1.4	Table 4.5, IPCC '96 GL
Swine	3	Table 4.6, IPCC '96 GL
Poultry	0.078	Table 4.6, IPCC '96 GL
Fur animals		
- Minks	0.405	Revised NIR 2007, Norway
- Foxes	0.65	Revised NIR 2007, Norway

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of methane emissions from Manure Management is 36% (with an activity data uncertainty of 20% and emission factor uncertainty of 30%). This can be seen in the quantitative uncertainty table in Annex II.

6.3.3 Nitrous Oxide Emissions

In order to calculate N_2O emissions from Manure Management, the default IPCC methodology was used, according to the following equation:

Direct N_2O Emissions from Manure Management

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

Where:
E = N_2O emissions
T = Animal species index
S = Manure management system index
N_T = Livestock population
Nex_T = Annual average N excretion per head of species
$MS_{T,S}$ = Fraction of total annual excretion for each livestock species that is managed in system S
EF_S = N_2O emission factor for system S.

The emission factors for N excretion (N_{ex}) are presented in Table 6.9. Emission factors for N_2O-N/N are those suggested by the 1996 IPCC Guidelines (Table 6.7).

Emission Factors

The N_2O emission factors for each type of manure management systems can be seen in Table 6.7.

Table 6.7: Emission factors N_2O-N for each type of manure managements system.

System Type	N_2O-N (kg N_2O-N/kg N_{ex})
Liquid system	0,001
Solid storage	0,02
Pasture range	0,02

The treatment of manure in different management systems per animal species was estimated by the Agricultural University of Iceland. There have been some changes in the manure management practices over the time series. For example the share of liquid systems for cattle is believed to have increased from 46% in 1990 to 53% in 2009. The shares of manure management systems per animal species differ therefore for the period 1990 – 2009. The situation over the years of 1990 to 2009 is reflected in Table 6.5.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of N_2O emissions from Manure Management is 54% (with an activity data uncertainty of 20% and emission factor uncertainty of 50%). This can be seen in the quantitative uncertainty table in Annex II.

6.3.4 Planned Improvements

The ratio of manure management systems in Iceland for sheep is intended to be reconsidered for next submission since lambs are mainly raised on Icelandic pastures. After this revision the ratio will be classified further to coordinate to the sheep classification.

6.4 Emissions from Agricultural Soils – N_2O (4D)

6.4.1 Description

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

- Direct emissions from agricultural soils (applicable to Iceland for the use of synthetic fertilizers, applied animal manure, crop residue, and cultivation of soils) (4D1)
    - This is a key source in level

- Direct soil emissions from production of animals.
- N_2O emissions indirectly induced by agricultural activities (N losses by volatilization, leaching, and runoff) (4D2)
    - This is key source in level and trend

Direct N_2O emissions was 115 Gg CO_2-equivalents in 2009 which accounts for 32% of Iceland's total N_2O emissions and emissions of indirect N_2O emissions amounted to 95 Gg CO_2-equivalents in 2009 or around 27% of the total N_2O emissions.

6.4.2 Methodological Issues

The methodology for calculating N_2O from agricultural soil is in accordance with the Tier 1b method of the 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

6.4.3 Use of Synthetic Fertilizer

Direct emissions of N_2O from the use of synthetic fertilizers are calculated from data on annual usage of fertilizers and their nitrogen content, corrected for volatilization, and multiplied by the IPCC default emission factor.

Activity Data

Since the closure of the fertilizer production plant in 2001, there is no domestic production of synthetic fertilizers in Iceland and Statistics Iceland collects information on the total annual import of synthetic fertilizers (Table 6.8). The amount of synthetic fertilizers used in the Forestry and Revegetation sectors is subtracted from the total imported amount to find out the amount used in the Agriculture sector. The emissions are corrected for ammonia that volatilizes during application. The IPCC default fraction of 0.1 for volatilization is used.

Table 6.8: Use of synthetic fertilizer in Iceland in tonnes.

	1990	1995	2000	2005	2008	2009
Total import	12,474	11,197	12,681	9,775	15,321	12,000
Use in Forestry	3	4	16	18	18	20
Use in Revegetation	334	303	362	812	775	652
Use in Agriculture	**12,140**	**10,894**	**12,319**	**8,946**	**14,528**	**11,328**

6.4.4 Manure applied to Soil

Activity Data

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

Nitrogen Excretion Factor (N_{ex})

The nitrogen excretion factors are presented in Table 6.9. They are taken from Sveinsson, Þ. (1998), Óskarsson and Eggertsson (1991), Norway's NIR 2007, and from Danish Statistics (Normtal for husdyrgödning, 2009). As mentioned above, pork production in Iceland is through imported breeds. As the breeds are imported from Denmark, and the feeding situation is according to Danish methods, the N_{ex} for poultry are taken from Danish Statistics. Pork production is also through imported Danish breed and Danish N_{ex} rates were used for Icelandic pork production. Danish N_{ex} is used for low producing dairy cattle as no country specific information was available. For cattle there have been some changes in the management practices over the time series. Therefore, the N_{ex} is believed to have grown linearly over the time series, reaching a final value in 2000. Since N_{ex} values are not available in 1990 for subcategories of cattle, they were found by multiplying the N_{ex} for dairy cattle with the ratio of N_{ex} for the subcategory to N_{ex} for high producing dairy cattle in year 2000.

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

Table 6.9: Nitrogen excretion factors (N_{ex}) depending on animal type.

	kg N per head per year		Source of EF	
	1990	2000	1990	2000
Cattle				
- Diary, high producing	60.0	103.0	[1]	[2]
- Dairy, low producing	35.0	60	Ratio	[3]
- Other mature cattle	22.1	38	Ratio	[2]
- Young cattle	11.1	19	Ratio	[2]
Sheep	5.76	5.76	[1]	[1]
Goats	5.76	5.76	Assumed to be the same as for sheep	
Horses	28.8	28.5	[1]	[1]
Swine	25.8	28.5	[3]	[3]
Pigs	3.0	3.0	[3]	[3]
Poultry	0.42	0.42	[1]	[1]
Fur animals				
- Minks	4.27	4.27	[4]	[4]
- Foxes	9.0	9.0	[4]	[4]

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

6.4.5 Crop Residue

There is not much arable crop production in Iceland, due to cold climate and subsequently short growing seasons. Cropland in Iceland consists mainly of cultivated hayfields. The total harvested area is close to 1.300 km^2 and area under horticulture, fodder, and grain fields is close to 70 km^2.

From the crops listed in the IPCC Good Practice Guidance (table 4.16) potatoes and barley are grown outdoors in Iceland on limited acreage. The potato production was significantly smaller in the years 1992, 1993, and 1995 due to an epidemic of fungal disease. The production of barley started in 1992 and has risen the last few years and is almost solely used as fodder. Only a very small fraction is used for human consumption but this portion is growing. Some vegetables are grown in greenhouses.

Activity Data

The activity data of crop residue was obtained from Statistics Iceland which collects information on the total annual crop production in Iceland. Figure 6.1 provides an overview of crop production of barley and potatoes in Iceland from 1990 to 2009.

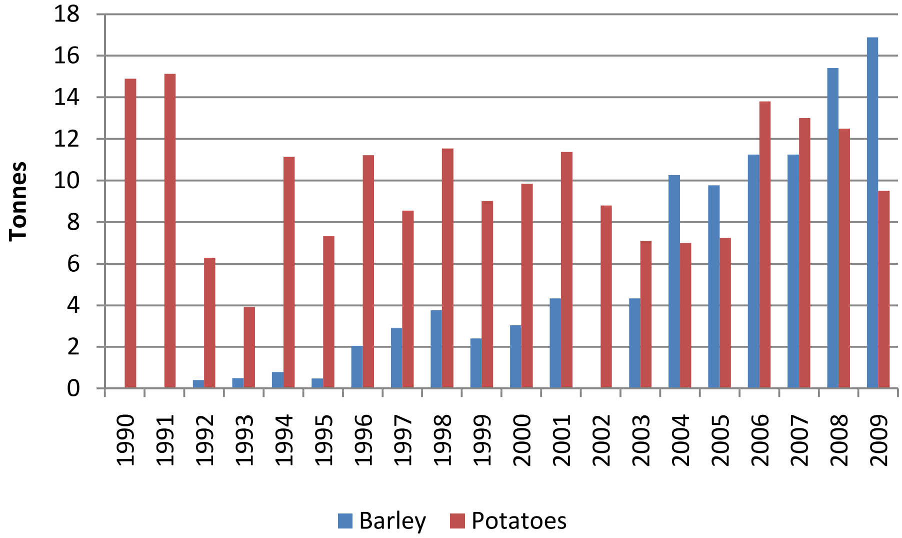

Figure 6.1: Potato and barley production in Iceland over the period of 1990 to 2009.

Emission Factors and N_2O Parameters

Emissions from crop residue are very small, since almost all barley is used as fodder and the crop residue is either used as animal bedding, compost, or in greenhouses. The emission factor (t N/t crop) used for crop residue of barley and potatoes are calculated using the crop product ratio, dry matter, and nitrogen fraction, and fraction of residue used as fodder. These parameters can be seen in Table 6.10.

Table 6.10: Parameters used for calculations of N_2O emissions from crop residue.

Crop residue N	Residue/Crop product ratio	Dry matter fraction	Nitrogen fraction	Fraction fodder or other use	EF N [t N/t crop]
Barley	1.2	0.85	0.0043	0.8	0.0008772
Potatoes	0.4	0.20	0.011	-	0.00088

6.4.6 Cultivation of Organic Soils

N_2O emissions from cultivated organic soils are included under the Agriculture sector, as was requested by the ERT that reviewed Iceland's 2009 submission. The area of cultivation of organic soils, including histosol, histic andosol, and hydric andosol, is estimated to be 53,994 ha for the year 2009. A country specific emission factor of 0.99 kg N_2O-N per ha is used which 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 (0.99 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 tilled drained soils (8.36 kg N_2O-N per ha). This research was conducted in Iceland over the period of 2006 to 2008 and they are considered to be reliable. The results have not been published in peer viewed paper but it is in preparation. Results are available in a project report to the Icelandic Research Council (Guðmundsson, 2009).

6.4.7 Direct Soil Emission from Animal Production

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

6.4.8 N Losses by Volatilization

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

6.4.9 N_2O from Leaching and Runoff

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

Emission Factors

The IPCC default emission factor of 0.0125 kg N_2O-N/kg N has been used for all sources of direct N_2O emissions from agricultural soils, except for the emissions of N_2O from animal production, which are calculated using the IPCC default factor of 0.02 kg N_2O-N/kg N. The IPCC default emission factor of 0.025 kg N_2O-N/kg N is used for leaching and runoff.

6.4.10Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of direct N_2O emissions from Agricultural Soils is 54% (with an activity data uncertainty of 20% and emission factor uncertainty of 50%) as well as for indirect emissions from nitrogen used in agriculture and animal production. This can be seen in the quantitative uncertainty table in Annex II.

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 forests and revegetation.

The CRF for LULUCF was prepared through UNFCCC CRF Reporter program (version 3.5.2). 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. Structure of further subdivision of land has been defined although only implemented for some categories. There is one modification from last submission in the structure of information of categories reported.

The category Grassland remaining grassland is divided to two subcategories i.e. "Natural birch shrubland" and "Other Grassland". Included under the category Natural birch shrubland is all land at least 0.5 ha in continuous area covered with *Betula pubescens* of minimum 10% vertical cover and *in situ* not expected to reach 2m height at mature stage.

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

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

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.

Accumulation and processing of land use information is revised implementing the definitions of land use categories and adopting new data. New map layer for lakes and rivers, is adopted and included in the previous map layer for lakes and rivers. The map layers for forests, revegetation and reservoirs are updated according to new activities. The land use map is re-compiled adopting these changes. 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 2009 equal 681.11 Gg CO_2-equivalents compared to 1,997 Gg CO_2-equivalents in 2008. In this year's submission the estimated LULUCF emission for 2008 is 718.26 Gg CO_2-equivalents reflecting recalculation effects. The revision of emission removal involves several previous reported categories and also estimates are provided for new categories hereto not estimated.

1. Emission/removal estimates for Forest Land is revised according to new data obtained since last submission. Carbon stock changes for dead organic matter are now estimated for all subcategories of 5.A.2.-Land converted to Forest Land, contributing a increase in carbon stock of 4.67 Gg C or removal of 17.1 Gg CO_2.
2. The carbon stock change of living biomass in 5.C.1-Natural birch forest is now reported for the first time. The stock changes are estimated for all years from 2000. Inclusion of this category resulted in net increase in carbon stock of 24.3 Gg C or removal of 89.0 Gg CO_2.
3. A new subcategory of Grassland remaining grassland is introduced, i.e. Natural birch shrubland. Carbon stock changes for living biomass of this category are estimated at 4.9 Gg C or removal of 18.1 Gg CO_2.
4. Emissions of CO_2 from drained organic soil under 5.C.2.3-Wetland converted to grassland were revised in accordance with the recommendations of the Expert Review Teams (ERT) reviewing the 2009 and 2010 submissions. The category has from the time it was first reported in the 2006 submission been recognized as key category in LULUCF and also for Iceland's total reported emissions. In this submission the default CO_2 emission factor for organic grassland soil is used for wetland converted to grassland. This resulted in a lower estimate for the category than in previous submissions, i.e. 307.40 Gg CO_2 for the year 2008 compared with 1,353 Gg CO_2 for the same year as reported in the 2010 submission.
5. Emissions of N_2O from drained organic soils of wetland converted to Grassland, reported as 5.G. (5(II)-Wetland converted to Grassland Non-CO_2 emission), was revised adopting a new country specific emission factor. This resulted in a lower emissions estimate; 0.23 Gg N_2O (71.8 Gg CO_2-

equivalents) compared with 0.95 Gg N_2O (294.2 Gg CO_2-equivalents) in the 2010 submission.

6. The carbon stock changes for 5.C.2.5-Other land converted to Grassland (Revegetation) was revised. Both the activity area of Revegetation since 1990 and the emission/removal factors were revised. The revision was based on preliminary results from the National Inventory of Revegetation Area (NIRA). This revision resulted in decreased carbon stock changes reported in this submission compared with last year's submission. The carbon stock changes reported now for the year 2009 is 119.8 Gg C for the whole category, whereof 53 Gg C are due to Revegetation since 1990. This equals removal of 493.4 and 194.3 Gg CO_2 respectively. In last year's submission total CO_2 removal for the category 2008 was reported as 548.5 Gg where of 276.8 were due to Revegetation since 1990. In this year's submission the removal for the whole category 2008 is estimated at 430.7 Gg CO_2 and as 185.7 Gg CO_2 for Revegetation since 1990 reflecting the recalculation effect.
7. The emissions factors for reservoirs were revised. Reservoirs specific emission factors for four reservoirs are introduced. One reservoir established in 2007 and three new established 2009. Data for carbon stock of the land inundated was utilized to prepare these new reservoir specific emission factors. This revision resulted in CO_2 emission estimate of 9.7 Gg and 0.4 Gg CH4 for 2009 compared to 16.8 and 0.66 Gg respectively for 2008 in last year's submission. In this year's submission the emissions for 2008 are estimated at 9.6 Gg CO_2 and 0.4 Gg CH_4 reflecting the recalculation effect.

7.2 Data Sources

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

The data sources and process of compiling the data to IGLUD will be described in details elsewhere (Guðmundsson et al. in prep). 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.

7.2.1 The Icelandic Geographic Land Use Database (IGLUD)

7.2.1.1 Introduction

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

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

7.2.1.2 Land use practices and consequences

The dominant land use in Iceland through the ages has been that of livestock grazing. The natural birch woodland, widespread in the lowland at the time of settlement (AD 875), was exhausted for most part by the end of the 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 completely ceased during the Little Ice-age. Due to better cultivars and warmer climate, grain cultivation has resurfaced in the last few decades (Hermannsson 1993). Livestock fodder, hay, was traditionally obtained from uncultivated grasslands and wetlands. With the mechanization of agriculture early in the 20th century farmers increasingly converted natural grasslands and wetlands into hayfields (Jónsson 1968).

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

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

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

7.2.1.3 Existing land use information

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

It is not until the 20th century that detailed countrywide mapping begins. First complete mapping of Iceland which included major landscape features and vegetation types was completed in 1943 (Landmælingar_Íslands 1943). Since then there have been ongoing efforts to map topography, vegetation, erosion and geology. Land use has only partially been mapped. Mapping of cultivated areas has been attempted a few times but never really completed. Settlements have been recorded on topographical maps and updated regularly. The first soil map of Iceland was produced in 1959 (Jóhannesson 1988). A new map was produced in the year 2000 and revised in 2001 (Arnalds and Gretarsson 2001) and again 2009 (Arnalds et al. 2009).

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

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 stared a remapping of the natural birch woodland in 2010 that are planned to be finished in 2014.

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 NYTJALAND full-scale 12 class (see Table 7.1

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.

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

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.

7.2.2 Main Data Sources compiled in IGLUD

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

7.2.2.1 NYTJALAND - Icelandic Farmland Database: Geographical Database on Condition of Farming Land

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

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

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

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

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 year's submission a new map layer is used for the layer "Lakes and rivers", where the previous layer has been improved by including new map layer from NLSI where lakes ponds and rivers or parts of rivers missing in previous map layer have been screen digitized.

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

7.2.2.2 CORINE CLC-2006

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

7.2.2.3 Maps of Forest

All known woodlands including both the natural birch woodland and the cultivated forest have been mapped at the IFR on the basis of aerial photographs, satellite images and activity reports. These maps form the geographical background for the 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.

7.2.2.4 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 "Farmers revegetate the land" (FRL) activity is more incomplete than for the remaining activities since 1990. This activity 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. The unmapped activities of FRL are included as activity in CRF and the difference in maps and activity is balanced against other land use (see chapter 7.5) The mapping of revegetation taking place before 1990 is less reliable with regard to activity, as the documentation focused on location rather than the activity. The category Revegetated land in IGLUD is based on these maps.

7.2.2.5 Maps of Drained land

The AUI in cooperation with NLSI has, on basis of satellite images (SPOT 5) and support of aerial photographs, digitized all ditches in Iceland. The map of ditches and several map layers from NYTJALAND were used to produce a map of drained soils (see Chapter 7.14.2.1). The Grassland subcategory "Wetland converted to Grassland" is identified in IGLUD on basis of this map.

7.2.2.6 Maps of cultivated Land

Maps of cultivated land are also produced in cooperation with NLSI. The digitization was completed in 2009 by AUI. The maps prepared are used in IGLUD to identify the Cropland category. The area of drained organic soil within Cropland was mapped on basis of density analyses of the digitized ditches.(Gísladóttir et al. 2010)

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

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

Land use categories	Sub categories	Map layers included in land use category	ID	Order of compilation
1.**Settlement**		Discontinuous urban fabric	101	3
		Industrial, commercial units	102	4
		Harbours	103	5
		Airports	104	6
		Mines	105	7
		Dump sites	106	8
		Constructions sites	107	10
		Green urban areas	108	17
		Sport and leisure facilities	109	18
		Roads (1)	110	16
		Roads (2)	111	9
2.Forest land	Cultivated forest	Forest cultivations	201	14
		Forest cultivations 1960-1989	202	11
		Forest cultivations 2000-2009	203	13
		Forest cultivations 1990-1999	204	12
	Natural birch forest	Natural birch forest >2m	205	15
3.**Cropland**	Other cropland	Cropland	301	23
	Drained cropland	Cropland with ditch density 10-15 km km^{-2}	302	20
		Cropland with ditch density 15-20 km km^{-2}	303	21
		Cropland with ditch density > 20 km km^{-2}	304	22
4.**Wetland**	Other wetlands	Semi-wetland (wetland upland eco-tone)	401	42
		Wetland	402	43
		Semi-wetland/wetland complex	403	44
	Rivers and lakes	Lakes and rivers	404	19
	Reservoirs	Reservoirs	405	1

Table 7.2 continues				
Land use categories	**Sub categories**	**Map layers included in land use category**	**ID**	**Order of compilation**
5.Grassland				
	Natural birch shrubland	Natural birch Woodland <2m	516	29
	Other grassland	Grassland (true grassland)	501	31
		Richly vegetated heath land	502	32
		Cultivated land	503	40
		Poorly vegetated heath land	504	33
		Mosses	505	35
		Partly vegetated land (1)	506	34
		Shrubs and forest	507	30
		Grassland, heath-land shrubs and forest complex	508	38
		Partly vegetated land (2)	509	39
		Cropland and pasture	510	41
		Revegetation area 1996-2008 with vegetation cover >33%	512	28
	Revegetated land	Revegetation before 1990	514	25
		Revegetation activity 1990-2009	515	24
		Farmers revegetation	511	26
	Drained grassland	Drained land	513	27
6.Other land	Other land	Historical lava fields with mosses (1)	601	36
		Historical lava fields with mosses (2)	602	37
		Sparely vegetated land (1)	603	46
		Sparely vegetated land (2)	604	47
		Revegetation area 1996-2008 with vegetation cover <33%	606	45
	Glaciers	Glaciers and perpetual snow	605	2

7.3 Definitions of Land use categories

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

7.3.1 Broad Land Use Categories

Settlements[4]: All artificial areas larger than 0.5 ha and linear features >10 m, as defined in the CORINE land cover classification. This category includes urban areas with >30% impermeable surface, industrial, commercial and transport units, mines, dumps and construction sites and artificial non-agricultural vegetated areas.

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

[4] This definition is according to CORINE definition

Cropland[5]: 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 as land being converted to Grassland.

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

Revegetation is not defined as 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.

7.3.2 Definition of Sub-Categories

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

Settlement: Settlement is divided to Settlement remaining Settlement and Land converted to Settlement. The data for Settlement remaining Settlement is divided into four subcategories according to the CORINE land cover technical guide (Bossard et al. 2000). These subcategories are represented by eleven map layers and compiled

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

according to the order of compilation shown in Table 7.2. Settlement is reported as aggregated area. For Land converted to Settlement, Forest land converted to Settlement (deforestation) is the only category data is available for.

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

1. Natural birch forest: Forest where the dominant species is *Betula pubescens* that has regenerated naturally from sources of natural origin.
2. Plantations within natural birch forest.
3. Afforested land: Forest where planted or directly seeded trees or trees naturally generated from cultivated forests are dominant.
    a. Afforestation 1-50 years old: Afforestation is considered one year old in the autumn of the year the seedlings were planted[6]. This category is reported under Land converted to Forest land and stratified according to previous land use category.
    b. Afforestation older than 50 years: This category is reported under Forest land remaining Forest land.

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

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

1. Lakes and rivers
2. Mires and fens: This category includes peat land and mineral soil wetlands. In this year's submission this category is reported as aggregated part of "other wetlands".
3. Semi-wet areas: This category includes the ecotone between peat land and upland ecosystems. This land is often grazed by livestock and therefore considered managed. This land is one of the land cover classes of the NYTJALAND database. In this year's submission this category is reported as aggregated part of "other wetlands" along with "Mires and fens" land subcategory (2).
4. Reservoirs: Land minimum of 0.5 ha where freshwater is stored for hydropower or other purposes, behind artificial dams. The area of the reservoirs is subdivided according to the type of land flooded.
    - Lakes and rivers: This part of the reservoir area is classified as land remaining wetland.

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

- Land with high soil organic carbon (SOC) >50 kg C m^2 (High SOC): This category includes land with organic soil or complexes of peatland and upland soils. This land is classified as land converted to Wetland or as changes between wetland subcategories. The high SOC soils are in most cases organic soils of peat lands or peat land previously converted to Grassland or Cropland through drainage.
- Land with medium SOC 5-50 kg C m^2 (Medium SOC): This land includes most grassland, cropland and forestland soils except the drained wetland soils.
- Land with low SOC < 5 kg C m^2 (Low SOC): This category includes land with barren soils or sparsely vegetated areas previously categorized under "Other land".

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

1. Grassland on drained wetland soils: This land is defined as previous wetland where the water table has been lowered permanently and now meets the classification criteria for Grassland. The land is identified on basis of existence of ditches or other drainage structures and reported as Wetland converted to Grassland.
2. Land being revegetated: All land recorded by the SCSI as land with Revegetation activity and not meeting the definitions of afforestation and reforestation or falls under Settlement, Cropland or Wetland. This land is reported as land being converted to Grassland subdivided according to land converted from. In this year's submission all land in this category is reported as Other land converted to Grassland although some areas might previously have been classified as grassland. SCSI estimates that <5% would belong to that category.
3. Natural birch shrubland: All land at least 0.5 ha in continuous area covered with *Betula pubescens* of minimum 10% vertical cover and *in situ* not expected to reach 2m height at mature stage. This land is reported as subcategory of Grassland remaining Grassland
4. Other Grassland: This land is reported as Grassland remaining Grassland.

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

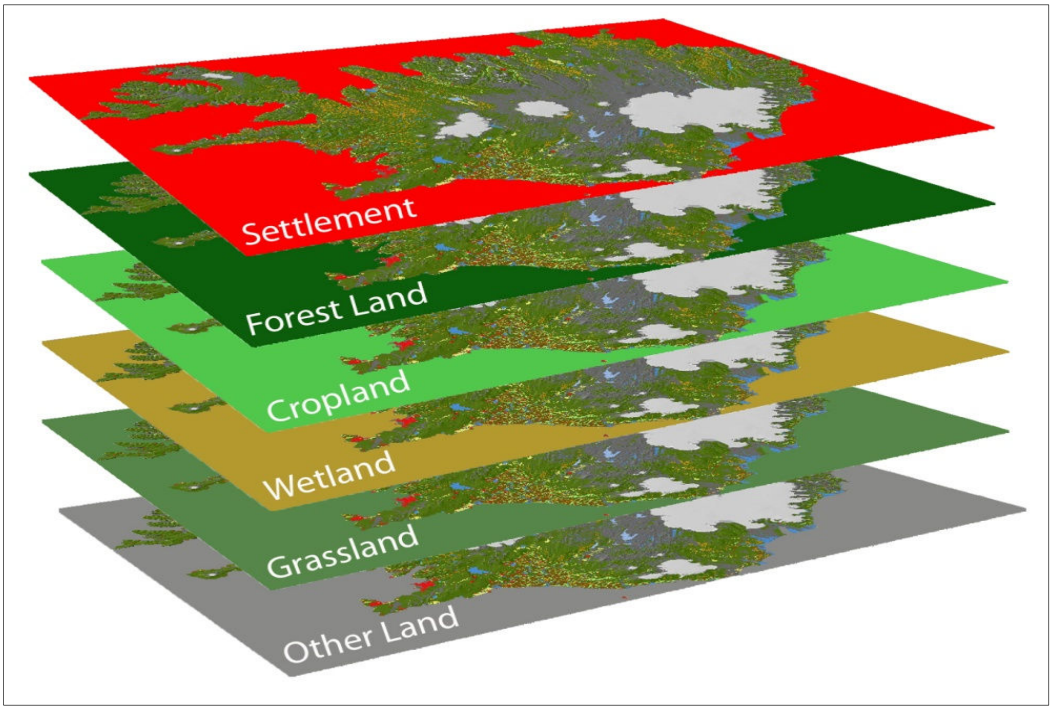

Figure 7.1: Hierarchy of land uses categories as included in the definitions of the categories.

7.4 Land Use Map

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

The resulting land use maps are shown in Figure 7.2, Figure 7.3 and Figure 7.4. The IGLUD is still under development and the maps produced are expected to develop considerable in coming years, including allocation of land between categories and to subcategories. The area of 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 7.5). The differences in these two area estimates, pinpoint the categories where either mapping or area estimate used for CRF needs to be revaluated. Solving these differences may include revised compilation of land use map-layers, improved mapping, adopting the mapping results in CRF, revision of method used for CRF area estimate or reallocation or subdivision of category area. In preparation of this year’s submission these methods were used to improve the coherence between the IGLUD maps and area reported in CRF.

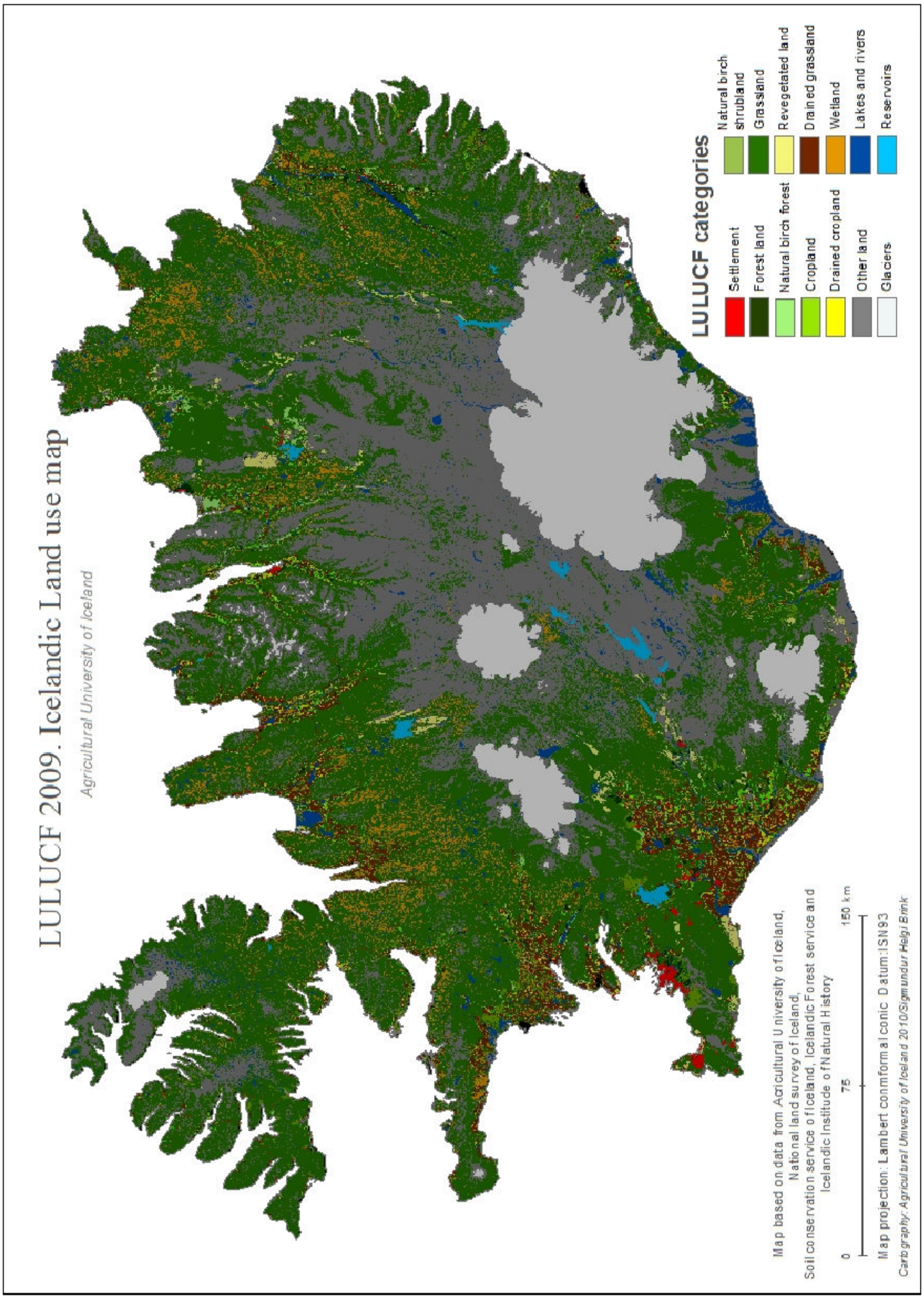

Figure 7.2: Map of Iceland showing the present status of land use classification in IGLUD.

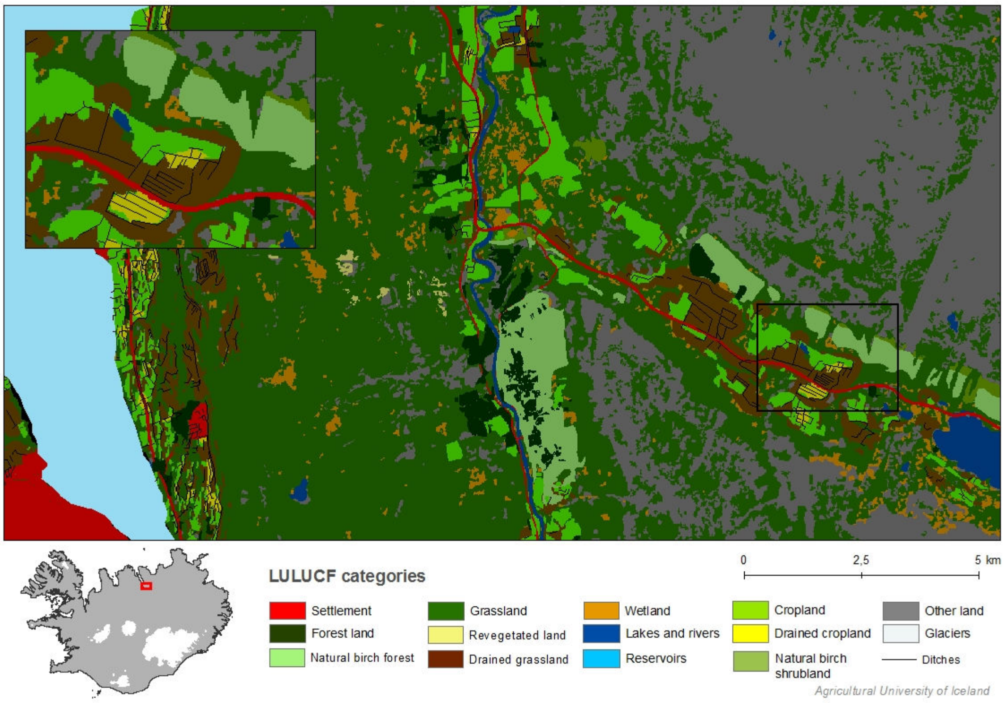

Figure 7.3: Enlarged map (I) showing details in IGLUD land use classification.

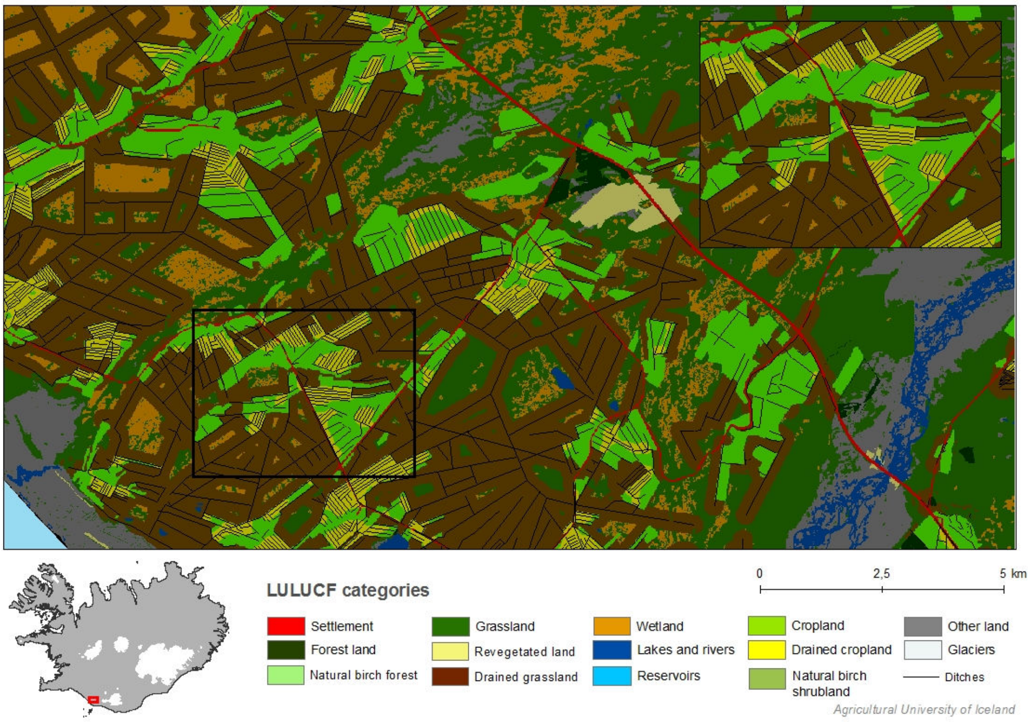

Figure 7.4: Enlarged map (II) showing details in IGLUD land use classification.

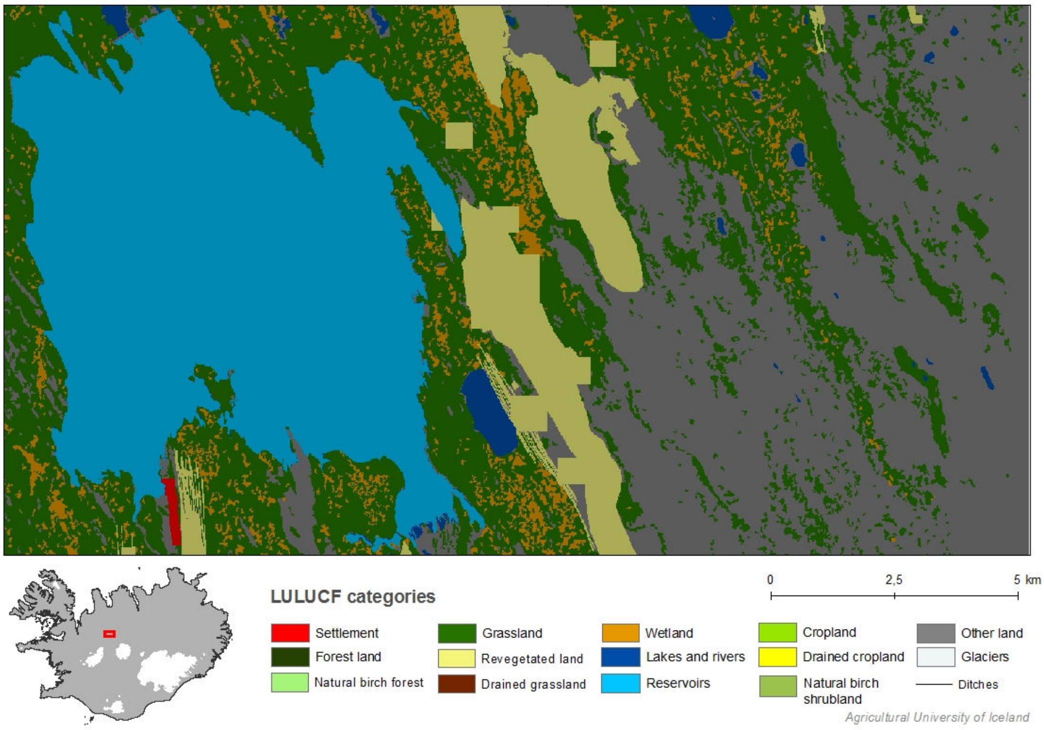

Figure 7.5: Enlarged map (III) showing details in IGLUD land use classification.

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

The order of compilation of the map layers used in IGLUD is the same as in last year's submission. The order of compilation is listed in Table 7.2. The mapping of two categories has been improved i.e. "Lakes and rivers" and "Reservoirs". In case of the map layer "Lakes and Rivers" new data available was added to the layer (see Chapter 7.2.2.1). In case of map layer "Reservoirs" the layer was revised designating most of the reservoirs reported as reservoirs and removing some lakes from the map layer. This revision of maps and their compilation in IGLUD changed the overlapping of the revised map layers with those layers lower in the compilation hierarchy and accordingly their area estimate in IGLUD changed. For the land use categories used in the CRF-LULUCF tables, where additional information on the category area is available and the information is ranked higher in reliability, they were used instead of mapped area. These changes in area were compensated by opposite change in other categories as described below.

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

Forest land: The area of Forest Land is estimated by the IFR through the New National Forest Inventory (see Chapter 7.12). The IFR also provides the maps for Forest land. The mapped areas differ from the NFI area estimate for both afforested land and natural birch forest applied in the CRF. The area of Natural birch forest as reported by IFR is larger than the area of map layer of forest >2 m as resulting from the compilation process of IGLUD as the area reported by IFR includes areas where the forest is still under 2m but expected to reach that height *in situ* at maturity. In the compilation process all land mapped as afforested land are excluded due to their higher ranking in the compilation order. The difference in area is balanced against area of the Grassland map layer "Natural birch woodland <2 m", i.e. difference in area is subtracted from the area of "Natural birch woodland < 2 m". The area of cultivated forest is reported smaller than the land mapped as cultivated forest. This difference is to some extent explained by the buffer zone (24m) applied on the underlying maps (see Chapter 7.12). To correct for the effects on area of those categories estimated from IGLUD mapping two corrections were done. Firstly the overlap of mapped cultivated forest with those lower ranking map layers in the compilation order, which GHG emission/removal is estimated for, was estimated. The proportion of the difference in area overlapping these categories was added to these categories accordingly. Secondly the remaining difference in area was added un-specified to the area of Grassland. Subdivision of forest land to organic and mineral soil and to previous land use is according to IFR data from the national forest inventory. Allocation of forest land to subcategories is according to information provided by the IFR.

Cropland: The area of Cropland in the CRF is based on IGLUD map area. The area of drained cropland, reported as "Wetland converted to Cropland" is also estimated from IGLUD maps. Both categories were corrected due to overestimation of cultivated forests in IGLUD (see above). The categories are identified on basis of two map layers i.e. map of ditches and map of cultivated land. The network of ditches was analysed with regard to aerial density of the network (Gísladóttir et al. 2010) and all land where the density of ditches was higher than 10 km/km^2 were categorized as Wetland converted to Cropland.

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

Grassland: The total area of the Grassland category used in the CRF is the area identified in IGLUD plus the area added due to difference in Forest Land map layer and CRF area as described above and correction for unmapped revegetation. Only a small portion of revegetation activities before 1990 is mapped. All that area is assumed to be detected as vegetated land and accordingly included in the map layers from NYTJALAND compiled to the grassland category and no correction toward other categories were executed. The area mapped as revegetation activity 1990-2009 is smaller than the area reported in CRF. As briefly mentioned above (chapter 7.2.2.4) the FRL activity is to lesser degree geographically identifiable than other revegetation activities. The NIRA is entirely based on mapped areas including the part of farmers revegetation already mapped. The activity area reported by SCSI is the mapped area for all activities except for the FRL area corrected according to ratio of sample points where activity was verified. For the FRL activity all recorded activities corrected with the same ratio are reported. Due to this lack of mapping of the FRL activity the total reported area of revegetation is larger than the IGLUD mapped area. Twenty percent of the difference is assumed to be already included in Grassland category and 80% to be mapped in IGLUD as other land. The reported activity area by SCSI is used in the CRF and the difference subtracted from the IGLUD area of the Grassland remaining grassland –subcategory Other Grassland and Other land accordingly.

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 in Table 7.2: 603 and 604), Partly vegetated land (ID: 506 and 509), Lakes and Rivers (ID: 404), Shrubs and forest (ID: 507) and Natural birch woodland <2 m (ID: 516). Additionally all areas where slope exceeded 10° and all areas extended below seashore line were excluded. To exclude steep areas the AUI elevation model (unpublished), based on NLSI elevation maps, was used. The map layer of drained land so prepared was used in the IGLUD compilation process and further limited by the map layers ranking higher in compilation order. The part of Forest Land mapped area exceeding reported area was added directly to the area of drained land as described above. It is estimated that 98% of the mapped drained areas are with organic soils based on soil samples taken randomly within 100 m from ditches in West Iceland. (AUI unpublished data)

The natural birch shrubland is for the first time reported separately in this year's submission. The total area of this category is estimated by the IFR as part of the NFI. In IGLUD there are two map layers for natural birch woodland i.e. "Natural birch forest >2m" and "Natural birch woodland <2m" (ID in Table 7.2: 205 and 516). The total area of these map layers is larger than the total area reported in CRF for Natural birch forests and Natural birch shrubland. The difference is assumed to be included in the map layer "Shrubs and forest" (ID in Table 7.2: 507) and reported as aggregated area of "Grassland remaining grassland -Other Grassland "

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

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

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

Mapped area	Area kha	Comparable area as reported in CRF	Area kha
Settlement	71.04	Settlement	71.04
Forest Land	70.96	Forest Land	89.64
Natural birch forest	24.76	Natural birch forest	55.09
Cultivated forest	46.20	Cultivated forest total	34.55
Cropland	168.89	Cropland	169.31
Drained Cropland	55.10	WL converted to CL	55.18
Other Cropland	113.79	CL remaining CL	114.13
Wetland	703.77	Wetland	703.77
Lakes and Rivers	262.79	Lakes and rivers	262.61
Reservoirs	45.88	Reservoirs	46.61
Other wetlands	395.10	Other wetlands	395.10
Grassland	5,277.05	Grassland	5,259.00
Natural birch shrubland	81.10	Natural birch shrubland	29.88
Other grassland	4,777.95	Other grasslands	4,709.76
Drained grassland	339.53	WL converted to GL	342.19
Revegetated land (RL)	78.47	OL converted to GL	177.17
RL before 1990	1.45	RL before 1990	98.81
RL since 1990	77.03	RL since 1990	78.37
Other Land	3,997.92	Other Land	3,996.87
Glaciers and perpetual snow	1,113.00	Glaciers and perpetual snow	Not rep

7.6 Time Series

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

7.7 Land Use Change

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

Table 7.4: Land use classification used in GHG inventory 2009 submitted 2011 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		89.64	2.91
Forest Land remaining Forest Land		56.55	
	Afforestation older than 50 years	0.43	
	Natural Birch forest	55.09	
	Plantation in natural birch forest	1.04	
Land converted to Forest Land		33.09	2.91
Grassland converted to Forest Land		28.19	2.91
	Afforestation 1-50 years old	28.19	2.91
Other Land converted to Forest Land		4.90	
	Afforestation 1-50 years old	4.90	
Total Cropland		169.31	54.07
Cropland remaining Cropland		114.13	
Land converted to Cropland		55.18	54.07
Wetlands converted to Cropland		55.18	54.07
Total Grassland		5,259.00	335.35
Grassland remaining Grassland		4,739.64	
Natural birch shrubland		29.88	
Other Grassland		4,709.76	
Land converted to Grassland		519.36	335.35
Wetlands converted to Grassland		342.19	335.35
Other Land converted to Grassland		177.17	
	Revegetation before 1990	98.81	
	Revegetation since 1990	78.37	
Total Wetlands		703.77	
Wetlands remaining Wetlands		677.35	
	Lakes and rivers	262.61	
	Other wetlands	395.10	
	Reservoirs	19.64	
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		71.04	
Settlements remaining Settlements		71.04	
Total Other Land		3,996.87	
Other Land remaining Other Land		3,996.87	

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

7.8 Uncertainties QA/QC

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. 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 lead 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, 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 classification have been controlled through extensive ground truthing process. The map layers of Settlement are based on ground mapping of individual municipal planning authorities and the maps of 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. Tracking back the changes in area of the land use categories on basis of the few time series provided is still highly uncertain as in previous submissions.

7.9 Planned Improvements regarding Land Use Identification and Area Estimates

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

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

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

7.10 Completeness and Method

Based on the above described accumulation of land use data and emission factors or C-stock changes the emission by source and removal by sinks were calculated.

Summary of method and emission factors used is provided in Table 7.5, Table 7.6 and Table 7.7.

Table 7.5: Summary of method and emission factors applied on CO_2 emission calculation.

		CO_2		
Source/sink	**Area (kha)**	**Method**	**EF**	**Gg Emission/ Removal (-)**
Forest Land remaining Forest Land	**56.55**			**-100.49**
Afforestation older than 50 years	**0.43**	**T3**	**CS**	**-1.68**
Living biomass		**T3**	**CS**	**-1.68**
Dead organic matter		**NE**		
Mineral soil		**NE**		
Organic soil	**NO**			
Natural Birch forest	**55.09**			**-88.95**
Living biomass		**T3**	**CS**	**-88.95**
Dead organic matter		**NE**		
Mineral soil		**NE**		
Organic soil	**NO**			
Plantations in natural birch forest	**1.04**			**-9.86**
Living biomass		**T3**	**CS**	**-9.86**
Dead organic matter		**NE**		
Mineral soil		**NE**		
Organic soil	**NO**			
Land converted to Forest Land	**33.09**			**-158,41**
Grassland converted to Forest Land	**28.19**			**-137.28**
Afforestation 1-50 years old	**28.19**			**-137.28**
Living biomass		**T3**	**CS**	**-90,54**
Dead organic matter		**T2**	**CS**	**-14,58**
Mineral soil	**25.28**	**T2**	**CS**	**-33,87**
Organic soil	**2.91**	**T1**	**D**	**1,71**
Other Land converted to Forest Land	**4.90**			
Afforestation 1-50 years old	**4.90**			**-21.13**
Living biomass		**T3**	**CS**	**-7.67**
Dead organic matter		**T2**	**CS**	**2.53**
Mineral soil	**4.90**	**T2**	**CS**	**-10.92**
Organic soil	**NO**			
Cropland remaining Cropland	**114.13**			**4.02**
Living biomass		**T1**		**NO**
Dead organic matter		**T1**		**NO**
Mineral soil		**T2**	**CS**	**0**
Organic soil	**NA**			
Agricultural liming	**NA**			**4.02**
Limestone $CaCO_3$		**T1**	**D**	**0.95**
Dolomite $CaMg(CO_3)_2$		**T1**	**D**	**0.60**
Shellsand (90% $CaCO_3$)		**T2**	**CS**	**2.46**

Table 7.5 Continues				
		CO_2		
Land converted to Cropland	**55.18**			
Wetlands converted to Cropland	**55.18**			**991.33**
Living biomass		**NE**		
Dead organic matter		**NE**		
Mineral soil	**1.10**	**NE**		
Organic soil	**54.07**	**T1**	**D**	**991.33**
Grassland remaining Grassland	**4,739.64**			
Natural birch shrubland	**29.88**			**-18.07**
Living biomass		**T3**	**CS**	**-18.07**
Dead organic matter	**NE**			
Mineral soil	**NE**			
Organic soil	**IE**			
Other Grassland	**4709,76**	**NE**		
Land converted to Grassland	**519.36**			**-131,98**
Wetlands converted to Grassland	**342.19**			**307,40**
Living biomass		**NE**		
Dead organic matter		**NE**		
Mineral soil	**6.84**	**NE**		
Organic soil	**335.35**	**T1**	**D**	**307,40**
Other Land converted to Grassland	**177.17**			**-439.38**
Revegetation before 1990	**98.81**			**-245.04**
Living biomass		**T2**	**CS**	**-24,50**
Dead organic matter		**IE**		
Mineral soil	**98.81**	**T2**	**CS**	**-220,53**
Organic soil	**NO**			
Revegetation since 1990	**78.37**			**-194.35**
Living biomass		**T2**	**CS**	**-19,43**
Dead organic matter		**IE**		
Mineral soil	**78.37**	**T2**	**CS**	**-174,91**
Organic soil	**NO**			
Wetlands remaining Wetlands	**677.35**			
Lakes and rivers	**262.61**	**NA**		
Other wetlands	**395.10**	**NA**		
Reservoirs	**19.64**	**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**

Table 7.5 Continues				
		CO_2		
Settlements remaining Settlements	**71.04**	**NA**		
Other Land remaining Other Land	**3,996.87**	**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 7.6: Summary of method and emission factors applied on CH_4 emission calculations.

		CH_4			
Source/sink	**Area**			**Gg Emission/**	
	kha	**Method**	**EF**	**Removal (-)**	**Gg CO_2 - eq**
Wetlands remaining Wetlands	677.35				
- Lakes and rivers	262.61	NA			
- Other wetlands	395.10	NA			
- Reservoirs	19.64	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 7.7: Summary of method and emission factors applied on N_2O emission calculations.

Source/sink	Area kha	Method	EF	N₂O Gg Emission/ Removal (-)	Gg CO_2 eq
Forest Land remaining Forest Land	56.55	NO			
Land converted to Forest Land	33.09				
- N_2O fertilizers		T1	D	0.00	0.12
Grassland converted to Forest Land					
- Mineral Soil	25.28	NE			
- Organic Soils N_2O	2.91	T1	D	0.00	0,85
Cropland remaining cropland	114.13	NE			
Land converted to cropland	55.18	NE			
- Mineral Soil	1.10	NE			
- Organic Soils N_2O	54.07	IE			
Grassland remaining Grassland	4,739.64	NE			
Land converted to Grassland	519.36				
Wetlands converted to Grassland	342.19				
- Mineral Soil	6.84	NE			
- Organic Soils N_2O	335.35	T2	CS	0.23	71,88
Other Land converted to Grassland	177.17				
- N_2O fertilizers		T1	D	0.01	3,81

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.

7.11 LULUCF Key Sources/Sink and Key Areas

Of all the sources/sinks as calculated for each subcategory, ten were recognized as LULUCF level key source with regard to CO_2-equivalents Table 7-9 Table 7.8. Non-estimated categories cannot be excluded as a potential level key source.

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

		CO_2-equivalents [Gg]			
Source/sink	**Direct GHG Emission/ Removal (-) [Gg]**	**Absolute value category**	**Level %**	**Cumulative level %**	**Key category**
Wetlands converted to Cropland-Organic soil	991,33	991,33	46,82	46,82	x
Wetlands converted to Grassland-Organic soil CO_2	307,40	307,40	14,52	61,34	x
Other Land converted to Grassland-Revegetation before 1990-Mineral soil	-220,53	220,53	10,42	71,76	x
Other Land converted to Grassland-Revegetation since 1990-Mineral soil	-174,91	174,91	8,26	80,02	x
Grassland converted to Forest Land-Afforestation 1-50 years old-Living biomass	-90,54	90,54	4,28	84,30	x
Natural Birch forest-Living biomass	-88,95	88,95	4,20	88,50	x
Wetlands converted to Grassland -drained organic Soils N_2O	0,23	71,88	3,40	91,89	x
Grassland converted to Forest Land-Afforestation 1-50 years old-Mineral soil	-33,87	33,87	1,60	93,49	x
Other Land converted to Grassland-Revegetation before 1990-Living biomass	-24,5	24,5	1,16	94,65	x
Other Land converted to Grassland-Revegetation since 1990-Living biomass	-19,43	19,43	0,92	95,57	x
Grassland remaining Grassland-Natural birch shrubland-Living biomass	-18,07	18,07	0,85	96,42	
Grassland converted to Forest Land-Afforestation 1-50 years old-Dead organic matter	-14,58	14,58	0,69	97,11	
Other Land converted to Forest Land-Afforestation 1-50 years old-Mineral soil	-10,92	10,92	0,52	97,62	
Plantations in natural birch forest-Living biomass	-9,86	9,86	0,47	98,09	
Other Land converted to Forest Land-Afforestation 1-50 years old-Living biomass	-7,67	7,67	0,36	98,45	
Grassland converted to Wetlands-Medium SOC CO_2	6,09	6,09	0,29	98,74	
Grassland converted to Wetlands-Medium SOC CH_4	0,25	5,19	0,25	98,99	
Other Land converted to Grassland-N_2O fertilizers	0,01	3,81	0,18	99,17	
Grassland converted to Wetlands-High SOC CO_2	2,75	2,75	0,13	99,30	
Other Land converted to Forest Land-Afforestation 1-50 years old-Dead organic matter	2,53	2,53	0,12	99,41	
Cropland remaining Cropland-Agricultural liming-Shellsand (90% $CaCO_3$)	2,46	2,46	0,12	99,53	
Grassland converted to Forest Land-Afforestation 1-50 years old-Organic soil CO_2	1,71	1,71	0,08	99,72	
Afforestation older than 50 years-Living biomass	-1,68	1,68	0,08	99,80	

Table 7.8 Continues					
Source/sink	**Direct GHG Emission/ Removal (-) [Gg]**	**Absolute value category**	**Level %**	**Cumulative level %**	**Key category**
Cropland remaining Cropland-Agricultural liming-Limestone $CaCO_3$	0,95	0,95	0,04	99,85	
Other Land converted to Wetlands-Low SOC CO_2	0,89	0,89	0,04	99,89	
Grassland converted to Forest Land-drained Organic Soils N_2O	0	0,85	0,04	99,93	
Land converted to Forest Land-N_2O fertilizers	0	0,12	0,01	100,00	
Cropland remaining Cropland-Mineral soil	0	0	0,00	100,00	
Total		2117,20 2			

Too much subdivision of sources can obscure the contribution of land use categories. Therefore the contributions within each main land use category were added and the total for the different categories are shown in Table 7.9. Four main land use categories were recognized as key sources.

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

	CO_2-equivalents Gg			
Main land-use category	**Sum of absolute values**	**Level %**	**Cumulative level %**	**Key source**
Land converted to Cropland	991,33	66,13	66,13	X
Land converted to grassland	207,67	13,85	79,99	X
Land converted to Forest land	158,53	10,58	90,56	X
Forest land remaining forest land	101,34	6,76	97,32	X
Grassland remaining grassland	18,07	1,21	98,53	
Land converted to wetland	18,05	1,20	99,73	
Cropland remaining Cropland	4,02	0,27	100,00	
Total	1499,01			

Trend key source assessment for emissions/removals within LULUCF was performed. The results of this analysis should be interpreted with caution as independent time series are not available for most of the categories. The results of this analysis are presented in Table 7.10, Table 7.11, and Table 7.12. For CO_2 five categories were recognized as key categories of trend (Table 7.10) i.e.: Carbon stock changes in Natural birch forest, Carbon stock changes associated with revegetation activity since 1990, Carbon stock changes associated with 1-50 years old afforestation on Grassland, Carbon stock changes in Natural birch shrubland, and Carbon stock changes associated with 1-50 years old afforestation on Other land. All the reported categories for CH_4 (Table 7.11) were identified as key categories of trend. Changes in emission from Low SOC- Flooded land dominate the changes in CH_4 emission, reflecting that most area inundated in since 1990 fall under that category.

Table 7.10: Key source analysis of trend assessment for CO_2 of LULUCF categories.

Category	$E_{x,0}$	$E_{x,t}$	$T_{x,t}$	% contribution	Cumulative %	key category trend
Forest land remaining forest land- Carbon stock changes- Natural Birch forest	NE	-88,95	0,056	34,73	34,7	x
Land converted to grassland- Carbon stock changes- OL_GL - revegetation since 1990	-5,27	-194,35	0,050	31,03	65,8	x
Land converted to Forest land- Carbon stock changes- GL_FL- Afforestation 1-50 years old	-19,98	-137,28	0,031	19,25	85,0	x
Grassland remaining grassland- Carbon stock changes- Natural birch shrubland	IE,NE	-18,07	0,011	7,05	92,1	x
Land converted to Forest land- Carbon stock changes- OL_FL- Afforestation 1-50 years old	-2,47	-21,13	0,005	3,06	95,1	x
Forest land remaining forest land- Carbon stock changes- Plantations in natural birch forest	-1,23	-9,86	0,002	1,42	96,5	
Cropland remaining Cropland-CO_2 emission from agricultural lime application -Shellsand 90% CaCO3	NE	2,46	0,002	0,96	97,5	
Land converted to wetland- Carbon stock changes- GL_WL - Medium SOC	0,24	6,09	0,002	0,96	98,5	
Cropland remaining Cropland- CO_2 emission from agricultural lime application -Limeston CaCO3	NE	0,95	0,001	0,37	98,8	
Land converted to grassland- Carbon stock changes- WL_GL	309,57	307,40	0,001	0,36	99,2	
Forest land remaining forest land- Carbon stock changes- Afforestation older than 50 years	-0,21	-1,68	0,000	0,24	99,4	
Cropland remaining Cropland- CO_2 emission from agricultural lime application -Dolomite MgCa(CO3)2	NE	0,60	0,000	0,24	99,7	
Land converted to wetland- Carbon stock changes- GL_WL - High SOC	1,36	2,75	0,000	0,23	99,9	
Land converted to wetland- Carbon stock changes- OL_WL - Low SOC	0,26	0,89	0,000	0,10	100,0	
Land converted to Cropland- Carbon stock changes- WL_CL	991,33	991,33	0	0,00	100,0	
Land converted to grassland- Carbon stock changes- OL_GL - revegetation before 1990	-245,04	- 245,0364	0	0,00	100,0	

Table 7.11: Key source analysis of trend assessment for CH_4 of LULUCF categories.

Category	$E_{x,0}$	$E_{x,t}$	$T_{x,t}$	% contribution	Cumulative %	key category trend
Land converted to wetland-Flooded land- Low SOC	0,0	0,2	13,1	74,1	74,1	X
Land converted to wetland--Flooded land- High SOC	0,1	0,1	3,2	17,9	92,0	X
Land converted to wetland-Flooded land- Medium SOC	0,0	0,0	1,4	8,0	100,0	X

Of the categories where N_2O emissions are reported three of four are identified as key categories of trend i.e.: N_2O due to fertilization as part of the revegetation activity, N_2O due to draining of organic soil associated with afforestation and N_2O associated with conversion of wetland to grassland with draining. As with CO_2 emissions from the last category the changes in N_2O emissions are due to changes in area due to balancing of area against increased afforestation.

Table 7.12: Key source analysis of trend assessment for N_2O of LULUCF categories.

Category	$E_{x,0}$	$E_{x,t}$	$T_{x,t}$	% contribution	Cumulative %	key category trend
Emissions due to Revegetation activity- N_2O emission from N fertilization	0,0066	0,0123	0,0007	57,5	57,5	X
Forest land remaining Forest Land - N_2O emission form draining of soil and wetlands	0,0005	0,0027	0,0003	22,8	80,3	X
Wetland converted to Grassland N_2O emission -draining of organic soil	0,2335	0,2319	0,0002	16,4	96,7	X
Land converted to Forest land- Direct N_2O emission from use of N fertilizers	0,0001	0,0004	0,0000	3,3	100,0	

Considering the present status of land use information the key land use categories on basis of area level were assessed. This key area assessment was performed to identify the most important land use categories on basis of their area. The emissions/removals reported are in most cases based on the emissions estimated per area unit and the total area of relevant land use category. Land use practiced on large area can potentially have much to say in the total emissions reported. On the land use categories as reported two assessments were performed; the highest resolution area subcategories (Table 7.13) and on main land use categories (Table 7.14). Including highest resolution area subcategories, six were recognised as key areas, two of which are by definition unmanaged and no emission is reported for i.e.; “Other land remaining other land” and “Lakes and rivers”. A third category recognised as key area, i.e. “Other wetlands” is an aggregate of two subcategories “Mires and fens” and “Semi-wet areas” where the former is mostly unmanaged. No emissions are presently reported for subcategory “Semi-wet areas”. No emissions are presently estimated for Other Grassland. Emissions are for the first time estimated in this submission for Cropland remaining Cropland (see chapter 7.13.1). This leaves only one of the categories recognised as key area considering all subcategories, where emissions are estimated i.e. “Wetland converted to Grassland-Organic soils”. Considering only main land use categories, four are recognized as key area i.e.; Other land remaining Other land, Grassland remaining Grassland, Wetlands remaining Wetland and Land converted to Grassland (Table 7.14).

Table 7.13: LULUCF area level assessment of land use categories for highest area resolution reported. Key areas are those contributing to 95% cumulative level on the list of land use categories listed from largest to smallest.

Land-use category at highest reported resolution	Area (kha)	Area level %	Cumulative level %	Key area
Other Grassland	4,709.76	45.77	45.77	x
Other Land remaining Other Land	3,996.87	38.84	84.62	x
Wetlands remaining Wetlands-Other wetlands	395.10	3.84	88.46	x
Wetlands converted to Grassland-Organic soil	335.35	3.26	91.71	x
Wetlands remaining Wetlands-Lakes and rivers	262.61	2.55	94.27	x
Cropland remaining Cropland-Mineral soil	114.13	1.11	95.38	x
Other Land converted to Grassland-Revegetation before 1990-Mineral soil	98.81	0.96	96.34	
Other Land converted to Grassland-Revegetation since 1990-Mineral soil	78.37	0.76	97.10	
Settlements remaining Settlements	71.04	0.69	97.79	
Natural Birch forest	55.09	0.54	98.32	
Wetlands converted to Cropland-Organic soil	54.07	0.53	98.85	
Grassland remaining Grassland-Natural birch shrubland	29.88	0.29	99.14	
Grassland converted to Forest Land-Afforestation 1-50 years old-Mineral soil	25.28	0.25	99.38	
Wetlands remaining Wetlands-Reservoirs	19.64	0.19	99.58	
Other Land converted to Wetlands-Low SOC CO_2	18.48	0.18	99.76	
Grassland converted to Wetlands-Medium SOC CO_2	6.96	0.07	99.82	
Wetlands converted to Grassland-Mineral soil	6.84	0.07	99.89	
Other Land converted to Forest Land-Afforestation 1-50 years old-Mineral soil	4.90	0.05	99.94	
Grassland converted to Forest Land-Afforestation 1-50 years old-Organic soil CO_2	2.91	0.03	99.97	
Wetlands converted to Cropland-Mineral soil	1.10	0.01	99.98	
Plantations in natural birch forest	1.04	0.01	99.99	
Grassland converted to Wetlands-High SOC CO_2	0.99	0.01	100.00	
Afforestation older than 50 years	0.43	0.00	100.00	
Total	**10,289.65**			

Emissions/removals are presently only estimated for “Land converted to Grassland” and for one subcategory of Grassland remaining Grassland, i.e. Natural birch shrubland.

Table 7.14: Area level assessment of main LULUCF land use categories. Key areas are those contributing to 95% cumulative level on the list of land use categories listed from largest to smallest.

Main land-use category	Area (kha)	Area level %	Cumulative level %	Key area
Grassland remaining Grassland	4.739.64	46.06	46.06	X
Other Land remaining Other Land	3.996.87	38.84	84.91	X
Wetlands remaining Wetlands	677.35	6.58	91.49	X
Land converted to Grassland	519.36	5.05	96.54	X
Cropland remaining Cropland	114.13	1.11	97.65	
Settlements remaining Settlements	71.04	0.69	98.34	
Forest Land remaining Forest Land	56.55	0.55	98.89	
Land converted to Cropland	55.18	0.54	99.42	
Land converted to Forest Land	33.09	0.32	99.74	
Land converted to Wetlands	26.42	0.26	100.00	
Total	**10,289,63**			

An additional area assessment was carried out, considering only applicable land use categories excluding the category other land and other categories which as by definition unmanaged and emission/removal calculation not applicable.
Considering only applicable land use categories, (Table 7.15) two additional land use categories are assessed as key areas, compared to those included when all categories reported at highest area resolution were considered. These categories were, “Other land converted to Grassland –Revegetation before 1990” and “Other land converted to Grassland –Revegetation since 1990”.

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

Table 7.15: Area level assessments of LULUCF land use categories considered relevant as potential source/ sinks and where area was identified. Key areas are those contributing to 95% cumulative level on the list of land use categories listed from largest to smallest.

Applicable land-use categories	Area (kha)	Area level %	Cumulative level %	Key area
Other Grassland	4,709.76	78.10	78.10	x
Wetlands remaining Wetlands-Other wetlands	395.10	6.55	84.66	x
Wetlands converted to Grassland-Organic soil	335.35	5.56	90.22	x
Cropland remaining Cropland-Mineral soil	114.13	1.89	92.11	x
Other Land converted to Grassland-Revegetation before 1990	98.81	1.64	93.75	x
Other Land converted to Grassland-Revegetation since 1990	78.37	1.30	95.05	x
Settlements remaining Settlements	71.04	1.18	96.23	
Natural Birch forest	55.09	0.91	97.14	
Wetlands converted to Cropland-Organic soil	54.07	0.90	98.04	
Grassland remaining Grassland-Natural birch shrubland	29.88	0.50	98.53	
Grassland converted to Forest Land-Afforestation 1-50 years old-Mineral soil	25.28	0.42	98.95	
Wetlands remaining Wetlands-Reservoirs	19.64	0.33	99.28	
Other Land converted to Wetlands-Low SOC CO_2	18.48	0.31	99.58	
Grassland converted to Wetlands-Medium SOC CO_2	6.96	0.12	99.70	
Wetlands converted to Grassland-Mineral soil	6.84	0.11	99.81	
Other Land converted to Forest Land-Afforestation 1-50 years old-Mineral soil	4.90	0.08	99.89	
Grassland converted to Forest Land-Afforestation 1-50 years old-Organic soil CO_2	2.91	0.05	99.94	
Wetlands converted to Cropland-Mineral soil	1.10	0.02	99.96	
Plantations in natural birch forest	1.04	0.02	99.98	
Grassland converted to Wetlands-High SOC CO_2	0.99	0.02	99.99	
Afforestation older than 50 years	0.43	0.01	100.00	
Total	6,030.17			

Considering the information presented in this inventory, two land use changes are most important considering both the area involved and emissions or removals reported. These land use changes are conversions of Wetlands and Other land to Grassland.

7.12 Forest Land

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

Natural birch woodland is included in the IFR new national forest inventory (NFI). In 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 represents 1.5 x 3.0 km^2 (Snorrason 2010b). On basis of new data from the NFI the area of natural birch woodlands has been revised from last submission. The part of natural birch woodland defined as forest (reaching 2 m or greater in height at maturity *in situ*) is revised on basis of new data obtained through plot measurement in 2010 that was added to the five years measurements of 2005-2009 which was the first national forest inventory of the natural birch woodland. New estimate of the area is now 55.09 kha ± 7.57 kha 95% CL) instead of 53.46 kha (± 7.6 kha 95% CL) in last submission.

In a chronosequence study (named ICEWOODS research project) where afforestation areas of the four most commonly used tree species of different age where compared in eastern and western Iceland, the results showed significant increase in the soil organic carbon (SOC) on fully vegetated sites with well-developed and deep mineral soil profile (Bjarnadóttir 2009). The age of the oldest afforestation sites examined were 50 years so increase of carbon in mineral soil can be confirmed up to that age. The conversion period for afforestation on Grassland soil is accordingly 50 years (see also Chapter 7.12.1.3). Conversion period for land use changes to “Forest land” from “Other land” is also 50 years. The area of cultivated forest in 2009 is estimated in NFI as 34.55 kha (±1.66 kha 95% CL) whereof; 28.19 kha (±1.69 kha 95% CL) are Afforestation 1-50 years old on “Grassland converted to Forest land”, 4.90 kha (±0.94 kha 95% CL) are Afforestation 1-50 years old on “Other Land converted to Forest land”, 1.04 kha (±0.46 kha 95% CL) are Plantations in natural birch forests and 0.43 (±0.30 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. In 2010 submission this area was estimated 34.38 kha (±1.64 kha 95% CL) in 2008 but in this year’s submission the estimate for 2008 is 32.77 kha (±1.67 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 was for the inventory year 2008 reported 2.53 kha (±0.70 kha 95% CL) in 2010 submission but is estimated 2.65 kha (±0.71 kha 95% CL) for 2008 in this year’s submission reflecting the recalculation.

Living biomass in Afforestation 1-50 years old on Grassland, Living biomass in Natural birch forest and mineral soil of Afforestation 1-50 years old on Grassland are recognised as level key sources/sinks in LULUCF considering subcategories resolution as reported Table 7.8. Forest land remaining forest land and Land converted to Forest land are recognised as key sources/sinks considering only main land use categories. Carbon stock changes in the categories “Natural Birch forest”, “Afforestation 1-50 years old on Grassland” and “Afforestation 1-50 years old on Other land” are recognised as key categories of trend within LULUCF in CO_2 emission/removal. Emission from draining of soil in forest is recognised as key category of trend in N_2O emission within LULUCF

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

7.12.1 Carbon Stock Changes (5A)

Changes in C-stock of natural birch forest are reported for the first time in this year’s submission based on the data of NFI. Total woody C-stock of the natural birch woodland was estimated at 1300 kt C with average of 11 t C ha^{-1} from data sampled in an inventory conducted in 1987-1991 (Sigurðsson and Snorrason 2000). New estimate of the C-stock of the natural birch woodland by the NFI data is 353 kt C with average of 4.15 t C ha^{-1}. The C-stock in the forest and the shrub part of the natural birch woodland is estimated to 302 kt C with average of 5.47 t C ha^{-1} and 51 kt C with average of 1.72 t C ha^{-1} accordingly.

7.12.1.1 Carbon Stock Changes in Living Biomass

Carbon stock gain in the living biomass of trees is estimated based on data from direct field measurement in the NFI. The figures provided by IFR are based on the inventory data from the first national forest inventory conducted in 2005-2009 (Snorrason 2010a; Snorrason in prep). 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. Few plots of the natural birch woodland that were left over in the first inventory of 2005-2009 were also measured in 2010.

Carbon stock losses in the living woody biomass is estimated based on data on activity statistics of commercial round-wood and wood-products production from domestic thinning of cultivated forest (Gunnarsson 2010). Carbon stock losses caused by natural mortality in the natural birch forest are accounted for first time in this year submission as carbon losses from selective cuttings in the natural birch forest

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 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.

In the already mentioned ICEWOODS research project, the carbon stock in other vegetation than trees did show very low increase 50 years after afforestation by the most used tree species, Siberian larch, although the variation inside this period was considerable. 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 NNFI data when sampling plots will be revisited in the second inventory.

7.12.1.2 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. Measurements of dead wood are also performed on the field plots. Estimate of carbon stock changes in dead organic matter will be available from the NFI data when sampling plots will be revisited in the next four years.

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 $ha^{-1}yr^{-1}$.

Carbon stock changes in dead wood are not estimated. Dead wood is measured on the field plot of the NFI. 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. With re-measurements of the permanent plot it will be possible to estimate the Carbon stock changes in this pool. Meanwhile carbon pool of dead wood will be assumed not to change in line with Tier 1 approach and changes in dead organic matter reported as the changes in woody debris, twigs and fine litter.

7.12.1.3 Net carbon Stock Change in Soils

In this year's submission drained forest organic soil is only reported in the category "Grassland converted to Forest Land- Afforestation 1-50 years' old" The estimated area is 10.3% of the category total area based on NFI data and has been revised from last submission according to new data from the national forest inventory. In the process of adjusting the IGLUD map area to the reported area of forest the overlap of mapped forest land with other mapped categories was tested including the maps of drained areas. The overlap of cultivated forests with drained land was 22.85%. These variable estimates show the uncertainty of these estimates. The natural birch forest and the remaining afforested areas are mostly situated on mineral soils which can be highly variable regarding carbon content. Research results do show increase of carbon of soil organic matter (C-SOM) in mineral soils (0.3-0.9 t C $ha^{-1}yr^{-1}$) due to afforestation (Snorrason et al. 2003; Sigurðsson et al. 2008), and in a recent study of the ICEWOODS data a significant increase in SOC was found in the uppermost 10 cm layer of the soil (Bjarnadóttir 2009). The average increase in soil carbon detected was 134 g CO_2 m^{-2} $year^{-1}$ for the three most used tree species. This rate of C-sequestration to soil was applied to estimate changes in soil carbon stock in mineral soils at afforested sites 1-50 years old. Measurements of carbon stock changes in soil on revegetated and afforested areas are currently sparse but work is in progress that is expected to increase our understanding in that field. A comparison of 16 years old plantation on poorly vegetated area to a similar open land gave e.g. an annual increase of C-SOM of 0.9 t C ha^{-1} (Snorrason et al. 2003). For the mineral soil of Other land converted to Forest land same removal factor as for revegetation 0.609 t C ha^{-1} yr^{-1} is used

7.12.2 Other Emissions (5(I), 5 (II), 5(III))

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

7.12.3 Land converted to Forest Land.

The AFOLU Guidelines define land use conversion period as the time until the soil carbon under the new land use reaches a stable level. Land converted to forest land is reported as converted from the land use categories "Other land" and from "Grassland". Small part of the land converted to Forest land is converted from Cropland or Wetland, but this land is included as Grassland converted to Forest land as data for separating these categorise is unavailable. Organic soil is only reported under land converted from Grassland- Afforestation 1-50 years old. Organic soils are not found in the land use category "Other land" and were not detected in the NFI for afforestation before 1960. Accordingly organic soils are reported as not occurring.

7.12.4 Methodological Issues

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

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

The area of natural birch forest is assumed to be unchanged since 1990. Historical area of cultivated forest is estimated by the age distribution of the forest in the sample. The changes in the C-stock of cultivated forest for other years than 2009 are built on a tree species specific growth model but are calibrated towards the inventory results of 2009.

7.12.5 Emission/Removal Factors

Tier 3 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 (Snorrason in prep). Emission from wood removals caused by thinning or clear cutting in the cultivated forest are now included. Currently they have minor importance as the mean age of plantation forest is low. Clear cuttings are not yet practiced but thinning is an increasing activity.

The losses reported in living biomass removed as wood are estimated by Tier 3 on basis of activity data of annual wood utilization from cultivated forest (Gunnarsson 2010).

In accordance to the Forest Law in Iceland the State Forest Service does hold register on planned activity that can lead to deforestation (Skógrækt ríkisins 2008). When deforestion activity takes place the State Forest Service is to be announced. No deforestation is reported for the inventory year 2009. No recalculations are made of the deforestation reported in last submission. A special inventory of deforestation was conducted by IFR in 2008 to map deforested area and measure carbon stock changes in the years 1990-2007. Estimated deforested area and carbon stock changes for that period are built on that special inventory. Since then no deforestation has been reported to the State Forest Service.

As mentioned before carbon stock changes in living biomass in the natural birch forest are reported as for the first time. A similar procedure and methodology is used as for the cultivated forest.

Carbon stock change in living biomass in other vegetation than trees is not estimated at current state. In-country research results (Sigurdsson et al. 2005) 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, 0.609 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. The changes in litter are reported as changes in dead organic matter assuming no changes in dead wood in line with the Tier 1 method for that component (see also chapter 7.12.1.2)

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

7.12.6 Uncertainties and QA/QC

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

The NFI and the special inventory of deforestation have greatly improved the quality of the carbon stock change estimates although some sources are still not included (e.g. dead wood). 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 have currently not been conducted but are planned in the nearest future. For the moment, error estimates are only available for the area of both natural birch forest and cultivated forest.

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

7.12.7 Recalculations

As described above the emission/removal estimate for forest land has been revised from previous submissions. The C-stock changes are based on direct stock measurements (Tier 3) as in last year's submission but reviewed on basis of additional data obtained since then. The estimate of carbon stock changes in living biomass of natural birch forest added 88.95 Gg CO_2-equivalents to the total removal associated with Forest land in the inventory year 2009. The estimate of changes in soil carbon dead organic matter in Afforestation 1-50 years old has also effects on the reported emission/removal. As result of these recalculations the total reported removal has increased from -122.47 Gg CO_2-equivalents for the year 2008 as reported in 2010 submission to -257.93 Gg CO_2-equivalents in this year's submission or a 111% increase 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.

7.12.8 Planned Improvements regarding Forest Land

Data from NFI are used for the third time to estimate main sources of carbon stock changes in the cultivated forest where changes in carbon stock are most rapid. In the nearest future efforts will be on improving the time series of the main source as the biomass changes in both the cultivated forest and the natural birch forest

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.

It is planned to improve estimates on area and stock changes of deforestation and reduction of living carbon stock due to wood removals in the national forests inventory. Also, a new mapping of the natural birch woodlands which started the summer 2010 will continue. That will *inter alia* make it possible to detect natural afforestation. One can therefore expect gradually improved estimates of carbon stock and carbon stock changes in forest in Iceland. As mentioned before improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.

7.13 Cropland

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

Carbon dioxide emissions from the category Wetland converted to Cropland- organic soil are recognized as key source/sink Table 7.8 considering all categories reported. Considering total emissions for each main land use category “Land converted to Cropland” is identified as key source/sink Table 7.9. Cropland remaining Cropland mineral soil is identified as key area considering land use categories at highest resolution reported Table 7.13.

Mapping of cropland based on satellite images and support of aerial photographs has been included in the construction of IGLUD. Previous mapping of Cropland was revised in 2009 by the AUI through on screen digitations. The total area of Cropland in IGLUD, taking into account the order of compilation applied, is estimated at 169.31 kha and reported in CRF.

The area of drained soils within Cropland was estimated separately on basis of a density study on the ditches network (Gísladóttir et al. 2009). All Cropland area where the ditches density was more than 10 km ditches km^{-2} was estimated as drained cropland. This estimate is 55.18 kha and is reported as wetland converted to Cropland.

No information is available on emission/removal regarding different cultivation types and subdivision of areas according to types of crops cultivated is not attempted. Cropland remaining Cropland is identified as a key area in applicable land use categories (Table 7.15).

7.13.1 Carbon Stock Change (5B)

7.13.1.1 Carbon Stock Changes in Living Biomass

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

7.13.1.2 Net Carbon Stock Changes in Dead Organic Matter

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

7.13.1.3 Net Carbon Stock Change in Soils

Net carbon stock changes in mineral cropland soil are 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 part of the growing season (spring and autumn in case of sheep farming). Most hayfields are fertilized with both synthetic fertilizers and manure. 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-moist” F_{LU} = 0.82 was selected based on the descriptions in Table 5.5 best describing the hayfields in Iceland. For management and input, F_{MG} =1.15 no tillage- temperate boreal -moist and F_I =1.00 medium input, were selected. The SOC_{REF}, 64.42 tC ha^{-1}, was calculated from average soil carbon in Brown Andosol in Iceland (Óskarsson et al. 2004). The initial mineral soil organic C stock is accordingly 64.42 t C ha^{-1} * 0.82*1.15*1.00 = 60.75 t C ha^{-1}. As area land use and management are assumed unchanged from first inventory year the final SOC is the same and $\Delta C_{Mineral}$ =0.

The area of drained cropland is estimated from IGLUD as described above. Of the area estimated drained, 98% is assumed to be on organic soil according to the AUI (unpublished data).

7.13.2 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 in Iceland can be assumed to be on organic soil as pH of mineral soils is generally so high that liming is unnecessary.

7.13.3 Land converted to Cropland

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

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

7.13.4 Emission Factors

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

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

7.13.5 Uncertainty and QA/QC

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

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

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

7.13.6 Recalculations

Emissions caused by changes in carbon stocks of living biomass, dead organic matter and mineral soil of Cropland remaining Cropland are estimated for the first time in this year’s submission. No changes in these carbon pools are assumed. Accordingly no recalculations are performed.

7.13.7Planned Improvements regarding Cropland

The use of IGLUD maps to estimate the area of Cropland and its subdivision into drained cropland and other croplands was an important step in improving the emission/removal estimate of the category. Further improvements of the mapping and subdivision are still needed as e.g. revealed through the cropland mapping survey described above. Continued field controlling of mapping, improved mapping quality and division of cropland soil to soil classes and cultivated crops is planned in coming years. 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.

Considering that the emissions from drained cropland are recognized as key source, it is important to move to a higher tier in estimating that factor. Establishing country specific emission factors, including variability in soil classes is already included in ongoing research projects at 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.

7.14 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 subdivided into four subcategories i.e. “Natural birch shrubland” and “Other Grassland” under “Grassland remaining Grassland“ and “Wetland converted to Grassland” and “Other land converted to Grassland” (revegetation) under “Land converted to Grassland.

7.14.1 Grassland remaining Grassland

Grassland remaining Grassland is for the first time in this year’s submission divided to two subcategories, i.e. “Natural Birch shrubland” and “Other Grassland”

7.14.1.1 Natural Birch Shrubland

Natural birch shrubland is a birch-woodland not meeting the thresholds to be accounted 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.

In IGLUD this area is mapped as Natural birch Woodland less than 2m. There is a considerable overlap between the categories Natural birch forest and Natural birch shrubland in the maps. The area mapped as forest is much smaller than the area reported (24.76 kha vs. 55.09 kha). The difference is supposed to be located under the map layer Natural birch woodland less than 2m, as considerable part of the birch woodland presently less than 2m in height is supposed to reach that height *in situ* at maturity. This part of the woodland reported as forest is geographically unidentifiable within the area mapped as Natural birch woodland less than 2m. The area of map layer “Natural birch woodland less than 2m” (81.10 kha) is still larger than reported area of Natural birch shrubland plus the difference of mapped and reported Natural birch forest (60.21 kha). The remaining area of that map layer is added to the category “Other Grassland”.

The Natural birch shrubland is included in the NFI the estimate of total area and changes in carbon pools are based on the data collected through that inventory.

7.14.1.2 Other Grassland

The category Other grassland includes all land where vascular plant cover is 20% or more as compiled from IGLUD. Accordingly all land within the land use categories above Grassland in the hierarchy (Figure 7.1) 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 except birch (*Betula pubescens*), grasses and mosses in variable combinations, fertile grasslands, and partly vegetated land.

Large areas in Iceland suffer from severe degradation where the vegetation cover is severely damaged or absent and the soil is partly eroded but the remaining Andic soil still has high amounts of carbon. 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 large areas of the former vegetated areas have been severely eroded and in large areas the entire soil mantle has been lost. It has been estimated that a total of 60-250×10^3 kt C has been oxidized and released into the atmosphere in the past millennium (Óskarsson et al. 2004). The estimated current ongoing loss of SOC due to erosion is 50-100 kt C yr^{-1} according to the same study. 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 size of this loss being of 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.

7.14.2 Land converted to Grassland

Two categories of “Land converted to Grassland” are reported, i.e. Wetland converted to Grassland and Other land converted to Grassland. Conversions of Forest land and Settlement to Grassland are reported as not occurring and conversion of Cropland to Grassland are not estimated as no data is available on the area converted.

7.14.2.1 Wetland converted to Grassland

Extensive drainage of wetland took place in Iceland mostly in the period 1940-1985 Figure 7.7. This drainage was aided by governmental subsidies. Only a minor 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. All ditches recognizable on satellite images (SPOT 5) have recently been digitized in a cooperative effort of the AUI and the NLSI (Figure 7.6). The drained wetlands are in this inventory reported under three categories i.e.; Grassland converted to Forest land- organic soil, and Wetland converted to Cropland, both already described and the third category reported is Wetland converted to Grassland.

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

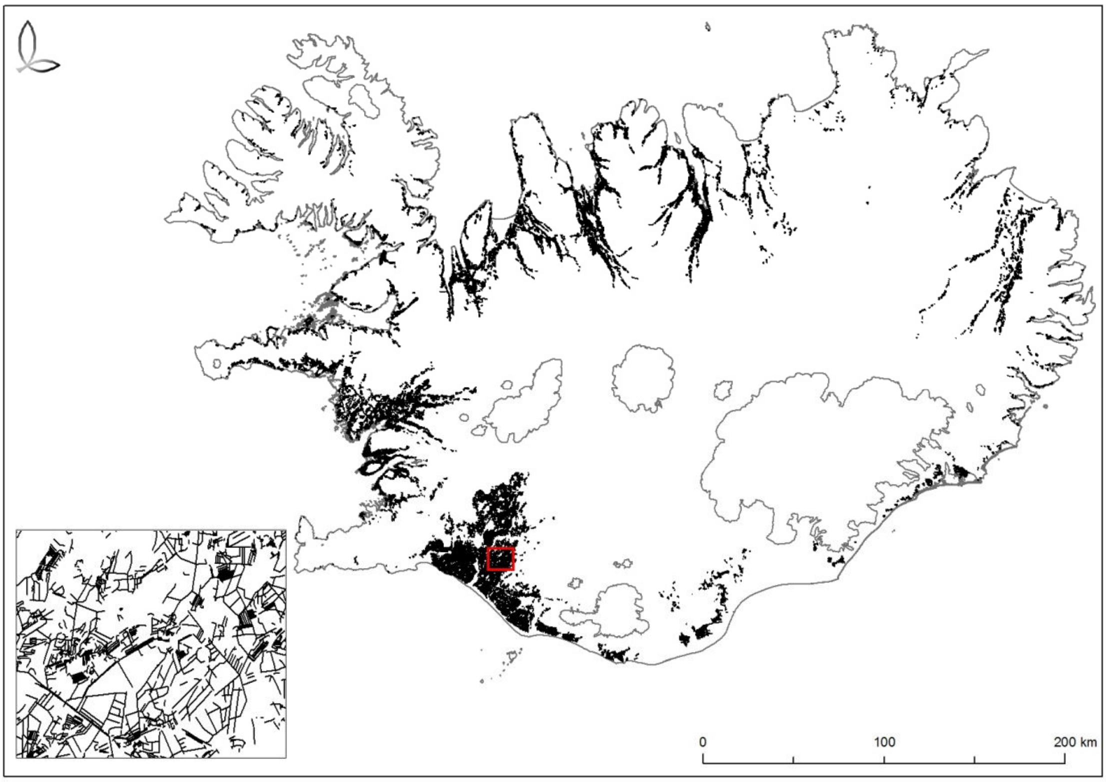

Figure 7.6: Map of Iceland showing all digitized ditches. (AUI 2008).

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.

7.14.3 Other Land converted to Grassland

7.14.3.1 Revegetation

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

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

The SCSI now keeps a national inventory on revegetation areas since 1990 based on best available data. The detailed description of methods will be published elsewhere (Halldórsson et al. 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.

Based on the available data from the NIRA, the area of revegetation activity since 1990 was revised from last submission. According to this data 30% of the land registered as revegetation activity since 1990 should not be included as such. In previous submissions some corrections of the area were made. These corrections are now revised according to this data. The area reported for the year 2009 is 78.37 kha compared to 100.65 kha reported in last year's submission for the year 2008. In this submission the area reported for 2008 is 74.87 kha showing the effect of this revision.

It can be expected that the area registered as revegetation activity before 1990 is overestimated in similar degree. In spite of that the area of revegetation activity before 1990 is not revised comparatively in this submission. A complete revision of the maps for that land is planned this year and will be reported in next submission (Thorsson J. personal communication)

7.14.4 Category Key Factors

Of ten LULUCF categories recognized as key source/sink of level, considering subcategories as reported, six are Grassland categories i.e. (1) Wetland converted to Grassland – Organic soil CO_2, (2) Other land converted to Grassland- Revegetation before 1990-Mineral soil (3) Other land converted to Grassland- Revegetation since 1990-Mineral soil, (4) Wetlands converted to Grassland -drained organic Soils N_2O, (5) Other Land converted to Grassland-Revegetation before 1990-Living biomass, (6) Other Land converted to Grassland-Revegetation since 1990-Living biomass (Table 7.8). Considering only main land use categories (Table 7.9) Land converted to Grassland is recognised as key source/sink. Of five categories recognized as key categories of trend within LULUCF two are Grassland categories i.e. "Grassland remaining grassland-Carbon stock changes- Natural birch shrubland", and "Land converted to grassland-Carbon stock changes- OL_GL -revegetation since 1990". As noted earlier the inclusion of the last category on the list is only due to balancing of afforestation on organic soil toward the category. The categories "Other Grassland" and "Wetlands converted to Grassland-Organic soil" are recognised as key area considering land use categories at highest resolution reported (Table 7.13). Both the categories Grassland remaining Grassland and Land converted to Grassland are recognised as key land use category considering area of main land use categories (Table 7.14) and of the categories classified as applicable toward emission removal contribution (Table 7.15) the category "Other Grassland" and both subcategories of "Other land converted to Grassland" i.e. Revegetation before and since 1990 are identified as key area.

7.14.5 Carbon Stock Change (5C)

Carbon stock changes are estimated for both subcategories included under Land converted to Grassland. The C-stock changes of one subcategory of Grassland remaining Grassland i.e. "Natural birch shrubland" is estimated for the first time in this submission. The emission/removal of the subcategory "Other Grassland" is not estimated in present submission.

7.14.5.1 Carbon Stock Change in Living Biomass

The changes in living biomass of Natural birch shrubland are estimated for the first time in this submission. The carbon stock in living biomass is estimated to have increased by 4.93 Gg C and thereby removing 18.07 Gg CO_2 from the atmosphere.

Carbon stock changes in living biomass are estimated for the category "Other land converted to Grassland (Revegetation)". The stock changes in living biomass reflect the increase in vegetation coverage and biomass achieved through revegetation activities. The changes in biomass are estimated as relative contribution (10%) of total C-stock increase as estimated in a research project aimed at estimating rate of carbon sequestration due to revegetation (Aradóttir et al. 2000; Arnalds et al. 2000). The carbon stock in living biomass is estimated to have increased by 6.68 Gg C and 5.30 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 24.50 Gg CO_2 and 19.43 Gg CO_2 from the atmosphere, respectively.

The changes in living biomass of "Other Grassland" are reported as not occurring based on Tier 1 method for that category. Division of the category is pending and are expected to make it possible to report changes that are occurring (Magnússon et al. 2006) in some areas. Carbon stock changes in living biomass on drained land are possible e.g. due to invasion of shrubs, changes in grazing pressure or increased nutrient availability due to mineralization of SOC components. No data is presently available for changes in living biomass in Wetlands converted to Grassland

7.14.5.2 Net Carbon Stock Changes in Dead Organic Matter

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

7.14.5.3 Net carbon Stock Change in Soils

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

For the category “Other land converted to Grassland (Revegetation)” the changes in carbon stock in mineral soils are estimated applying Tier 2 and CS emission (/removal) factor. The carbon stock in mineral soils is estimated to have increased by 60.15 Gg C and 47.70 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 220.53 Gg CO_2 and 174.91 Gg CO_2 from the atmosphere.

Carbon stock changes in mineral soil of land both under “Other land converted to Grassland- Revegetated before 1990” and “Other land converted to Grassland-Revegetated since 1990”is recognised as key source/sink in LULUCF considering categories as reported at highest resolution Table 7.8. The same categories were also identified as key area considering only applicable land use categories Table 7.15.

The carbon stock changes in organic soils of land under Wetland converted to Grassland are estimated applying Tier 2 methodology. Of the drained area 98% are assumed organic soil, based on AUI unpublished data. Three soil types; Histosol, Histic Andosol and Gleyic Andosol are included. The two organic soil types are Histic Andosol and Histosol. Although Gleyic Andosol is not classified as organic, it is included here. Organic soils in Iceland have in general relatively low C/N ratio and are therefore considered nutrient rich. The carbon stock in drained organic soils is estimated to have decreased by 83.84 Gg C in the inventory year emitting 307.40 Gg CO_2. This is a 77.3 % decrease in emission from last submission which is explained by adoption of the default emission factor (see chapter 7.14.7).

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

7.14.6 Other Emissions (5(IV))

Liming of Grassland soil is not practiced and therefore reported as not occurring. Due to the structure of the CFR- Reporter software version 3.5.2, 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 “*Wetland converted to Grassland Non-CO_2 emission-5(II) Non- CO_2 emission from drainage of soils and wetlands-Organic soils*” (see chapter 7.18.2.1).

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

7.14.7 Emission Factors

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

No Tier 1 default emission/removal factors are available for Revegetation. The emission factor used for calculating emission/removal resulting from revegetation efforts was estimated at -0.75 kt C/kha/yr based on precautious estimates from data collected in 1998-2000 (Aradóttir et al. 2000; Arnalds et al. 2000). Also, based on the same data the contribution of changes in carbon stock of living biomass (including dead organic matter) and soil were estimated as 10% and 90% respectively. All revegetated areas are assumed to accumulate carbon stock at the same rate in the present submission. Based on the new data already collected in NIRA the previous emission/removal factors have now been revised (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 -0.068 and -0.609 kt C/kha/yr respectively.

Emissions of CO_2 from organic soil in Wetland converted to Grassland are calculated according to Tier 1 methodology EF= 0.25 [t C ha^{-1} yr^{-1}], responding to ERT recommendation. 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.

7.14.8 Conversion Periods for Land converted to Grassland.

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

The AFOLU criterion on length of transition period is that it lasts until the soil has reached stabile carbon level of the resulting land use category. The drained areas have generally not reached the same level of soil carbon as grassland mineral soils (AUI unpublished information). Length of transition period has not been determined, but all drained grassland is assumed to still remain in transition period. The excavation of ditches was mostly finished before 1990 according to records of subsided ditches (Figure 7.7). Since subsidies ended the centralized recording of drainage has not been maintained as before and numbers annual drainage is not available. The total length of ditches registered in these records is comparable to the total length of ditches included in the satellite images derived map of ditches. This supports the assumption that most of the present ditches were excavated in this period.

The revegetation activity involves establishing vegetation on eroded or decertified land or reinforcing existing vegetation. Most land hereto revegetated has involved establishing vegetation on land which has less than 20% cover of vascular plants according to SCSI and does therefore not meet the definitions of grassland (Halldórsson et al. in prep.). The transition period for “Other land converted to Grassland” has not been determined but it will take decades to centuries to reach the C level of Brown Andosol (2-7%) at the rate of accumulation assumed in EF. All revegetated land is therefore reported as land still being converted to Grassland. The conversion period for Other land converted to Forest land is 50 years as for Grassland converted to Forest land, the same emission/removal factor is still used for soil in both categories. These conversion periods are arrived at through different assumptions and need to be harmonized or supported by direct measurements. This does not affect the inventory as all afforestation on devegetated land is younger than 50 years..

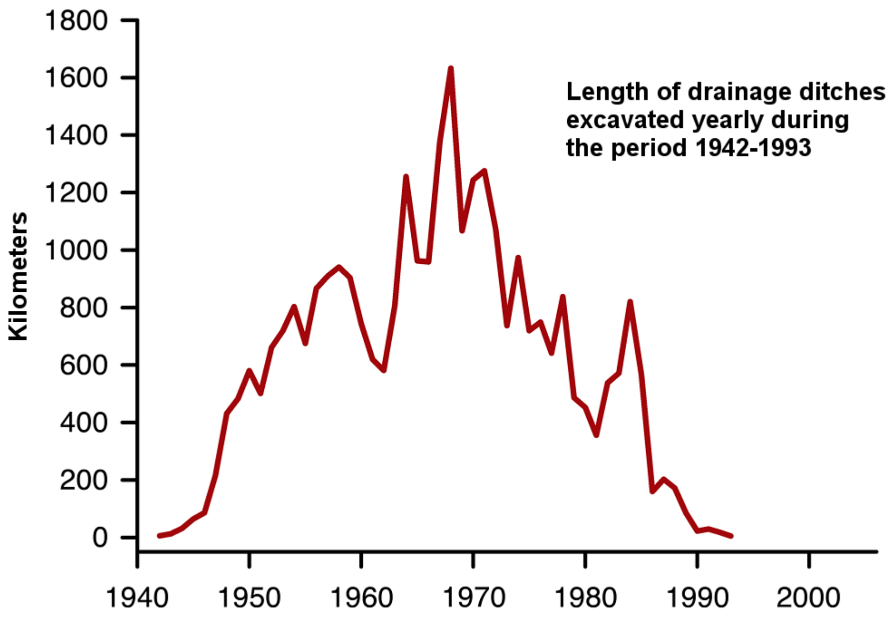

Figure 7.7: Length of ditches subsidised in 1942-1993 (Based on information from the Icelandic Farmers’ Association).

7.14.9 Uncertainty and QA/QC

Uncertainty in reported emissions from this category is assumed to be large. Several components contribute to this uncertainty. The CO_2 emissions from mineral soils of

Grassland remaining Grassland are not estimated. This is potentially a large source considering the severe erosion in large areas. These emissions might be counteracted by carbon sequestration in areas where vegetation is recovering from previous degradation. Carbon stock changes of living biomass in one subcategory of Grassland remaining Grassland i.e. Natural birch shrubland are estimated for the first time in this submission. That estimate shows that changes were occurring in the living biomass of that category. Comparable changes in other pools of that category until reaching new equilibrium would be expected. As no specific actions have been taken to increase the living biomass of that category the observed changes indicate that 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.

Uncertainty in reported emissions from drained soil is also substantial. That uncertainty is both due to uncertainty in the estimate of the size of the drained area and in the uncertainty of EF's applied. The size of the drained area is in this year's submission estimated from IGLUD as described above. The accuracy of that mapping still needs to be tested through ground truthing. Many factors can potentially contribute to the uncertainty of the size of drained area. Among these is the quality of the map of ditches. Ongoing survey on the type of soil drained has already revealed that some features mapped as ditches are not ditches but tracks or fences for example. 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 on the ditches to estimate area of drained land, have their own uncertainty, which is transferred to the estimate of 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.

Calculation of removals/emissions of carbon due to revegetation depends on the size of the area and the chosen emission/removal factor. The approach is ‘Tier 1 (2)’ approach based on a simple removal rate factor based on measurement of chrono-sequential accumulation of carbon on revegetated areas of known age. The revised EF for revegetation is based on Current but unpublished results for 2007 – 2008. These results indicate considerable variation between reclamation methods and land types, as well as intrinsic 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 emission/removal factor was suggested by SCSI, and applied in emission calculations for this year’s submission. As the data has been analysed the uncertainty regarding the emission/removal factor are expected to decrease considerably in next submission.

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

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

7.14.10 Planned Improvements regarding Grassland

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

Severely degraded soils are widespread in Iceland as a result of extensive erosion over a long period of time. Changes in mineral soil carbon stocks are a potentially large source of carbon 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) Dividing the area of grassland remaining grassland into subcategories, based on management and by taking soil and vegetation degradation into account is currently under preparation as part of the IGLUD project.

Emissions of both CO_2 and N_2O from Wetland converted to Grasslands are identified as key sources for LULUCF. Improving the resolution of recorded land use, soil types and refinement of emission factors is highly important for this category. Data for dividing the drained area according to soil type drained have been collected. It is planned to process this data and use the results 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. To move forward in that direction two projects are planned. Firstly in connection with HiRes mapping of some land use categories within the CORINE project, training sets for remote sensing of some 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 mapping of drained wetlands. Secondly the application of plant index proxy to evaluate the effectiveness of draining will be tested the summer 2011.

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, as data on reclamation projects started after 1990 are currently under revision. This revision will be concluded by the end of 2010. Mapping of all activities since 1990 is verified by visiting points within the 1×1 km inventory grid. Recording of activities initiated before 1990 is also ongoing. The second improvement is pre-activity sampling to establish a zero-activity baseline for future comparisons of SOC. This will be implemented for all new areas established in 2010 and later (Halldórsson et al. 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.

7.14.11 Recalculation

Grassland remaining Grassland is in this submission divided into two categories i.e. Natural birch shrubland and Other grassland. Changes in carbon pool of living biomass are for the first time in this year’s submission estimated for Natural birch shrubland and are also estimated for the years 2000-2008.

The emission factor for CO_2 (and for N_2O see chapter 7.18.2.2) on drained organic soil of Wetland converted to Grassland has been revised. There is also a small change in the estimated area of the category and also some changes in Forest land area which affect the backward balancing of the area estimate of the category. Accordingly the estimated emissions for that category have been recalculated for that category for the years 1990-2008.

The emission/removal factors for revegetation have been revised. Accordingly emission/removal for both soil carbon and carbon stock in living biomass for the years 1990-2008 have been recalculated for both “Revegetation before 1990” and “Revegetation since 1990”. The area of revegetation activities since 1990 has been revised for all the years 1990-2008 and the revised area is included in the recalculations.

7.15 Wetland

The reported emissions for this category are structured as in last year’s submission. Flooded land is divided to “Land converted to wetland” and “Wetland remaining wetland”. An improved map-layer for the category “Lakes and rivers” is used to prepare the land use maps of this submission. The area of the new map layer increased from 200.47 kha to 262.79 kha and thereby changing the area estimate of many of the categories lower in the compilation order of the map layers Table 7.3.

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 changed from last year’s submission. The changes are due to new reservoirs established in 2009, revision of emission factors and also the method for estimating emission from one reservoir has been changed from applying general CS EF’s to reservoir specific EF’s. The reported emissions for the category are 18.05 Gg CO_2-equivalents in this submission for the year 2009 and 17.82 Gg CO_2-equivalents, for the year 2008, compared with 30.11 Gg CO_2-equivalents. for the year 2008 in last year’s submission. This value is 40% lower than in last year’s submission.

7.15.1 Carbon Stock Changes (5D)

Areas of Wetland remaining wetlands are divided into three subcategories, “Lakes and Rivers”, “Reservoirs” and “Other wetlands”. Two categories are considered unmanaged, 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 7.16.1).

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

The subcategories ‘Wetland remaining wetland -other wetland ’ and ‘Wetland remaining wetland- lakes and rivers’ are identified as key areas with regard, to reported land use categories at highest resolution reported Table 7.13. When considering only main land use categories the category Wetlands remaining wetlands are also recognized as key area.

7.15.1.1 Flooded Land

CO_2 emission from reservoirs is presented for three subcategories:

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

The emissions 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 2009 equal 9.72 compared to 16.18 Gg reported in last year's submission for the year 2008. The estimate for CO_2 emissions for the year 2008 are in this submission 9.60 Gg reflecting the effect of revision of emission factors.

7.15.2 Other Emissions (5II)

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

7.15.2.1 Flooded Land

Emissions of CH_4 from reservoirs 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 emissions from reservoirs equal 0.40 Gg CH_4 compared to 0.66 Gg CH_4 in last year's submission. The emissions for the year 2008 are now estimated at 0.39 Gg CH_4 reflecting the effect of revised emission factors. Because of revised emission factors the emissions have decreased from last submission by 40% in spite of three new reservoirs.

7.15.3 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. New reservoir specific emission factors were calculated for four reservoirs, three established in the inventory year and one established 2007. 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 7.16: 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 for the latter also bubble emission.

7.15.4 Land converted to Wetland

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

7.15.5 Uncertainty and QA/QC

The main uncertainty is associated with the emission factors used and how well they apply to reservoirs of different age. The emission factors for CH_4 are estimated from measurements on freshly flooded soils. The CO_2 emission factors are based on measurements on 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.

7.15.6 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.

7.15.7 Recalculations

Both CO_2 and CH_4 emission of reservoirs for the years 1990-2008 have been recalculated according to the revision of emissions factors.

7.16 Settlement

The area of Settlement reported is the area estimate of IGLUD. Only minor change is in the reported area 71.04 compared to last year’s submission 71.06 kha. This difference is explained by uncertainty in the compiling process as the relevant map layers have not changed.

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

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

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

Part of the drained land is within the area classified as Settlement. Due to 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.

7.16.2 Other Emissions (5)

As discussed above the area of drained wetlands, which is inside Settlement has not been estimated. The N_2O emissions due to this land use have not been estimated in this year’s submission since the methodology and area estimate need to be elaborated. Burning of biomass in open areas within the category Settlement does take place (see chapter 7.19). No other sources of CH_4 or N_2O have been recognized.

7.16.3 Land converted to Settlement

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

7.16.4 Planned Improvements regarding Settlement

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

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

7.17 Other Land (5, 5F)

No emission/removal 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 of areas with vegetation cover < 20 % or covered with mosses. Also included is the map layer of "Revegetation area 1996-2008 with vegetation cover <33%". This map layer includes land defined as revegetation area but not necessary land where active revegetation has been done. Possibly, some of this area represents revegetation activity before 1990 where revegetation failed, and should accordingly not be defined as unmanaged land.

7.17.1 Planned Improvements regarding other Other Land

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

7.18 Other (5)

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

7.18.1 Harvested Wood Products

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

7.18.2 Wetland converted to Grassland Non CO_2 Emissions

Non-CO_2 emissions from Wetland converted to Grassland are reported here. The present structure of Reporter software (version 3.5.2) 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 changed EF. There is also a minor change in reported area. The estimated emissions in this year's submission are 0.23 Gg N_2O or 71.88 Gg CO_2-equivalents. These numbers are lower than last year's estimate, 0.95 Gg N_2O or 294.21 Gg CO_2-equivalents, and correspond to a decrease of 76%.

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

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

Emissions of N_2O due to drainage of organic soils of Grassland are reported here under "5(II) Non-CO_2 emissions from drainage of soils and wetlands- Organic soils".

7.18.2.2 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 sown or fertilized and are not agricultural soils as cultivated soils.

7.18.3 Revegetation

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

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

7.18.3.2 Emission Factors

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

7.19 Biomass Burning (5V)

Accounting for biomass burning in all land use categories is addressed commonly in this section. The only 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.

7.19.1 Planned Improvements regarding Biomass Burning

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

7.20 Planned Improvements of Emission/Removal Data for LULUCF

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

In parallel with gathering of land use information for the purpose of the new geo-referenced land use database IGLUD, data will be collected regarding the carbon stocks of the land use category used in the classification. These efforts are aimed at gradually improving the reliability of reported emission/removal of the LULUCF sector and enable the transfer from Tier 1, which is presently used to calculate emission/removal in many categories, to higher tier levels.

The results of ongoing and recent research activity on emissions/removal and stocks in several ecosystems will be used in emissions calculations.

8 WASTE

8.1 Overview

This sector includes emissions from solid waste disposal in landfill sites (landfills, 6A), wastewater treatment (6B), waste incineration (6C), and other (composting, 6D). The Waste sector has been in transition since 1990 (Figure 8.1 and Figure 8.2). Open-pit burning, which used to be the most common means of waste disposal outside the capital area, has gradually decreased since 1990 as landfills have become more common. The only open-pit burning that takes place in Iceland is bonfires on New Year's Eve and waste incineration in a small island municipality, Grímsey. The open-pit burning that took place in Grímsey was without permit and the exact yearly total amount burnt is not fully known. Other incinerations that work without permits are not known to exist in Iceland. The trend has been toward managed landfills as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This has resulted in larger landfills and enabled the shutdown of a number of small sites. Today, 73% of total landfilled waste is sent to managed landfill sites for disposal. Recycling of waste has also increased due to efforts made by the government, local municipalities, recovery companies, and others. Composting started in 1990s and has increased slowly since. Over recent years, composting has become a publically known option in waste treatment and composting facilities have been taken into operation. Currently about 64% of municipal waste is landfilled, 24% recycled or recovered, 7% incinerated with energy recovery, and 5% is composted.

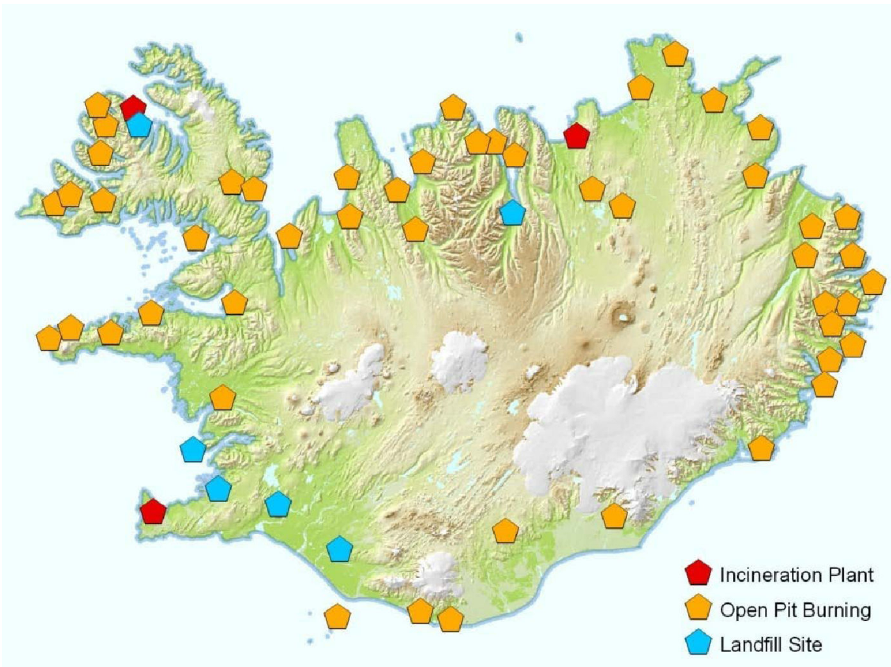

Figure 8.1: Solid waste disposal on land in 1990.

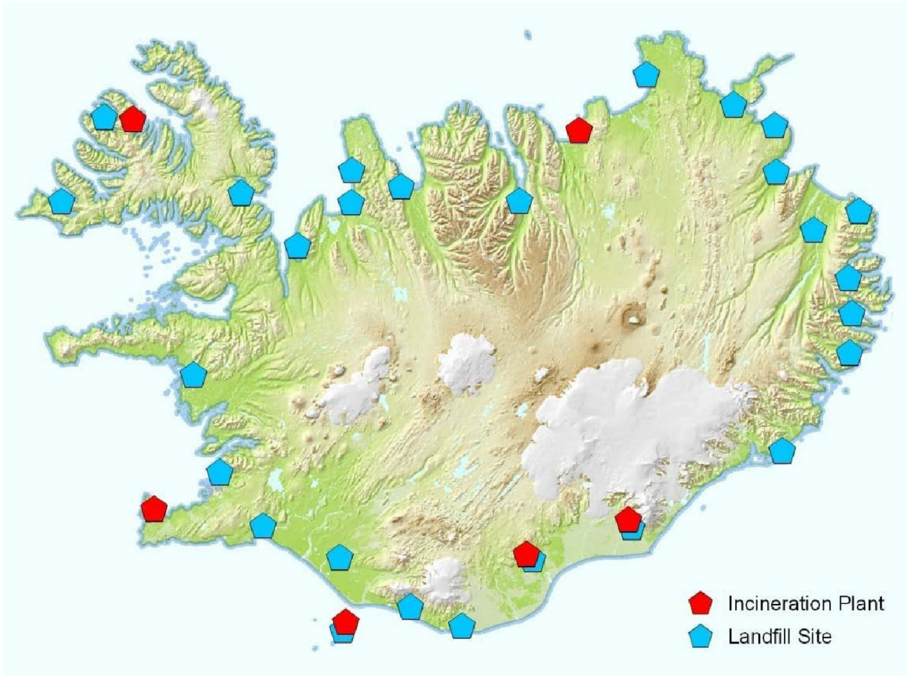

Figure 8.2: Solid waste disposal on land in 2009.

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 this area, mostly by the coast. The practice of wastewater treatment has undergone a radical change in Iceland since 1990. In 1990, 6% of the Icelandic households and industries were connected to wastewater treatment plants. In 2009 the ratio was 68%. Wastewater handling is a minor source of CH_4 as only a minor part of wastewater treatment is anaerobic.

Landfills account for about 84% of the sector's total emissions in CO_2-equivalents. Wastewater handling accounts for around 11% and waste composting accounts for 1% of the emissions. Incineration without energy recovery accounts for less than 0.1%. The Waste sector accounted for 5% of the total GHG emissions in Iceland in 2009.

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 and the Good Practice Guidance. Methodology for each category within the Waste sector is described separately below.

8.1.2 Key Sources Analysis

As indicated in Table 1.1, the key source analysis performed for 2009 has revealed that in terms of total level and/or trend uncertainty the key sources in the agriculture sector are as follows:

- Solid waste disposal sites – CH_4 (6A)
  - This is a key source in level
- Waste incineration – CO_2 (6C)
  - This is a key source in 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 sub-sources in the Waste sector.

Table 8.1: Waste – completeness (E: estimated, NE: not estimated, NA: not applicable, IE: included elsewhere).

	Direct GHG			Indirect GHG			
Waste Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Solid waste disposal on land (6A)							
- Managed	NE	E	NA	NE	NE	NE	NA
- Unmanaged	NE	E	NA	NA	NA	NA	NA
Wastewater treatment (6B)							
- Industrial	NA	E	NE	NE	NE	NE	NA
- Domestic and commercial	NA	E	IE	NE	NE	NE	NA
Waste incineration (6C)	E	E	E	E	E	E	E
Other – Composting (6D)	NA	E	E	NA	NA	NA	NA

8.1.4 Source Specific QA/QC Procedures

The QC activities include general methods such as accuracy checks on data acquisition and calculations 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)

Solid waste disposal in Iceland is divided between managed landfill sites and unmanaged landfill sites. The definition for a managed site is a landfill deeper than 4 meters with a thorough registration system for waste type and amount. Sites that are shallow, with less than 4 meters of waste are defined as unmanaged landfill sites.

This division is in line with measurements made by Kamsa and Meyles (2003) where the methane concentration in landfill gas formation in landfills with a waste layer thickness of less than 4 meters is not considered substantial and less than 20%. Therefore it is not possible according to Kamsma and Meyles to utilize or flare the gas itself. Total waste going to landfills is divided into two major waste streams, municipal solid waste (MSW) and industrial waste (IW) as the CH_4 production potential of solid waste is determined by the amount of degradable organic carbon (DOC) in the waste.

8.2.1 Methodology

The methodology for calculating methane from solid waste disposal on land is according to the Tier 2 method and the 2006 IPCC First Order Decay model (FOD) was used for calculations. MSW is defined as waste collected from households, commerce and trade and IW is waste collected from industry. Waste from commerce and trade can be included both in MSW and IW, especially in smaller municipalities where separation between MSW and IW is not well specified. Inert waste, such as demolition, tiles, and, other is excluded from the IW figures, but included in official data on solid waste disposal sites in Iceland.

8.2.2 Activity Data

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

In line with IPCC guidelines, historical data was calculated by extrapolation from 1994 back to 1950 using Gross Domestic Product (GDP), and population as drivers. These parameters are considered reliable. GDP is correlated with a country's waste production and is a reliable estimation method. Available reported waste figures, since 1995, GDP and population are used to estimate the total amount of waste generated from 1950 to 1995. From 1950 to 1980, all waste disposal is rated as uncategorized as waste management was poor and uncontrolled in these years and private incineration was common with non-existent waste management. For that period, the MCF value of 0.6, given by IPCC guidelines for default value of the MCF for uncategorised landfilled waste, was used. After 1980 the default IPCC values for unmanaged (shallow) landfills (MCF = 0.4) and managed landfills (MCF = 1.0) was used.

GDP based calculation uses waste figures generated in 1995, 2000, and 2004 as multiple reference figures. GDP and MSW per person, which are strongly correlated, were used to determine the amount of generated MSW per person per year and multiplied by population to obtain the total MSW figures. Industrial waste, however, was extrapolated by using GDP as the only driver. GDP and waste generation increased rapidly in the years 2000-2007, with a sudden drop in 2008 and a continuing decrease in 2009 (Figure 8.3). A decrease in the waste generation rate can be seen from the year 2006 and especially from 2007 to 2009. This can partly be explained by the fact that the in the year 2008 a financial crisis occurred (decrease of 9% in kg MSW/cap/yr). Between 2008 and 2009 the total population decreased by around 1% and the financial depression continued. This is reflected in the waste generation rate as it continued to decrease (-16%) as can be seen in Figure 8.3.

During revision of the activity data it was noticed that the methodology of data collection and analysis has been changed over the years. Also, waste from commerce and trade can be included both in MSW and IW and the origin of such waste is often not registered, some waste was included in MSW the year 2007 but from 2008 the same waste was included in IW. This waste was registered as recycled waste and included, among other things, cardboard boxes and scrap metal (other than cars). Moreover, previous to the year 2007 landfilled waste was not categorised as managed or unmanaged so the total amount was used. The amount for managed landfill was collected from municipalities and the amount of unmanaged landfill was estimated using those data. For this submission the specialists of EA did some recalculations which led to some changes in the waste generation rate (kg MSW/cap/yr).

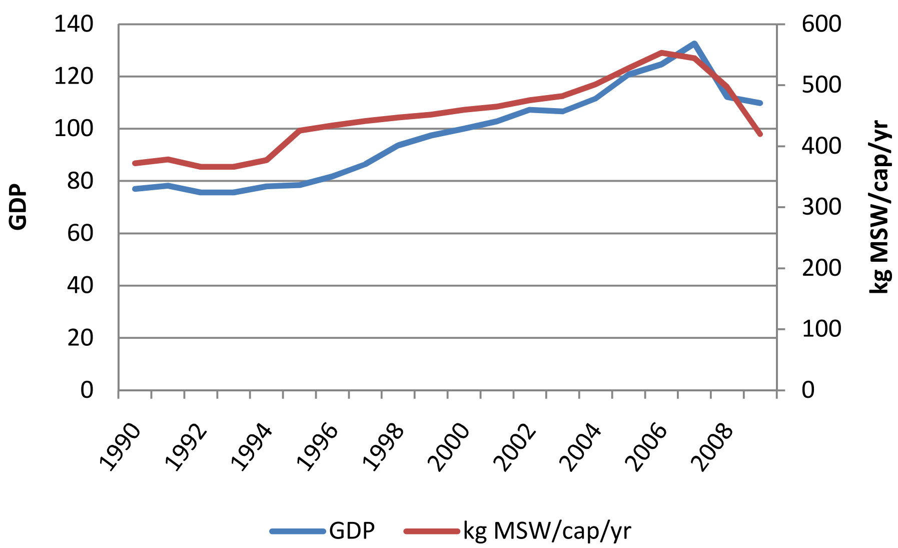

Figure 8.3: The relationship between GDP and municipal waste generation in the years 1990-2009.

The activity data was mostly collated by the EA through electronic data collection such as e-mail surveys and etc. Also, municipalities and larger waste companies report their activity data directly to the EA. Categorisation of waste treatment in Iceland between 1990 and 2009 is shown in Figure 8.4. The decrease in landfilled waste seen in 2005 and 2007 is most likely due to an increase in country-wide recycling.

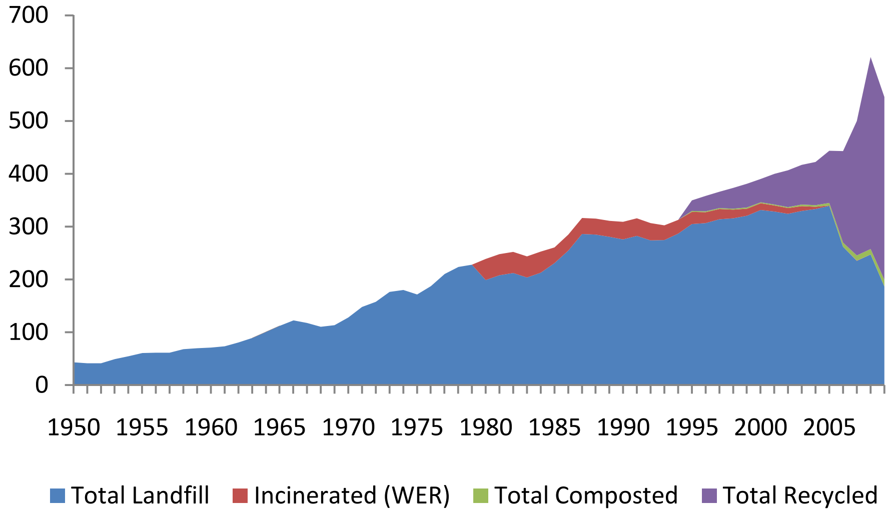

Figure 8.4. Total waste volume (Gg) per sector over the period of 1950 to 2009 (WER: without energy recovery).

8.2.3 Emission Factors

Municipal Waste – Mixed household Waste

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

The composition of mixed household waste in Iceland going to landfills has been surveyed since 1999 by SORPA, the largest waste treatment facility in Iceland. SORPA serves the capital area and thus covers around 63% of the Icelandic population. The composition over the last 8 years has shown to be relatively consistent. Because very little is known about the MSW composition before 1999, the average composition from 1999 to 2004 has been used in the IPCC model for each year between 1950 and 2009.

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

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

Table 8.2: Results from a mixed household waste composition survey made by Sorpa over the period of 1999-2004. Shows proportion of different waste categories.

Type of waste	1999	2000	2001	2002	2003	2004	Average
Food waste	0.33	0.28	0.31	0.26	0.24	0.26	**0.28**
Garden waste	0.04	0.00	0.01	0.00	0.02	0.01	**0.01**
Paper and cardboard	0.24	0.29	0.21	0.22	0.26	0.27	**0.25**
Wood waste	0.00	0.01	0.01	0.01	0.01	0.00	**0.01**
Textile waste	0.04	0.04	0.03	0.03	0.03	0.04	**0.03**
Diapers/nappies	0.05	0.04	0.06	0.07	0.05	0.06	**0.06**
Sludge	0.04	0.04	0.04	0.04	0.04	0.04	**0.04**
Plastics, other inert	0.26	0.30	0.33	0.37	0.35	0.32	**0.32**

Methane is generated as a result of degradation of organic material under anaerobic conditions. Part of the methane is oxidised in the cover of the solid waste disposal sites (SWDS), or can be recovered for energy or flaring. The methane emission from solid waste disposal was estimated using the default equation given by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and is as follows:

CH_4 Emissions from SWDS

$$CH_4\ Emissions = \left[\sum_x \left(CH_4\ generated_{x,T} - R_T\right)\right] \cdot (1 - OX_T)$$

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).

Sewage sludge was excluded when calculating emission from MSW. In Iceland, proper wastewater handling started around 1990. Septic tanks were used prior to 1990 to some extent. Today, 68% of buildings are connected to municipal wastewater handling facilities. Little is known of sewage sludge disposal prior to 1990 and the amount that was disposed in landfills is considered insignificant. Emissions from sewage sludge in landfills are included in landfill emissions from the year 1990. Parameters used are in accordance with IPCC default values for northern Europe and wet temperate conditions, except for the country specific values for

MSW composition. The parameters for IPCC Category 6A Municipal Solid Waste are reported in Table 8.3.

Table 8.3: Calculation parameters for municipal solid waste.

	Food	Garden	Paper	Wood	Textile	Nappies
MSW composition (average 1999 - 2004)	28%	1.4%	25%	0.6%	3%	5.6%
Methane correction factor (MCF)*						
- Unmanaged-shallow	0.4					
- Managed	1.0					
- Uncategorized	0.6					
Fraction of degradable organic carbon dissimilated (DOC_F)*	0.5					
Degradable organic carbon (DOC)*	0.15	0.2	0.4	0.43	0.24	0.24
Methane generation constant (k)*	0.185	0.1	0.06	0.03	0.06	0.1
Half-life time (h) (years) (h = Ln(2)/k)	4	7	12	23	12	7
Delay time (month)*	6					
Number of considered years	56					
Fraction of CH_4 in landfill gas (F)*	0.5					
Oxidation factor (OX)*	0.05					
Conversion factor (C to CH_4)	1.33					

*IPCC default value for northern Europe and wet temperate conditions.

Recalculations

Waste from commerce and trade can be included both in MSW and IW. In the year 2007 some waste data was defined as MSW which was later defined as IW. Due to this difference in waste assortment some recalculations where performed which led to some changes in the MSW generation rate. These changes are presented in Table 8.4.

Table 8.4: Recalculation results for the waste generation rate (kg MSW/cap/yr).

	1995	2000	2005	2007	2008
MSW/cap/yr (Submission 2010)	426	460	528	588	476
MSW/cap/yr (Submission 2011)	420	480	528	544	497

Industrial Waste

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

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

As no national data are available on emissions from landfill waste, default IPCC data for northern Europe and wet temperate conditions are used. The emission factors and parameters for IPCC Category 6A Industrial Waste are reported in Table 8.5.

Table 8.5: Calculation parameters for industrial waste.

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

*IPCC default value for northern Europe and wet temperate conditions.

Landfill Gas Recovery

Iceland's only landfill gas recovery facility is at Álfsnes, a landfill site which receives waste from the capital area. It serves 65% of the population and receives 50% of the total amount of landfilled waste. The recovery of CH_4 from landfill started in 1997 and the amount recovered per year can be seen in Figure 8.5.

In Figure 8.5 an immense decrease in methane recovery is seen the year 2006. This is due to failure in the methane recovery device at the landfill site. This failure led to limited recovery and uncertainty in recovery data. Therefore data for the years 2006 and 2007 for methane recovery are estimates made by SORPA personnel. A new methane recovery device has been taken into use and by the end of 2009 the new device should be fully active.

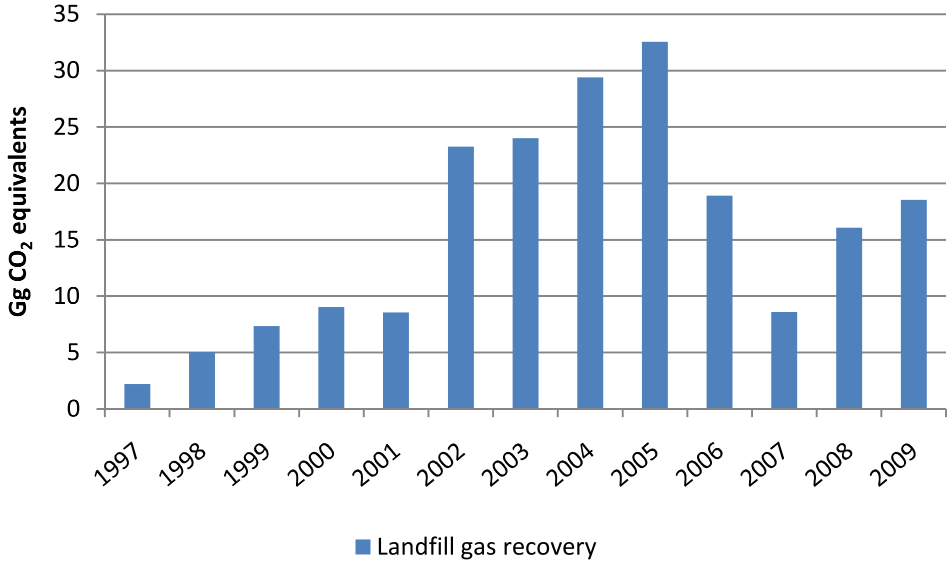

Figure 8.5: Landfill gas recovery in Iceland in Gg CO_2-equivalents over the period of 1997 to 2009.

8.2.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from solid waste disposal sites is 51% (with an activity data uncertainty of 10% and emission factor uncertainty of 50%). This can be seen in the quantitative uncertainty table in Annex II. The quality of the activity data for Iceland may be considered somewhat lacking, but needs further improvement to ensure its accuracy and quality.

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

Landfilled Waste between 1950 and 1980

The exact amount of waste going to managed or unmanaged landfill sites between 1950 and 1980 is unknown. Therefore the methane correction factor (MCF) in the IPCC model has been set to uncategorized for this period (MCF = 0.6 – see Table 8.3 and Table 8.5).

Amount and Composition of Industrial Waste

The exact composition of mixed IW and thus the fraction of biodegradable waste are unknown. Scrap metal, tires and construction and demolition waste are excluded from the total. Large amounts of waste from companies are similar in composition to MSW and this is included in the mixed fraction of industrial waste. Methane emissions from landfilled IW might be slightly overestimated as studies (Kamsma and Meyles, 2003) have revealed that methane emissions from landfills that accept slaughterhouse waste, are very low, as this type of waste decomposes at a slow rate.

Composition of Municipal Solid Waste between 1950 and 1998

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

8.2.5 Planned Improvements

The activity data of landfilled waste and methane recovery are constantly under revision every year.

8.3 Emission from Wastewater Handling (6B)

8.3.1 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 wastewater as well as 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 Domestic Wastewater

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

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

Only about 6% of the population is living in rural areas and fewer than 1000 people live at an elevation higher than 200 meters above sea level. This explains the high percentage of primary treatment. In 2007 one of the municipalities located close to Reykjavík that had been using septic tanks as an treatment system was connected to the Reykjavík sewage system. This led to a decrease in overall emissions from wastewater handling. The sludge from wastewater handling is disposed of in landfill sites (managed and unmanaged). Only septic tanks existed prior to 1990, and little is known of where sludge was placed earlier, it is assumed that placing of sludge in landfills started in 1990 in connection with the construction of the wastewater treatment plants.

Activity Data

The prevalent treatment of domestic wastewater is aerobic, 57% is primary treatment, and 32% of the population has no wastewater treatment. About 2% of the facilities are secondary treatment and 9% are septic tanks (Table 8.6). The development of the activity data from 1990 to 2009 can be seen in Figure 8.6.

Table 8.6: Total Icelandic population and proportion connected to wastewater handling facilities in Iceland.

		Connected to wastewater facilities			
Year	Population	Total	Primary treatment (MFC=0.1)	Secondary treatment (MFC=0.3)	Septic tanks (MFC=0.5)
1990	253,785	6%	2%	0%	4%
1995	266,978	10%	4%	0%	6%
2000	279,049	39%	33%	0%	6%
2005	299,891	68%	54%	2%	11%
2007	315,459	68%	57%	2%	9%
2008	319,368	68%	57%	2%	9%
2009	317,630	68%	57%	2%	9%

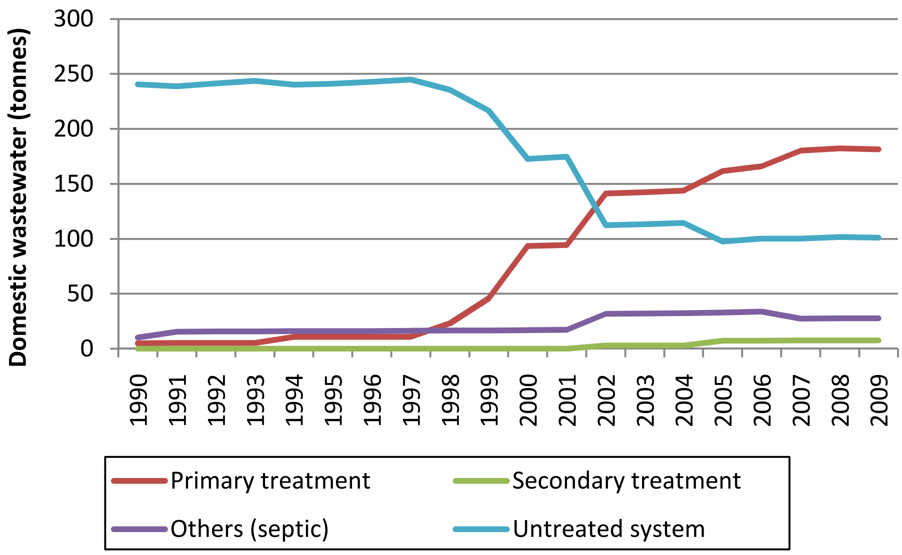

Figure 8.6: Total amount of domestic wastewater (tonnes) over the period of 1990 to 2009 depending on treatment.

The Environment Agency collects data on domestic wastewater and the methane correction factor (MCF) is chosen in line with 2006 IPCC guidelines (Table 8.5).

The equation for the total amount of organically degradable material in the wastewater (TOW) is a function of human population and biochemical oxygen demand (BOD) generation per person and is as follows:

Total Organically Degradable Material in Domestic Wastewater

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

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

Total Domestic Organic Sludge:

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

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

8.3.3 Methane Emissions from Domestic Wastewater

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

Total CH_4 Emissions from Domestic Wastewater:

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

Where:
CH_4 Emissions = CH_4 emissions in the inventory year, kg CH_4/yr
TOW = Total organics in wastewater in inventory year, kg BOD/yr
S = Organic component removed as sludge in inventory year, kg BOD/yr
U_i = Fraction of population in income group *i* in inventory year
$T_{i,j}$ = Degree of utilization of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year
i = Income group: rural, urban high income and urban low income
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

Emission Factors

Of the total population connected to wastewater handling facilities, most are connected to primary treatment (57%), some are connected to handling facilities such as septic (and settling) tanks (9%). In the year 2002, secondary treatment (two step treatment) was introduced on a small scale. By the year 2005 secondary treatment had been introduced in three municipalities, Hveragerði, Hvolsvöllur, and Egilsstaðir, which accounts for around 2% of the total Icelandic population (see Table 8.6).

Different MCF applies to these handling methods. The MCF used is in accordance with the IPCC 2006 guideline default values (Table 8.3). Primary treatment is most common, where little treatment exist as the wastewater is led to the sea where mixing is vigorous (MCF = 0.1). Due to this vigorous mixing, the sea is considered less sensitive and therefore a primary treatment is appropriate. Few secondary treatment facilities exist, where the wastewater is lead to fresh water and treated to some extent, although the treatment is mostly aerobic (MCF = 0.3). Secondary treatment usually involves a biological treatment with a secondary settlement. The rest are septic systems (MCF = 0.5) where around half of BOD is reduced in anaerobic tanks. Parameters for IPCC Category 6B Wastewater Handling are reported in Table 8.7.

Table 8.7: Parameters for wastewater handling.

Parameters	Value
Biochemical oxygen demand (BOD)*	60 g/person/day
Methane correction factor (MFC)	
- Septic treatment*	0.5
- Primary treatment*	0.1
- Secondary treatment*	0.3
- Untreated*	0.1
Maximum CH_4 producing capacity (B_o)*	0.6 kg CH_4/kg BOD
Protein intake	31.76 kg/person/year
D_{dom}	18.25kg BOD/person/year
DS_{dom}	15%
Fraction values (F)	
- Fraction of nitrogen in protein (F_{NPR})*	0,16kg N/kg protein
- Factor for non-consumed protein added to wastewater ($F_{NON-CON}$)*	1.4
- Factor for industrial and commercial co-discharged protein into sewer system ($F_{IND-COM}$)*	1.5
Nitrogen removed with sludge (N_{SLUDGE})*	0 kg N/yr
Correction factor (I)*	1.25

*IPCC default value.

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (B_o) and the methane correction factor (MCF) for the wastewater treatment and discharge system and is as follows:

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

$$EF_j = B_o \cdot MCF_j$$

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

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from wastewater handling is 58% (with an activity data uncertainty of 50% and emission factor uncertainty of 30%). This can be seen in the quantitative uncertainty table in Annex II.

8.3.4 Nitrous Oxide Emissions from Domestic Wastewater

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

Nitrous oxide emissions from human sewage were calculated according to the IPCC default method, which is based on the annual per capita protein intake. Annual protein intake in Iceland is high compared to other countries, or 31.76 kg/person/year (Surveys made in 2002-2003). Another survey on Icelanders food intake is being conducted at the moment and the final results will be published in the summer of 2011. Those results will be used when estimating N_2O emissions from domestic wastewater in the next submission 2012.

N_2O Emissions from Wastewater Effluent:

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

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

Activity Data

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

Total Nitrogen in the Effluent:

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

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
$F_{NON\text{-}CON}$ = Factor for non-consumed protein added to the wastewater
$F_{IND\text{-}COM}$ = Factor for industrial and commercial co-discharged protein into the sewer system
N_{SLUDGE} = Nitrogen removed with sludge (default = zero), kg N/yr

Emission Factors

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

8.3.5 Industrial Wastewater

Emissions from fish, dairy products, and meat and poultry industrial wastewater are evaluated as these groups constitute the majority of emissions from industrial wastewater in Iceland. Vegetables and beer production is also taken into account (Table 8.8). The fish processing is the dominant factor in the estimate. Scandinavian data on tonnes COD produced per tonne for different fish groups were used to estimate wastewater handling in the fish processing industry. For uncategorized fishing (fish species that are captured as by-catch), meat and poultry, and dairy products, default IPCC values were used.

Table 8.8: List of industrial sectors included in the wastewater emissions estimation and proportion of CH_4 emissions within the sector.

Sectors	CH_4 emissions (%)
Fish processing	50
Meat and poultry	6
Dairy products	5
Vegetables	7
Beer production	31

The following equations were used to estimate CH_4 emissions from industrial wastewater.

Total CH_4 Emissions from Industrial Wastewater:

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

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

Activity Data

The activity data used for estimation of industrial wastewater emissions is obtained from Statistics Iceland and the Icelandic Dairy Association. Data on COD (chemical oxygen demand) per tonne product is available for different fish/seafood groups from Scandinavian sources. For dairy products, meat and poultry produce, and uncategorized fish catch, the default IPCC values on water usage and COD were used. The maximum CH_4 producing capacity (B_o) is also by IPCC default. See Table 8.9.

The activity data for this source category is the amount of organically degradable material in wastewater (TOW) and is as follows:

Organically Degradable Material in Industrial Wastewater:

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

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

Table 8.9: COD (chemical oxygen demand) and MCF (methane correction factor) for industrial wastewater handling.

Parameters	Value
Chemical oxygen demand (COD)	
- White fish	17 kg O_2/m^3
- Herring	22 kg O_2/m^3
- Shrimp	115 kg O_2/m^3
- Fishmeal (capelin)	1.25 kg O_2/m^3
- Fish processing$_{\text{Uncategorised}}$*	2.5 kg/m^3
- Dairy products*	2.7 kg/m^3
- Meat and poultry*	4.1 kg/m^3
Maximum CH_4 producing capacity (B_o)**	0.25 kg CH_4/kg
Methane correction factor (MCF)**	0.1

*IPCC example value, **IPCC default value.

Emission Factors

The IPCC COD-default factor for B_o was used (0.25 kg CH_4/kg COD) for estimating the CH_4 emitting potential in the following equation given by the 2006 IPCC Guidelines:

CH_4 Emission Factor for Industrial Wastewater:

$$EF_j = B_o \cdot MCF_j$$

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

8.3.6 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of N_2O emissions from wastewater handling is 58% (with an activity data uncertainty of 50% and emission factor uncertainty of 30%). This can be seen in the quantitative uncertainty table in Annex II.

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

MCF Parameter

Default MCF parameters for domestic wastewater were used. Most domestic wastewater falls under primary treatment and is pumped out into the sea, therefore MCF = 0.1 was used. Wastewater going through secondary treatment and septic tanks where MCF = 0.3 and 0.5, respectively, according to IPCC default MCF values and EA specialist judgement.

$F_{IND\text{-}COM}$ Parameter

Default IPCC factor for industrial wastewater and commercial co-discharged protein into sewer system (FIND-COM) range between 1.0 and 1.5. As Iceland has significant fish processing, 1.5 was set as a factor to allow for co-discharge of industrial nitrogen into sewers. This factor might be higher.

DS_{dom} Parameter

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

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

8.3.7 Planned Improvements

The review of the 2010 National Inventory Report showed some concerns for the high value of the annual protein intake in Iceland compared to other countries, or 31.76 kg/person/year (Surveys made in 2002-2003). A new dietary survey is being conducted at the moment and the final results will be published in the summer of 2011. Therefore, the value for protein intake remains unchanged for this submission. Before the next submission in 2012, the results from the new study on protein intake will be used for revision of the protein intake value when estimating N_2O emissions from domestic wastewater.

8.4 Waste Incineration (6C)

Emissions from waste incineration with energy recovery are reported in sector 1A1a (public electricity and heat production) and 1A4a (commercial and institutional heat production) in the Energy sector (chapter 3). Emissions from waste incineration without energy recovery (WER) have decreased by 99% from 1990 to 2009. This is because the total amount of waste being incinerated without energy recovery in Iceland has decreased while increasing levels have been incinerated with energy recovery and thus reported under 1A1a and 1A4a. Waste incineration without energy recovery is virtually non-existent in Iceland today except for legitimate bonfires around the New Year celebrations, where only untreated wood is burned (Table 8.10).

8.4.1 Methodology

The methodology for calculating emissions from waste incineration is in accordance with the 2006 IPCC Guidelines Tier 1 method. The activity data are the waste inputs into the incinerator and the emission factor is based on the carbon content of the waste that is of fossil origin only. The burnout efficiency of the combustion is also included in the calculation. The activity data are categorised into different waste types (e.g. municipal solid waste, industrial waste, clinical waste and hazardous waste).

8.4.2 Activity Data

Activity data on incinerated waste from the incineration plants have been collected by the EA since 2000 and can be seen in Table 8.10. Historic data, as well as data on open-pit burning, that are not reported to the EA, were estimated with the assumption that 500 kg/yr of waste were incinerated per inhabitant in the communities where waste is known to have been incinerated (both in primitive incineration plants as well as open-pit burning) in 1990, 1995, and 2000. These data were interpolated in the years between 1990, 1995, and 2000. The communities which were known to have their waste incinerated were mapped by the EA in the respective years.

Table 8.10: Total waste incinerated in Iceland from 1990 to 2009 (1.000 tonnes) categorised into groups.

	Total waste incinerated (x1000 tones)							
	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**
Total waste incinerated	37.8	32.7	25.3	24.4	28.8	32.0	27.9	22.9
- Incinerated 1A1a	0.0	4.7	6.1	6.0	10.8	12.0	10.3	8.0
- Incinerated 1A4a	0.0	0.5	0.6	11.5	12.0	13.9	12.1	9.8
Incinerated (without energy recovery)	33.8	22.6	12.7	0.047	0.047	0.047	0.047	0.047
Bonfires (New Years)	4.0	5.0	6.0	7.0	6.0	6.0	5.5	5.0
Incinerated other	-	-	-	0.0	0.0	0.0	0.0	0.0
Incinerate non-biogenic (without energy recovery)	37.8	27.6	18.7	7.0	6.0	6.0	5.5	5.0

The data after the year 2000 are considered reliable excluding the amount incinerated in the island Grímsey. The total amount incinerated in Grímsey in an open-pit was estimated at 46.5 tonnes, which includes municipal waste and the amount estimated for bonfires was 5 tonnes. The data on the total amount incinerated without energy recovery are estimates made by the EA and are currently under revision. The data prior to 2000 are also an estimate.

8.4.3 CO_2 Emissions from Incineration

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

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

$$CO_2Emissions = \sum_i (SW_i \cdot dm_i \cdot CF_i \cdot FCF_i \cdot OF_i) \cdot 44/12$$

Where:
CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr
SW_i = Total amount of solid waste of type *i* (wet weight) incinerated or open-burned, Gg/yr
dm_i = Dry matter content in the waste (wet weight) incinerated or open-burned (fraction)
CF_i = Fraction of carbon in the dry matter (total carbon content) (fraction)
FCF_i= Fraction of fossil carbon in the total carbon (fraction)
OF_i = Oxidation factor (fraction)
44/12 = Conversion factor from C to CO_2
i = Type of waste incinerated/open-burned specified as follows: MSW: municipal soldi waste; ISW: industrial solid waste; SS: sewage sludge; HW: hazardous waste; CW: clinical waste.

Emission Factors

Data for the estimation of CO_2 emissions from waste incineration are utilised according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Values for municipal solid waste (MSW) were estimated using the following equations from the 2006 IPCC Guidelines.

Dry Matter Content in MSW:

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

Where:
dm = Total dry matter content in the MSW
WF_i = Fraction of component *i* in the MSW
dm_i = Dry matter content in the component *i*

Total Carbon Content in MSW:

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

Where:
CF = Total carbon content in MSW
WF_i = Fraction of component *i* in the MSW
CF_i = Carbon content in the waste type/material *i* in MSW

Fossil Carbon Fraction (FCF) in MSW:

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

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

Parameters for MSW were calculated using the composition of waste according to local data on MSW. Default values for industrial waste were used according to IPCC guidelines. Bonfires are supervised by local Environmental and Public Health Authorities, and only timber is allowed. Parameters for bonfires are IPCC default data for wood.

Values for individual parameters of waste incineration are presented in Table 8.11.

Table 8.11: Parameters for estimating CO_2 emissions from waste incineration.

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

As IPCC guidelines do not account for open-pit burning of IW or bonfires the default oxidation factor for MSW was used. Dry matter of IW is an estimate made by specialists of the EA.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from Waste Incineration 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.

8.4.4 N_2O Emissions from Incineration

The following equation is used for calculating N_2O emissions from waste incineration and is according to the Tier 1 method in the 2006 IPCC Guidelines:

N_2O Emission Estimate based on the Waste Input to the Incinerators

$$N_2O\ Emissions = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6}$$

Where:
N_2O Emissions = N_2O emissions in inventory year, Gg/yr
IW_i = Amount of incinerated/open-burned waste of type *i*, Gg/yr
EF_i = N_2O emission factor (kg N_2O/Gg of waste) for waste of type *i*
10^{-6} = Conversion from kilogram to gigagram
i = Category or type of waste incinerated/open-burned, specified as; MSW: municipal solid waste; ISW: industrial solid waste; HW: hazardous waste; CW: clinical waste; SS: sewage sludge; other.

Emission Factors

The emission factors (EF) used in the estimation of N_2O emissions from incineration are default values given by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and can be seen in Table 8.12.

Table 8.12: Emission factors (EF) for estimating N_2O emissions from incineration. 2006 IPCC Guidelines for National Greenhouse Gas Inventories default values.

Type of Waste and Technology	EF (g N_2O/t waste)	Weight Basis
MSW batch type incinerators	60	Wet weight
MSW open- pit burning	150	Dry weight
IW all types	100	Wet weight

CH_4 Emissions from Incineration

$$CH_4\ Emissions = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6}$$

Where:
N_2O Emissions = N_2O emissions in inventory year, Gg/yr
IW_i = Amount of incinerated/open-burned waste of type *i*, Gg/yr
EF_i = N_2O emission factor (kg N_2O/Gg of waste) for type incineration *i*
10^{-6} = Conversion from kilogram to gigagram
i = Type of waste incineration technology, specified as CI: continuous incineration; SCI: semi-continuous incineration; BTI: batch type incineration.

Emission Factors

Most incineration facilities in Iceland use a batch type incineration technology and therefore the default value for such a type of incineration technology from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was used when estimating the methane emissions. The default emission factor for waste incinerated on a wet weight basis is 237 kg/Gg CH_4. For open burning of waste the CH_4 emission factor of 6.500 g/t MSW was used when calculating methane emissions from bonfires. These bonfires only occur around the New Year celebrations and require permits from the local Environmental and Public Health Authorities.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of N_2O emissions from waste incineration is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%). This can be seen in the quantitative uncertainty table in Annex II.

8.4.5 Recalculations

Every year activity data and calculation methods are revised. During this revision when estimating emissions from incineration some miscalculations were noticed in the 2010 submission. This has been rectified for this submission.

8.4.6 Uncertainties

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

Open-Pit burning

The data on bonfires are estimates. The exact amount of untreated wood burnt (without energy recovery) is not known. Likewise, the amount of municipality waste incinerated with an open-pit burning in the island in the north (Grímsey) is estimated at 46.5 tonnes. This incineration was operated without permission and no documentation exists for it. Therefore no information was collected from the island.

Emission Factors

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories the default emission factors for estimating N_2O emissions from incineration have a relative high level of uncertainty.

8.4.7 Panned Improvements

Open-Pit Burning

Untreated wood is burnt in bonfires around the New Year celebrations. Previous data on the amount of wood are an estimate and are being revised. Data on incinerated waste in Grímsey are also an estimate and are being revised.

8.5 Composting (6D)

Composting has been practiced for some years in Iceland. Composted municipal waste mainly includes waste from slaughterhouses, and garden and park waste. Garden and park waste has been collected from the Reykjavík capital area and composted according to the “Windrow method”, where grass, tree crush, and horse manure is mixed together. In some small municipalities there is an active composting program where most organic waste is collected and composted. Composting methods were not officially taken into use in Iceland until in the 1990s and official data collection by local Environmental and Public Health Authorities started in 1995. Increased emphasis is placed on composting as an option in waste treatment for the future as is evident by the opening of new composting facilities in Sauðárkrókur the year 2007 and in Eyjafjörður in Northern Iceland as well as smaller facilities around Iceland in the year 2009. The amount of composted waste has been increasing since the year 2003 as can be seen in Figure 8.7. The proportion of composted waste reached up to 7% of the total landfilled waste the year 2009.

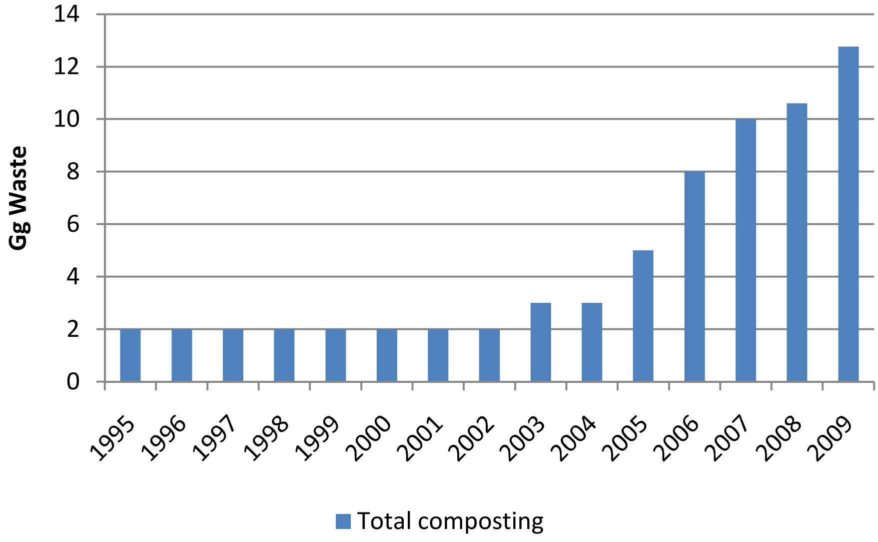

Figure 8.7: The composting amount (Gg) in Iceland over the period of 1995 to 2009.

8.5.1 Methodology

To estimate the methane and nitrous oxide emissions from biological treatment the default equations for Tier 1 method of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories were used and can be seen below:

Methane emissions equation:

CH_4 Emissions from Biological Treatment

$$CH_4\ Emissions = \sum_i (M_i \cdot EF_i) \cdot 10^{-3}$$

Nitrous oxide emissions equation:

N_2O Emissions from Biological Treatment

$$N_2O\ Emissions = \sum_i (M_i \cdot EF_i) \cdot 10^{-3}$$

Where:
CH_4/N_2O Emissions = Total CH_4/N_2O emissions in inventory year, Gg CH_4/N_2O
Mi = Mass of organic treated by biological treatment type i, Gg
EF = Emission factor for treatment i, g CH_4/N_2O /kg waste treated
I = Composting or anaerobic digestion.

8.5.2 Activity Data

Local Environmental and Public Health Authorities issues operation permits to composting treatment facilities and the EA collects activity data straight from the composting facilities. Data have been received from these composting facilities since 1999. Earlier figures are estimates. The data can be seen in Figure 8.7.

8.5.3 Emission Factors

The emissions from composting depend on factors such as type of waste composted, amount, and type of supporting material used, temperature, moisture, and more. Choice of emission factor for composting in Iceland is in accordance with IPCC Tier 1 method (see Table 8.13) which applies to composting on a wet weight basis.

Table 8.13: Emission factors for CH_4 and N_2O emissions from composting of waste on a wet weight basis.

Gas type	Emission factor
CH_4*	4 g CH_4/kg
N_2O*	0.3 g N_2O/kg

*IPCC default values from the 2006 IPCC Guidelines.

8.5.4 Uncertainties

Since 1999, composting facilities in Iceland have been required to have operation permits and data collected from composting facilities after 2005 are considered quite reliable. Data on the amount of composted waste in Iceland previous to the year 2005 are estimates made by EA specialists. This is due the fact that composting was not supervised prior to 1995 and municipalities were not obliged to do so. This gives some uncertainty to the emissions estimate for previous years. The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from composting is 50% (with an activity data uncertainty of 5% and emission factor uncertainty of 50%) and the uncertainty of N_2O emissions is 50% (with an activity data uncertainty of 5% and emission factor uncertainty of 50%). This can be seen in the quantitative uncertainty table in Annex II.

8.5.5 Planned Improvements

The EA of Iceland will continue to improve the quality of the activity data by revising new data as they are received. There are no plans in improving estimates previous to the year 2005.

9 RECALCULATIONS AND IMPROVEMENTS

9.1 Overall Description of Recalculations

The Icelandic greenhouse gas emission inventory has in 2011 been recalculated to a minor extent (Table 9.1). All recalculations made are calculated for the entire time series 1990-2009. Recalculation for some components and sources have been made, to account for new knowledge and/or more accurate approximation of activity data, emission factors, and to correct for some errors in the calculations. The figures reported in this submission are therefore consistent throughout the whole time series.

Table 9.1: Total recalculations in 2011 submission compared to 2010 submissions (without LULUCF) in Gg CO_2-equivalents.

Year	Submission 2010	Current Submission 2011	Change in %
1990	3,415	3,415	0.003
1995	3,204	3,204	0.000
2000	3,767	3,766	-0.011
2005	3,727	3,727	0.021
2006	4,263	4,264	0.009
2007	4,508	4,507	0.018
2008	4,880	4,880	0.002

9.2 Specific Description of the Recalculation

9.2.1 Energy

No recalculations were in the Energy sector for this submission.

9.2.2 Industry

Mineral Wool (2A7)

Activity data for mineral wool production in 2008 was corrected. This resulted in lower CO_2 emissions that year, from 1.39 to 1.01 Gg.

Consumption of Halocarbons and SF_6 (2F)

Emissions of HFCs were revised as the EA received new data on HFC-134a exported for disposal. Export was underestimated and this correction has led to some changes in total HFC emissions since 1992 (Table 9.2).

Table 9.2: Recalculations results for HFC-134a in Gg CO_2-equivalents.

Year	Submission 2010	Current submission 2011	Change in %
1992	0.1	0.1	-20.4
1995	1.2	1.1	-9.9
2000	5.0	4.5	-9.6
2005	10.1	10.1	0.0
2006	10.8	10.9	1.1
2007	13.9	14.1	1.9
2008	15.4	15.2	-1.5

Emissions of SF_6 were revised as the EA received new data on electricity transmission system insulation for the years 1974, 1977, 1989, 2003-2006, and 2008. This revision leads to an increase in SF_6 emission over the period 1990 to 2008 with the highest increase in the period of 2003 to 2005 as can be seen in Table 9.3.

Table 9.3: Recalculation results for SF_6 emissions in Gg CO_2-equivelents.

Year	Submission 2010	Current submission 2011	Change in %
1990	1.0	1.1	7.6
1995	1.4	1.5	5.8
2000	3.0	3.1	2.7
2005	3.4	4.2	24.8
2006	7.0	7.3	4.0
2007	9.9	10.2	3.0
2008	5.9	6.3	5.3

9.2.3 Solvent and other Product Use

During data and calculating revision, some changes were made within this sector. Import data on degreasing and dry cleaning products (3B) were updated which led to a slight increase in CO_2 and MNVOC emissions for the years 2007 and 2008 (Table 9.4).

Table 9.4: Recalculation results for degreasing and dry cleaning emissions in CO_2-equivalents.

Year	Submission 2010	Current submission 2011	Change in %
2007	12.24	12.47	1.9
2008	8.92	9.25	3.7

9.2.4 Agriculture

No recalculations were in the Energy sector for this submission.

9.2.5 LULUCF

Forest land

As described above the emission/removal estimate for forest land has been revised from previous submissions. The C-stock changes are based on direct stock measurements as in last year's submission but reviewed on basis of additional data. The EF for mineral soils of "other land converted to Forestland- Afforestation 1-50 years old has been revised, reflecting the revised EF for revegetation (see below).The estimate of carbon stock changes in living biomass of natural birch forest added 88.95 Gg CO_2-equivalents to the total removal associated with Forest land in the inventory year 2009. The estimate of changes in soil carbon dead organic matter in Afforestation 1-50 years old has also effects on the reported emission/removal. As result of these recalculations the total reported removal has increased from -122.47 Gg CO_2-equivalents for the year 2008 as reported in 2010 submission to -257.93 Gg CO_2-equivalents in this year's submission or a 111% increase 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.

Grassland

Grassland remaining Grassland is in this submission divided into two categories i.e. Natural birch shrubland and Other grassland. Changes in carbon pool of living biomass of Natural birch shrubland are estimated for the first time in this submission and also estimated for the years 2000-2008.

Emission factor for CO_2 (and for N_2O see chapter 7.18.2.2) on drained organic soil of Wetland converted to Grassland has been revised applying the default EF. There is also a small change in the estimated area of the category and also some changes in Forest land area which affect the backward balancing of the area estimate of the category. Accordingly the estimated emission for that category has been recalculated for that category for the years 1990-2008.

The emission/removal factors for revegetation have been revised. Accordingly emission/removal for both soil carbon and carbon stock in living biomass for the years 1990-2008 has been recalculated for both "Revegetation before 1990" and "Revegetation since 1990". The area of revegetation activities since 1990 has been revised for all the years 1990-2008 and the revised area is included in the recalculations.

Wetland

Both CO_2 and CH_4 emission of reservoirs for the years 1990-2008 have been recalculated according to the revision of emissions factors.

Other emissions

The EF for N_2O from drained organic soil of Grassland is revised in this submission and the emission for the years 1990-2008 revised accordingly.

9.2.6 Waste

Minor changes in the sector are due to recalculation on landfill emission.

Solid Waste Disposal on Land (6A)

Data on solid waste disposal on land were revised for 2006 and 2008 due to new and revised activity data and emissions. This was mainly due to revision of waste classification and industrial waste, where larger part was recycled rather than placed on landfill as reported in previous submission. This led to a minor increase in emissions from landfills (Table 9.5).

Table 9.5: Recalculations of the Waste section in 2011 submission compared to 2010 submissions in Gg CO_2-equivalents**.**

Year	Submission 2010	Submission 2011	Change in %
2008	221	221	0.02

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 native woodland will reach 5 m height at maturity according National Forest Inventory (NFI) data. By widening the definition of forest, natural birch woodland can be included as an ARD activity under the Kyoto Protocol, hence promoting the use of native species in afforestation and prevent deforestation of the natural birch woodlands.

The functional definition of Forest land as it is applied under the KP – LULUCF is: All forested land, not belonging to Settlement, that is presently covered with trees or woody vegetation more than 2 m high, crown cover of a minimum 10% and at least 0.5 ha in continuous area with 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 inventories aimed at deforested areas are 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. 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.

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 years interval. The NIRA started in 2007 and estimation of changes in C-pools on revegetated land based on the data from NIRA will be available before the 2013 submission as first SSPP will be revisited 2012. In the present submission the data already available from 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 7.14 of this report.

The NIRA was designed to detect changes in C-pools and area of revegetation activity since 1990. The estimation of revegetation activity in the base year and of relevant sinks and sources is based on same methods as described in Chapter 7.14 of this report. The maps of revegetation activity before 1990 are far less accurate than the maps of activity since 1990. To secure clear separation of activities before and since 1990 the SCSI is improving these maps 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.

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, 822 sampling points have been selected as potential sampling points. 341 have been discarded after site visits or are still undetermined, (24%), 435 been sampled (53%), and 46 (6%) 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 will start in 2012.

The 1 x 1 km sampling grid is also used to add sampling points from new reclamation areas to the NIRA database, following the same methodology as described above. Quantities of pre-1990 reclamation sites remains to be determined (see information on Article 3.4 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 both cultivated forest and natural birch woodlands. The area of afforestation 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.

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 and 2009. All revegetation activity involving tree planting are categorized from the beginning as Afforestation and reported as Other land converted to Forest land. 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.

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 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 and dead wood is assumed not to occur, as described in chapter 7.12.1.2.

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 - 2008 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

The only carbon pool that is omitted under Article 3.3 in this year's submission is the carbon pool of dead wood. Measurements of dead wood are performed on the field SSPPs in the NNFI and dead wood is defined in similar way as in NFIs in other European countries (Snorrason 2010b). It is only possible to estimate changes in the dead wood pool after all the plots have been revisited in years 2010-2014. It can be stated that dead wood in land Afforested since 1990 was very rare in the first NFI conducted in the year's 2005-2009 which can be explained by young age of the these afforestation sites.

Carbon stock samples of litter are collected on field plots under the field measurement in NFI. As for the dead wood, carbon stock changes in litter will also be available from NFI data when sampling plots have been revisited in the period 2010-2014. In the meantime results from two separate studies 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). They did show significant and considerable increase in the carbon stock of litter for up to 50 years old afforestation areas with different tree species on different sites. Similarly, 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 with larch did show very low increase C-stock 50 years after afforestation although the variation inside this period where considerable (Sigurdsson et al. 2005).

Changes in other carbon pools are currently only partially omitted. Afforestation of natural birch forest on abandoned grazing land is currently omitted for all carbon pools as crucial mapping data for these afforestation sites are still lacking. Mapping of these afforestation sites started in 2010 and is planned to be finished in 2014.

Losses of aboveground biomass of trees because of wood removal after thinning or clear cutting are omitted as wood removal was not detected for afforestation since 1990 in the first NFI. Wood removal was only detected on older afforestation sites and in natural birch forests, where its extraction did not result in deforestation. These sources will be estimated as they are detected when revisiting field plots in future NFIs after commercial thinning with wood removal has started on sites afforested since 1990.

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 34.55 kha (±1.66 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. As mentioned before afforestation of natural birch forest is still missing but will in the future also be estimated in field. They are self-seeded areas in the neighbourhood of older 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 can be 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 7.14.

10.5.3 Information Relating to Forest Management

Forest management is not elected.

10.6 Other Information

10.6.1 Key Category Analysis for Article 3.3 Activities and any Elected Activities under Article 3.4

Of the three categories reported under Article 3.3 and Article 3.4 both Revegetation and Afforestation and Reforestation are larger than mineral production CO_2 emission (30.05 Gg CO_2) the smallest key category of level including LULUCF in the year 2009. Deforestation was detected as not occurring in 2009.

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 Icelandic Greenhouse Gas Registry is maintained by the Environment Agency. A full description of the registry was given in Iceland's Initial Report. Some changes have been made since then. The current status of the registry was presented in NIR 2010.

As Iceland is part of the EU ETS a CITL connection is planned in the near future. In May 2010 the Icelandic registry did go live with the ITL as non-operational registry during the period prior to the connection to the CITL, since CITL cannot recognize transactions made only within the ITL.

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

No public information is available but will be made available as soon as the registry will have operational live connection with the ITL.

11.5 Calculation of the Commitment Period Reserve (CPR)

The Annex to Decision 11/CMP.1 specifies that: 'each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90% 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 × 4,618,163 tonnes CO_2 equivalent
= 23,090,816 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 114.910 Gg in 2008 and 147.234 Gg in 2009 or to 262.144 Gg in total for these two years. Removals from Article 3.4 amounted to 180.401 Gg in 2008 and 189.072 Gg in 2009 or to 369.474 Gg in total for these two years. This would allow issuance of 631,618 RMUs.

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 and 2009. 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 1163 Gg in 2008 and to 1187 Gg in 2009.

12 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes have been made regarding the national system since last submission.

13 INFORMATION ON CHANGES IN NATIONAL REGISTRY

As Iceland is part of the EU ETS a CITL connection is planned in the near future. In May 2010 the Icelandic registry did go live with the ITL as non-operational registry during the period prior to the connection to the CITL, since CITL cannot recognize transactions made only within the ITL.

No changes have been made to the registry since last NIR submission. A full description of the registry was given in Iceland's Initial Report. Some changes have been made since then. The current status of the registry was presented in NIR 2010.

14 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Actions	Implementation
The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities, in pursuit of the objective of the Convention	Planning of economic instruments in Iceland, *inter alia* for limiting emissions in the greenhouse gas emitting sectors is subject to different methodologies. These involve feasibility and efficiency and consideration of national and international circumstances.
Removing subsidies associated with the use of environmentally unsound and unsafe technologies	Subsidies associated with the use of environmentally unsound and unsafe technologies have not been identified in Iceland
Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end	Icelandic research institutes and technological development centres have not been engaged in development of non-energy uses of fossil fuels
Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort	Icelandic researchers cooperate with French and U.S. colleagues on an experimental project (CarbFix) that is under way at the Hellisheiði geothermal plant, injecting CO_2 captured in geothermal steam back into the basaltic rock underground. The aim of the Carbfix Project is to study the feasibility of sequestering the greenhouse-gas carbon dioxide into basaltic bedrock and store it there permanently as a mineral. The project's implications for the fight against global warming may be considerable, since basaltic bedrock susceptive of CO_2 injections are widely found on the planet and CO_2 capture-and-storage and mineralization in basaltic rock is not confined to geothermal emissions or areas

Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil 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

Althing (2007). Lög um losun gróðurhúsalofttegunda nr. 65. Lagasafn. Íslensk lög 15. maí 2009. Útgáfa 136b.

Aradóttir, Á. L., K. Svavarsdóttir, T. H. Jónsson and G. Guðbergsson (2000). *Carbon accumulation in vegetation and soils by reclamation of degraded areas.* Iclandic Agricultural Science 13: 99-113.

Arnalds, O. and E. Gretarsson (2001). Soil Map of Iceland. 2nd edition. Reykjavík, Agricultural Research Institute.

Arnalds, Ó. and H. Óskarsson (2009). *Íslenskt Jarðvegskort*. Náttúrufræðingurinn, 78(3-4): 107-121.

Arnalds, Ó., E.F. Thorarinsdóttir, S. Metúsalemsson, Á. Jónsson, E. Gretarsson and A. Árnason. (2001). *Soil erosion in Iceland*. Reykjavík, Soil Conservation Service, Agricultural Research Institute.

Arnalds, Ó., G. Guðbergsson and J. Guðmundsson (2000). *Carbon sequestration and reclamation of severely degraded soils in Iceland*. Búvísindi 13: 87-97.

Arnalds, Ó., Hlynur Óskarsson, Fanney Ósk Gísladóttir and E. Grétarsson (2009). *Íslenskt Jarðvegskort Landbúnaðarháskóli Íslands*.

Auðunsson, G.A (2002). *Hegðun og samsetning fráveituvatns í Skolpu 2000-2001.* Icelandic Fisheries Laboratories Report Summary 27/03/2002.

Ármannsson, H., Friðriksson, Þ., Kristjánsson, B. (2005). *CO_2 emissions from geothermal power plants and natural geothermal activity in Iceland*. Geothermics.

Bjarnadóttir, B. (2009). *Carbon stocks and fluxes in a young Siberian larch (Larix sibirica) plantation in Iceland*. Department of Physical Geography and Ecosystem Analysis. Lund, Lund University. Ph.D: 171.

Bossard, M., Feranec, J., and Otahel, J.(2000). *CORINE land cover technical guide – Addendum 2000*, European Environment Agency, CopenhagenNo 40, 10.

Bændasamtök-Íslands (2010). *Hagtölur landbúaðarins*, Bændasamtök Íslands.

Damgaard Poulsen H. (2009). *Normtal for husdyrgödning*. http://www.agrsci.dk/var/agrsci/storage/original/application/6ad0435ef70c7cb3b7c30f15b406c0e3

EA (2002). *Starfsreglur um góða búskaparhætti (Codes of good agricultural practice)*. Starfshópur um meðferð úrgangs frá landbúnaði: 17. http://www.ust.is/media/fraedsluefni/buskaparhaettir.pdf

EA (2003). *Landfill Gas Formation in Iceland. A study on Landill Gas Formation in landfills in Iceland, in relation to the implementation of the Landfill Directive into the national act*. http://www.ust.is/media/fraedsluefni/LFG_formation_in_Iceland_final_2003.pdf

EA (2004). *Landsáætlun um meðhöndlun úrgangs 2004 - 2016 (National waste treatment plan 2004 - 2016)*. Environment Agency of Iceland: 46.

EA (2004). *Report to the EFTA Surveillance Authority regarding the implementation of Directive 92/271/EU on the treatment of wastewater from built-up areas.* Environmental and Food Agency of Iceland.

EA (2007). *Quality Assurance and Quality Control Plan for the Icelandic Greenhouse Gas Inventory*. http://www.ust.is/media/fraedsluefni/pdf-skjol//Iceland_QAQC_plan.pdf

EA (2007). *Iceland's Initial Report under the Kyoto Protocol.* http://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/msword/initial_report_-_iceland.doc

Energy in Iceland, 2004. *Historic Perspective, Present Status, Future Outlook (2004)*. National Energy Authority and Ministries of Industry and Commerce.

Friðriksson et al (2005). *CO_2 emissions and heat flow through soil, fumaroles, and steam heated mud pools at the Reykjanes geothermal area, SW Iceland*. In preparation for Applied Geochemistry.

Gísladóttir, F. Ó., Metúsalemsson, S., and Óskarsson, H. (2007). *Áhrifasvæði skurða: Greining með fjarkönnunaraðferðum*. Fræðaþing landbúnaðarins, Reykjavík, 371-376,

Gísladóttir, F. Ó., J. Guðmundsson and S. Áskelsdóttir (2009). Íslenskt skurðakort og greining á þéttleika skurða. Fræðaþing Landbúnaðarins.

Gísladóttir, F., J. Gudmundsson and S. Áskelsdóttir (2010). *Mapping and density analyses of drainage ditches in Iceland. Mapping and monitoring of Nordic Vegetation and landscapes*. Hveragerði, Norsk Insitute for Skog og landskap.

Grétarsdóttir, J. and J. Guðmundsson (2007). *Skammtímaáhrif sinubruna á Mýrum 2006 á gróðurfar og uppskeru*. Fræðaþing landbúnaðarins, Reykjavík.

Guðmundsson, J. (2009). *Vísinda og tæknileg lokaskýrsla:Verkefni: Losun hláturgass og annarra gróðurhúsalofttegunda úr lífrænum jarðvegi við mismunandi landnotkun*. Lbhi: 11

Guðmundsson, J. and H. Óskarsson (in prep). *Carbon dioxide emission from drained organic soils in West-Iceland*.

Guðmundsson, J., F. Gísladóttir, S. H. Brink and H. Óskarsson (2010). *The Icelandic Geographic Land Use Database (IGLUD). Mapping and monitoring of Nordic Vegetation and landscapes*. Hveragerði, Norsk Insitute for Skog og landskap.

Guðmundsson, J., F. Ó. Gísladóttir and S. H. Brink (in prep). *Description of methods and definitions of land use classes used in the Icelandic Land Use Database*.

Gunnarsson, E. (2009). *Skógræktarárið 2008.* Skógræktarárið 2008 2009(2): 90-95.

Gunnarsson, E. (2010). *Skógræktarárið 2009.* Skógræktarritið 2010(2): 90-95.

Halldórsson, G., Agustdottir, AM., Bau, A., Thorarenssen J., Thorsson, J. & Svavarsdóttir K (2009) (in prep.). *A national inventory of carbon stocks in revegatation areas in Iceland.*

Hanne Damgaard Poulsen (2009). *Normtal for husdyrgødning – 2009*, 35 sider. http://www.agrsci.dk/ny_navigation/institutter/institut_for_husdyrbiologi_og_sundhed/husdyrernaering_og_miljoe/normtal.

Hermannsson, J. (1993). *Kornrækt á Íslandi. Ráðunautafundur 1993*, Reykjavík, RALA.

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php. Revised National Inventory Report 2007, Norway.

http://unfccc.int/resource/docs/2008/irr/isl.pdf. Report *of the Review of the Initial Report of Iceland.*

Icelandic Association of Farmers, Agricultural Genetic Resources Committee, and Nordic Gene Bank for Domestic Animals (2004). *Icelandic Livestock Breeds*. ISBN 9979-885-02

Icelandic Nutrition Council (2002). *The Diet of Icelanders*. Dietary Survey of the Icelandic Nutrition Council 2002. Main findings.

Inga Þórsdóttir, Ingibjörg Gunnarsdóttir (2006). *The Diet of Icelandic 9- and 15-year-old children and adolescents*. Dietary Survey of Unit for Nutrition Research 2002-2003.

International Aluminium Institute (2010). *Results of the 2009 anode effect survey.* Report on the Aluminium Industry's Global Perfluorocarbon Gasses Emission Reduction Programme, 1-47.

IPCC (1997). *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 1 – 3*. Intergovernmental Panel on Climate Change.

IPCC (2000). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Intergovernmental Panel on Climate Change.

IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*,. B. L. Prepared by the National Greenhouse Gas Inventories Programme. Eggleston H.S., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IPCC, Ed. (2003). *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, IGES.

Jóhannesson, B. (1988). *Íslenskur jarðvegur*. Reykjavík, Rannsóknastofnun landbúnaðarins.

Jónsson, J. (1968). *Ræktun landsins. Bættir eru bænda hættir: landbúnaðurinn, saga hans og þróun*. Bókaútgáfan Þorri: 30-50.

Kamsma & Meyles (2003). *Landfill Gas Formation in Iceland*. Environmental and Food Agency of Iceland: 37

Landmælingar_Íslands (1943). Herforingjaráðskort.

Landsvirkjun, *Landsvirkjun´s history*. WWW.lv./ENcategory.asp?catID=465

Magnússon, B. ó., B. H. Barkarson, B. E. Guðleifsson, B. P. Maronsson, S. Heiðmarsson, G. A. Guðmundsson, S. H. Magnússon and S. r. Jónsdóttir (2006). *Vöktun á ástandi og líffræðilegri fjölbreytni úthaga 2005*. Fræðaþing Landbúnaðarins, Reykjavík.

Ministry for the Environment (2007), *Climate Change Strategy.* http://eng.umhverfisraduneyti.is/media/PDF_skrar/Stefnumorkun_i_loftslagsmalum_en.pdf

Ministry for the Environment, I. (2007). *Vernd og endurheimt íslenskra birkiskóga, Skýrsla og tillögur nefndar (Icelandic)*. Protection and restoration of Icelandic birch forests, Ministry for the Environment, Iceland.

Ministry for the Environment. 2010. *Aðgerðaáætlun í loftslagsmálum (Climate Change Action Plan)*. Ministry for the Environment, Reykjavík, 40 pp.

National Energy Forecast Committee (2009). *Eldsneytisnotkun Íslendinga eftir notkunarflokkum, innlend notkun. Fuel use in Iceland per type, domestic use*. (Available on the committee's website: http://orkuspa.is/eldsneyti/Innlend.PDF)

Norwgian Pollution Control Authority (2007). *Revised National Inventory Report 2007*.

Norwgian Pollution Control Authority (2009). *National Inventory Report 2009*.

Óskarsson, H. and J. Guðmundsson (in prep). *Magn kolefnis i lónstæðum Hraunaveitu og áætluð losun gróðurhúsalofttegunda úr þeim*. Landsvirkjun.

Óskarsson, H. and J. Guðmundsson (2001). *Mat á gróðurhúsaáhrifum fyrirhugaðs Hálslóns*. Reykjavík. Rala, Landsvirkjun: 31.

Óskarsson, H. and J. Guðmundsson (2008). *Gróðurhúsaáhrif uppistöðulóna; Rannsóknir við Gilsárlón 2003-2006*. Landsvirkjun: 142.

Óskarsson, H., O. Arnalds, J. Gudmundsson and G. Gudbergsson (2004). *Organic carbon in Icelandic Andosols: geographical variation and impact of erosion.* CATENA 56(1-3): 225-238.

Óskarsson, M. and Eggertsson, M. (1991). *Áburðafræði (Fertilisers)*. Búnaðarfélag Íslands: 135

Reykjavíkurborg (2008). *Áætluð losun gróðurhúsalofttegunda frá bílaumferð í Reykjavík*. Samantekt fyrir árin 1999-2007 með samanburði við 1990.

Road Traffic directorate (2009). http//www.us.is

SFT, SN (2004). *National Inventory Report 2004 – Norway*. Norwegian Pollution Control Authority & Statistics Norway: 176.

Sigurdsson, B. D., B. Magnusson, A. Elmarsdottir and B. Bjarnadottir (2005). *Biomass and composition of understory vegetation and the forest floor carbon stock across Siberian larch and mountain birch chronosequences in Iceland.* Annals of Forest Science 62(8): 881-888.

Sigurðsson, B. D. and A. Snorrason (2000). *Carbon sequestration by afforestation and revegetation as a means of limiting net-CO_2 emissions in Iceland*. Biotechnol. Agron. Soc. Environ. 4(4): 303-307.

Sigurðsson, B. D., Á. Elmarsdóttir, B. Bjarnadóttir and B. ó. Magnússson (2008). *Mælingar á kolefnisbindingu mismunandi skógargerða*. Fræðaþing landbúnaðarins.

Skógrækt ríkisins, S. (2008). *Skógrækt í skipulagsáætlunum sveitarfélaga*.

Snorrason, A. (2010a). *Global Forest Resources Assessment 2010, Country Report, Iceland*, Food and Agriculture Organization of the United Nations. Forestry Department, p. 67.

Snorrason, A. (2010a). *Iceland. National Forest Inventories - Pathways for Common Reporting*. E. Tomppo, T. Gschwantner, M. Lawrence and R. E. McRoberts, Springer: 612.

Snorrason, A. (in prep). *Methodology of carbon accounting and other data analysis and aggregations concerning forest and woodland in Iceland for the reporting year of 2007 and 2008* Rit Mógilsár Rannsóknastöðvar skógræktar. Nr. 23/2010.

Snorrason, A. and B. Kjartansson. (2004). *Íslensk skógarúttekt. Verkefni um landssúttekt á skóglendum á Íslandi. Kynning og fyrstu niðurstöður. (Islandic National Inventory. Project on inventory of forests in Iceland. Presentation and First Results).* Skógræktarritið(2): 101-108 (In Icelandic).

Snorrason, A. and B. T. Kjartansson (2004). *Towards a general woodland and forsestry inventory for Iceland*: 6.

Snorrason, A. and S. F. Einarsson (2006). *Single-tree biomass and stem volume functions for eleven tree species used in Icelandic forestry.* Icelandic Agricultural Science 19: 15-25.

Snorrason, A., B. D. Sigurðsson, G. Guðbergsson, K.Svavarsdóttir and Þ.J.Jónsson (2003). *Carbon sequestration in forest plantations in Iceland.* Búvísindi (Icel. Agr. Sci.) 15(02): 81-93.

Snorrason, A., o. H. Jónsson, K. Svavarsdóttir and G. Guðbergsson (2000). *Rannsóknir á kolefnisbindingu ræktaðra skóga á Íslandi.* Skógræktarritið(1): 71-89.

Statistical Yearbook of Iceland, 2007 (Statistics Iceland).

Sveinsson, Th. (1998). *Næringarefnabókhald fyrir kúabú*. Ráðunautafundur: 124-140 (in Icelandic).

The Environment Agency of Iceland (2007). *Grænt bókhald,* http://ust.is/Adofinni/starfsleyfi/graentbokhald/

Thorsson, J., G. Halldórsson, A. M. Ágústsdóttir and A. Bau (in prep). *Monitoring carbon seqestration in reclaimed lands.*

Traustason, B. and A. Snorrason (2008). *Stærð Skóglendis á Íslandi byggt á CORINE flokkun*. Fræðaþing Landbúnaðarins 2008, Reykjavík.

U.S. Department of Energy and the U.S. Environmental Protection Agency (2000). *Carbon Dioxide Emissions from the Generation of Electric Power in the United States.* http://tonto.eia.doe.gov/ftproot/environment/co2emiss00.pdf

UNFCCC (2010). *Report of the individual review of the annual submission of Iceland. Submitted in 2009*. FCCC/ARR/2009/ISL, UNFCCC.

UNFCCC secretariat (2009). *Report of the individual review of the greenhouse gas inventory of Iceland.* Submitted in the year 2009 *(in-country review).*

UNFCCC secretariat. *Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories* (available on the secretariat web site http://unfccc.int/resource/docs/cop5/07.pdf)

UNFCCC/WEB/IRI/2004/ISL (available on the secretariat web site http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600005115#beg

United Nations (2002), *Report of the Conference of the Parties on its Seventh Session, Held at Marrakesh From 29 October to 10 November 2001*. Addendum. Part two: Action Taken by the Conference of the Parties. Volume I: 68.

Þóroddur Sveinsson (1998). *Næringarefnabókhald fyrir kúabú* Ráðunautafundur. 124-140 (In Icelandic).

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 1 lists identified key sources. Table A1 shows the level assessment of the key source analysis for 2009, Table A2 the level assessment of the key source analysis for 1990 and Table A3 the trend assessment of the key source analysis.

Table A1: Key source analysis – level assessment 2009.

			Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assessment without LULUCF	Cumulative Total of Column H	Level Assessment with LULUCF	Cumulative Total of Column j
			E	F	G	H	I	J	K
			4610,76	681,11	6724,57	1		1	
2.C.3	Aluminium	CO_2	1212,12		1212,12	0,2629	0,263	0,180	0,180
5.B.2.3	Wetlands converted to Cropland	CO_2		991,33	991,33	0,0000	0,263	0,147	0,328
1.AA.3b	Road transport	CO_2	852,19		852,19	0,1848	0,448	0,127	0,454
1.AA.4c	Fishing	CO_2	597,22		597,22	0,1295	0,577	0,089	0,543
5.C.2.5	Other land converted to grassland, revegetation	CO_2		-439,38	439,38	0,0000	0,577	0,065	0,609
2.C.2	Ferroalloys	CO_2	340,87		340,87	0,0739	0,651	0,051	0,659
5.C.2.3	Wetlands converted to grassland	CO_2		307,40	307,40	0,0000	0,651	0,046	0,705
1.AA.2	Manufacturing industry and construction	CO_2	244,88		244,88	0,0531	0,704	0,036	0,741
6.A	Solid waste disposal on land	CH_4	184,58		184,58	0,0400	0,744	0,027	0,769
1.B.2	Geothermal energy	CO_2	175,02		175,02	0,0380	0,782	0,026	0,795
5.A	Forest land-Afforestation	CO_2		-169,95	169,95	0,0000	0,782	0,025	0,820
2.C.3	Aluminium	PFC	152,75		152,75	0,0331	0,815	0,023	0,843
4.A.3	Enteric fermentation, sheep	CH_4	130,56		130,56	0,0283	0,844	0,019	0,862
4.D.1	Direct soil emissions	N_2O	115,48		115,48	0,0250	0,869	0,017	0,879
4.D.3	Indirect soil emissions	N_2O	95,19		95,19	0,0206	0,889	0,014	0,876
5.A	Forest land-Natural birch forest	CO_2		-88,95	88,95	0,0000	0,889	0,013	0,890
2.F	Consumption of halocarbons and SF6	HFC	85,82		85,82	0,0186	0,908	0,013	0,902
5.G.5(II)	Wetlands converted to Grassland	N_2O		71,88	71,88	0,0000	0,908	0,011	0,913
4.A.1	Enteric fermentation, cattle	CH_4	70,38		70,38	0,0153	0,923	0,010	0,924
1.AA.3a/d	Transport	CO_2	53,13		53,13	0,0115	0,935	0,008	0,931
4.D.2	Animal production	N_2O	46,16		46,16	0,0100	0,945	0,007	0,938

Table continues									
1.AA.3b	Road transport	N_2O	39,20		39,20	0,0085	0,953	0,006	0,944
4.A.4-10	Enteric fermentation, rest	CH_4	31,84		31,84	0,0069	0,960	0,005	0,949
2.A	Mineral production	CO_2	30,05		30,05	0,0065	0,967	0,004	0,953

Table A2: Key source analysis – level assessment 1990.

			Base Year Estimate Non-LULUCF	Base Year Estimate LULUCF	Base Year Estimate Absolute Value	Level Assessment without LULUCF	Cumulative Total of Column H	Level Assessment with LULUCF	Cumulative Total of Column j
			E	F	G	H	I	J	K
			3350,32	1104,73	5003,46	1		1	
5.B.2.3	Wetlands converted to Cropland	CO_2		991,33	991,33	0	0,000	0,198	0,198
1.AA.4c	Fishing	CO_2	655,49		655,49	0,196	0,196	0,131	0,329
1.AA.3b	Road transport	CO_2	521,26		521,26	0,156	0,351	0,104	0,433
2.C.3	Aluminium	PFC	419,63		419,63	0,125	0,476	0,084	0,517
1.AA.2	Manufacturing industry and construction	CO_2	360,79		360,79	0,108	0,584	0,072	0,589
5.C.2.3	Wetlands converted to Grassland	CO_2		309,57	309,57	0,000	0,584	0,062	0,651
5.C.2.5	Other land converted to grassland, revegetation	CO_2		-250,31	250,31	0,000	0,584	0,050	0,701
2.C.2	Ferroalloys	CO_2	204,13		204,13	0,061	0,645	0,041	0,742
4.A.3	Enteric fermentation, sheep	CH_4	158,73		158,73	0,047	0,692	0,032	0,774
2.C.3	Aluminium	CO_2	136,49		136,49	0,041	0,733	0,027	0,801
6.A	Solid waste disposal on land	CH_4	133,86		133,86	0,040	0,773	0,027	0,828
4.D.1	Direct soil emissions	N_2O	118,08		118,08	0,035	0,808	0,024	0,851
1.AA.3a/d	Transport	CO_2	91,11		91,11	0,027	0,836	0,018	0,870
4.A.1	Enteric fermentation, cattle	CH_4	76,51		76,51	0,023	0,858	0,015	0,885
5.G.5(II)	Wetlands converted to Grassland	N_2O		72,39	72,39	0,000	0,858	0,014	0,899
1.B.2	Geothermal energy	CO_2	66,63		66,63	0,020	0,878	0,013	0,913
2.A	Mineral production	CO_2	52,28		52,28	0,016	0,894	0,010	0,923
2.B	Chemical industry	N_2O	48,36		48,36	0,014	0,908	0,010	0,933
4.D.2	Animal production	N_2O	43,24		43,24	0,013	0,921	0,009	0,941
4.D.3	Indirect soil emissions	N_2O	43,24		43,24	0,013	0,934	0,009	0,950
4.B	Manure management	N_2O	31,74		31,74	0,009	0,944	0,006	0,956
1.AA.4a/b	Residential/institutional/commercial	CO_2	30,87		30,87	0,009	0,953	0,006	0,963

Table A3: Key source analysis – trend assessment.

			Base Year Estimate	Current Year Estimate	Absolute Estimate	Level Assessment	Trend Assessment	Contribution to Trend	Cumulative Total
			4450,506	5291,866	6724,575		0,403	1,000	
2.C.3	Aluminium	CO_2	136,486	1212,117	1212,117	0,180	0,131	0,325	0,325
2.C.3	Aluminium	PFC	419,631	152,745	152,745	0,023	0,043	0,107	0,433
1.AA.3b	Road transport	CO_2	521,263	852,186	852,186	0,127	0,029	0,072	0,505
5.B.2.3	Wetlands converted to Cropland	CO_2	991,330	991,327	991,327	0,147	0,023	0,058	0,563
1.AA.2	Manufacturing industry and construction	CO_2	360,792	244,877	244,877	0,036	0,023	0,057	0,620
1.AA.4c	Fishing	CO_2	655,490	597,218	597,218	0,089	0,023	0,056	0,677
5.C.2.5	Other land converted to grassland, revegetation	CO_2	-250,310	-439,383	439,383	0,065	0,018	0,044	0,720
5.A	Forest land-Afforestation	CO_2	-23,895	-169,952	169,952	0,025	0,018	0,044	0,764
2.C.2	Ferroalloys	CO_2	204,132	340,866	340,866	0,051	0,012	0,030	0,795
1.B.2	Geothermal energy	CO_2	66,631	175,018	175,018	0,026	0,012	0,030	0,824
2.F	Consumption of halocarbons and SF_6	HFC	0,000	85,816	85,816	0,013	0,011	0,027	0,851
5.C.2.3	Wetlands converted to grassland	CO_2	309,570	307,402	307,402	0,046	0,008	0,019	0,870
4.A.3	Enteric fermentation, sheep	CH_4	158,728	130,561	130,561	0,019	0,007	0,018	0,888
1.AA.3a/d	Transport	CO_2	91,108	53,126	53,126	0,008	0,007	0,017	0,905
4.D.3	Indirect soil emissions	N_2O	43,237	95,186	95,186	0,014	0,005	0,014	0,919
1.AA.3b	Road transport	N_2O	0,000	39,199	39,199	0,006	0,005	0,012	0,931
2.A	Mineral production	CO_2	52,282	30,047	30,047	0,004	0,004	0,010	0,941
6.C	Incineration	CO_2	25,526	0,872	0,872	0,000	0,004	0,009	0,950

ANNEX II QUANTITATIVE UNCERTAINTY

TIER 1 UNCERTAINTY CALCULATION AND REPORTING OF SOURCES IN ICELAND 2009												
Input Data					Uncertainty of Emissions			Uncertainty of Trend				
IPCC Source Category	Gas	Base year emissions (1990)	Year t emissions (2009)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combine uncertainty as % of total national emissions in year 2009	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF unc.	Uncertainty in trend in national emissions introduced by a.d.	Uncertainty introduced into the trend in total national emissions
		Gg CO_2 equivalents		%	%	%	%	%	%	%	%	%
1.AA.1 Public electricity and heat production	CO_2	13,33	14,56	1,0	5,0	5,10	0,02	-0,001	0,004	-0,01	0,01	0,01
1.AA.2 Manufacturing industry and construction	CO_2	360,79	244,88	2,0	5,0	5,39	0,29	-0,071	0,072	-0,36	0,20	0,41
1.A.3.a Transport	CO_2	91,11	53,13	5,0	5,0	7,07	0,08	-0,021	0,016	-0,10	0,11	0,15
1.A.3.b Transport - Road Transportation	CO_2	521,26	852,19	5,0	5,0	7,07	1,30	0,043	0,250	0,22	1,76	1,78
1.AA.4a/b Residential/institutional/ commercial	CO_2	30,87	23,88	3,0	5,0	5,83	0,03	-0,005	0,007	-0,03	0,03	0,04
1.AA.4c Mobile Combustion - Fishing	CO_2	655,49	597,22	2,0	5,0	5,39	0,70	-0,085	0,175	-0,42	0,49	0,65
1.B.2 Geothermal energy	CO_2	66,63	175,02	10,0	1,0	10,05	0,38	0,025	0,051	0,02	0,72	0,73
2.A Mineral Production (Cement Production)	CO_2	52,28	30,05	5,0	6,5	8,20	0,05	-0,012	0,009	-0,08	0,06	0,10
2.C.2 Ferroalloys Production	CO_2	204,74	341,78	5,0	10,0	11,18	0,83	0,019	0,100	0,19	0,71	0,73
2.C.3 Aluminium Production	CO_2	136,49	1.212,12	1,0	10,0	10,05	2,64	0,301	0,355	3,01	0,50	3,05
3 Solvent and other Product Use	CO_2	7,94	4,98	5,0	50,0	50,25	0,05	-0,002	0,001	-0,08	0,01	0,08

UNCERTAINTY TABLE CONTINUES												
Input Data					Uncertainty of Emissions			Uncertainty of Trend				
IPCC Source Category	Gas	Base year emissions (1990)	Year t emissions (2009)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combine uncertainty as % of total national emissions in year 2009	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF unc.	Uncertainty in trend in national emissions introduced by a.d.	Uncertainty introduced into the trend in total national emissions
5.A Forest Land - Natural Birch Forest	CO_2		-88,95	14,0	10,0	17,20	-0,33	-0,026	-0,026	-0,26	-0,52	0,58
5.A Forest Land-Afforestation	CO_2	-23,90	-169,95	5,0	10,0	11,18	-0,41	-0,040	-0,050	-0,40	-0,35	0,54
5.C.2.5 Other land converted to grassland, revegetation	CO_2	-250,31	-439,38	10,0	10,0	14,14	-1,35	-0,030	-0,129	-0,30	-1,82	1,84
6.C Incineration	CO_2	25,53	0,03	5,0	40,0	40,31	0,00	-0,010	0,000	-0,40	0,00	0,40
1.AA.1 Public electricity and heat production	CH_4	0,01	0,05	1,0	100,0	100,00	0,00	0,000	0,000	0,00	0,00	0,00
1.AA.2 Manufacturing industry and construction	CH_4	0,25	0,20	2,0	100,0	100,02	0,00	0,000	0,000	0,00	0,00	0,00
1.A.3.a Transport	CH_4	0,12	0,07	5,0	200,0	200,06	0,00	0,000	0,000	-0,01	0,00	0,01
1.A.3.b Transport - Road Transportation	CH_4	2,96	1,58	5,0	40,0	40,31	0,01	-0,001	0,000	-0,03	0,00	0,03
1.AA.4a/b Residential/institutional/commercial	CH_4	0,01	0,01	3,0	100,0	100,04	0,00	0,000	0,000	0,00	0,00	0,00
1.AA.4c Mobile Combustion - Fishing	CH_4	1,31	1,19	2,0	100,0	100,02	0,03	0,000	0,000	-0,02	0,00	0,02
4.A Enteric Fermentation, cattle	CH_4	76,51	70,38	20,0	20,0	28,28	0,43	-0,010	0,021	-0,19	0,58	0,61
4.A Enteric Fermentation, sheep	CH_4	158,73	130,56	20,0	20,0	28,28	0,80	-0,025	0,038	-0,49	1,08	1,19
4.A Enteric Fermentation, other	CH_4	29,75	31,84	20,0	20,0	28,28	0,20	-0,002	0,009	-0,05	0,26	0,27
4.B Manure Management	CH_4	22,28	21,01	20,0	30,0	36,06	0,16	-0,003	0,006	-0,08	0,17	0,19
6.A Solid Waste Disposal on Land	CH_4	133,86	184,58	10,0	50,0	50,99	2,04	0,001	0,054	0,05	0,76	0,77
6.B Wastewater	CH_4	13,53	16,12	50,0	30,0	58,31	0,20	-0,001	0,005	-0,02	0,33	0,33
6.D Other, composting	CH_4		1,07	5,0	50,0	50,25	0,01	0,000	0,000	0,02	0,00	0,02
1.AA.1 Public electricity and heat production	N_2O	0,02	0,20	1,0	150,0	150,00	0,01	0,000	0,000	0,01	0,00	0,01

Table Continues												
1.AA.2 Manufacturing industry and construction	N_2O	15,91	16,68	2,0	150,0	150,01	0,54	-0,001	0,005	-0,21	0,01	0,21
1.A.3.b Transport - Road Transportation	N_2O	4,54	39,20	5,0	50,0	50,25	0,43	0,010	0,011	0,48	0,08	0,49
1.AA.4a/b Residential/institutional/commercial	N_2O	0,08	0,05	3,0	150,0	150,03	0,00	0,000	0,000	0,00	0,00	0,00
1.AA.4c Mobile Combustion - Fishing	N_2O	5,51	5,00	2,0	150,0	150,01	0,16	-0,001	0,001	-0,11	0,00	0,11
3 Solvent and other Product Use	N_2O	6,00	0,90	5,0	50,0	50,25	0,01	-0,002	0,000	-0,11	0,00	0,11
4.B Manure Management	N_2O	31,74	28,63	20,0	50,0	53,85	0,33	-0,004	0,008	-0,21	0,24	0,32
4.D.1 Direct soil emissions	N_2O	118,08	115,48	20,0	50,0	53,85	1,35	-0,013	0,034	-0,65	0,96	1,15
4.D.2 Animal Production	N_2O	43,24	46,16	20,0	50,0	53,85	0,54	-0,004	0,014	-0,18	0,38	0,42
4.D.3 Indirect emissions from Nitrogen used in agriculture	N_2O	94,92	95,19	20,0	50,0	53,85	1,11	-0,010	0,028	-0,49	0,79	0,93
5.A Forest Land	N_2O		0,97	5,0	10,0	11,18	0,00	0,000	0,000	0,00	0,00	0,00
6.B Wastewater	N_2O	6,65	8,26	50,0	30,0	58,31	0,10	0,000	0,002	-0,01	0,17	0,17
6.C Incineration	N_2O	1,17	0,16	5,0	100,0	100,12	0,00	0,000	0,000	-0,04	0,00	0,04
6.D Other, composting	N_2O		1,19	5,0	50,0	50,25	0,01	0,000	0,000	0,02	0,00	0,02
2.C.3 Aluminium Production												
CF4	PFC	355,02	98,26	5,0	7,0	8,60	0,18	-0,112	0,029	-0,78	0,20	0,81
C2F6	PFC	64,61	23,52	5,0	22,0	22,56	0,11	-0,019	0,007	-0,41	0,05	0,41
2.F Substitutes for Ozone Depleting Substances	HFC	0,00	85,82		100,0	100,00	1,86	0,025	0,025	2,51	0,00	2,51
2.F.6 SF6	SF6	1,13	5,94		100,0	100,00	0,13	0,001	0,002	0,13	0,00	0,13
Other Non-Key Source Emissions	All	334,84	736,38	10,0	30,0	31,62	5,04	0,083	0,216	2,49	3,05	3,94
	Total emissions (all sources):	**3.415,02**	**4.618,16**			**Total H :**	**7,1**	**Level Uncertainty**		**Total M :**	**6,8**	

ANNEX III CRF SUMMARY 2 FOR 1990 TO 2009

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS Inventory 1990
(Sheet 1 of 1) Submission 2011 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)	**3.200,71**	**446,70**	**451,59**	**IE,NA,NE,NO**	**419,63**	**1,13**	**4.519,76**
1. Energy	**1.751,76**	**4,67**	**26,86**				**1.783,29**
A. Fuel Combustion (Sectoral Approach)	1.685,13	4,67	26,86				1.716,66
1. Energy Industries	13,33	0,01	0,02				13,36
2. Manufacturing Industries and Construction	360,79	0,25	15,91				376,96
3. Transport	612,37	3,08	5,32				620,77
4. Other Sectors	698,64	1,33	5,61				705,57
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66,63	NA,NE,NO	NA,NO				66,63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66,63	NE,NO	NA,NO				66,63
2. Industrial Processes	**393,26**	**0,61**	**48,36**	**IE,NA,NE,NO**	**419,63**	**1,13**	**862,99**
A. Mineral Products	52,28	NE,NO	NE,NO				52,28
B. Chemical Industry	0,36	NE,NO	48,36	NA	NA	NA	48,72
C. Metal Production	340,62	0,61	NA	NA,NE,NO	419,63	NA,NO	760,86
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				IE,NA,NE,NO	NA,NE,NO	1,13	1,13
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**7,94**		**6,00**				**13,94**
4. Agriculture		**287,27**	**287,97**				**575,24**
A. Enteric Fermentation		264,98					264,98
B. Manure Management		22,28	31,74				54,02
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE	256,23				256,23
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry (1)	**1.028,55**	**1,60**	**74,58**				**1.104,73**
A. Forest Land	-23,90	NE,NO	0,16				-23,73
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	59,26	NE,NO	NE,NO				59,26
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	74,42				74,42
6. Waste	**19,19**	**152,56**	**7,82**				**179,57**
A. Solid Waste Disposal on Land	NA,NE,NO	133,86					133,86
B. Waste-water Handling		13,53	6,65				20,18
C. Waste Incineration	19,19	5,16	1,17				25,53
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	318,65	0,23	2,76				321,64
Aviation	219,65	0,03	1,92				221,61
Marine	99,00	0,20	0,84				100,03
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.415,02
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.519,76

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2011 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)	**3.123,69**	**445,41**	**443,55**	**IE,NA,NE,NO**	**348,34**	**3,28**	**4.364,26**
1. Energy	**1.707,17**	**4,80**	**26,31**				**1.738,28**
A. Fuel Combustion (Sectoral Approach)	1.640,53	4,80	26,31				1.671,65
1. Energy Industries	14,91	0,01	0,02				14,94
2. Manufacturing Industries and Construction	285,34	0,21	15,07				300,62
3. Transport	624,15	3,22	5,47				632,83
4. Other Sectors	716,14	1,36	5,75				723,25
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66,63	NA,NE,NO	NA,NO				66,63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66,63	NE,NO	NA,NO				66,63
2. Industrial Processes	**359,70**	**0,51**	**46,81**	**IE,NA,NE,NO**	**348,34**	**3,28**	**758,64**
A. Mineral Products	48,65	NE,NO	NE,NO				48,65
B. Chemical Industry	0,31	NE,NO	46,81	NA	NA	NA	47,12
C. Metal Production	310,74	0,51	NA	NA,NE,NO	348,34	NA,NO	659,59
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				IE,NA,NE,NO	NA,NE,NO	3,28	3,28
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**11,29**		**4,87**				**16,16**
4. Agriculture		**277,63**	**282,64**				**560,27**
A. Enteric Fermentation		255,61					255,61
B. Manure Management		22,02	30,72				52,73
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	251,92				251,92
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1.026,49**	**6,31**	**75,01**				**1.107,82**
A. Forest Land	-25,59	NE,NO	0,22				-25,37
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	53,39	NE,NO	NE,NO				53,39
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	74,79				74,79
6. Waste	**19,04**	**156,16**	**7,91**				**183,11**
A. Solid Waste Disposal on Land	NA,NE,NO	137,83					137,83
B. Waste-water Handling		13,20	6,75				19,95
C. Waste Incineration	19,04	5,12	1,16				25,33
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	259,64	0,11	2,26				262,01
Aviation	221,99	0,03	1,94				223,96
Marine	37,65	0,08	0,32				38,05
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.256,45
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.364,26

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2011 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]	**3.237,86**	**445,20**	**425,18**	**0,05**	**155,28**	**1,41**	**4.264,99**
1. Energy	**1.832,74**	**5,03**	**26,03**				**1.863,80**
A. Fuel Combustion (Sectoral Approach)	1.766,11	5,03	26,03				1.797,17
1. Energy Industries	13,92	0,01	0,02				13,95
2. Manufacturing Industries and Construction	339,15	0,24	14,15				353,54
3. Transport	634,57	3,30	5,57				643,44
4. Other Sectors	778,46	1,49	6,29				786,24
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66,63	NA,NE,NO	NA,NO				66,63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66,63	NE,NO	NA,NO				66,63
2. Industrial Processes	**362,69**	**0,53**	**41,85**	**0,05**	**155,28**	**1,41**	**561,81**
A. Mineral Products	45,69	NE,NO	NE,NO				45,69
B. Chemical Industry	0,25	NE,NO	41,85	NA	NA	NA	42,10
C. Metal Production	316,74	0,53	NA	NA,NE,NO	155,28	NA,NO	472,55
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				0,05	NA,NE,NO	1,41	1,46
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**9,94**		**4,77**				**14,71**
4. Agriculture		**272,08**	**269,76**				**541,84**
A. Enteric Fermentation		250,17					250,17
B. Manure Management		21,90	29,78				51,68
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [3]		NA,NE	239,98				239,98
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [1]	**1.013,97**	**6,31**	**74,82**				**1.095,10**
A. Forest Land	-30,30	NE,NO	0,30				-30,00
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	45,58	NE,NO	NE,NO				45,58
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	74,51				74,51
6. Waste	**18,53**	**161,25**	**7,95**				**187,73**
A. Solid Waste Disposal on Land	NA,NE,NO	141,79					141,79
B. Waste-water Handling		14,46	6,82				21,28
C. Waste Incineration	18,53	5,00	1,14				24,66
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	263,56	0,15	2,29				266,00
Aviation	203,62	0,03	1,78				205,43
Marine	59,95	0,12	0,51				60,57
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.169,89
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.264,99

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2011 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)]	**3.331,93**	**449,59**	**437,45**	**0,24**	**74,86**	**1,42**	**4.295,48**
1. Energy	**1.893,05**	**5,11**	**27,57**				**1.925,73**
A. Fuel Combustion (Sectoral Approach)	1.826,42	5,11	27,57				1.859,10
1. Energy Industries	16,27	0,02	0,13				16,43
2. Manufacturing Industries and Construction	366,43	0,26	15,28				381,96
3. Transport	635,04	3,28	5,60				643,91
4. Other Sectors	808,68	1,56	6,56				816,79
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66,63	NA,NE,NO	NA,NO				66,63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66,63	NE,NO	NA,NO				66,63
2. Industrial Processes	**410,31**	**0,60**	**44,02**	**0,24**	**74,86**	**1,42**	**531,44**
A. Mineral Products	39,68	NE,NO	NE,NO				39,68
B. Chemical Industry	0,24	NE,NO	44,02	NA	NA	NA	44,26
C. Metal Production	370,39	0,60	NA	NA,NE,NO	74,86	NA,NO	445,85
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				0,24	NA,NE,NO	1,42	1,65
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8,50**		**4,71**				**13,21**
4. Agriculture		**272,69**	**279,38**				**552,07**
A. Enteric Fermentation		250,90					250,90
B. Manure Management		21,79	30,41				52,20
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	248,97				248,97
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1.004,30**	**6,31**	**73,87**				**1.084,49**
A. Forest Land	-35,10	NE,NO	0,32				-34,79
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	40,72	NE,NO	NE,NO				40,72
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	73,56				73,56
6. Waste	**15,77**	**164,87**	**7,90**				**188,55**
A. Solid Waste Disposal on Land	NA,NE,NO	145,16					145,16
B. Waste-water Handling		15,24	6,89				22,12
C. Waste Incineration	15,77	4,48	1,02				21,27
D. Other	NA	NO	NO				NA,NO
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	293,02	0,22	2,54				295,78
Aviation	195,64	0,03	1,71				197,38
Marine	97,38	0,19	0,82				98,40
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.211,00
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.295,48

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2011 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)]	**3.285,37**	**454,23**	**444,36**	**0,60**	**44,57**	**1,42**	**4.230,55**
1. Energy	**1.855,45**	**5,10**	**27,74**				**1.888,28**
A. Fuel Combustion (Sectoral Approach)	1.788,82	5,10	27,74				1.821,65
1. Energy Industries	16,14	0,02	0,13				16,29
2. Manufacturing Industries and Construction	343,79	0,25	15,50				359,54
3. Transport	637,79	3,31	5,65				646,75
4. Other Sectors	791,10	1,52	6,45				799,07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66,63	NA,NE,NO	NA,NO				66,63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66,63	NE,NO	NA,NO				66,63
2. Industrial Processes	**411,28**	**0,57**	**44,33**	**0,60**	**44,57**	**1,42**	**502,77**
A. Mineral Products	37,37	NE,NO	NE,NO				37,37
B. Chemical Industry	0,35	NE,NO	44,33	NA	NA	NA	44,68
C. Metal Production	373,55	0,57	NA	NA,NE,NO	44,57	NA,NO	418,69
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				0,60	NA,NE,NO	1,42	2,02
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**10,02**		**3,88**				**13,89**
4. Agriculture		**273,67**	**286,78**				**560,46**
A. Enteric Fermentation		251,91					251,91
B. Manure Management		21,76	30,96				52,72
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	255,82				255,82
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**994,09**	**6,31**	**73,75**				**1.074,15**
A. Forest Land	-38,00	NE,NO	0,33				-37,67
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	33,40	NE,NO	NE,NO				33,40
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	73,42				73,42
6. Waste	**14,54**	**168,58**	**7,88**				**191,00**
A. Solid Waste Disposal on Land	NA,NE,NO	148,15					148,15
B. Waste-water Handling		16,24	6,93				23,18
C. Waste Incineration	14,54	4,18	0,95				19,67
D. Other	NA	NO	NO				NA,NO
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	307,10	0,22	2,66				309,98
Aviation	213,62	0,03	1,87				215,52
Marine	93,49	0,19	0,79				94,46
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.156,40
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.230,55

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2011 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)	**3.300,96**	**449,26**	**444,94**	**4,24**	**58,84**	**1,46**	**4.259,70**
1. Energy	**1.875,74**	**4,58**	**38,21**				**1.918,54**
A. Fuel Combustion (Sectoral Approach)	1.794,06	4,58	38,21				1.836,86
1. Energy Industries	18,95	0,03	0,17				19,15
2. Manufacturing Industries and Construction	359,56	0,27	19,29				379,13
3. Transport	613,50	2,73	12,20				628,43
4. Other Sectors	802,06	1,54	6,55				810,15
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	81,68	NA,NE,NO	NA,NO				81,68
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	81,68	NE,NO	NA,NO				81,68
2. Industrial Processes	**427,64**	**0,59**	**42,16**	**4,24**	**58,84**	**1,46**	**534,93**
A. Mineral Products	37,87	NE,NO	NE,NO				37,87
B. Chemical Industry	0,46	NE,NO	42,16	NA	NA	NA	42,62
C. Metal Production	389,32	0,59	NA	NA,NE,NO	58,84	NA,NO	448,75
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				4,24	NA,NE,NO	1,46	5,70
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**9,38**		**4,71**				**14,09**
4. Agriculture		**264,67**	**277,39**				**542,06**
A. Enteric Fermentation		242,95					242,95
B. Manure Management		21,72	29,21				50,93
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	248,18				248,18
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**975,37**	**6,31**	**74,46**				**1.056,15**
A. Forest Land	-47,00	NE,NO	0,38				-46,62
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	23,68	NE,NO	NE,NO				23,68
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	74,08				74,08
6. Waste	**12,82**	**173,11**	**8,00**				**193,93**
A. Solid Waste Disposal on Land	NA,NE,NO	151,43					151,43
B. Waste-water Handling		17,74	6,96				24,71
C. Waste Incineration	12,82	3,77	0,86				17,44
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	380,15	0,32	3,28				383,76
Aviation	236,15	0,04	2,07				238,25
Marine	144,00	0,29	1,21				145,50
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.203,56
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.259,70

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2011 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)]	**3.379,33**	**457,12**	**465,90**	**7,86**	**25,15**	**1,46**	**4.336,81**
1. Energy	**1.966,68**	**4,75**	**38,16**				**2.009,59**
A. Fuel Combustion (Sectoral Approach)	1.884,50	4,75	38,16				1.927,41
1. Energy Industries	15,34	0,04	0,20				15,58
2. Manufacturing Industries and Construction	399,02	0,30	18,78				418,10
3. Transport	604,42	2,76	12,11				619,29
4. Other Sectors	865,72	1,66	7,06				874,44
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	82,18	NA,NE,NO	NA,NO				82,18
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	82,18	NE,NO	NA,NO				82,18
2. Industrial Processes	**427,18**	**0,57**	**49,29**	**7,86**	**25,15**	**1,46**	**511,51**
A. Mineral Products	41,78	NE,NO	NE,NO				41,78
B. Chemical Industry	0,40	NE,NO	49,29	NA	NA	NA	49,69
C. Metal Production	385,00	0,57	NA	NA,NE,NO	25,15	NA,NO	410,72
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				7,86	NA,NE,NO	1,46	9,32
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**9,00**		**4,71**				**13,71**
4. Agriculture		**266,57**	**291,51**				**558,08**
A. Enteric Fermentation		244,56					244,56
B. Manure Management		22,01	30,36				52,36
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	261,15				261,15
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**964,99**	**7,70**	**74,25**				**1.046,93**
A. Forest Land	-50,77	NE,NO	0,38				-50,39
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	15,45	NE,NO	NE,NO				15,45
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	73,87				73,87
6. Waste	**11,49**	**177,53**	**7,98**				**196,99**
A. Solid Waste Disposal on Land	NA,NE,NO	155,25					155,25
B. Waste-water Handling		18,66	7,01				25,67
C. Waste Incineration	11,49	3,44	0,78				15,72
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	395,45	0,29	3,42				399,17
Aviation	271,51	0,04	2,38				273,93
Marine	123,95	0,25	1,04				125,24
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.289,88
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.336,81

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2011 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)]	**3.455,35**	**453,25**	**463,28**	**12,28**	**82,36**	**1,47**	**4.467,98**
1. Energy	**2.002,43**	**4,27**	**49,07**				**2.055,76**
A. Fuel Combustion (Sectoral Approach)	1.931,05	4,27	49,07				1.984,38
1. Energy Industries	10,25	0,03	0,20				10,48
2. Manufacturing Industries and Construction	467,41	0,35	22,64				490,40
3. Transport	615,75	2,26	19,35				637,36
4. Other Sectors	837,63	1,62	6,88				846,14
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	71,38	NA,NE,NO	NA,NO				71,38
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	71,38	NE,NO	NA,NO				71,38
2. Industrial Processes	**485,06**	**0,60**	**41,11**	**12,28**	**82,36**	**1,47**	**622,87**
A. Mineral Products	46,55	NE,NO	NE,NO				46,55
B. Chemical Industry	0,44	NE,NO	41,11	NA	NA	NA	41,54
C. Metal Production	438,08	0,60	NA	NA,NE,NO	82,36	NA,NO	521,04
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				12,28	NA,NE,NO	1,47	13,75
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8,06**		**4,71**				**12,77**
4. Agriculture		**261,64**	**285,60**				**547,24**
A. Enteric Fermentation		240,22					240,22
B. Manure Management		21,43	30,29				51,72
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	255,30				255,30
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**948,74**	**7,70**	**74,78**				**1.031,21**
A. Forest Land	-57,36	NE,NO	0,41				-56,95
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	5,79	NE,NO	NE,NO				5,79
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	74,37				74,37
6. Waste	**11,07**	**179,05**	**8,02**				**198,14**
A. Solid Waste Disposal on Land	NA,NE,NO	156,86					156,86
B. Waste-water Handling		18,67	7,07				25,75
C. Waste Incineration	11,07	3,34	0,76				15,18
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	440,80	0,34	3,81				444,95
Aviation	292,12	0,04	2,56				294,72
Marine	148,68	0,30	1,25				150,23
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.436,78
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.467,98

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2011 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)	**3.447,86**	**456,19**	**462,04**	**20,04**	**180,13**	**1,84**	**4.568,10**
1. Energy	**1.988,68**	**4,24**	**49,58**				**2.042,50**
A. Fuel Combustion (Sectoral Approach)	1.894,60	4,24	49,58				1.948,42
1. Energy Industries	13,56	0,03	0,20				13,79
2. Manufacturing Industries and Construction	445,87	0,33	22,89				469,09
3. Transport	619,00	2,30	19,83				641,13
4. Other Sectors	816,18	1,57	6,66				824,41
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	94,08	NA,NE,NO	NA,NO				94,08
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	94,08	NE,NO	NA,NO				94,08
2. Industrial Processes	**512,73**	**0,44**	**35,84**	**20,04**	**180,13**	**1,84**	**751,02**
A. Mineral Products	54,39	NE,NO	NE,NO				54,39
B. Chemical Industry	0,40	NE,NO	35,84	NA	NA	NA	36,23
C. Metal Production	457,95	0,44	NA	NA,NE,NO	180,13	NA,NO	638,53
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				20,04	NA,NE,NO	1,84	21,87
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8,09**		**4,96**				**13,05**
4. Agriculture		**264,89**	**288,22**				**553,11**
A. Enteric Fermentation		243,17					243,17
B. Manure Management		21,72	30,59				52,30
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	257,64				257,64
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**928,97**	**7,80**	**75,40**				**1.012,18**
A. Forest Land	-64,64	NE,NO	0,51				-64,13
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	-6,82	NE,NO	NE,NO				-6,82
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	74,90				74,90
6. Waste	**9,38**	**178,81**	**8,04**				**196,23**
A. Solid Waste Disposal on Land	NA,NE,NO	158,27					158,27
B. Waste-water Handling		17,30	7,15				24,45
C. Waste Incineration	9,38	3,07	0,70				13,16
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	514,67	0,40	4,44				519,51
Aviation	338,13	0,05	2,96				341,14
Marine	176,54	0,35	1,48				178,37
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.555,92
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.568,10

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2011 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)]	**3.633,35**	**459,27**	**484,67**	**25,98**	**173,21**	**11,02**	**4.787,51**
1. Energy	**2.046,82**	**3,60**	**61,29**				**2.111,70**
A. Fuel Combustion (Sectoral Approach)	1.923,86	3,60	61,29				1.988,74
1. Energy Industries	10,69	0,03	0,20				10,92
2. Manufacturing Industries and Construction	470,83	0,36	25,04				496,23
3. Transport	640,69	1,67	29,49				671,84
4. Other Sectors	801,65	1,54	6,56				809,75
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	122,96	NA,NE,NO	NA,NO				122,96
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	122,96	NE,NO	NA,NO				122,96
2. Industrial Processes	**659,15**	**0,68**	**36,18**	**25,98**	**173,21**	**11,02**	**906,21**
A. Mineral Products	61,46	NE,NO	NE,NO				61,46
B. Chemical Industry	0,43	NE,NO	36,18	NA	NA	NA	36,61
C. Metal Production	597,26	0,68	NA	NA,NE,NO	173,21	NA,NO	771,15
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				25,98	NA,NE,NO	11,02	37,00
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8,99**		**4,68**				**13,67**
4. Agriculture		**265,51**	**299,34**				**564,84**
A. Enteric Fermentation		243,94					243,94
B. Manure Management		21,56	30,62				52,19
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	268,71				268,71
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**910,72**	**7,80**	**75,15**				**993,67**
A. Forest Land	-69,73	NE,NO	0,53				-69,19
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	-19,99	NE,NO	NE,NO				-19,99
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	74,62				74,62
6. Waste	**7,67**	**181,69**	**8,04**				**197,40**
A. Solid Waste Disposal on Land	NA,NE,NO	160,77					160,77
B. Waste-water Handling		18,08	7,25				25,34
C. Waste Incineration	7,67	2,66	0,60				10,94
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	527,25	0,38	4,57				532,20
Aviation	363,37	0,05	3,18				366,61
Marine	163,88	0,33	1,38				165,59
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.793,84
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.787,51

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2011 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)	**3.623,49**	**453,61**	**463,25**	**26,96**	**127,16**	**3,05**	**4.697,51**
1. Energy	**1.988,43**	**3,47**	**61,13**				**2.053,03**
A. Fuel Combustion (Sectoral Approach)	1.824,95	3,47	61,13				1.889,55
1. Energy Industries	9,52	0,03	0,20				9,75
2. Manufacturing Industries and Construction	423,87	0,33	25,50				449,70
3. Transport	642,83	1,65	29,29				673,77
4. Other Sectors	748,73	1,45	6,15				756,33
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	163,48	NA,NE,NO	NA,NO				163,48
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	163,48	NE,NO	NA,NO				163,48
2. Industrial Processes	**768,81**	**0,94**	**18,63**	**26,96**	**127,16**	**3,05**	**945,55**
A. Mineral Products	65,68	NE,NO	NE,NO				65,68
B. Chemical Industry	0,41	NE,NO	18,63	NA	NA	NA	19,04
C. Metal Production	702,72	0,94	NA	NA,NE,NO	127,16	NA,NO	830,82
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				26,96	NA,NE,NO	3,05	30,01
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**10,36**		**4,53**				**14,89**
4. Agriculture		**256,11**	**295,88**				**551,99**
A. Enteric Fermentation		234,99					234,99
B. Manure Management		21,12	28,95				50,07
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	266,93				266,93
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**848,68**	**7,80**	**74,96**				**931,44**
A. Forest Land	-114,92	NE,NO	0,71				-114,21
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	-36,84	NE,NO	NE,NO				-36,84
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	74,26				74,26
6. Waste	**7,21**	**185,28**	**8,12**				**200,61**
A. Solid Waste Disposal on Land	NA,NE,NO	163,97					163,97
B. Waste-water Handling		18,59	7,35				25,95
C. Waste Incineration	7,21	2,55	0,58				10,34
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	626,29	0,50	5,41				632,20
Aviation	407,74	0,06	3,57				411,37
Marine	218,55	0,44	1,84				220,82
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.766,07
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.697,51

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2011 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)	**3.609,11**	**459,08**	**455,63**	**30,82**	**91,66**	**4,60**	**4.650,89**
1. Energy	**1.952,53**	**3,35**	**60,31**				**2.016,19**
A. Fuel Combustion (Sectoral Approach)	1.798,05	3,35	60,31				1.861,71
1. Energy Industries	9,27	0,03	0,20				9,50
2. Manufacturing Industries and Construction	470,93	0,35	25,08				496,36
3. Transport	653,53	1,68	29,58				684,79
4. Other Sectors	664,32	1,28	5,45				671,06
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	154,48	NA,NE,NO	NA,NO				154,48
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	154,48	NE,NO	NA,NO				154,48
2. Industrial Processes	**805,29**	**0,91**	**16,15**	**30,82**	**91,66**	**4,60**	**949,42**
A. Mineral Products	58,99	NE,NO	NE,NO				58,99
B. Chemical Industry	0,49	NE,NO	16,15	NA	NA	NA	16,64
C. Metal Production	745,80	0,91	NA	NA,NE,NO	91,66	NA,NO	838,37
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				30,82	NA,NE,NO	4,60	35,42
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**12,66**		**4,03**				**16,69**
4. Agriculture		**255,80**	**291,83**				**547,64**
A. Enteric Fermentation		234,72					234,72
B. Manure Management		21,08	28,66				49,75
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	263,17				263,17
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**831,95**	**7,80**	**75,12**				**914,87**
A. Forest Land	-123,95	NE,NO	0,73				-123,22
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	-44,54	NE,NO	NE,NO				-44,54
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	74,39				74,39
6. Waste	**6,69**	**191,21**	**8,18**				**206,08**
A. Solid Waste Disposal on Land	NA,NE,NO	170,28					170,28
B. Waste-water Handling		18,34	7,44				25,78
C. Waste Incineration	6,69	2,43	0,55				9,67
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	498,17	0,35	4,32				502,83
Aviation	349,13	0,05	3,06				352,24
Marine	149,04	0,30	1,26				150,60
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.736,02
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.650,89

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2011 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)]	**3.678,54**	**446,37**	**422,18**	**31,89**	**72,54**	**3,45**	**4.654,97**
1. Energy	**2.030,08**	**3,50**	**59,63**				**2.093,21**
A. Fuel Combustion (Sectoral Approach)	1.870,74	3,50	59,63				1.933,86
1. Energy Industries	10,96	0,04	0,20				11,20
2. Manufacturing Industries and Construction	474,54	0,35	23,52				498,42
3. Transport	657,22	1,69	29,89				688,80
4. Other Sectors	728,01	1,42	6,01				735,44
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	159,35	NA,NE,NO	NA,NO				159,35
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	159,35	NE,NO	NA,NO				159,35
2. Industrial Processes	**822,84**	**0,97**	**NA,NE,NO**	**31,89**	**72,54**	**3,45**	**931,68**
A. Mineral Products	39,76	NE,NO	NE,NO				39,76
B. Chemical Industry	0,45	NE,NO	NE,NO	NA	NA	NA	0,45
C. Metal Production	782,62	0,97	NA	NA,NE,NO	72,54	NA,NO	856,13
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				31,89	NA,NE,NO	3,45	35,34
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8,92**		**4,03**				**12,95**
4. Agriculture		**250,83**	**274,96**				**525,78**
A. Enteric Fermentation		230,60					230,60
B. Manure Management		20,22	27,92				48,15
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE	247,04				247,04
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [(1)]	**810,49**	**7,80**	**75,37**				**893,66**
A. Forest Land	-136,58	NE,NO	0,78				-135,80
B. Cropland	991,33	NE,NO	IE,NE,NO				991,33
C. Grassland	-53,36	NE,NO	NE,NO				-53,36
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	74,58				74,58
6. Waste	**6,21**	**183,27**	**8,20**				**197,68**
A. Solid Waste Disposal on Land	NA,NE,NO	161,20					161,20
B. Waste-water Handling		19,59	7,49				27,08
C. Waste Incineration	6,21	2,31	0,53				9,05
D. Other	NA	0,17	0,19				0,35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	517,17	0,46	4,46				522,10
Aviation	309,85	0,05	2,71				312,61
Marine	207,32	0,41	1,75				209,49
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.761,30
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.654,97

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2011 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)]	**3.637,12**	**449,50**	**411,37**	**37,80**	**59,78**	**3,64**	**4.599,21**
1. Energy	**2.013,80**	**3,52**	**58,87**				**2.076,19**
A. Fuel Combustion (Sectoral Approach)	1.875,91	3,52	58,87				1.938,30
1. Energy Industries	10,23	0,03	0,20				10,46
2. Manufacturing Industries and Construction	427,33	0,33	21,52				449,18
3. Transport	751,18	1,81	31,44				784,43
4. Other Sectors	687,17	1,35	5,71				694,23
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	137,89	NA,NE,NO	NA,NO				137,89
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	137,89	NE,NO	NA,NO				137,89
2. Industrial Processes	**826,79**	**0,94**	**NA,NE,NO**	**37,80**	**59,78**	**3,64**	**928,95**
A. Mineral Products	33,48	NE,NO	NE,NO				33,48
B. Chemical Industry	0,48	NE,NO	NE,NO	NA	NA	NA	0,48
C. Metal Production	792,83	0,94	NA	NA,NE,NO	59,78	NA,NO	853,56
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				37,80	NA,NE,NO	3,64	41,44
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**6,33**		**3,72**				**10,05**
4. Agriculture		**248,24**	**263,63**				**511,88**
A. Enteric Fermentation		228,41					228,41
B. Manure Management		19,84	27,44				47,28
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	236,19				236,19
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**784,91**	**7,80**	**76,81**				**869,53**
A. Forest Land	-151,32	NE,NO	0,81				-150,51
B. Cropland	993,69	NE,NO	IE,NE,NO				993,69
C. Grassland	-66,57	NE,NO	NE,NO				-66,57
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	76,00				76,00
6. Waste	**5,30**	**188,98**	**8,34**				**202,61**
A. Solid Waste Disposal on Land	NA,NE,NO	165,37					165,37
B. Waste-water Handling		21,13	7,55				28,68
C. Waste Incineration	5,30	2,23	0,51				8,03
D. Other	NA	0,25	0,28				0,53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	476,72	0,34	4,13				481,19
Aviation	333,00	0,05	2,92				335,97
Marine	143,72	0,29	1,21				145,22
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.729,68
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.599,21

(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.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2011 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)	**3.682,12**	**441,03**	**409,97**	**42,30**	**38,58**	**4,44**	**4.618,43**
1. Energy	**2.069,04**	**3,64**	**64,52**				**2.137,20**
A. Fuel Combustion (Sectoral Approach)	1.944,96	3,64	64,52				2.013,12
1. Energy Industries	9,93	0,04	0,20				10,17
2. Manufacturing Industries and Construction	462,10	0,36	25,79				488,26
3. Transport	803,26	1,91	32,77				837,93
4. Other Sectors	669,66	1,34	5,76				676,77
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	124,08	NA,NE,NO	NA,NO				124,08
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	124,08	NE,NO	NA,NO				124,08
2. Industrial Processes	**848,59**	**0,96**	**NA,NE,NO**	**42,30**	**38,58**	**4,44**	**934,86**
A. Mineral Products	51,45	NE,NO	NE,NO				51,45
B. Chemical Industry	0,39	NE,NO	NE,NO	NA	NA	NA	0,39
C. Metal Production	796,75	0,96	NA	NA,NE,NO	38,58	NA,NO	836,29
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				42,30	NA,NE,NO	4,44	46,74
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**6,91**		**3,41**				**10,32**
4. Agriculture		**242,81**	**256,44**				**499,25**
A. Enteric Fermentation		223,46					223,46
B. Manure Management		19,35	27,14				46,49
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	229,30				229,30
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**755,10**	**7,80**	**77,34**				**840,24**
A. Forest Land	-163,22	NE,NO	0,86				-162,36
B. Cropland	993,85	NE,NO	IE,NE,NO				993,85
C. Grassland	-84,70	NE,NO	NE,NO				-84,70
D. Wetlands	9,11	7,80	NA,NO				16,91
E. Settlements	0,07	NE	NE				0,07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	76,48				76,48
6. Waste	**2,49**	**185,81**	**8,26**				**196,56**
A. Solid Waste Disposal on Land	NA,NE,NO	164,83					164,83
B. Waste-water Handling		19,17	7,62				26,80
C. Waste Incineration	2,49	1,55	0,35				4,40
D. Other	NA	0,25	0,28				0,53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	576,21	0,45	4,98				581,64
Aviation	380,00	0,06	3,33				383,39
Marine	196,21	0,39	1,65				198,25
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.778,19
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.618,43

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

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)]	**3.600,05**	**440,01**	**417,16**	**48,54**	**26,09**	**4,23**	**4.536,09**
1. Energy	**2.026,24**	**3,27**	**72,14**				**2.101,65**
A. Fuel Combustion (Sectoral Approach)	1.902,86	3,27	72,14				1.978,26
1. Energy Industries	12,68	0,04	0,20				12,91
2. Manufacturing Industries and Construction	425,40	0,35	27,85				453,60
3. Transport	808,94	1,57	38,43				848,93
4. Other Sectors	655,85	1,31	5,66				662,82
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	123,38	NA,NE,NO	NA,NO				123,38
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	123,38	NE,NO	NA,NO				123,38
2. Industrial Processes	**837,77**	**0,97**	**NA,NE,NO**	**48,54**	**26,09**	**4,23**	**917,60**
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	782,04	0,97	NA	NA,NE,NO	26,09	NA,NO	809,10
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				48,54	NA,NE,NO	4,23	52,77
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**12,89**		**3,29**				**16,18**
4. Agriculture		**242,88**	**255,51**				**498,39**
A. Enteric Fermentation		223,17					223,17
B. Manure Management		19,72	27,18				46,90
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	228,33				228,33
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**723,12**	**7,80**	**77,76**				**808,69**
A. Forest Land	-181,25	NE,NO	0,87				-180,38
B. Cropland	994,78	NE,NO	IE,NE,NO				994,78
C. Grassland	-99,59	NE,NO	NE,NO				-99,59
D. Wetlands	9,11	7,80	NA,NE,NO				16,91
E. Settlements	0,07	NE	NE				0,07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	76,90				76,90
6. Waste	**0,03**	**185,09**	**8,47**				**193,58**
A. Solid Waste Disposal on Land	NA,NE,NO	166,74					166,74
B. Waste-water Handling		16,97	7,78				24,75
C. Waste Incineration	0,03	0,96	0,22				1,21
D. Other	NA	0,42	0,47				0,89
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	532,59	0,28	4,62				537,50
Aviation	421,63	0,06	3,69				425,39
Marine	110,96	0,22	0,93				112,11
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3.727,40
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4.536,09

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2011 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)]	**3.741,83**	**463,37**	**445,31**	**51,69**	**333,22**	**7,26**	**5.042,68**
1. Energy	**2.103,50**	**3,29**	**71,72**				**2.178,51**
A. Fuel Combustion (Sectoral Approach)	1.947,01	3,29	71,72				2.022,03
1. Energy Industries	15,07	0,06	0,34				15,47
2. Manufacturing Industries and Construction	406,89	0,32	25,31				432,52
3. Transport	951,27	1,76	41,07				994,09
4. Other Sectors	573,79	1,16	5,00				579,95
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	156,48	NA,NE,NO	NA,NO				156,48
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	156,48	NE,NO	NA,NO				156,48
2. Industrial Processes	**940,82**	**0,99**	**NA,NE,NO**	**51,69**	**333,22**	**7,26**	**1.333,99**
A. Mineral Products	62,72	NE,NO	NE,NO				62,72
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	878,11	0,99	NA	NA,NE,NO	333,22	NA,NO	1.212,32
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				51,69	NA,NE,NO	7,26	58,95
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**5,93**		**3,43**				**9,36**
4. Agriculture		**245,57**	**282,87**				**528,44**
A. Enteric Fermentation		225,17					225,17
B. Manure Management		20,40	27,77				48,18
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	255,10				255,10
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**691,56**	**9,10**	**78,36**				**779,03**
A. Forest Land	-199,72	NE,NO	0,89				-198,83
B. Cropland	994,87	NE,NO	IE,NE,NO				994,87
C. Grassland	-113,65	0,07	0,03				-113,56
D. Wetlands	9,11	9,03	0,45				18,60
E. Settlements	0,96	NE	NE				0,96
F. Other Land	NE	NE	NE				NE
G. Other	IE,NE,NO	NA,NE,NO	76,99				76,99
6. Waste	**0,03**	**204,41**	**8,92**				**213,35**
A. Solid Waste Disposal on Land	NA,NE,NO	186,06					186,06
B. Waste-water Handling		16,85	7,99				24,84
C. Waste Incineration	0,03	0,83	0,19				1,04
D. Other	NA	0,67	0,74				1,42
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	637,13	0,35	5,53				643,00
Aviation	499,89	0,07	4,38				504,35
Marine	137,23	0,27	1,15				138,66
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4.263,66
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5.042,68

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2011 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)]	**3.963,58**	**478,35**	**464,15**	**58,07**	**281,13**	**10,15**	**5.255,43**
1. Energy	**2.158,50**	**3,36**	**72,52**				**2.234,37**
A. Fuel Combustion (Sectoral Approach)	2.006,98	3,36	72,52				2.082,85
1. Energy Industries	29,09	0,07	0,40				29,56
2. Manufacturing Industries and Construction	400,21	0,32	25,42				425,94
3. Transport	986,01	1,78	41,53				1.029,32
4. Other Sectors	591,67	1,19	5,17				598,03
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	151,52	NA,NE,NO	NA,NO				151,52
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	151,52	NE,NO	NA,NO				151,52
2. Industrial Processes	**1.134,32**	**1,04**	**NA,NE,NO**	**58,07**	**281,13**	**10,15**	**1.484,70**
A. Mineral Products	64,52	NE,NO	NE,NO				64,52
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1.069,79	1,04	NA	NA,NE,NO	281,13	NA,NO	1.351,96
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				58,07	NA,NE,NO	10,15	68,22
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8,31**		**4,16**				**12,47**
4. Agriculture		**248,68**	**302,12**				**550,80**
A. Enteric Fermentation		227,89					227,89
B. Manure Management		20,79	28,03				48,82
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	274,09				274,09
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**662,42**	**8,22**	**76,10**				**746,75**
A. Forest Land	-218,31	NE,NO	0,91				-217,39
B. Cropland	996,12	NE,NO	IE,NE,NO				996,12
C. Grassland	-125,06	NE,NO	NE,NO				-125,06
D. Wetlands	9,60	8,22	NA,NE,NO				17,82
E. Settlements	0,07	NE	NE				0,07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	75,19				75,19
6. Waste	**0,03**	**217,05**	**9,25**				**226,33**
A. Solid Waste Disposal on Land	NA,NE,NO	200,47					200,47
B. Waste-water Handling		14,91	8,13				23,05
C. Waste Incineration	0,03	0,83	0,19				1,04
D. Other	NA	0,84	0,93				1,77
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	718,45	0,49	6,21				725,15
Aviation	511,53	0,08	4,48				516,09
Marine	206,92	0,41	1,73				209,06
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4.508,68
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5.255,43

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2011 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)]	**4.227,31**	**475,63**	**473,68**	**66,53**	**349,00**	**6,26**	**5.598,41**
1. Energy	**2.019,28**	**3,13**	**69,20**				**2.091,61**
A. Fuel Combustion (Sectoral Approach)	1.834,14	3,13	69,20				1.906,47
1. Energy Industries	14,25	0,06	0,33				14,64
2. Manufacturing Industries and Construction	342,92	0,28	24,22				367,42
3. Transport	932,13	1,70	39,91				973,73
4. Other Sectors	544,85	1,09	4,74				550,68
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	185,14	NA,NE,NO	NA,NO				185,14
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	185,14	NE,NO	NA,NO				185,14
2. Industrial Processes	**1.569,17**	**0,88**	**NA,NE,NO**	**66,53**	**349,00**	**6,26**	**1.991,84**
A. Mineral Products	62,31	NE,NO	NE,NO				62,31
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1.506,86	0,88	NA	NA,NE,NO	349,00	NA,NO	1.856,74
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				66,53	NA,NE,NO	6,26	72,79
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**6,15**		**3,10**				**9,25**
4. Agriculture		**251,59**	**314,79**				**566,39**
A. Enteric Fermentation		230,63					230,63
B. Manure Management		20,97	27,77				48,73
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	287,03				287,03
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**632,68**	**8,22**	**77,35**				**718,26**
A. Forest Land	-237,38	NE,NO	0,88				-236,50
B. Cropland	996,85	NE,NO	IE,NE,NO				996,85
C. Grassland	-136,39	NE,NO	NE,NO				-136,39
D. Wetlands	9,60	8,22	NA,NE,NO				17,82
E. Settlements	NA,NE,NO	NE	NE				NA,NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	76,47				76,47
6. Waste	**0,03**	**211,80**	**9,24**				**221,06**
A. Solid Waste Disposal on Land	NA,NE,NO	195,70					195,70
B. Waste-water Handling		14,50	8,14				22,63
C. Waste Incineration	0,03	0,76	0,17				0,96
D. Other	NA	0,84	0,93				1,77
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	656,36	0,51	5,64				662,52
Aviation	427,83	0,06	3,75				431,64
Marine	228,53	0,45	1,90				230,88
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4.880,15
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5.598,41

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2011 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)]	**4.151,74**	**468,64**	**434,39**	**85,82**	**152,75**	**5,94**	**5.299,27**
1. Energy	**1.967,59**	**3,14**	**61,77**				**2.032,50**
A. Fuel Combustion (Sectoral Approach)	1.792,57	3,14	61,77				1.857,48
1. Energy Industries	14,56	0,05	0,20				14,81
2. Manufacturing Industries and Construction	244,88	0,20	16,68				261,76
3. Transport	905,31	1,65	39,65				946,61
4. Other Sectors	627,82	1,24	5,24				634,30
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	175,02	NA,NE,NO	NA,NO				175,02
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	175,02	NE,NO	NA,NO				175,02
2. Industrial Processes	**1.583,03**	**0,91**	**NA,NE,NO**	**85,82**	**152,75**	**5,94**	**1.828,44**
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	1.552,98	0,91	NA	NA,NE,NO	152,75	NA,NO	1.706,64
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)]				85,82	NA,NE,NO	5,94	91,75
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**4,98**		**0,90**				**5,88**
4. Agriculture		**253,80**	**285,46**				**539,25**
A. Enteric Fermentation		232,79					232,79
B. Manure Management		21,01	28,63				49,63
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	256,83				256,83
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)]	**596,11**	**8,33**	**76,66**				**681,11**
A. Forest Land	-258,90	NE,NO	0,97				-257,93
B. Cropland	995,34	NE,NO	IE,NE,NO				995,34
C. Grassland	-150,05	NE,NO	NE,NO				-150,05
D. Wetlands	9,72	8,33	NA,NE,NO				18,05
E. Settlements	NA,NE,NO	NE	NE				NA,NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	75,69				75,69
6. Waste	**0,03**	**202,47**	**9,60**				**212,09**
A. Solid Waste Disposal on Land	NA,NE,NO	184,58					184,58
B. Waste-water Handling		16,12	8,26				24,38
C. Waste Incineration	0,03	0,69	0,16				0,87
D. Other	NA	1,07	1,19				2,26
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	4.618,16
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5.299,27

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

ANNEX IV FACT SHEET FOR SINGLE PROJECTS

Fact sheet Single Projects under 14/CP.7

Name of the single project	Rio Tinto Alcan – expansion of aluminium plant
Name of the company/ production facility	Rio Tinto Alcan
Location of the project	PO 224, 220 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 2,172 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 2,172 Gg Total industrial CO_2 emissions from the project in 2009 were 133 Gg or 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 2009 to 89,355 tonnes of aluminium (189,533 tonnes in 2009 compared to 100,198 tonnes in 1995). The resulting CO_2 emissions are 133 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in for the expanded part in 2009 is thus 1.47 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check

	on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5	Rio Tinto Alcan uses LPG for heating of melting pots and residual fuel oil in the foundry. In 2009 the total energy consumption was 3,322 tonnes of residual fuel oil, 368 tonnes of gas oil and 122 tonnes of LPG leading to emissions of 11.8 Gg of GHG. The EF for residual fuel oil is 3.08 t CO_2-equivalents per tonne of fuel. The EF for gas oil is 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 0.07 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2009 the total use of electricity was 2,932 GWh, thereof 1,382 GWh were used for the expansion project. As stated in chapter 3.2., almost all energy in Iceland is produced from renewable energy sources (99.98%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emission per kWh from electricity production in Iceland is 11.6 CO_2/kWh. The total CO_2 emissions from the electricity use for the project amounts to 16 Gg. Had the energy been from coal powered power plant the per kWh emissions would amount to 954 Gg. The resulting emissions from electricity use in the project would thus have amounted to 1,318 Gg. The resulting emissions savings are 1,302 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 2,172 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 2,172 Gg. Total industrial CO_2 emissions from the project in 2009 were 120 Gg or 6% 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 2009 to 35,397 tonnes of ferrosilicon (all production in furnace 3). The resulting CO_2 emissions are 120 Gg. CO_2 emissions are calculated based on the quantity of coal and coke as reducing agents, as well as from the consumption of electrodes, using emission factors from the IPCC Guidelines. The implied emission factor in 2009 was 3.48 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 2009 the total energy consumption was 0.34 tonnes of gasoil leading to emissions of 1.1 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 2009 the total use of electricity was 894 GWh, thereof 323 GWh were used for the expansion project. As stated in chapter 3.2., almost all energy in Iceland is produced from renewable energy sources (99.98%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emissions per kWh from electricity production in Iceland are 11.6 g. The total CO_2 emissions from the electricity use for the project amounts to 4 Gg. Had the energy been from coal powered power plant the per kWh emissions would amount to 954 g. The resulting emissions from the project would thus have amounted to 308 Gg. The resulting emissions savings are 304 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 2,172 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 2,172 Gg (according to Iceland's Initial Report under the Kyoto Protocol). Total industrial CO_2 emissions from the project in 2009 were 41 Gg or 19% 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 2009 to 278,244 tonnes of aluminium. The resulting CO_2 emissions are 411 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in 2009 is thus 1.47 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils	Century Aluminium uses LPG and gasoil for heating of melting pots. In 2009 the total fuel consumption was 402 tonnes of gasoil and 219

paragraph 2.(b) and paragraph 5	tonnes of LPG leading to emissions of 1.9 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-equivalents per tonne of fuel. The IEF for energy use is 0.007 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2009 the total use of electricity was 4,176 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 13.2 g/kWh. The total CO_2 emissions from the electricity used for the project amounts to 49 Gg. Had the energy been from coal powered power plant the per kWh emissions would amount to approximately 954 g. The resulting emissions from the project would thus have amounted to 3,984 Gg. The resulting emissions savings are 3,935 Gg
Provide evidence that the project fulfils paragraph 2.(c)	As stipulated in the operating permit for Century Aluminium plant at Grundartangi, BAT as defined by the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is applied at the plant. Century Aluminium is preparing implementation of an environmental management system according to ISO 14001.

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

Fact sheet Single Projects under 14/CP.7

Name of the single project	Alcoa Fjarðaál – establishment of aluminium plant
Name of the company/production facility	Alcoa Fjarðaál
Location of the project	Reyðarfjörður, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Alcoa Fjarðaál plant at Reyðarfjörður in 2007. In 2008 the plant reached full production capacity of 346,000 tonnes of aluminium. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant in Reyðarfjörður and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year. See also description previously in this annex.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2,172 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 2,172 Gg (according to Iceland's Initial Report under the Kyoto Protocol). Total industrial CO_2 emissions from the project in 2009 were 523 Gg or 24% 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 2009 to 349,504 tonnes of aluminium. The resulting CO_2 emissions are 523 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in 2009 is thus 1.53 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and	Alcoa Fjarðaál uses LPG and gasoil for heating of melting pots. In 2009 the total fuel consumption was 421 tonnes of gasoil and 263 tonnes of LPG leading to emissions of 2.1 Gg of GHG. The EF for gasoil is 3.18 t

paragraph 5	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 0.009 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2009 the total use of electricity was 4,838 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 13.2 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 56 Gg. Had the energy been from coal powered power plant the per kWh emissions would amount to approximately 954 g. The resulting emissions from the project would thus have amounted to 4,615 Gg. The resulting emissions savings are 4,559 Gg
Provide evidence that the project fulfils paragraph 2.(c)	As stipulated in the operating permit for Alcoa Fjarðaál plant at Reyðarfjörður, BAT as defined by the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is applied at the plant. Alcoa Fjarðaál is preparing implementation of an environmental management system according to ISO 14001. Further, two audits have been performed in accordance with Alcoa´s Self Assessment Tool (ASAT). If the provisions of ASAT are met, all requirements of ISO 14001 should be met.

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7