Status Report for Iceland

pursuant to the United Nations Framework Convention on Climate Change

Ministry for the Environment, 1994

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Foreword by the Minister for the Environment

It was the international concern about possible global human impact on the earth's climate, that initiated a process that resulted in the Framework Convention on Climate Change in 1992. Iceland was among the initial signatories of the Convention.

Science has not been able to produce a definite answer to the question if climate change is on its way. However, there is increasing evidence that human activities are inducing climate change. Further, the analysis of the Intergovernmental Panel on Climate Change shows that climate change is potentially a serious threat to the well being of humankind as well as all other life on earth. Consequently, it is imperative that the countries of the world respond to this threat.

The Icelandic Government is committed to implementing the programme of action that is presented in this report. However, there is no reason to create the illusion that it will be easy to achieve the goal of maintaining greenhouse gas emissions in Iceland at the 1990 level by the year 2000.

Iceland has already made some substantial efforts to reduce the use of fossil fuels as an energy source. This effort resulted in a reduction in the emission of carbon dioxide from stationery energy production in Iceland from 590 thousand tons in 1973 to 145 thousand tons in 1990. Currently, about 95% of the total stationery energy production in Iceland comes from renewable energy sources. It will be difficult, if not impossible, to achieve further reduction in this area.

Fishing is the main pillar of Icelandic economy and emissions from fishing vessels constitute over one third of the total emissions of carbon dioxide in Iceland. The programme of action presented in this report addresses this issue with actions that are aimed at reducing emissions from the fishing fleet. However, the fact that technical developments concerning vessel design and fuel efficiency is brought forward by forces outside Iceland's jurisdiction limits the scope of action. Here, there is a need to analyse the feasibility of an internationally co-ordinated action to promote the use of more energy efficient technologies in fisheries.

I have described some of the difficulties Iceland faces in addressing this complex and difficult issue. This does not imply that the Icelandic Government does not take the issue of climate change seriously. On the contrary, it underlines the need to use all possible means to achieve the goals set out in the Framework Convention for Climate Change.

Guomundur Bjarnason
Minister for the Environment

1. Introduction

1.1. Background

Today people throughout the world are concerned at the increasing atmospheric concentration of various gases which could result in an increase to the mean temperature on earth, accompanied by climatic change, and disrupt ecological conditions in many areas of the world. The warming effects caused by these atmospheric gases are referred to in general as the greenhouse effect and the gases which cause it as greenhouse gases. This is explained in more detail in Chapter 1.2. Carbon dioxide is the most common of the anthropogenic greenhouse gases, and the danger of an increased atmospheric greenhouse effect is to a considerable extent attributed to the substantial and steady increase of anthropogenic emissions of carbon dioxide. This is further aggravated by the effects of other greenhouse gases, although they do not equal carbon dioxide in significance.

The amount of carbon dioxide in the atmosphere has increased by 25% over the past 150 years for two main reasons: the use of fuel and the destruction of vegetation. If the trend continues the amount of carbon dioxide in the atmosphere will double in the next century. Even if the burning of carbon-rich minerals and deforestation were not to increase beyond present levels, scientists are of the opinion that the concentration of atmospheric carbon dioxide will nevertheless increase substantially until a balance is reached in a century's time.

A general warming of the earth is regarded as practically inevitable in the coming decades due to an increase in atmospheric carbon dioxide and other greenhouse gases. The exact extent of the warming is uncertain. It has been estimated that if the concentration of carbon dioxide were to double, for instance, by the middle of the next century, the mean temperature at the earth's surface could increase by about two degrees from the present level. It is evident that there is a real danger of climatic and ecological changes although the specific effects this could have on individual regions of the world are still unclear.

The nations of the world have generally recognised this danger and the United Nations Framework Convention, which was signed in Rio de Janeiro, Brazil, in June of 1992, sets out the main objectives and means of averting it. Preparatory work for the Convention grew out of efforts by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO), who together founded the Intergovernmental Panel on Climate Change (IPCC), to evaluate existing knowledge of climate change caused by the greenhouse effect. This Panel convened for the first time in November of 1988 and issued its first report in August of 1990. The Intergovernmental Negotiation Committee for an international convention on atmospheric protection (INC) was subsequently established by these same parties. This committee met for the first time in January of 1991 and concluded its work in 1992 with proposals for the UN Framework Convention on Climate Change which was

subsequently adopted in Rio de Janeiro in June that same year. The Convention came into force in March 21, 1994 when it had been legally ratified by 50 states. In a parliamentary resolution in the spring of 1993 the Icelandic Parliament (*Althingi*) authorised the government to ratify the convention on behalf of Iceland.

The primary objective of the Framework Convention is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". As a method of achieving this objective, the Convention involves the obligation that each of the developed states (listed in Annex I of the Framework Convention) provide detailed information of policies and measures to limit emissions of carbon dioxide and other greenhouse gases and to increase vegetation and other sinks (see Points 2.a and 2.b of Article 4 of the Framework Convention). Gases which are covered by the Montreal Protocol (for the protection of the ozone layer) are excepted. The policies and measures of the states are to provide, individually or collectively, for a return by the end of the present decade to 1990 emission levels. A conference of the parties to the Convention shall, at its first session in the beginning of 1995, review the information in the status reports of the developed countries to determine whether the existing obligations are adequate.

The present status report is Iceland's contribution towards complying with Point 2.b of Article 4 and with Article 12 of the UN Framework Convention on Climate Change. Most of the report was prepared in accordance with draft guidelines from IPCC and OECD.

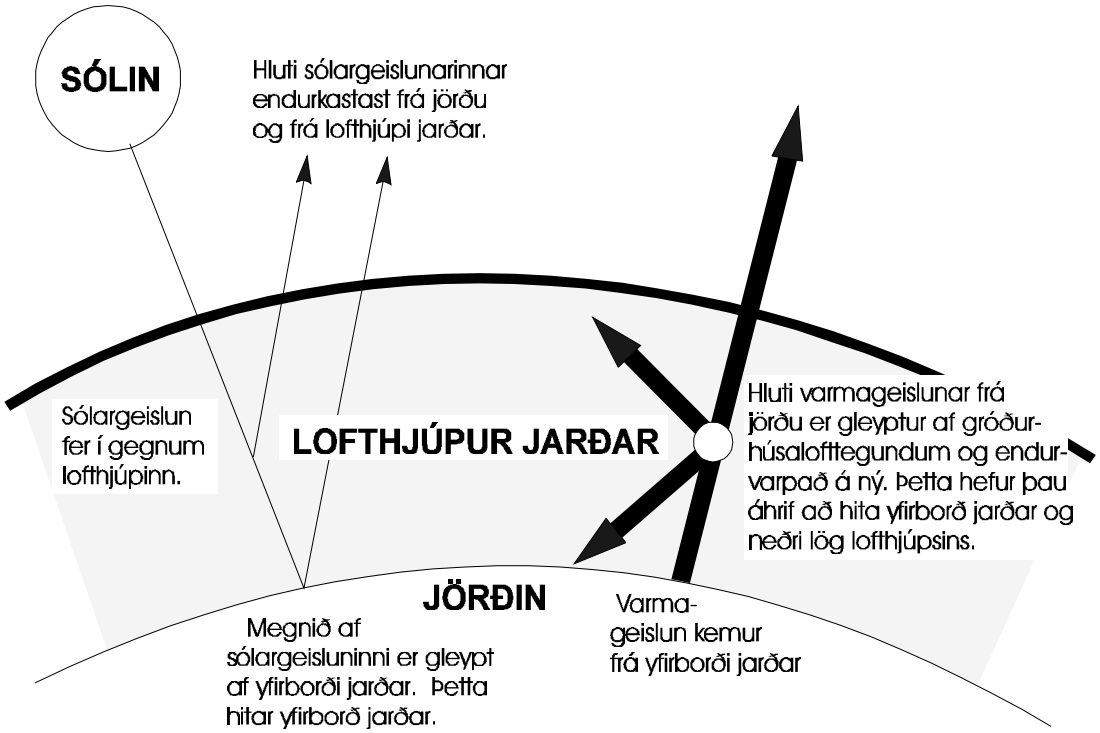
1.2. The greenhouse effect

The earth may to some extent be compared to a greenhouse. Its atmosphere serves a purpose similar to that of the glass in greenhouse. It allows the visible radiation of the sun to easily penetrate, while absorbing or containing much of the thermal radiation from the earth's surface. In this manner the atmosphere limits heat loss from the earth. This atmospheric effect on the temperature and climate on earth are generally referred to collectively as the greenhouse effect. Figure 1 shows a stylised representation of the greenhouse effect.

The greenhouse effect itself is by no means an adverse one; on the contrary, it is necessary to create conditions favourable for life on earth. The mean temperature at the earth's surface is now approximately 15°C and has remained relatively steady for a long period. Were it not for the greenhouse effect the surface temperature would be some 33 degrees less and the earth frigid and completely uninhabitable.

The problem now facing humanity is caused by the substantial increase in the concentration of anthropogenic greenhouse gases in the atmosphere, with the result that, if the trend continues, it will result in global climatic disruption with unforeseen consequences.

Figure 1: Stylised representation of the greenhouse effect. (not available electronically in English)



The main components of the atmosphere, nitrogen (N_2) and oxygen (O_2), do not absorb thermal radiation from the earth and thus do not contribute to the greenhouse effect, as do, however, water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrous oxide (N_2O) and various halocarbons (CFC etc.). These gases are referred to as greenhouse gases because of the greenhouse effect they cause. Since anthropogenic emissions of water vapour and ozone are low in comparison with natural emissions, these two gases are generally not included in discussions of the increasing anthropogenic greenhouse effect.

In addition to the previously mentioned greenhouse gases there are other gases which contribute mainly in an indirect manner to the greenhouse effect, for instance by increasing the concentration of ozone (in the troposphere) or of carbon dioxide. The main gases in this group are carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC). The effect of these gases is considered to be relatively slight, however, in comparison with other greenhouse gases.

The effect of the different greenhouse gases on the atmosphere varies greatly according to their nature. The greenhouse effect is determined chiefly by their concentrations in the air, their ability to absorb thermal radiation and the length of time they persist in the atmosphere. The global warming potential (GWP) of a gas is a measure of the greenhouse effect caused by the gas in comparison with that of the same weight of carbon dioxide. The GWP factors apply for a specified period, most

commonly for the next 100 years (GWP-100). Carbon dioxide is used as a reference in determining warming factors and has the factor 1 for any period under consideration. Most of the common greenhouse gases have a higher warming factor than carbon dioxide, even several thousand times greater. The extensive effect of carbon dioxide is primarily the result of how much of it there is in the atmosphere and of the enormous amount released anthropogenically by the burning of fuel.

1.3. Probable consequences of an increase in the greenhouse effect

There is considerable uncertainty as to how much warming can be expected due to an increase in the greenhouse effect, but it is considered likely to average between 1 and 5°C during the next century, and in all likelihood to be slightly more in higher latitudes than in lower ones.

The probable consequences of the global warming are likely to be an increase in the desert areas and the extinction of many life forms. At the same time, ecological conditions in general in some of the hotter countries could worsen. Due to thermal expansion of the oceans and the melting of ice caps the level of the oceans would gradually rise and the danger of flooding increase in some fertile and densely populated areas, as a considerable part of the world population lives just above sea level. Additional changes could occur in ecological conditions in the sea, due to changes in ocean currents or salinity. Not all areas are equally vulnerable to the effects of warming and conditions for agriculture could even improve in colder regions in the long term. Nonetheless, it is clear that the consequences of rapid and extensive changes in the global climate could be very serious, even though no attempt is made to predict the effects on the world economy or on international political stability.

Iceland is located at the junction of warm and cold air and ocean currents, which determine the climate in the country to a large extent. There is still a great deal of uncertainty as to regional changes in currents and winds, and as a result there is little to be said conclusively on the changes which could occur here. Warming by a few degrees here would probably have a positive effect on the vegetation in the country, but it is not clear what the effects would be on fisheries and the habitats of various marine species.

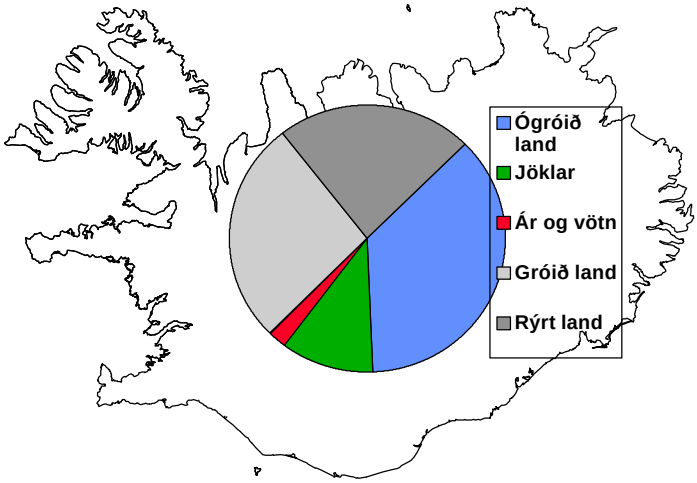
2. Basic Data and National Circumstances

2.1. Location and geography

Iceland is the second largest island in Europe, 103,000 km^2 in area. The land lies in the North Atlantic astride the mid-Atlantic ridge, with its most northerly extremes bounding on the Arctic Circle. Located at the junction of warm and cold ocean and atmospheric currents, the biosphere is extremely sensitive to any change in the global meteorological and oceanographic systems. Iceland is a volcanic country, with numerous active volcanoes and extensive geothermal resources. Mean elevation is 500 m above sea level and the highest mountain, Öræfajökull, is 2119 m. Only one-fourth of the country lies below the 200 m elevation line. The landscape is characterised by mountains and glaciers, valleys and a coastline intersected by fjords and inlets, with relatively little lowland area except along the southern coast.

Some 51 thousand km^2 (49%) of the country is wasteland and of this some 11 thousand km^2 (11%) are covered by glaciers and another 2300 km^2 (2.2%) by rivers and lakes. The numerous fast-flowing rivers transport a great volume of water and eroded soil to the sea. Most lakes, however, are relatively small. Some 28.5 thousand km^2 (28%) of the country have extensive or fairly extensive ground cover, almost two-thirds of it dryland vegetation and the remaining one-third wetland vegetation. Some 24 thousand km^2 (23%) of the country have sparse or poor ground cover. The remains of former forests cover less than one thousand km^2, or about 1% of the country. Some 25 thousand km^2 of land are arable (24%) and 1400 were under cultivation in 1990.

Figure 2.1.1. *Physical geography*



Source: Icelandic Geodetic Survey

Iceland is surrounded by its 758 thousand km^2 exclusive economic zone, which has a rich variety of marine life due to the warming effects of the Gulf Stream and the

convergence of the warm ocean currents of the Atlantic with cold seas moving southward from the Arctic Ocean.

2.2. Climate

Iceland has a cold temperate oceanic climate, with relatively mild winters and cool summers. The weather is constantly changing and precipitation is frequent, but the mean temperature is considerably higher than might be expected at this latitude. In lowland areas along the southern coast mean January temperature is around 0°C but around -2°C on the northern coast. Areas further inland are somewhat colder. Mean July temperature in most lowland areas is around 10°C, but around 8°C along the northern and eastern coasts. Winds are considerable and rain frequent. Mean precipitation ranges from 400 to 4000 mm annually depending upon the location. The annual average in Reykjavík is 805 mm. Because of the low mean temperature interior heating is practically a necessity all year round. On the other hand, emissions of greenhouse gases due to heating are low due to the fact that 85% of buildings have geothermal heating. Emissions of carbon dioxide due to space heating in 1990 amounted to less than 3% of the total released in the country and emissions due to thermal energy production less than 4%.

2.3. Natural resources

Iceland is scarcely rich in natural resources in the traditional sense of the word. There are no important minerals found in the country and the geographical location and harsh climate make crop raising difficult, so that livestock raising is the basis of agriculture. Clean sources of energy are, however, found in plenty (geothermal and hydroelectric power), the fishing banks are rich and, last but not least, the natural surroundings are unique.

The technically harnessable hydro power potential of Icelandic rivers has been estimated at 64 terawatthours (TWh) annually, of which 30 TWh could be economically developed. The geothermal potential is considered to be around 200 TWh annually for 100 years and some 20 TWh of electricity could be produced annually using present technology. Less than one-seventh of the hydro power potential which is considered feasible for development has already been developed and only 1% of the geothermal potential.

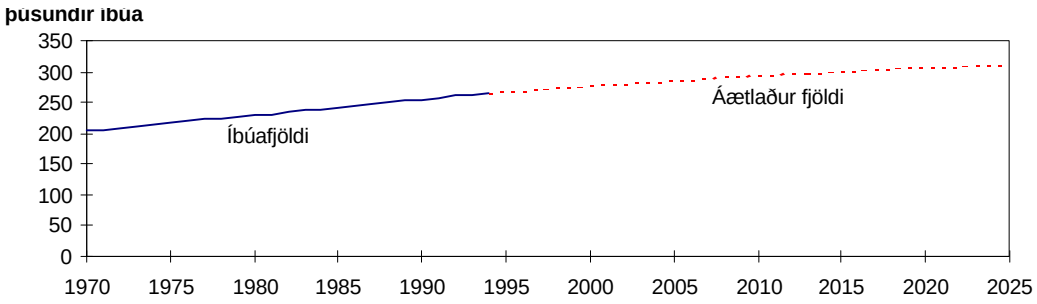
A wide variety of fish stocks are found in the waters surrounding Iceland, and over 270 different species have been identified within the country's exclusive economic zone. Some 150 of them spawn in the region. These ocean resources are extensively utilised and the total catch on the Icelandic banks in 1990 was approximately 1500 thousand tons. This large-scale pursuit results in substantial emissions of greenhouse gases due to the oil consumption of the fishing fleet. About 30% of the total emissions of carbon dioxide in Iceland in 1990 were released by fishing vessels.

2.4. Society

Some 263 thousand people live in Iceland. Settlement is primarily along the coast, and is concentrated especially in the capital, Reykjavík, and the vicinity, where about 57%

of the nation lives. Outside of this area settlement is sparse, with less than one inhabitant per square kilometre. In 1990 emissions of carbon dioxide were estimated to be 8.5 tons of CO_2 per inhabitant. The sparse settlement of the country requires considerable transport over long distances, and it is thus understandable that transportation should play a large role in the emissions of greenhouse gases in Iceland, as here there are few energy alternatives other than petroleum products. Some 64% of total emissions of carbon dioxide in Iceland in 1990 were from transportation (air transport, coastal shipping and road transport).

Figure 2.4.1. *Population and projected population growth 1970 - 2025*



Source: Statistics Iceland

The living conditions and economic situation in Iceland is comparable to that of other western countries. The general educational level of the population is among the highest in Europe and the distribution of wealth and incomes relatively equal. Public health is generally good, as are health services, with the result that life expectancy at birth is among the highest in the world.

2.5. Government

The government in Iceland is a representative parliamentary democracy. There are close connections between the cabinet and the Parliament (*Althingi*) and cabinet ministers are almost without exception selected from among the leaders of the parties forming the governing majority in Parliament.

The *Althingi*, with which legislative power rests, prepares, debates and adopts legislation. The government, consisting of 13 ministries, holds the executive power. The cabinet ministers exercise executive power in their own ministries on behalf of the government to whom they are responsible. A minister has the power to issue regulations on specific matters on the basis of applicable laws adopted by the *Althingi*. A minister also has control of the public institutions under his jurisdiction on the basis of the relevant laws and regulations. The country is divided into 26 administrative districts (*sýslur*), in each of which district administrators (*sýslumenn*) perform certain functions in the name of the national government.

Iceland also has local administration. The basic unit is the local authority, which have been slightly reduced in number recently through unification actions, and number at present 171. The local authorities, some of which are divided into several smaller townships, have their own sources of revenue and budgets and are responsible for certain affairs in their own region, in accordance with the applicable laws and rules,

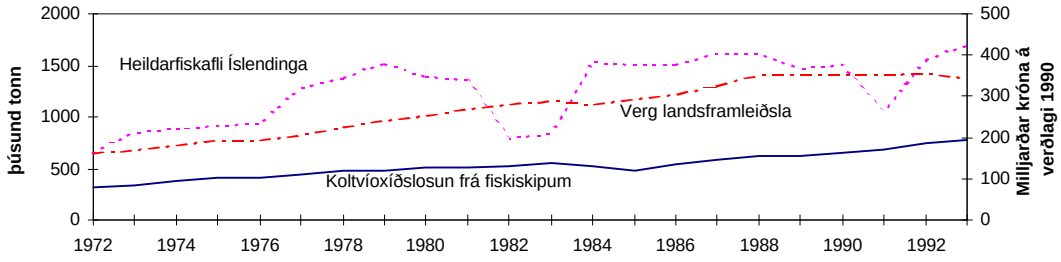
with at most nominal interference from the national government. Local authorities are responsible for various areas which are important with regard to emissions of greenhouse gases, for example, concerning the planning and operation of public transportation, part of educational affairs and regional planning.

The Ministry of the Environment plays a key role in shaping the action programme for the UN Framework Convention on Climate Change. Other Ministries which have also made a substantial contribution to policy formation and the implementation of policies and measures include the Ministries of Industry, Transport and Communications, Fisheries, Agriculture and Finance. Public institutions and public enterprises, operating under the auspices of these Ministries which participated directly or indirectly in preparing the action programme for the UN Framework Convention on Climate Change include: the National Centre for Hygiene, Food Control and Environmental Protection; Icelandic Meteorological Office; National Energy Authority; National Power Company; State Land Reclamation Service; Iceland Forestry Service; Marine Research Institute; and Agricultural Research Institute.

2.6. Industries and economy

Agriculture, fisheries and energy production have accounted for about one-quarter of GDP for the last two decades. The fisheries sector, including both actual fishing and fish processing, is the central pillar of the Icelandic economy. This is the all-important economic sector which has stimulated economic growth and provided full employment, and in many communities both the residents and the local enterprises are almost completely dependent upon a good catch. Catch quotas were imposed on vessels pursuing fishing stocks within the exclusive economic zone and as a result high-sea fishing has increased in recent years. Fisheries supports 15% of domestic production and accounts for some 75% of goods exports. Figure 2.6.1 shows clearly the relationship between carbon dioxide emissions of fishing vessels, total catch and national production.

Figure 2.6.1. *Total fishing catch, emissions of carbon dioxide and GDP*



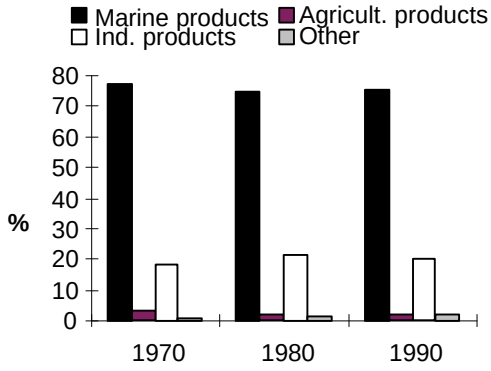
Sources: National Economic Institute, Ministry of the Environment

Despite the fact that the location of the country and its natural conditions are relatively unfavourable, agriculture in Iceland satisfies domestic demand for dairy and meat products and is thus important to the economy despite the fact that its share of national production is only 3%. Most of the grasslands are used for fodder production or as grazing for sheep, milch cows and horses, which comprise the major portion of Icelandic livestock. Market gardening and crop raising in very limited, although considerable quantities of potatoes, turnips, carrots and cabbage are produced.

Geothermal sources are widely utilised in cultivation of flowers and vegetables in greenhouses and nursery boxes under glass.

The unique natural surroundings in Iceland attract a large number of travellers and the travel industry is a growing sector, accounting for 9% of the nation's foreign currency earnings in 1990.

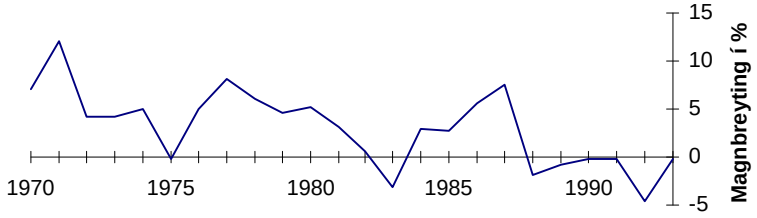
Figure 2.6.2. *Exports (fob-value) 1970, 1980 and 1990*



Source: National Economic Institute

The Icelandic economy is highly dependent upon foreign trade and is structurally similar to that of other western countries. Most Icelanders work in commerce and service industries, while manpower in fisheries and agriculture is steadily decreasing. Per capita production capacity is comparable to that of industrialised nations and the lifestyle is similar. Annual mean growth was 4.6% during the years 1970-90 but in recent years there has been a contraction in growth and stagnation in domestic production. The reasons for this decline are, in particular, reduced catch quotas of cod due to poor recruitment several years in a row, and the consequent loss of the value they would have added to the national economy.

Figure 2.6.3. *Change in GDP per capita from previous year 1970-93*



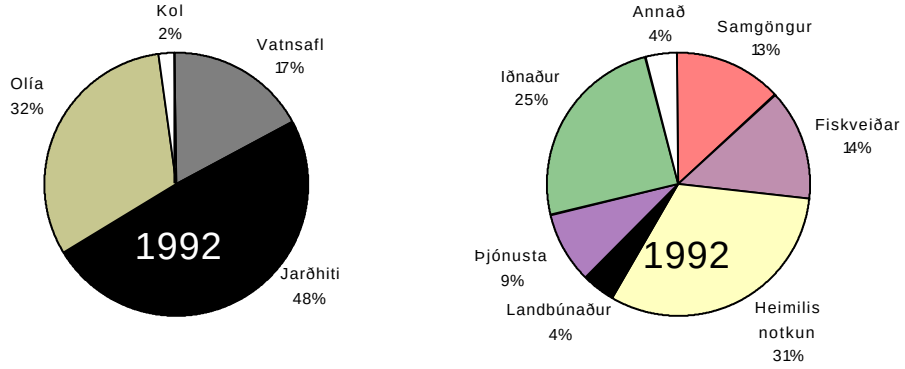
Source: National Economic Institute.

2.7. Energy production

Per capita energy consumption in Iceland is among the highest in the world. The total domestic energy consumption in 1993 was approximately 89 petajoules (PJ) or the equivalent of 2119 thousand tons of oil, which corresponds to about 341 gigajoules (GJ) per capita. Consumption of energy from primary sources in Europe in 1991 was about 140 GJ per capita and 320 GJ per capita in North America. The total energy consumption in Iceland includes geothermal heat, which is utilised both for space heating and the production of electricity. Fuel purchased by Icelandic vessels and

aircraft abroad is not included (9 PJ). Some 65% of this energy is obtained from environmentally clean domestic energy sources, see Figure 2.7.1. The comparable figure for OECD countries is 2-3%.

Figure 2.7.1. *Primary energy sources (A) and domestic energy consumption (B) 1992*



Source: The National Energy Authority

In 1990 Icelanders obtained 93.5% of their electricity from hydro power stations and 6.4% from thermal power plants. Approximately one-half of the electricity is used by power intensive industry.

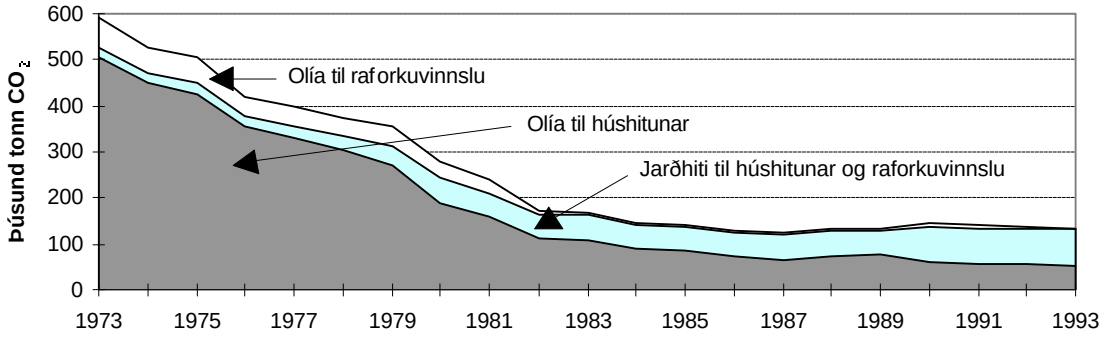
Iceland's unique situation is reflected in its fuel consumption. The size and pursuit capacity of the fishing fleet together with transportation requirements of sparse settlement explain most of the fuel consumption and are also in a class by themselves as far as growth is concerned. See Table 2.10.1.

Approximately 85% of oil consumption is for fisheries and transportation, where domestic energy sources cannot be utilised for technical and economic reasons.

2.8. Limits on emissions prior to 1990

From 1970 to 1987 very substantial efforts were made in Iceland to establish geothermal heating distribution centres throughout the country, to utilise geothermal resources and reduce oil consumption for space heating purposes. Hydroelectric transmission systems were also extended to reduce oil-powered electricity production. This resulted in a reduction in the emission of carbon dioxide (CO_2) from stationary power production in Iceland of from 590 thousand tons in 1973 to only 145 thousand tons in 1990, despite a considerable increase in total energy consumption during the same period. This dramatic reduction in emissions, 445 thousand tons, is the equivalent of 20% of the total emissions in the country in 1990. This remarkable change is depicted in Figure 2.8.1.

Figure 2.8.1. *Emissions of carbon dioxide from space heating and electricity production 1973-1993*



Source: The National Energy Authority

As mentioned previously, fisheries and industry connected with fisheries are the most important economic sectors in Iceland and the main pillars of the Icelandic economy. Despite the increase in oil consumption up until 1990, much was done to forestall this increase. The fishing fleet was renewed extensively and the technical equipment aboard is among the best anywhere. Oil consumption indicators were installed in most trawlers to facilitate fuel conservation and increased emphasis was placed on improving both hull and propeller design of vessels to reduce resistance and improve fuel utilisation. In addition to technical measures intended to reduce the fuel consumption of the fishing fleet there has been a great change in pursuit. Changes were made to the system of fisheries management in the Icelandic exclusive fisheries zone in 1984, when a special catch quota system was introduced with transferable fishing quotas. The quota system increases cost-effectiveness in fisheries and encourages fuel conservation in fishing.

The aircraft of Icelandic airlines, in both domestic and international services, have been extensively renewed in recent years. This has led to a substantial reduction in their fuel consumption, often amounting to almost 40%. The greater part of the reduction occurred prior to 1990, and extensive additional savings are considered unlikely during the remaining years of this century.

2.9. Future prospects

On the economic scene, GDP is not expected to increase significantly in Iceland until the closing years of this decade, if attempts to strengthen the cod stock prove successful. On the other hand, both national income and national production are expected to increase somewhat more rapidly due to a reduction in foreign debt and improved terms of trade. Foreign debt is expected to drop from 58% of domestic production to 50% by 1998.

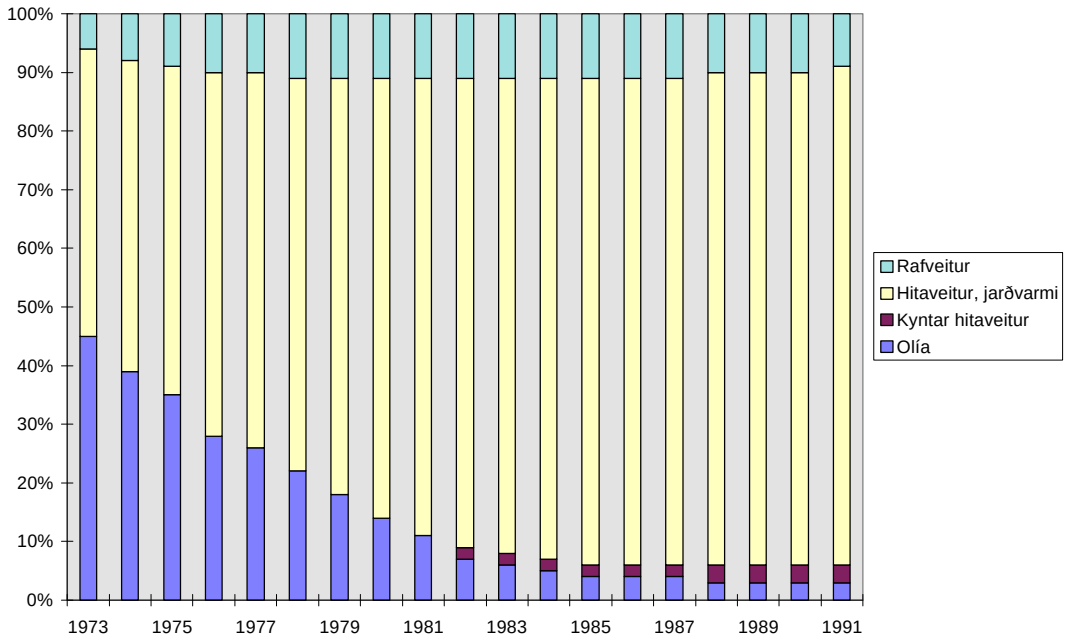
The possibilities for reducing emissions of greenhouse gases in Iceland are relatively limited. Renewable energy sources have already practically replaced oil and coal to the furthest extent possible. Mobile sources of greenhouse gases (vehicles, ocean vessels and aircraft) are more difficult to deal with, especially with regard to emissions from fishing vessels. The importance of fisheries for the national economy is such that it makes it very difficult to apply restrictions on emissions. On the other hand, we can expect a reduction in the rate of increase of emissions from fishing vessels seen in recent years, as the pursuit capacity of the fishing fleet is already beyond the capacity

of the fishing stocks to support. Increased high-sea fishing may, however, have an effect here and postpone this development.

2.10. Special circumstances

The unique position of Iceland is characterised by the bountiful supply of environmentally clean energy sources and by the importance of transportation and fisheries for the national economy. Concerted attempts have been made over the last two decades to increase consumption of energy from renewable domestic sources and by so doing reduce the use of fossil fuels. Stationary energy consumption has benefited from these developments, but it has been more difficult to deal with mobile consumption, i.e. in fisheries and transportation. Figure 2.10.1 shows how environmentally clean, domestic energy sources have in past decades gradually replaced oil for space heating in Iceland. A similar picture was given previously in Figure 2.8.1.

Figure 2.10.1. *Space heating in Iceland by type of energy supply. Annual values 1973-1991*



2.10.1. Industry and energy production

Unlike most OECD countries, economic development in Iceland has been supported to a large extent by the utilisation of energy sources which are both renewable and pollute less than fossil fuels. Highly successful domestic power developments over the past 20 years have substantially reduced atmospheric pollutants and accelerated the decrease in dependency on imported energy sources. The greatest portion of this reduction occurred prior to 1990. These extensive measures implemented in Iceland prior to 1990 reduce the country's possibility of fulfilling its obligations in accordance with the Framework Convention in their current form.

Continuing development of the hydroelectric and geothermal energy potential of the country is proposed, for increasing use industry, in power intensive industry, or even for export via submarine cable. Should plans for additional heavy industrial development, such as proposals for the construction of a new 200 thousand ton aluminium smelter, become a reality, for instance, a substantial increase in the emissions of greenhouse gases can be expected from industrial activities in Iceland.

The position of the national government is that the success which was achieved in Iceland prior to 1990 in reducing the use of fossil fuels and in limiting emissions from stationary sources should be taken into account by international authorities, and recognition made of the limited possibilities at present for reducing emissions of carbon dioxide in the country from mobile sources. Furthermore, the government is of the opinion that it would be in contradiction to the real objectives of the Framework Convention should measures to restrict emissions of greenhouse gases prevent the utilisation of the environmentally clean, practically emission-free energy resources in Iceland. In this connection it should be kept in mind that industrial development in Iceland involves only a fraction of the emissions of greenhouse gases produced by comparable industry in other locations where the energy would be provided by fossil fuels.

2.10.2. Fisheries

Few nations are as dependent upon the prosperity of a single industrial sector as the Icelanders are where fisheries are concerned, as this sector alone brings in over 70% of the country's goods export income. Per capita fishing catch was well over 7 tons in 1988, approximately 185 times the average for OECD countries and more than 16 times the per capita catch of Norway, for instance.

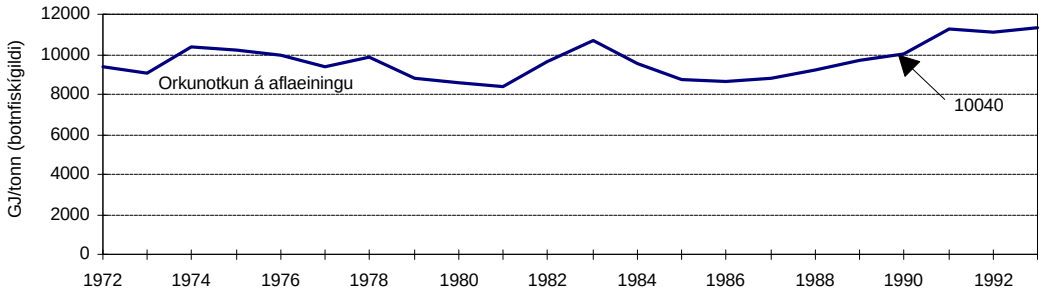
Because of the extreme dependence of the national economy on the production and export of marine products, the authorities have introduced special measures to protect this vital resource. The extension of the limit of fisheries jurisdiction to 200 miles in 1975 brought the Icelanders full jurisdiction over the fishing banks surrounding the country and opened the way for measures to encourage rational exploitation of marine resources. Fisheries management has been in force for 16 years, to begin with in the form of limits on the number of pursuit days, then with a quota system whereby catch is allocated to individual vessels. Additional technical measures are also applied, including rules on minimum mesh size of nets and temporary closures of specific ocean areas.

The renewal of the fishing fleet has progressed rapidly over the past decade and its pursuit capacity exceeds that which the fishing stocks of the Icelandic banks can sustain. It will require some time to adapt the fishing fleet to catch levels sustainable by the fishing stocks, but efforts aim at this objective, and the management system in use fulfils the requirements necessary to reduce the capacity of the fleet without reducing catches or the amount of fish landed. The fuel consumption of the fishing fleet has, however, increased due to increasing trawling, full processing of catches aboard freezer vessels, larger trawls, increasing fishing efforts on distant banks and an increase in the number of small boats. The outlook is for the fleet to adapt itself to the

sustainable catch levels of the fishing stocks in coming years, although increased high-sea fishing could affect these developments, at least in the short term.

Research has provided an estimate of the equilibrium catch of the Icelandic banks. Equilibrium catch refers to the size of the total catch which can be taken without endangering the fishing stocks. Subsequent to this research proposals have been advanced to the effect that it would be logical to limit emissions of carbon dioxide from fishing vessels to the level of energy consumption required to fish the equilibrium catch.

Figure 2.10.2. *Energy consumption of Icelandic fishing vessels per catch unit (demersal species equivalents) 1972-1993. The composition and quantity of the catch in 1990 is the closest to that of the estimated equilibrium catch.*



2.10.3. Transportation

Transportation is a prime factor in determining regional development in Iceland. Improvements to the domestic transportation system are one of the most important aspects of progress in general and can make the deciding difference for settlement in many districts of the country. The rugged landscape and harsh climate of the country make efficient transportation throughout the country difficult and the small size of the population and sparse settlement prevents the implementation of expensive solutions in public passenger and goods transportation. Private automobiles are highly necessary and it is clear that this situation will continue in the future. Domestic transport of goods is primarily carried out by ships and transport vehicles, while buses and small aircraft look after passenger transport. Population growth and an increase in the numbers of foreign travellers will result in increasing emissions from transportation in the coming years.

Table 2.10.1. *Fuels and carbon sources in 1990-93, 1995 and 2000[1)].*

		1990 Use 1000 ton	**1991 Use** 1000 ton	**1992 Use** 1000 ton	**1993 Use** 1000 ton	**1995 Est.** 1000 ton	**2000 Est.** 1000 ton
Fuels and carbon sources							
Gasoline	Road transport	128	133	136	135	133	148
Aircraft fuel	Dom. air transport	2	2	1	1	1	1
Jet fuel	Dom. air transport	8	8	7	7	7	7
Kerosene		1	0	0	0	-	-
Diesel oil		**286**	**267**	**281**	**288**	**288**	**281**
	Power production	2	2	2	1	1	1
	Industry	2	2	2	2	2	2

	Road transport	80	71	70	72	75	79
	Fishing vessels[2)]	175	168	182	191	190	185
	Coastal shipping	11	11	11	8	8	8
	Space heating and swimming pools	16	14	14	13	12	6
Heavy fuel oil		**99**	**95**	**121**	**132**	**127**	**119**
	Industry	56	35	59	65	63	60
	Fishing vessels[1)]	32	50	52	53	53	50
	Coastal shipping	7	7	7	11	8	8
	Space heating and swimming pools	3	3	3	3	3	1
Natural gas	Industry	1	1	1	1	1	1
Coal		**89**	**76**	**74**	**93**	**94**	**96**
	Industry	19	17	12	13	15	17
	Industrial processes	70	59	63	80	79	79
Carbon electrodes		**43**	**43**	**42**	**44**	**43**	**43**
	Industry	1	1	1	1	-	-
	Industrial processes	42	43	41	43	43	43
Wood chips	Industrial processes	17	13	13	10	10	10
Oil wastes	Commerce and services	3	4	3	4	-	-

[1)]Fuel estimates are in accordance with provisional fuel forecasts by the National Energy Authority and carbon sources are estimated by the carbon dioxide committee.
[2)] Calculations assume that the fishing fleet decrease gradually in size in coming years to adapt to sustainable catch levels of the fishing stocks.

Sources: The National Energy Authority and the Ministry of the Environment.

Emissions inventory

3.1. Introduction

This chapter explains the main conclusions of calculations of emissions of anthropogenic greenhouse gases in Iceland in 1990, using methods of calculation based on the standardised draft guidelines of the IPCC.

Basic information was collected from the National Energy Authority and innumerable other enterprises and institutions. Emphasis was placed on obtaining a comprehensive picture of the emissions of the most significant types of greenhouse gases, i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC) and fluorocarbons (PFC). Gases causing an indirect greenhouse effect, such as nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO), are included in a similar manner, to the point these are covered by IPCC methods.

Sources of greenhouse gases are grouped under the following six categories in accordance with the draft guidelines of the IPCC: energy (fuel combustion, fugitive emissions, and geothermal energy), industrial processes, solvents, agriculture, forestry and land use change, refuse and waste water. These main categories are further divided into sub-categories as can be seen in Table 3.1.1. which shows the emissions of greenhouse gases in Iceland in 1990.

In Table 3.1.1 an additional two categories have been added to the classification system of IPCC. Emissions from fishing vessels are reported separately under emissions from transportation and in addition emissions from geothermal energy production have been added as an extra category under energy. It was felt that emissions from geothermal energy should be included, as geothermal energy production increases the emissions of geothermal steam and of the gases present in this steam.

The release of greenhouse gases resulting from international transport, including all emissions from international ocean and air transport, is not included in the figures for the total emissions from the country.

Carbon dioxide which is released by the decaying and combustion of vegetal residues and other biomass is not included in emission figures, as a balance is assumed to exist between growth and decay. On the other hand, the release of other greenhouse gases from decomposition of biomass is included.

The absorption of carbon dioxide in land reclamation and afforestation, and emissions due to soil erosion, are not included in these figures because of a lack of accurate basic data. Efforts are underway to provide the information which is lacking, for instance, by research investigations, so that calculations will be able to include the absorption of carbon dioxide when the report comes up for review.

Table 3.1.1. *Estimated total emissions of anthropogenic greenhouse gases (GHG) in Iceland in 1990*.*

	CO_2 1000 tons	CH_4 1000 tons	N_2O 1000 tons	NO_x 1000 tons	CO 1000 tons	NMVOC 1000 tons	HFC 1000 tons	PFC 1000 tons
Total emissions	**2171.9**	**23.1**	**0.6**	**20.4**	**26.1**	**5.9**	**0**	**0.045**
1 Energy (combustion and fugitive fuel emissions)	**1777.0**	**0.2**	**0.1**	**20.3**	**24.8**	**3.6**	**-**	**-**
A Fuel combustion	1698.2	0.2	0.1	20.3	24.8	3.6	-	-
1 Energy and transport	5.1	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry	233.3	0.0	-	0.6	0.1	-	-	-
3 Transport	1392.7	0.2	0.0	19.1	24.7	3.6	-	-
- fishing vessels	655.5	0.0	0.0	14.9	3.8	0.8	-	-
4 Commerce/Services	5.7	0.0	0.0	0.0	0.0	-	-	-
5 Space heating	59.9	0.0	0.0	0.1	0.0	-	-	-
6 Agricult./Forestry	-	-	-	-	-	-	-	-
7 Other	1.6	-	-	-	-	-	-	-
8 Biomass		-	-	0.4	-	-	-	-
B Fugitive fuel emissions	-	-	-	-	-	-	-	-
1 Oil	-	-	-	-	-	-	-	-
C Geothermal	78.8	-	-	-	-	-	-	-
1 Geothermal production	78.8	-	-	-	-	-	-	-
2 Industrial processes	**390.5**	**-**	**-**	**0,0**	**-**	**-**	-	**0.045**
A Iron and steel industry	203.5	-	-	-	-	-	-	-
B Non-ferrous metals	136.5	-	-	-	-	-	-	0.045
C Inorganic chemicals	-	-	-	0,0	-	-	-	-
D Organic chemicals	-	-	-	-	-	-	-	-
E Non-metallic mineral products	50.5	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	-
3 Use of solvents	**-**	**-**	**-**	**-**	**-**	**2.3**	**-**	**-**
A Paint	-	-	-	-	-	1.1	-	-
B Degreasing and dry cleaning	-	-	-	-	-	0.4	-	-
C Chemical manufact./processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	0.9	-	-
4 Agriculture	**4.5**	**11.9**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric fermentation	-	11.0	-	-	-	-	-	-
B Animal fertiliser	-	0.9	-	-	-	-	-	-
C Rice growing	-	-	-	-	-	-	-	-
D Agricultural soils	4.5	-	0.5	-	-	-	-	-
E Agricultural waste	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Change in land use and forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Deforestation and combustion	-	-	-	-	-	-	-	-
B Grassland conversion	-	-	-	-	-	-	-	-
C Abandonment of cultivated land	-	-	-	-	-	-	-	-
D Forestry	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**11.0**	**-**	**0.1**	**1.3**	**-**	**-**	**-**
A Refuse disposal	-	11.0	-	0.1	1.3	-	-	-
B Waste water	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International use (not incl. in total)	294.1	0.0	0.0	2.5	1.1	0.2	-	-

**In accordance with IPCC categories.*
Source: Ministry of the Environment

3.2. Emissions of carbon dioxide

Emissions of anthropogenic carbon dioxide in Iceland in 1990 amounted to 2172 thousand tons, if emissions from biomass and international transport are excepted. The main portion was the result of fuel combustion, some 78% of the total, and another 18% from industrial processes. Industrial processes include the emissions from industry which do not result from the combustion of fuel, such as emissions from carbon electrodes, carbon sources, the use of calcium carbonate from mollusc shell

sand in cement production, etc. Other significant emissions include the carbon dioxide released by steam from geothermal energy production.

Figure 3.2.1. *Main sources of carbon dioxide 1990 (thousand tons of emissions). The figure on the right shows a breakdown of the transport category.*
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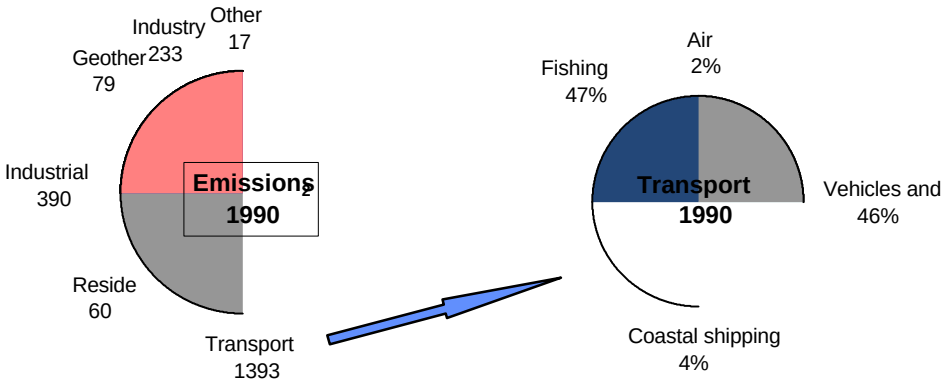


Source: Ministry of the Environment

Emissions due to soil erosion and absorption due to self-generated land reclamation, plantings of ground cover or forestry are not included in this summary because of a lack of data.

3.2.1. Combustion of fossil fuels

Some 1698 thousand tons of carbon dioxide were released through the burning of fossil fuels in Iceland in 1990. Fishing vessels account for the greatest single portion of the amount, some 655 thousand tons of carbon dioxide or just over 30% of the country's total emissions. Vehicles and machinery emitted a similar amount, 647 thousand tons, while industry contributed 11%, accounted for primarily by fish oil and meal processing plants and a cement plant. Other sources were coastal shipping, 3%, residential use, 3%, and domestic air transport, with slightly more than 1% of the total emissions for the year. The total represents just over 78% of the total emissions from the country.

In recent years the use of liquid fuels has increased steadily in Iceland. From 1987 to 1993 consumption of diesel fuel increased from 267 thousand tons to 288 thousand tons, of heavy fuel oil from 81 to 132 thousand tons and of gasoline from 118 to 135 thousand tons. This corresponds to the increased energy consumption of the fishing fleet and the increase in number of vehicles.

3.2.2. Industrial processes

Some 390 thousand tons of carbon dioxide come from industrial processes. The ferrosilicon plant emitted 203 thousand tons of carbon dioxide (just over 9% of total emissions) in the production of almost 63 thousand tons of ferrosilicon. The production of ferrosilicon requires carbon sources, coal and coke, together with electrodes, for the reduction of quartz (SiO_2). The process produces carbon monoxide which in the end combusts at the surface to form carbon dioxide.

The aluminium smelter in Straumsvík emitted 6% of total emissions of carbon dioxide in Iceland, or about 136 thousand tons. Almost all of the emissions come from the carbon electrodes used in the reduction of aluminium oxide (Al_2O_3) in the production of aluminium.

The non-metallic mineral industry produces just over 2% of the total emissions of carbon dioxide, in particular through the production of cement. Upon heating in the cement furnaces the sand formed from mollusc shells ($CaCO_3$) breaks down into calcium oxide, which is one of the main ingredients in cement, and carbon dioxide which is released into the atmosphere. In 1990 some 50 thousand tons of carbon dioxide were emitted in the production of 114 thousand tons of cement.

At the diatomite plant near Lake Mývatn diatomite is processed from the deposits of diatomaceous algae on the lake bottom. In the production process organic remains are removed by calcination and in the process carbon dioxide is released into the atmosphere. In 1990 some 26 thousand tons of diatomite were produced and the process is estimated to have emitted some 5 thousand tons of carbon dioxide.

Emissions from industrial processes have remained fairly constant in recent years, as in heavy industry emphasis is placed on maintaining a steady rate of production. The slight variation which has occurred was mainly the result of a decrease in the production of ferrosilicon.

3.2.3. Geothermal energy

The carbon dioxide present in harnessed geothermal steam varies depending upon the geothermal area. The National Energy Authority has estimated that emissions of carbon dioxide from geothermal areas have increased by some 79 thousand tons due to the utilisation of geothermal energy. This corresponds to 4% of the total emissions in 1990. There is, however, a considerable degree of uncertainty in these estimates, and the figures are only a general indication of the dimensions of emissions from thermal energy development.

Emissions from geothermal areas have increased in recent years corresponding with the increased exploitation of geothermal energy. If emissions of carbon dioxide from geothermal energy are compared to those from the combustion of fossil fuels, it is evident that fossil fuel combustion emits almost 40 times more carbon dioxide per unit of energy than does geothermal energy. Geothermal energy is thus relatively speaking a very clean energy source.

3.3. Emissions of methane

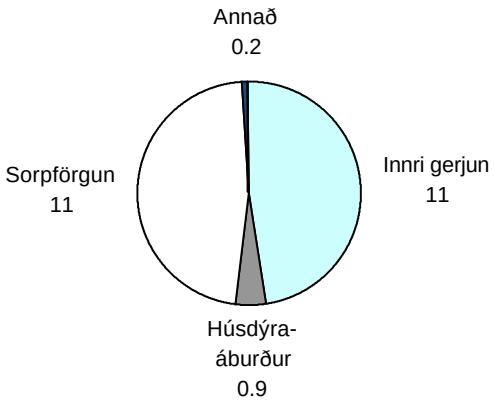
Total emissions of methane from agriculture and other activities was estimated at 23 thousand tons in 1990. The principal sources are enteric fermentation in domestic animals and refuse disposal as landfill, which each account for slightly over 47% of total emissions. Other emissions come from animal wastes, 4%, and fuel, 1%.

According to the draft guidelines from IPCC, the 100-year global warming potential (GWP-100) for methane is 11, if only the direct effects of the gas are taken into

account. On this basis, 23 thousand tons of methane emissions are the equivalent of 254 thousand tons of carbon dioxide.

Methane emissions from landfills in Iceland have not been investigated, nor do any reliable figures exist as to the composition and quantity of refuse. In calculating emissions estimated figures from the Food Control and Environmental Protection Agency of Iceland on the quantity of refuse produced annually were used: 630 kg per person in urban areas and 435 in rural areas. Local authorities were also grouped according to the method of disposal used in order to estimate the quantity of refuse disposed of in landfills, incinerated in open refuse incinerators and burnt in refuse disposal furnaces. Information on the composition of refuse, energy content and methane emission factor was obtained, on the other hand, from the IPCC guidelines.

Figure 3.3.1. *Sources and emissions of methane 1990 in thousand tons.*



Source: Ministry of the Environment

No research has been done in Iceland on emissions of methane from domestic animals and all emission factors have been obtained from foreign sources. Figures for the number of domestic animals and quantity of animal wastes are, however, Icelandic and fairly reliable. Despite the increase in the number of horses emissions of methane have decreased in recent years due to a considerable decrease in the number of sheep.

Transport vehicles, especially passenger cars, cause some methane emissions due to incomplete combustion and fugitive fuel emissions. Many factors affect these emissions, such as the type of motor, correct tuning of its ignition system, carburetion and driving practices.

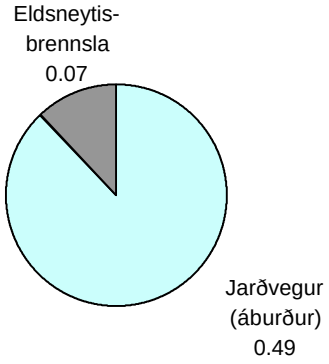
3.4. Emissions of nitrous oxide

Emissions of nitrous oxide were estimated to be around 550 tons in Iceland in 1990. Chemical fertiliser and animal wastes were considered to make the principal contribution, or approx. 88%, but here there is a high degree of uncertainty. Over 4% of the emissions were attributed to the use of nitrous oxide in health services and to the use of nitrous oxide as a power source for vehicles specially equipped for motor sports.

According to the IPCC draft guidelines the 100 year global warming potential (GWP-100) of nitrous oxide is estimated at 270. This means that 550 tons of nitrous oxide emissions are equivalent to 150 thousand tons of carbon dioxide.

Nitrous oxide is released into the atmosphere in the combustion of fossil fuels and about 5% of emissions in 1990 are attributed to transport, including fishing vessels. There is a high degree of uncertainty, however, as to the emission of nitrous oxide from motors, as many different factors are involved, such as type of motor, manner of use, maintenance, etc. Furthermore, research indicates catalytic converters (mandatory in new vehicles with gasoline engines as of mid-1992) increase emissions of nitrous oxide and there is thus likely to be some increase in emissions from gasoline-powered vehicles in coming years. Interior oil heating is considered to produce 3% of the total emissions of nitrous oxide in Iceland.

Figure 3.4.1. *Sources and emissions of nitrous oxide 1990 in thousand tons.*



Source: Ministry of the Environment

3.5. Emissions of fluorocarbons

Emissions of fluorocarbons from the aluminium smelter in 1990 were estimated to be 45 tons, but this figure is subject to a high degree of uncertainty. The calculations are based on information on the number and length of the anode effects between electrodes in the furnaces of the aluminium smelter and on measurements of emissions as a function of length of anode effect in comparable aluminium smelters in Norway.

If converted to carbon dioxide equivalents (GWP-100), 45 tons of fluorocarbon emissions correspond to some 210 thousand tons of carbon dioxide. In recent years these emissions have decreased substantially and for 1993 emissions are estimated to be just under 8 tons of fluorocarbons, which is only slightly more than one-sixth of the emissions in 1990. It should be pointed out that there is a high degree of uncertainty in the estimation of the quantity of fluorocarbons and their global warming potential as well. The calculations are made on the assumption that 90% of these emissions are tetrafluorocarbons (CF_4) and the remainder hexafluorocarbons (C_2F_6), but there is a

great deal of uncertainty in this assessment. According to the IPCC draft guidelines the 100 year global warming potential of these substances is >4500 for CF_4 and >6300 for C_2F_6.

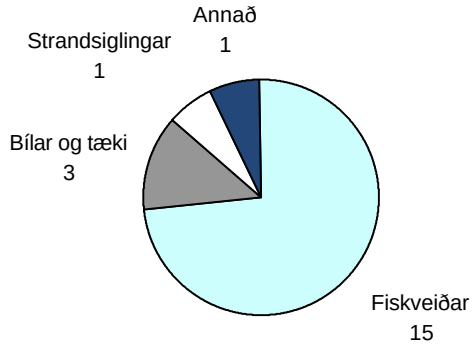
3.6. Indirect greenhouse gases

3.6.1. Emissions of nitrogen oxides

Nitrogen oxides are formed chiefly in the combustion of fossil fuels. Emissions depend upon the mixing of air and fuel in motors, the heat of combustion and pollution control devices. Diesel-burning motor vehicles without pollution control devices emit as a rule less nitrogen oxides than do comparable gasoline-burning vehicles. Gasoline-burning motor vehicles with catalytic converters, on the other hand, emit similar amounts of nitrogen oxides as do comparable diesel vehicles.

In 1990 emissions of nitrogen oxides in Iceland were estimated to be about 20 tons. Of this 73% was attributed to the fishing fleet, 7% to coastal shipping and 13% to motor vehicles and machinery. Other sources included industry, 3%, and combustion of biomass, 2%. Biomass in this connection refers to emissions caused by the calcination of organic remains in diatomaceous deposits.

Figure 3.6.1. *Sources and emissions of nitrogen oxide 1990 in thousand tons.*



Source: Ministry of the Environment

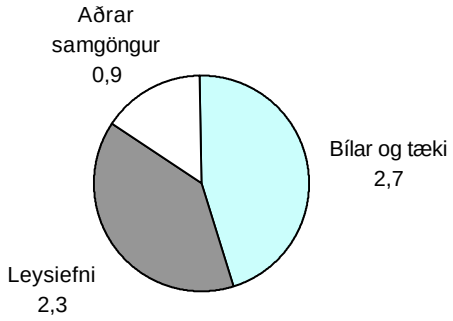
3.6.2. Emissions of volatile organic compounds

Non-methane volatile organic compounds (NMVOC) are released especially through combustion of fossil fuels and fugitive fuel and solvent emissions. Emissions of volatile organic compounds in the combustion of fossil fuels in motors is least with complete combustion. Where combustion is only partial, as is the case especially when motors are allowed to idle or run at low speeds, part of the fuel escapes unused through the combustion chambers and out into the atmosphere unless pollution control devices are used.

Emissions of non-methane volatile organic compounds were estimated to be slightly less than 6 thousand tons in Iceland in 1990. Transport is the main contributor with 61% of total emissions and the use of organic solvents is responsible for most of the rest, or just over 37%. Motor vehicles and machinery were responsible for more than two-thirds of the transport contribution (or 44% of total emissions) and fishing vessels

for almost one-quarter (14% of total emissions). As far as other factors are concerned, more than one-half of the solvent use was attributed to various types of paint and cleaning fluids, and more than one-third to road surfacing.

Figure 3.6.2. *Sources and emissions of volatile organic compounds 1990 in thousand tons.*



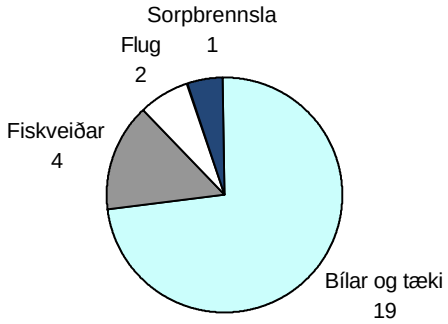
Source: Ministry of the Environment

3.6.3. Emissions of carbon monoxide

The primary sources of carbon monoxide are combustion of fossil fuels and biomass and most emissions come from automobile traffic. Carbon monoxide is formed in incomplete combustion of fuel. Generally speaking, the formation of carbon monoxide is the greatest when vehicles are idling or running at slow speeds after a cold start.

Emissions of carbon monoxide in Iceland were estimated to be slightly over 26 thousand tons in 1990. The major share comes from transport, 95%, and refuse incineration, especially open-air incineration, 5%. In transport it was automobiles and machinery which produced 72% of total emissions and fishing vessels 15%. Other contributors were domestic air transport, 7%, and coastal shipping, 1%. Increasing use of catalytic converters is expected to reduce emissions of carbon monoxide from gasoline-burning automobiles in coming years.

Figure 3.6.3. *Sources and emissions of carbon monoxide 1990 in thousand tons.*



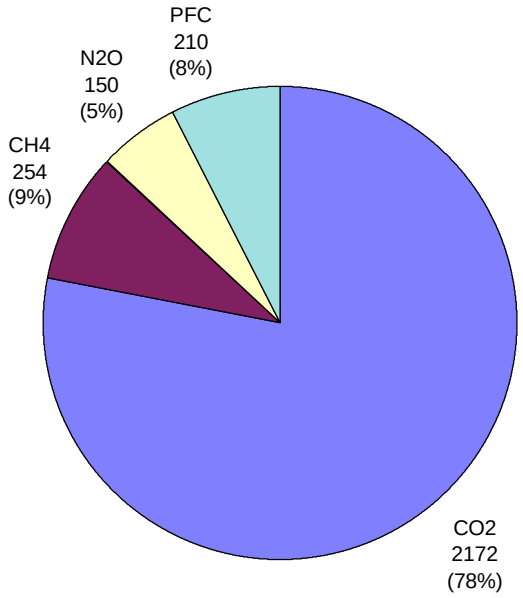
Source: Ministry of the Environment

3.7. Summary of calculations

Total emissions of the greenhouse gases carbon dioxide, methane, nitrous oxide and fluorocarbons were estimated to be 2785 thousand tons (in CO_2 equivalents, GWP-100) in the reference year 1990, if emissions due to soil erosion and absorption through afforestation and land reclamation are excepted. Total per capita emissions were about 10.9 tons in CO_2 equivalents, and 8.5 tons of this were emitted as CO_2. There were no emissions due to hydrofluorocarbons, as these gases were not imported for use as coolants until 1992.

Figure 3.7.1. shows the proportions of the above-mentioned gases in total emissions. The 100 year global warming potentials (GWP-100) for estimated direct greenhouse effects of the gases from the IPCC draft guidelines were used in converting their effects into CO_2 equivalents. Indirect effects of the gases can also be considerable, but no warming potentials were available for the indirect effects of the gases when this report was prepared.

Figure 3.7.1. *Proportions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorocarbons (PFC) in total emissions in 1990. CO_2 equivalents in thousand tons.*



Source: Ministry of the Environment

3.8. Uncertainty

3.8.1. Carbon dioxide

The principal emissions of carbon dioxide come from the combustion of fossil fuels and industrial processes. Information on fuel consumption in Iceland and the main industrial processes in heavy industry were used to calculate emissions. This information is highly accurate and there is thus little uncertainty involved in the calculations based upon it. There is thus little uncertainty in the conclusions on emissions of carbon dioxide.

3.8.2. Methane

There is considerable uncertainty as to the quantity and composition of the refuse disposed of in landfills in Iceland. Calculations here are based on IPCC figures for the composition of refuse in Western Europe. Refuse was either disposed of as landfill or otherwise combusted. The landfills have often not been very deep, which creates some uncertainty as to whether the bacterial action in the refuse is aerobic or anerobic. The estimates for methane emissions from refuse disposal as landfill is thus characterised by considerable uncertainty.

Domestic animals are prime contributors to emissions of methane. Enteric fermentation in animals releases large quantities of methane as does waste. Emissions

are highly dependent upon the amount of fodder consumed and the type of domestic animal and estimates are based upon IPCC emission factors. Figures for the number of domestic animals in Iceland are known and relatively reliable. It is, however, clear that substantial uncertainty is involved in the emission factors and additional bias is caused by the fact that the animal strains, their mean size, fodder consumed, etc. is not exactly the same as for animals in the countries where the emission factors were developed.

3.8.3. Nitrous oxide

There is a great deal of uncertainty involved in the figures for emissions of nitrous oxide. The nitrogen content and quantity of artificial fertiliser used is known, and an attempt has been made to estimate the amount and nitrogen content of domestic animal waste in Iceland. On the other hand, how much of the nitrogen is emitted in the form of nitrous oxide is not known. Calculations were based on the IPCC guidelines in order to arrive at some general indication of the emissions of nitrous oxide arising from the use of fertiliser.

Another source of nitrous oxide is fuel combustion. Fuel consumption is well known and emission factors from the IPCC guidelines were used in the calculations. Emissions of nitrous oxide from combustion engines is dependent upon many aspects which affect fuel combustion so the uncertainty in these figures is high.

3.8.4. Other gases

The uncertainty concerning emissions of other gases is almost completely due to the dependability of IPCC emission factors and the degree to which they can be applied to the usage in question.

There is, for example, considerable uncertainty in the area of road transport with regard to the composition and fuel consumption figures for the Icelandic automobile fleet. Added to this is the uncertainty involved in applying emission factors, calculated on the basis of the type composition and fuel consumption of automobiles in the US (Mobil 4), to the automobiles owned by Icelanders.

4. Policies and Measures

4.1. Introduction

At the beginning of 1991 the Minister of the Environment appointed a carbon dioxide committee to investigate emissions of greenhouse gases and lay the foundations of an action programme to limit these emissions in accordance with the obligations of the UN Framework Convention on Climate Change.

The carbon dioxide committee collected an extensive amount of data on all the main sources of greenhouse gases for the year 1990 and other years to the extent possible. The committee prepared a provisional assessment of emissions of greenhouse gases which it published in an interim report in 1992. The report was subsequently sent to the oil companies, associations of industry, the principal heavy industrial enterprises, institutions, professional organisations and other interested parties for their comments and suggestions as to ways in which to reduce emissions of greenhouse gases and to increase their absorption. The proposals which were received were, naturally enough, chiefly focused on the aspects which the carbon dioxide committee had calculated to play the main roles in net emissions from Iceland, i.e. fishing, road transport, industrial processes and forestry. The present action programme reflects to a significant extent the emphases which characterised their responses.

Following the UN Conference on Environment and Development, the Earth Summit, held in Rio de Janeiro in June of 1992, and to implement government policy in environmental affairs, the Minister of the Environment appointed seven working groups in 1993 to work towards formulating environmental protection policy and towards sustainable development in the following sectors: Industry and energy, fisheries, transport, planning, refuse disposal and treatment of toxic wastes, agriculture, and public education. The present action programme is to some extent based on the conclusions of these seven working groups.

Upon receiving the proposals of the carbon dioxide committee the national government adopted, late in 1994, a special action programme on climate change which is described in more detail below. The action programme is based on the government's overall policy context, as described in a special chapter below, and is in accordance with the government's policy statement in environmental affairs, "Towards sustainable development" which was published in March 1993. The policy statement takes into account the conclusions of the UN Conference on Environment and Development, which was held in Rio de Janeiro in June of 1992.

4.2. OVERALL POLICY CONTEXT

It is the objective of the government of Iceland, in attempting to forestall the greenhouse effects, to limit emissions of carbon dioxide and other greenhouse gases at the end of this century to the same levels as in 1990, in accordance with the UN Framework Convention on Climate Change. The government places emphasis on

achieving these objectives in the most efficient manner possible. Thus, measures, which are profitable for the national economy will be prioritised, such as improved utilisation of fuel in transport vehicles, including fishing vessels. Continuing emphasis will be placed on increasing the proportion of hydro power and geothermal energy in total energy consumption and thus reduce emissions of greenhouse gases arising from the combusting of fossil fuels. The government realises that hydro power and geothermal energy have already replaced, to a large extent, fossil fuels in those areas where it is technically possible and cost-efficient, and that at present these energy sources provide the nation with almost 2/3 of primary energy consumption. The government therefore is emphasising land reclamation and forestry to provide greater flexibility and security in the action programme and reduce the probability that unforeseen changes to the given premises prevent Iceland from achieving this objective.

The government is of the opinion that obligations to limit emissions of greenhouse gases should not prevent new heavy industrial development in the country, for the purposes of exploiting the country's clean energy sources, in spite of the fact that these enterprises may use coal or coke as raw materials and thus increase emissions of greenhouse gases. Nevertheless, the government stresses that the best technology available be used in any new heavy industrial plants which may be constructed in Iceland in the coming years, so that emissions of greenhouse gases as a result of the raw materials used in the industrial processes will be as low as is technologically possible.

In its action programme the government places emphasis on four main lines of approach, i.e.:

1. Incentive measures
2. Public education
3. Instruments of economic policy
4. Compulsory measures

Incentive measures include actions taken by the national government and its institutions to strengthen the work of local authorities, private parties and volunteer groups in order to further limit emissions of greenhouse gases or to increase the absorption of carbon dioxide.

Public education is an important part of the action programme, which will be directed at the general public, industry and pupils in the public school system. The objective is to increase public knowledge of the environment and anthropogenic effects on climate. In addition, the aim is to involve the general public, private enterprises, and various organisations and associations in efforts to reduce emissions of greenhouse gases and to increase the absorption of carbon dioxide in biomass.

The prime emphasis is placed on measures which directly increase efficiency or which contribute towards achieving other goals and ends. Accordingly, the government will emphasise the following measures:

1. Fuel conservation, especially in fishing, transport and industry.
2. Increased exploitation of non-polluting, domestic energy sources wherever this is feasible for the national economy.

3. Compilation of a general plan for land use in Iceland. Emphasis will be placed on sustainable land exploitation and the adaptation of agriculture and other industries to this end.
4. Land reclamation and afforestation to halt soil erosion, reclaim cultivated land that has been lost and improve the vegetation cover. In addition, the establishment of silviculture where such is practicable.

As was specifically described in Chapter 3, the largest portion of carbon dioxide emissions in Iceland (64%) is attributable to mobile sources (transport and fishing). The remaining 36% are released from stationary sources, in particular industrial processes in heavy industry and boilers and furnaces in other industrial enterprises. The share of stationary power production in carbon dioxide emissions was only 17.7% in 1990, or considerably less than in other industrialised countries. As a result, the main thrust in the Icelandic action programme is directed towards reducing emissions from automobiles and seafaring vessels (including fishing vessels). The government is well aware that it will prove difficult to impose compulsory measures on the fisheries sector, which is the main pillar of the nation's economy and accounts for over half of the country's foreign currency earnings. Nor is it considered possible to limit emissions of carbon dioxide from industrial processes significantly, since the only method of achieving this would be to limit the production of these enterprises.

There is considerable uncertainty as to the success of such measures, especially since most of them are directed at many small sources, as is the case in Iceland. But even though success is not certain, the government feels it important that the action programme be directed at all the main sources of greenhouse gases in the country. The progress will be closely monitored, for instance, by compiling detailed calculations of emissions each year. The government will subsequently review the action programme in the light of the experience gained, and strengthen certain measures as considered necessary.

Because of the special situation in Iceland, i.e. that stationary power production is already for the most part supplied by environmentally clean sources, and because of the importance of fishing, from which it is difficult to limit emissions, considerable emphasis is placed on absorption of carbon dioxide by vegetation in the present action programme. Land reclamation and afforestation will thus be extensively bolstered, and in addition efforts directed at halting soil erosion. Special action programmes have been drawn up for these purposes.

4.3. POLICIES AND MEASURES

The policies and measures of the national government are divided into two sections, one consists of general and economic measures, which will affect the general public and most of industry, while the other includes specific measures, which apply to specific industrial or service sectors in Icelandic society.

GENERAL AND ECONOMIC MEASURES

The Icelandic government has decided that emphasis should be placed on incentive measures, public education and efficiency encouraging measures to restrict emissions of greenhouse gases in Iceland.

The national government intends to encourage an effective increase in the flow of information provided on the greenhouse effect and ways to limit emissions of greenhouse gases, both in the mass media, in schools and by other means. To this end it will seek the co-operation of local authorities, schools, institutions, associations and private enterprises, as appropriate. The information and education material will be aimed at the general public, students, employers and employees in main industrial sectors.

The Icelandic government intends to review fuel taxation, so that it will take into account emissions of carbon dioxide and have a restricting effect on them. Plans call for the levying of a special CO_2 tax on fossil fuel for uses other than activities which must compete in the international market; apart from this the provisions will be similar to those which apply to CO_2 tax in countries competing on the same markets as Iceland.

Levies on motor vehicles and fuel will also be reviewed by the government for the purpose of increasing the proportion of low-fuel-consumption cars in use. Pollution-free vehicles, for example, electric cars, are likely to be exempted from excise taxes.

The Minister of the Environment will appoint a special ministerial co-ordination committee, in consultation with other Ministers involved, to implement the action programme for the UN Framework Convention on Climate Change. The role of this committee will be to evaluate the progress of the measures and actions of the current programme. In addition, it will make proposals to the Ministries or parties responsible on new or stricter measures or the review of measures, as it considers necessary in order to achieve the objectives of limiting emissions and increasing absorption of greenhouse gases.

Rules will be set to restrict the use of fluorocarbons and other powerful and persistent greenhouse gases wherever possible.

Research and monitoring of the effects of climatic changes and responses to them will be systematically strengthened.

Monitoring of the implementation of the policies and measures will be established, for instance, through regular review of the emissions calculations and the preparation of predictions on future developments concerning emissions.

Budget allocations to development aid will be increased during the remaining years of this century with the aim of allocating an amount equal to 0.3-0.4% of GNP in the year 2000.

SPECIFIC MEASURES

The general rule followed by the Icelandic government is to aim at restricting emissions from every industrial sector to the extent practicable, with the aim of ensuring that total emissions of carbon dioxide from domestic consumption in the year 2000 will not exceed the 1990 total. The attempt will also be made, however, to follow the main rule of keeping the costs to society of reaching this objective at a minimum. The policies and measures are described in more detail below.

4.3.1. Emissions from fishing vessels

Emissions from fishing vessels are primarily related to energy consumption for fishing, processing and sailing to and from the fishing grounds. Emissions due to the operation of generators while in harbour are another minor factor. Energy consumption for fishing and processing has increased substantially in recent years due, for instance to the increased emphasis on trawling and increase in freezing aboard ship. Trawling is not as susceptible to the vagaries of the weather as are other types of fishing, and this is very important in increasing the certainty of supplies of raw material and thus the profitability of processing enterprises, especially during the winter months. Freezing aboard ship is also important in preserving the quality of the catch, and emphasis on freezing has increased in recent years. Energy consumption in sailing is dependent upon the sailing speed of the vessel, in addition to other factors, and could probably be reduced to some extent.

The Icelandic government has for some time now attempted to increase cost efficiency in fisheries wherever possible. One aspect of this policy is the system of fisheries management, which also encourages energy conservation. The current fisheries management system, based on individually transferable quotas (ITQs) on catches, is intended to encourage fishing of the catch for the least cost. It involves encouraging cost-efficient measures such as a reduction in the number of vessels and energy conservation in fishing and fish processing wherever possible. The government realises that the current fisheries management system has not achieved the hoped-for economies, and that the Icelandic fishing fleet still has considerable over-capacity in relation to the total allowable catch. It is evident that considerations of regional development and measures to protect peripheral communities substantially restrict the possibilities for economising and reducing the number of vessels.

Emissions from fishing vessels in harbours are primarily due to the production of electricity by diesel generators. This year and the year preceding Icelandic electricity authorities reached agreement with harbour authorities throughout most of the country to lower the price of electricity in order to increase the sale of electricity to vessels in port. These agreements should ensure that it will be more economical for vessels to obtain their electricity supplies from land sources while in port than to produce it using their own diesel generators.

Action programme for fisheries

The national government has entrusted the Ministry of Fisheries with the implementation of the following action programme for fisheries, in co-operation with the Ministries of the Environment and Industry. Emphasis will be placed on the following aspects:

1. **Working group on environmental and energy issues in fisheries:** The Ministry of Fisheries will appoint a special working group, in consultation with the Ministry of the Environment, to prepare proposals as to how the objectives of reducing emissions of carbon dioxide and other greenhouse gases from the fishing fleet can be achieved.
2. **Concerted encouragement of energy conservation in fishing:** The Ministry of Fisheries will support the introduction of measures to encourage energy conservation by the fishing fleet in as many areas as possible. Among the projects

undertaken will be a survey of the cost efficiency and fuel consumption of various types of fishing and fishing gear and proposals on relevant measures, such as the application of measures to encourage efficiency. In addition, efforts will be made at increasing instruction of vessel owners, captains and marine engineers on ways to avoid fuel wastage and to reduce fuel consumption in fishing and sailing.

3. **Electricity supplies for vessels in port:** Action will be taken to see to it that in all ports vessels can obtain electricity ashore at rates competitive with electricity produced by generators. Furthermore, if considered necessary, rules will be set to limit the use of generators in port.

4.3.2. Emissions from domestic transport

Emissions of carbon dioxide (CO_2) from domestic transport (incl. domestic air and road transportation and marine traffic other than fishing vessels) in 1990 amounted to some 737 thousand tons, which is 34% of total emissions of carbon dioxide in Iceland. The main portion of the emissions are attributed to road transport. The Ministries of Industry and the Environment are responsible for regularly producing educational materials to encourage fuel conservation of motor vehicles.

The Minister of the Environment issued a regulation on July 1, 1992 to limit air pollution from motor vehicles. In order to fulfil the limits set in the regulation all new vehicles must be equipped with catalytic converters or other comparable equipment. Emissions of NO_x and CO from motor vehicles are expected to decrease substantially during the remaining years of the century as the vehicles in the country are renewed. At the same time measurement of air pollution from vehicles was introduced as part of the annual inspection process. This has resulted in some fuel conservation and a reduction in carbon dioxide emissions, as vehicle engines are now tuned more frequently than before.

Action programme for transport

The national government has entrusted the Ministry of Transport and Communications to implement, in co-operation with the Ministries of the Environment and Industry, policies and measures to limit emissions of greenhouse gases from transport. Emphasis will be placed on the following aspects:

1. **Overall organisation of transport with regard to environmental and energy questions:** The Ministry of Transport will appoint a special working group, in consultation with the Ministries of the Environment and Industry, to lay the foundation for the overall organisation of transport in Iceland, with regard to environmental and energy questions. The working group will be entrusted with providing greatly increased public education to reduce fuel wastage and improve the utilisation of motor vehicles. The working group will also have a survey conducted on the cost efficiency and fuel consumption of various modes of transport, with the aim of supporting socially efficient, low-polluting, fuel-conserving modes of transport.
2. **Strengthening of public transport:** Well-directed and effective co-operation with local authorities will be introduced in order to bolster public transport in urban areas. An attempt will be made to ensure that special attention is given to public

transport in municipal planning. An investigation will be made of the economic feasibility of electrically powered public transport on certain routes.

3. **Improved provision for pedestrians and cyclists:** Changes will be made to provide pedestrians and cyclists with safe and easy routes through towns and villages throughout the country. The co-operation of local authorities and planners will be sought as necessary in implementing measures in this area.
4. **Obligations of vendors of new motor vehicles to provide data:** Rules will be adopted to oblige the vendors of new motor vehicles to provide prospective customers with standardised data on the fuel consumption of new vehicles offered for sale.
5. **Limits on the use of solvents in road construction:** to reduce emissions of volatile organic substances the Public Roads Administration will be instructed to seek economical ways of reducing the use of solvents and the pollution caused by their use in road construction.

4.3.3. Emissions from industry

Industrial processes and raw materials

The aluminium smelter and ferrosilicon plant in Iceland use hydro power so that there are no emissions produced in its production. Emissions of carbon dioxide from the aluminium smelter are chiefly due to the oxidation of electrodes and emissions from the ferrosilicon plant due to the coke and coal used as raw materials in production. There are no possibilities of reducing these emissions and prospects are that they will increase during the remaining years of this century as the result of increased production following improved prices on markets for aluminium and ferrosilicon.

The aluminium smelter in Straumsvík is the only known source of fluorocarbons in the country. There is a great deal of uncertainty as to the total amount, as estimates of emissions are not based on measurements, but rather on calculations made using the results of a small number of measurements made in aluminium smelters abroad. It is known that the emissions depend both on the length and number of anode effects between the electrodes of the smelter pot line. Fluorocarbons (CF_4 and C_2F_6) have extensive effects as greenhouse gases, their warming factors (GWP-100) are >4500 to >6200.

In order to reduce emissions of fluorocarbons and other pollutants, concerted efforts have been made in recent years to reduce the number of anode effects and shorten their duration as much as possible. It is estimated that emissions of fluorocarbons have been reduced by as much as 80% from 1990 levels as a result of these measures, according to information from the Icelandic Aluminium Company Ltd. If this reduction is converted to carbon dioxide equivalents, it corresponds to at least 173 thousand tons of carbon dioxide, or about 8% of total emissions of carbon dioxide in the country in 1990.

Energy consumption in industry

For several years now a campaign has been underway to increase the proportion of electricity in the national energy consumption instead of oil and thus utilise the

country's excess energy production. The National Power Company and public electric authorities have, in areas where energy supply is more than sufficient, offered fish meal and oil plants and other industrial enterprises substantial discounts on the price of non-guaranteed electricity. The aim of these agreements is to assist the enterprises in meeting costs involved with installing electrode boilers and connection these new boilers with electricity suppliers. Agreements for the sale of 89 GWh of electricity annually have been concluded, which are estimated to reduce emissions of carbon dioxide by almost 30 thousand tons. It is also regarded as economically feasible to increase sales of non-guaranteed electricity to fish meal and oil plants up to an additional 125 GWh during the remaining years of the century, and thus reduce emissions of carbon dioxide by a further 40 thousand tons.

Action programme for industry

The Icelandic government has requested that the Ministry of Industry, in consultation with the Ministry of the Environment, implement government policies concerning emissions of greenhouse gases in industry. The main objectives of the government are to increase energy conservation and the use of environmentally clean energy sources instead of fossil fuels, and to restrict emissions of greenhouse gases from industry so that they will not exceed in the year 2000 the levels of 1990. It is the opinion of the national government, however, that this objective should not preclude the utilisation of the country's clean energy sources, for example, in new heavy industrial enterprises, even though such enterprise would pursue activities which would unavoidably lead to increased emissions of carbon dioxide or other greenhouse gases due to industrial processes. The action programme emphasises the following aspects:

1. **Energy conservation campaign in industry:** A fuel and energy conservation campaign will be launched in industrial concerns. Special emphasis will be placed on preventing energy wastage and reducing use of fossil fuels.
2. **Increasing use of hydro power and geothermal energy:** Efforts will be devoted towards increasing yet further the use of geothermal energy and hydro power instead of fossil fuels as extensively as possible. Further conversion of industrial boilers to electricity will be encouraged wherever economically feasible. Ways will be sought to increase the competitiveness of electricity with oil for industrial purposes as extensively as possible.
3. **Emissions from industrial processes reduced:** Possibilities of reducing emissions of greenhouse gases from industrial processes and the use of raw materials in industry will be reviewed. Possibilities of increasing the use of lumber refuse, wood chips or charcoal as carbon sources in ferrosilicon production will be investigated.

4.3.4. Emissions from refuse disposal

Disposal of refuse in Iceland has been revolutionised in recent years with the advent of joint waste disposal by local authorities in the capital area and new waste incineration plants in other regions. The decomposition of refuse in refuse dumps is one of the two major sources of methane gas emissions in the country (47%), releasing some 11 thousand tons in 1990 which corresponds to roughly 227 thousand tons in carbon

dioxide equivalents (GWP-100). Increased recycling of waste, especially of lumber and paper, has resulted in a drop in the total methane emissions of 10% from 1990.

Action programme in refuse collection and waste disposal

The Icelandic government has entrusted the Ministry of the Environment with the task of implementing its policy in refuse collection and waste disposal and to encourage as much reduction as possible in emissions of greenhouse gases and other pollutants from refuse disposal. Emphasis will be placed on the following aspects:

1. **Less refuse:** Concerted efforts will be made to reduce the amount of packaging, increase recycling and increase composting of refuse with the aim of reducing waste disposal by 50% by the end of the century. A special "garbage collection plan" will be drawn up for the entire country, in order to achieve this goal. In compiling this plan special attention will be given to efficiency encouraging measures to bolster recycling and composting of wastes and reduce the quantity of refuse.
2. **Combustion of methane:** Research will be carried out on the methane gas production of the refuse dump for Reykjavík and the surrounding area on Álfsnes and ways of utilising or disposing of it investigated.
3. **Open incineration of refuse terminated:** The national government has decided to put an end to all open incineration of refuse in the country by January 1, 1996.

4.3.5. Emissions from agriculture

Although a considerable portion of the emissions of methane and nitrous oxide in Iceland are attributed to agriculture, these emissions are relatively little in comparison with total emissions of greenhouse gases in the country. Emissions of methane have decreased slightly from the 1990 levels due to a reduction in the number of sheep and milch cows. An increase in the number of horses has counteracted the effect of this decrease to some extent.

4.3.6. Emissions due to soil and ground cover erosion

Both soil and ground cover have been extensively eroded in Iceland since the country was settled more than 11 centuries ago. Despite a widespread campaign in support of land reclamation in recent years wind and other soil erosion are still considerable and a large amount of soil and ground cover is lost each year. It is thought that much of this destruction can be attributed to over-grazing, although natural conditions, such as less favourable climatic conditions, volcanic eruptions and sand storms have in many areas set the erosive forces in motion or greatly increased their effects. It is expected that as a result of extensive efforts to bolster efforts in land reclamation in recent years, the annual soil and ground cover erosion has not increased since 1990 and will not increase during the remaining years of this century.

The Icelandic government set itself the objective in its environmental policy statement, "Towards sustainable development", that "the utilisation of all natural resources, on land or sea, would become sustainable as soon as possible". Furthermore, a "concerted effort shall be made to halt soil and ground cover erosion by the end of the

century and renew, as extensively and quickly as possible the soil and ground cover which has been lost". To reach this objective the government has decided to have a special comprehensive plan for land utilisation throughout the country drawn up. A special programme for land reclamation will also be compiled, as described in more detail in Chapter 4.2.7.

Comprehensive land utilisation plan for Iceland

The national government has decided to have the Ministries involved co-operate in preparing without delay a comprehensive land utilisation plan for Iceland. Emphasis will be placed on sustainable land use and on the adaptation of agriculture and other sectors to this. In conjunction with the preparation of this comprehensive plan, the vegetation condition of grazing lands will be assessed, together with the extent of soil erosion. Measures will subsequently be taken to introduce, in co-operation with landowners, grazing controls or the total protection of areas plagued by soil and ground cover erosion. A further objective will be the protection of the remains of willow and birch woods and support their self-proliferation. Rules will be set to restrict the draining of wetlands and experiments are proposed involving closing off the draining ditches of deserted farmlands.

4.3.7. Absorption of carbon dioxide through land reclamation and afforestation

In many areas of Iceland there are remains of natural birch woods, the total area of which is estimated at 100 000 hectares. Grazing sheep and horses have access to many of these woods, so that they fail to proliferate to any significant extent. Protection of these birch woods remains and their expansion through support for self-proliferation is regarded as a highly desirable method to increase the absorption of carbon dioxide in Iceland considerably. Following the completion of a comprehensive land use plan for Iceland the protection of natural birch woods is expected to increase the absorption of carbon dioxide substantially.

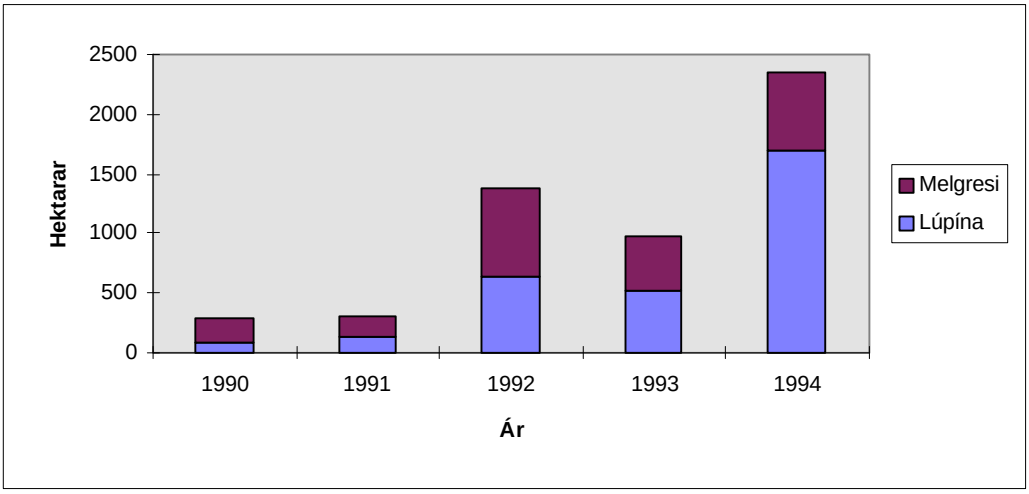
Fens cover a sizeable portion of the land under vegetation in Iceland, although they have decreased greatly as a result of drainage efforts in this century. These fens absorb large quantities of carbon dioxide but release, on the other hand, some methane. The extent of the carbon dioxide absorption and methane emissions of Icelandic wetlands is not known, but natural conservation plans call for the protection of as much as possible of the remaining wetlands. In addition, the total land use plan, described in Chapter 4.2.6., will propose filling in drainage ditches in wetland areas no longer needed for agricultural purposes, with the aim of restoring the fens to their original state. This action is expected to increase the absorption of carbon dioxide in these areas considerably.

Public support for land reclamation and afforestation has grown extensively in recent years, not least because of wide scale educational efforts and the increasing consciousness of the public of soil and ground cover erosion in the country. The Icelandic government and its institutions, together with local authorities throughout the country, have supported substantially increased land reclamation and afforestation efforts all around the country. Large amounts of grass seed and fertiliser are sown each year in areas suffering from ground cover erosion and experiments have been

made in sowing Nootka lupine and lyme grass over large deserts and gravel wastelands. Large sums have been spent on land reclamation and afforestation projects, both on behalf of the national government and local authorities, private enterprises and various volunteer associations. Mention could be made, for instance, of the fact that one-half the price paid for each carrier bag in food stores throughout Iceland goes towards land reclamation and afforestation efforts. The oil companies have also made substantial contributions to projects of this sort.

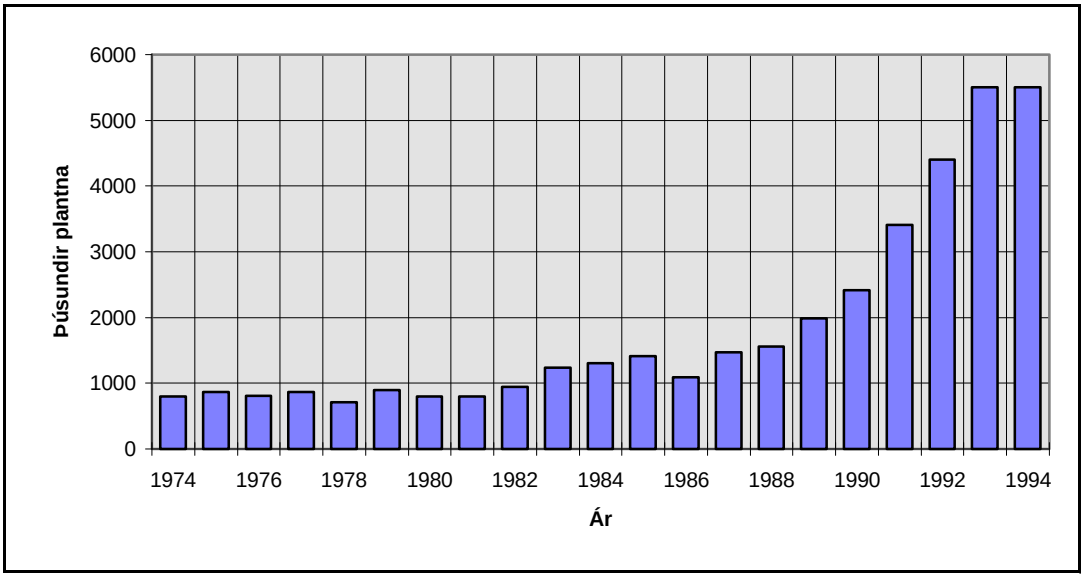
The sowing of lupine and lyme grass has been widely practised to introduce vegetation into deserts and gravel wastelands in Iceland. Figure 4.3.1 shows how much this sowing has increased since 1990. The increase in the spread of lupine as a result of seeding is in fact almost three times that shown in the figure, due to the self-sowing of the lupine in seeded patches which have begun to expand. The growing of lyme grass or lupine in sparsely vegetated areas results in considerable absorption of carbon dioxide in biomass. Furthermore, the soil gradually improves so that the area can more readily support subsequent afforestation. The State Land Reclamation Service and Iceland Forestry Service propose to plant birch or other trees in patches of lupine and thus achieve even more and more permanent absorption of carbon dioxide.

Figure 4.3.1. *Sowing of lyme grass and lupine 1990-1994.*



The production and planting of seedlings in Iceland has multiplied greatly in recent years. During the seven-year period from 1973 to 1979 a total of 4.4 million seedlings were planted, a number similar to that planted in 1992 alone. Furthermore, while the numbers of trees planted has increased greatly their density has also been reduced. The absorption and sequestration of carbon dioxide is dependent upon the area of the forest rather than the number of trees, so that the same number of plants can now be expected to absorb more carbons than before. Figure 4.3.2. shows a summary of the number of trees planted in Iceland 1974-1994.

Figure 4.3.2. *Number of trees planted in Iceland 1974-1994*[*].



[*]*Provisional figures from Iceland Forestry Service*

The mean density of plantings in 1990 is estimated to have been in the area of 7000 per hectare, although there is some uncertainty involved in this figure. If we assume that the annual mean absorption of carbon dioxide by forests in Iceland to be about 5 tons per hectare, then the forest planted in 1990 should absorb about 1.7 thousand tons of carbon dioxide annually. In 1992 5.5 million seedlings were planted, which will absorb almost 4000 tons of carbon dioxide annually, if planted with the same density. Double the amount of carbon dioxide could be absorbed by the same number of plants if they were planted with a density of 3500 per hectare, as Iceland Forestry Service advises.

Action programme in land reclamation and afforestation

The national government has made the Ministry of Agriculture responsible for producing special land reclamation and afforestation plans in co-operation with the Ministry of the Environment. The prime objective of these proposals is to halt the rapid erosion of soil and ground cover in the country by the end of this century and reclaim as much of the country's lost vegetation as possible. An additional objective is to increase the annual absorption of carbon dioxide by lupine, forests and other vegetation so that it will be at least 100 thousand tons more in the year 2000 than it was in 1990. Emphasis will be placed on the following aspects in the plan:

1. **Plan for land reclamation:** A special land reclamation plan will be prepared for all of Iceland, the first version of which is to be completed no later than 1996. The main objective of this plan is to halt the rapid erosion of soil and ground cover in the country by the end of this century and reclaim as much of the country's lost vegetation as possible, in accordance with the policy of the national government. Ways will be sought to establish effective co-operation with farmers and other interested parties in this project.
2. **Plan for afforestation:** An additional special afforestation plan will be drawn up, taking into account the overall land utilisation plan for Iceland referred to earlier, and the plan for land reclamation. The aim is to increase afforestation efforts

throughout Iceland so that by the end of the century four times as many seedlings will be planted annually as were planted in 1990. In addition concerted efforts will be made to reduce the density of planting, in accordance with the advice of Iceland Forestry Service. Emphasis will be placed on enabling landowners in areas suitable for silviculture to take up this form of agriculture, for instance, with grants for planting new forest patches.

3. **Projects for the absorption of carbon dioxide in biomass:** Public institutions in the area of land reclamation and afforestation will be entrusted with the co-ordination and direction of actions in land reclamation and afforestation, together with additional measures as necessary, to increase the annual absorption of carbon dioxide by vegetation as economically as possible by 100 thousand tons by the end of this century. The objective is to comply with the obligations of the UN Framework Convention on Climate Change by the end of this century and increase the absorption of carbon dioxide and improve vegetation in the country in the long term. Special emphasis will be placed on economically profitable actions, including the planting of harvestable forests and the termination of land and soil erosion.

4.4. PROJECTIONS AND ASSESSMENT OF MEASURES

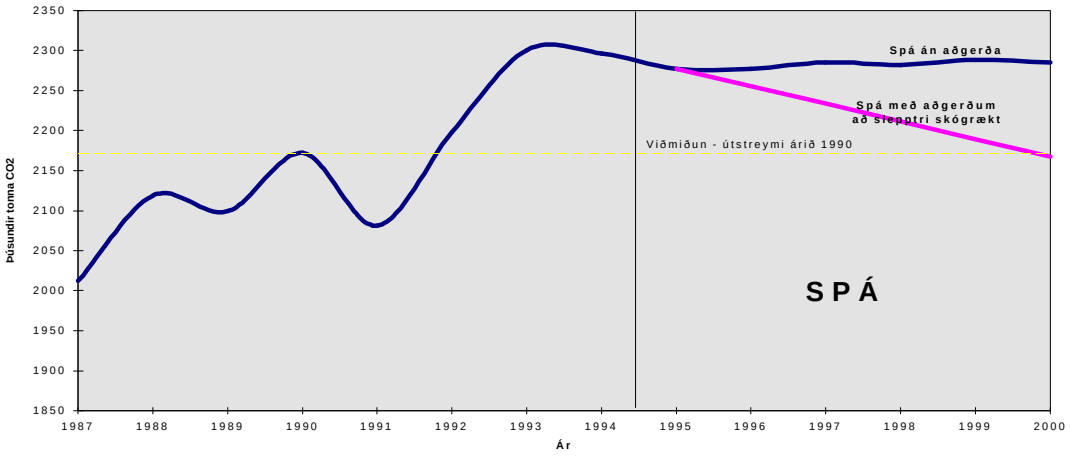
4.4.1. Carbon dioxide

In May 1994 the National Energy Authority concluded its calculating of provisional forecasts for fuel consumption, which were prepared on the basis of fuel projections from 1988 (fuel projections 1988-2015), taking into account subsequent changes in the situation. The main premise underlying the new provisional projection is steady economic growth during this period, an increase in individual purchasing power and similar governmental policy for the next few years. At the same time the fisheries sector is expected to carry out certain economising measures, so that emissions from fishing vessels should decrease slightly during the remaining years of this century.

On the basis of the provisional fuel projections of the National Energy Authority and predictions on the development of emissions from industrial processes and other sources of carbon dioxide, anthropogenic emissions of carbon dioxide in Iceland are expected to increase by about 5% from 1990 to the end of the century, if no actions were taken.

The policies and measures of the government concerning the UN Framework Convention on Climate Change are expected to fully counteract this increase in the emissions of carbon dioxide which is expected to occur from 1990 to 2000, of some 110 thousand tons. Measures aim at achieving a reduction of 35 thousand tons through introducing changes in the pricing of fuels, of 50 thousand tons through the electricising of boilers and other measures in industry, and of 15 thousand tons through measures in transport. In addition a reduction of 10 thousand tons is to be achieved in the emissions from fishing vessels. These objectives are shown in Figure 4.4.1 here below. Thus, total emissions of carbon dioxide in Iceland are expected to be no more in the year 2000 than they were in 1990.

Figure 4.4.1. *Emissions of carbon dioxide from 1987 onwards, and projections up until the year 2000.*



Source: Ministry of the Environment.

In addition to the measures previously described very extensive measures are proposed in land reclamation and afforestation to increase the absorption of carbon dioxide in biomass, but no exact estimates have been made as to how great an amount of carbon dioxide will be absorbed as a result of these measures. These additional measures are intended to create additional flexibility, and increase the dependability of the action programme. Thus the intention is to reduce the possibility that unforeseen changes to the premises for estimates of emissions will result in emissions in the year 2000 exceeding those of 1990.

4.4.2. Methane

As related in Chapter 3, the main portion of methane emissions in Iceland can be attributed to waste disposal as landfill and to domestic animals. Various types of recycling are expected to increase during the remainder of the century, especially of timber, metals, paper and organic wastes. As a result, emissions from refuse dumps are expected to decrease somewhat. Even though a slight increase is expected in emissions of methane from domestic animals the decreasing emissions from refuse dumps are expected to more than counteract this. This is shown in Figure 4.4.2.

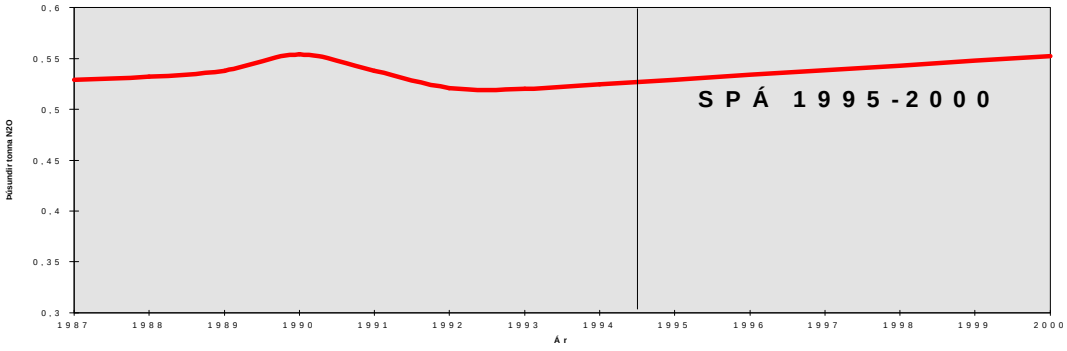
Figure 4.4.2. *Estimated emissions of methane 1987-2000.*

Source: Ministry of the Environment

4.4.3. Nitrous oxide

Nitrous oxide is released through the use of nitrogen fertiliser in agriculture. Little change is expected in emissions for the remainder of the century, as can be seen in Figure 4.4.3.

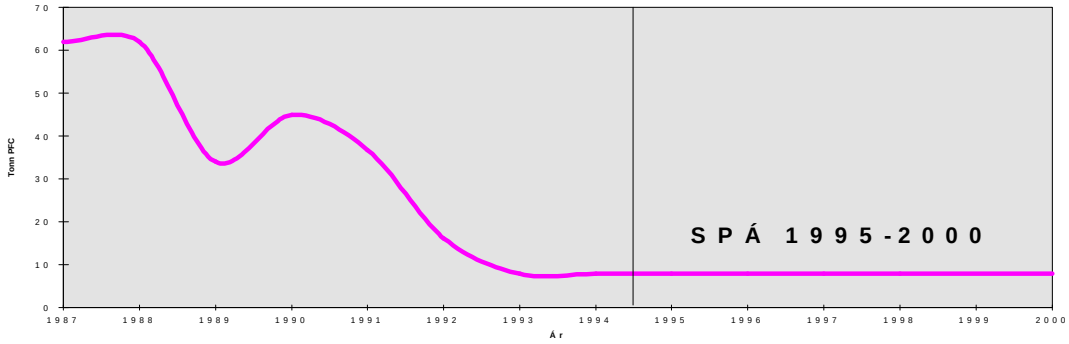
Figure 4.4.3. *Estimated emissions of nitrous oxide 1987-2000.*



4.4.4. Fluorocarbons

It is estimated that emissions of fluorocarbons from the aluminium smelter in Straumsvík have been greatly reduced in recent years due to concentrated efforts to reduce the number and length of anode effects in the production process. Fluorocarbons are very influential greenhouse gases, and the restriction on emissions which has already been achieved, converted to carbon dioxide equivalents reveals, that it more than counteracts the increase in emissions of carbon dioxide expected in the country for the remainder of the century. Figure 4.4.4 summarises the development of fluorocarbon emissions from 1987 onwards and projections up until the year 2000, assuming no new measures are introduced.

Figure 4.4.4. *Estimated emissions of fluorocarbons 1987-2000.*



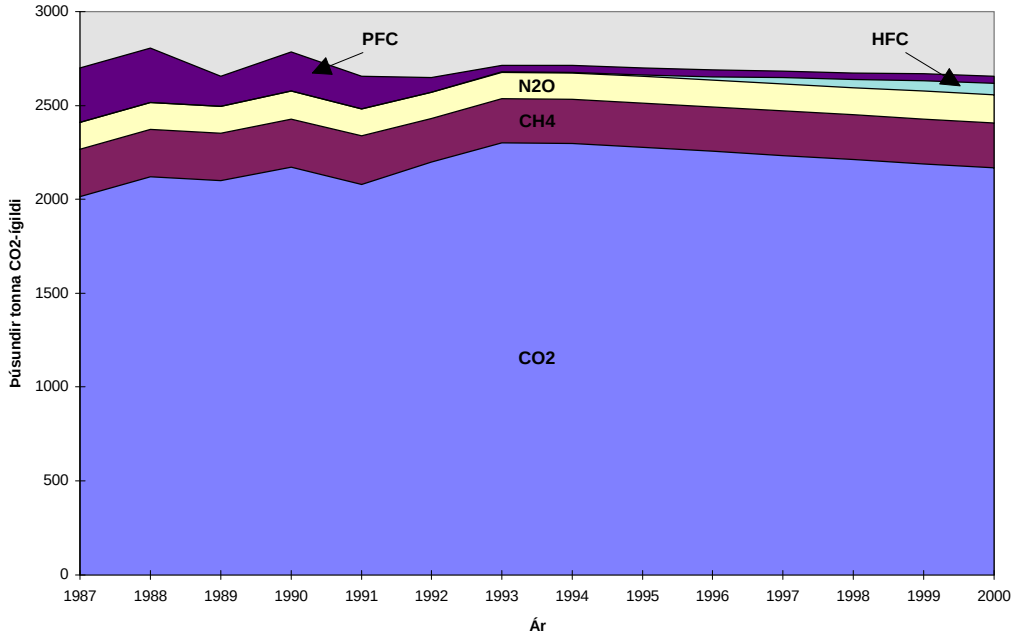
Source: Ministry of the Environment

4.4.5. Cumulative emissions of all greenhouse gases

Since the quantity and warming factors of the various types of greenhouse gases vary greatly, their effects in increasing the greenhouse effect over the next 100 years also vary greatly in significance.

Carbon dioxide is by far the most significant greenhouse gas, accounting for about 78% of total emissions of greenhouse gases in Iceland if all are calculated in carbon dioxide equivalents. The proportion of carbon dioxide is expected to increase to 82% by the year 2000, as a result of both the increase in emissions of carbon dioxide and considerable decrease in emissions of fluorocarbons. Figure 4.4.5 shows a summary of estimates of cumulative emissions of all greenhouse gases in Iceland from 1987 to 2000.

Figure 4.4.5. *Estimated cumulative emissions of greenhouse gases in Iceland 1987-2000, calculated as carbon dioxide equivalents (GWP-100).*



Source: Ministry of the Environment

As the figure shows, cumulative emissions of greenhouse gases are not expected to increase in Iceland from 1990 to 2000. This is primarily the result of a reduction in fluorocarbon emissions from the aluminium smelter. Measures prescribed by the current action programme to reduces emissions of carbon dioxide also make a significant contribution.

4.5. NEW RESEARCH AND MONITORING

The Icelandic government intends to strengthen research and monitoring efforts in Iceland to increase knowledge of the effects of climate change in Iceland and to lay the foundation for measures to reduce the detrimental effects of those changes which can be expected. The main areas of research and monitoring which the government will emphasise are: climatological research, monitoring of the atmosphere, marine research, investigation of the effects of sea level rise in Iceland and research in the areas of land reclamation and forestry.

4.5.1. Climatological research and monitoring of the atmosphere

The government realises that living conditions and economic pursuits in Iceland are extremely sensitive to changes in climate. For this reason the Icelandic government intends to support and strengthen research on the climate of the country and climatic change, in addition to the monitoring of the atmosphere with regard to greenhouse gases. In addition, concerted efforts will be made to follow the efforts of foreign research on climatic models and their conclusions as to probable climatic change due to the greenhouse effect, as well as supporting the participation of Icelandic scientists in international co-operation projects in this area. In this way we can ensure that sufficient expertise will always be available within the country on the nature and effects of climatic change in Iceland.

4.5.2. Marine research and investigation of the effects of sea level rise

Prosperity in Iceland depends to a very large extent on the fishing and processing of marine products. For this reason the Icelandic government intends to bolster research on the effects of prospective climate change on the interaction of the atmosphere and the ocean, ocean currents and living conditions in the ocean. This will serve to increase human knowledge of the conceivable effects on the productive capacity of Icelandic ocean areas, on the fishing grounds of exploitable marine species, their spawning grounds and the routes of fish runs.

In addition, an investigation will be carried out into the possible effects of sea level rise in Iceland, and ways to reduce the possible detrimental effects of such rise examined. Special attention will be given to the possibility of a flooding threat in coastal communities around Iceland and the possibilities for adapting to this situation or counteracting an increasing threat of flooding.

4.5.3. Research in the areas of land reclamation and afforestation

Land reclamation and afforestation in Iceland are not only important in order to combat soil erosion and improve living conditions in the country. They are also among the methods emphasised in order to increase the absorption of carbon dioxide in biomass and thus to counteract increases in carbon dioxide in the atmosphere, and by so doing prevent increasing the greenhouse effect. For these reasons the government intends to strengthen efforts in land reclamation and forestry in Iceland, through increasing research on the carbon cycle in soil and vegetation in Iceland, emphasising those aspects which determine the speed of absorption and emission of carbon in soil and plants. The effect of land reclamation and afforestation on the speed with which organic material collects will also be investigated in order to lay the foundation for planning and to increase the economy of measures to increase absorption of carbon dioxide in biomass. Finally, research into the extent and rapidity of soil and ground cover erosions will be strengthened, with regard to the loss of carbon in the soil and to the lost capacity of Icelandic vegetation cover to absorb CO_2.

4.6. EDUCATION AND INSTRUCTION

The government of Iceland has decided to substantially increase education in all areas of society concerning the greenhouse effect and the climatic changes which could result due to increasing concentrations of greenhouse gases in the earth's atmosphere. In addition, instruction will be specifically increased concerning the possible consequences of the climate changes and ways in which the public and private enterprises can reduce emissions of greenhouse gases or increase their absorption. Considerable emphasis will be placed on the possibilities of enterprises to combat the increasing greenhouse effect through specific measures to conserve fuel and energy which at the same time can contribute to improving economical situation of the enterprises. Last but not least, the government will publicise extensively the measures taken by government authorities in Iceland and which are included in the current action programme.

The Icelandic government aims at establishing systematic and co-ordinated education on the greenhouse effect in compulsory and secondary schools. Emphasis will be placed on the complex interplay of factors, such as the nature and effects of the greenhouse effect and its connections with climate and the biosphere. Furthermore, an explanation will be provided of the efforts in Iceland and other countries to prevent or mitigate the changes which are feared to be in the offing, and what the public at large can do to support this.

4.7. INTERNATIONAL CO-OPERATION

The Icelandic government aims at increasing Iceland's contribution to development aid significantly during the remaining years of this century, so that this contribution will amount to at least 0.3-0.4% of GDP by the year 2000. Emphasis will be placed on specialist assistance in the areas of geothermal energy development and the reclamation of desertified areas, together with fisheries projects.

4.7.1. UN Geothermal Training Programme

The UN Geothermal Training Programme was established in Iceland in 1979 and the National Energy Authority is the only institution co-operating with the UN Training Programme which offers instruction in geothermal science and technology. Specialists from developing countries receive through the programme practical training on six-month courses held each year. Specialised training is offered in geological exploration, borehole geology, geophysical exploration, borehole geophysics, reservoir engineering, the chemistry of thermal fluids, geothermal utilisation, and drilling technology. The operating costs of the UN Geothermal Training Programme are divided between the Icelandic government (80%) and the UN Training Programme (20%).

The objective of instruction in the Geothermal Training Programme is to give participants sufficient knowledge and practical experience to work independently, to facilitate their active participation in developing geothermal energy in their home countries. This objective has acquired new importance in the light of the greenhouse effect and the role played by in it by traditional energy production from coal and oil. Geothermal energy production provides the states in question the possibility of producing a large amount of energy with minimum damage to the environment. In developing countries this geothermal energy often replaces fossil fuels or firewood, and thus reduces the environmental destruction which would otherwise take place. In accepting applicants to the programme, priority is given to those from institutions in developing countries, where research on geothermal energy and its utilisation is already underway. Participants most often are granted scholarships to study by the Icelandic government and the UN Training Programme and, in some instances, from the UN Development Programme.

4.7.2. Reclamation of desertified land

As was discussed in Chapter 4.3.6, soil erosion has been extensive in Iceland since the country was settled some 11 centuries ago. Substantial efforts have been devoted in recent years to attempts to reverse this trend. As a result of decades of research and work at reclaiming wastelands, for instance, through controlled grazing, sowing and fertilisation, Iceland now possesses extensive knowledge of the nature and processes of soil erosion and ways of halting it. It is very probable that this knowledge could prove of use to those nations which are now struggling to counteract the forces of desertification.

In accordance with the proposals advanced by the working of the Ministry of the Environment concerning “environment and agriculture” the national government has decided to strengthen research of wastelands and desertification and methods of combating it. At the same time experience and technical knowledge in areas such as land reclamation, soil and vegetation protection, grazing control, land utilisation, and education, for instance through the scientific and technical training of specialists from developing countries.

To this end the Icelandic International Development Agency will be instructed to make an effort to increase co-operation with institutions in the field of soil protection in developing and other countries, with the aim of providing Icelandic specialists to assist in projects in developing countries.

4.8. MONITORING THE IMPLEMENTATION OF THE PROGRAMME

An important aspect of the current programme is the monitoring of the progress of projects, in order to make it possible to review and reorganise efforts to comply with the obligations of the Framework Convention. For this purpose the Icelandic government has decided to establish a system for monitoring the progress of individual projects and measures in the current programme concerning the greenhouse effect. The surveillance will involve the following aspects/factors:

Emission accounts will be compiled each year under the auspices of the Ministry of the Environment, in order to monitor the developments in emissions of anthropogenic greenhouse gases from all sources and to assess the absorption of carbon dioxide in biomass. In addition, the progress of individual policies, actions and projects in the programme will be followed and an assessment made of their effect on emissions or absorption of greenhouse gases. Finally, predictions as to emissions in the year 2000 will be reviewed each year.

The Ministry of the Environment will subsequently, in co-operation with the Ministry or Ministries and institutions concerned reconsider former policies and measures in the action programme and review the programme. Specific projects may be strengthened or new ones added as necessary. Thus concerted efforts will be directed at complying with the obligations of the UN Framework Convention on Climate Change, so that emissions of greenhouse gases in Iceland in the year 2000 will not exceed those of 1990.

5. Vulnerability and adaptation

The effects of climatic changes in Iceland are very uncertain. The conclusions of most recent calculations indicate that warming due to the greenhouse effect will be less in the North Atlantic area, and thus in Iceland, than elsewhere at the same latitude. The country is located at the junction of cold and warm air and ocean currents, and possible changes to the current systems and the most common routes of low pressure zones resulting from an overall warming caused by the greenhouse effect could thus have very extensive effects. Existing climatological simulations are too primitive to provide dependable data for individual regions, least of all in Iceland and the surrounding ocean areas. It should be mentioned, however, that according to the conclusions of a joint Nordic research project, "Climate Change and Energy Production", it is considered possible that the summers in Iceland will become warmer over the next decades by an average of approximately 0.25°C per decade, and the winters by an average of some 0.35°C. There is a high degree of uncertainty involved in this assessment. But it is considered most likely that there will be some, even fairly considerable, warming of the country in the next century which is expected to have in most respects positive effects on the land itself, although the effects on the fishing banks are less certain.

Because of the high degree of uncertainty as to possible climatic changes in Iceland, there has been little attempt to adapt to possible changes. Instead, the policies and measures of the government are as yet still aimed in particular at increasing research and monitoring, in order to provide a basis for subsequent adaptive measures. Special emphasis is placed, in this connection, on research into the effects of climate change on the fishing banks surrounding the country.

5.1. FISHERIES

At this point in time there appears to be little possibility of predicting the effects of increased greenhouse effects on the abundance of fish and fishing around Iceland and in nearby ocean areas. It is clear, however, that the areas of distribution of various species, the routes of fish runs, location of spawning grounds and nursery grounds for juvenile fish, are dependent upon external conditions, such as the currents and ocean temperature. We must also keep in mind that the primary productivity of algae, which form the first link in the food chain, is naturally dependent upon environmental conditions. In this connection there are sufficient lessons to be learned from the drastic changes which have occurred in environmental conditions on the Icelandic fishing banks during this century.

In the light of the enormous interests at stake for Icelandic fisheries, the national government has decided to increase research on the direct and indirect effects of climate change on the fishing grounds, in order to facilitate adaptation to the changes which may occur. The intention is to entrust the relevant research institutions in Iceland with the direction of this research.

5.2. SEA LEVEL RISE

There appears to be great danger of a rise in the sea level, occurring gradually during the coming century due to the rise in mean temperature on earth. The great majority of Icelanders live in towns and villages along the coast. It is clear that if a rise in sea level occurs, it could cause considerable financial damage due to increased flooding and damages they would cause to roads and structures, in harbour areas, for instance.

Several villages are located so close to sea level and right on the sea front that special measures have had to be taken to protect them from the ocean's assault. Flooding has caused damage to them nonetheless. It is clear that the danger of flooding will increase if the sea level rises. In addition to the increased danger of flooding, land erosion by the ocean could increase at certain locations along the southern coast.

The government of Iceland has decided to have a special analysis carried out of the danger of flooding and land erosion due to increased ocean assault following a rise in sea level, and to seek ways to reduce the effects and damages caused by the change.

5.3. AGRICULTURE AND FORESTRY

The climate has a great effect on agriculture in Iceland. Possible effects of climate changes on Icelandic agriculture, with respect to both warming and cooling, was assessed by Icelandic scientists as part of an analysis for UNEP. The analysis also included Canada, Finland, countries of the former Soviet Union, and Japan. This investigation indicates that warming of about 1.3°C could result in an increase of 16-19% in Icelandic hay production. The consequences of other climate changes, such as cloud cover, wind or precipitation, were not assessed.

It is to be expected that accompanying an increase in average temperature in Iceland various pests (insects or plant diseases) could become more of a problem than at present, both in agriculture and forestry. Potato blight made a reappearance for instance following the warm temperatures in recent years, after it had disappeared for thirty years after the general cooling in the early 1960s.

5.4. HYDROELECTRIC POWER PRODUCTION

In connection with the joint Nordic research project "Climate Change and Energy Production" the effects of warming on HEP production in Iceland in the coming decades was investigated. The affects of climatic warming on HEP production in Iceland were considered to be relatively positive, due especially to the increased melting of glaciers and resulting increased flows of glacial rivers. This is discussed in a preliminary report published by the National Energy Authority and the Icelandic Meteorological Office, "Climate Change Scenarios for the Nordic Countries, a preliminary report" in 1994.

6. Research and systematic observation

6.1. *CLIMATE AND SYSTEMATIC OBSERVATION*

6.1.1. *Climatological research*

Ever since it was established 75 years ago the Icelandic Meteorological Office has industriously carried out the collection and processing of a variety of data on weather, climate and climate changes in Iceland. The oldest weather station still in active operation, in the town of Stykkishólmur, began its observations in 1845, and today weather information is collected from some 130 locations throughout Iceland.

The results of regular climatic measurements are published by the Meteorological Office in its monthly periodical *Veðráttan* (State of the Weather), the results of polar ice observations in the series *Hafís við strendur Íslands* (Sea Ice off the Icelandic Coast), and summaries of avalanche activity in the annual *Jökull* (Glacier). Work is progressing steadily at computerising older weather data in order to thus make it accessible for climatological research. The Icelandic Meteorological Office is constantly providing information and distributing data in connection with climatological research in other countries. Example of projects of this sort in progress abroad include research on the connection between soil erosion and wind patterns, into the flow fluctuation of glacial rivers and on the connection between the development of settlement and climate change.

The Meteorological Office has participated in a number of international climatological research projects on climate and climate changes in northern regions. Among the main projects of this sort are:

Work on co-ordination of data and climate assessment in the project entitled the North Atlantic Climatological Dataset (NACD), carried out with the support of the Nordic Council of Ministers, the Nordic Environmental Research Programme and funds from the EU. Participants come from all the Nordic countries, Belgium, the Netherlands, Germany, the UK and Ireland. This project has now been accepted as part of the European Climate Support Network (ECSN), which is a co-ordinating office for European Meteorological Offices on climatological research.

Work is in progress on the recording of information on polar ice from the first quarter of this century on a grant from the British Leverhulme Institute and the preparation for publication of a summary of measurements in Reykjavík and at nearby Nes við Seltjörn for the period 1820 to 1854. Parallel to this, work is in progress on processing data from the 18th century in co-operation with a database of older weather data, the Euro-climhist database in Berne, Switzerland.

The Meteorological Office has also participated in WASA-cooperation (on WAve and Storm climate of the Atlantic) under the auspices of the EU, although Icelanders are not principal participants in the project.

The Icelandic Meteorological Office, together with the National Energy Authority, took part in a joint Nordic project on Climate Change and Hydroelectric Energy Production. Predictions were drawn up as to the probable changes in climate due to the greenhouse effect and the effects of such changes on HEP production investigated. The Meteorological Office has also worked extensively on comparing the climate simulation of the Max Planck Institute for Meteorology in Hamburg with actual climatic conditions in Iceland.

Finally, the Icelandic Meteorological Office is taking an active part in Nordic co-operation under the auspices of the Nordic Council of Ministers. As part of this co-operation the Office has a representative in the Nordic Atmospheric and Oceans Environment Group and a deputy representative in the Nordic "Environmental Monitoring and Data Group".

6.1.2. ***Drilling on the Greenland Ice-cap, the GRIP project***

Iceland took an active part in the European GRIP (Greenland Icecore Project) drilling on the Greenland ice-cap, the preparation and carrying out of which extended from 1989 to 1992. The purpose of the drilling was to obtain from the ice cores a variety of information on earlier changes in the earth's environment and climate in order to better understand the nature of these changes. By examining climate fluctuations over the past 200 thousand years and their causes, researchers hope to acquire a better understanding of the possible effects of carbon dioxide pollution on the earth's climate. They also hope to achieve a better understanding of climate changes in the northern Atlantic and of the role played by the Gulf Stream in this connection, as changes in that current appear to provide the impetus for all the principal changes in climate in the North Atlantic and in fact throughout the entire world.

The GRIP project is a co-operative project of eight European countries (Belgium, Denmark, the UK, France, Germany, Italy, Switzerland and Iceland), supported by the Research Councils of the participating countries and by the EU. Representatives of the University of Iceland took an active part in the actual drilling and in designing the drill which was used. Furthermore, specialists of the Science Institute, University of Iceland, work in co-operation with Danish and French researchers at isotope analyses of the cores. These measurements provide information on the mean annual temperature of the glacier when the precipitation fell to earth. By measuring the isotope values along a 3028.8 metre long ice core the climatic history of the North Atlantic area can be read over the past 200 thousand years.

6.1.3. ***Atmospheric monitoring***

Because of Iceland's position in the mid-North Atlantic is was thought advisable to carry out fairly extensive measurements of ozone in the country as well as, in recent years, various measurements of greenhouse gases.

Measurements of the total amount of ozone using a Dobson spectrometer have been carried out regularly by the Icelandic Meteorological Office since 1957.

The Icelandic Meteorological Office, in co-operation with the Laboratory of Atmospheric Physics of the Aristotle University of Thessaloniki in Greece, has since 1992 also carried out measurements of the total amount of ozone in Reykjavík using a Brewer spectrometer. Additional measurements have been made of the total amount of NO_2 and SO_2 at increasing altitudes in the atmosphere.

Measurements of ozone levels at the surface of the earth are made, in co-operation with NOAA (National Oceanic and Atmospheric Administration) in Boulder, Colorado, in the US, at two Icelandic weather stations, in Reykjavík and Stórhöfði in the Westman Islands.

During the winter, weekly measurements are made at Keflavík airport by the Icelandic Meteorological Office, in co-operation with INTA (Instituto Nacional de Tecnica Aerospatial), Madrid, Spain, using a weather balloon which is sent up through the troposphere and the lower part of the stratosphere.

Weekly atmospheric samples have been collected, in co-operation with NOAA, at the weather station at Stórhöfði in the Westman Islands, for the analysis of greenhouse gases CO_2 and CH_4. In co-operation with the University of Maryland monitoring of CO has also been carried out there.

6.2. *RESEARCH INTO THE EFFECTS OF CLIMATE CHANGE ON THE ICELANDIC ECOSYSTEM*

The Research station of the Iceland Forestry Service, the Agricultural Research Institute and the State Land Reclamation Service began in 1989 extensive research on the environmental changes and energy balance studies in the succession of black cottonwood forests on open land, in co-operation with Queen's University in Kingston, Canada, and the Canadian Forestry Service in Newfoundland. Black cottonwood seedlings were planted in a 14 hectare area of the State Land Reclamation Service and a complete range of equipment for measuring climatic and environmental factors installed. This experimental area is regarded as a suitable location for research into carbon dioxide sequestration in connection with afforestation in Iceland.

Work commenced at this same location in 1993 on two Nordic research projects. One of these is an investigation into the direct effects of an increased concentration of carbon dioxide on the carbon balance of black cottonwoods, and equipment to double the carbon dioxide concentration surrounding the trees has been installed. The other project is aimed at assessing the effects of increased soil temperature on the nitrogen cycle of the soil and testing a mathematical model of this cycle.

On the peninsula Snæfellsnes in western Iceland the Institute of Biology of the University of Iceland, in co-operation with San Diego State University, is conducting research on the effects of carbon dioxide from mineral springs on surrounding vegetation.

6.3. *LAND RECLAMATION AND AFFORESTATION*

The State Land Reclamation Service and the Agricultural Research Institute are currently working on mapping soil erosion throughout all of Iceland and a more comprehensive assessment of the extent of soil and ground cover erosion and carbon loss can be expected when the first stage of this mapping concludes in 1995. In addition, the Agricultural Research Institute has carried out extensive mapping of vegetation and vegetation maps have been drawn up for 2/3 of the country. In recent years satellite surveys have also been used for these purposes and in 1993 the Iceland Geodetic Survey, the State Land Reclamation Service and the Agricultural Research Institute jointly published a vegetation picture of the entire country based on data processed from the satellite Landsat.

Extensive research and developmental work is carried out in Iceland in the areas of land reclamation and afforestation at the Research Station of Iceland Forestry Service, the Agricultural Research Institute and the State Land Reclamation Service. Considerable success has been achieved in the growing and processing of seeds of plants important for land reclamation.

6.4. *MARINE RESEARCH*

The vessels of the Marine Research Institute make quarterly expeditions to assess oceanographic conditions around Iceland, collecting data on temperature conditions and distribution of sea types in the nearby waters. In addition to the oceanographic research, investigations of algae and zoological plankton are carried out in spring and summer. The flow of warm sea into the northern banks is assessed by continuous current monitoring.

Oceanographic and ecological conditions on the spawning grounds of commercial fish stocks off the southern and south-western coasts have been investigated in recent years as part of attempts to gain increased knowledge of all the factors which may effect the strength of year classes and recruitment of commercial fish stocks.

As part of the co-operation of the Marine Research Institute with foreign parties, research on the carbon dioxide in the ocean and the air-sea flux of this gas has been underway since 1983. In co-operation with Norwegians and Swedes, a three-year research programme was drawn up in 1992 on research on carbon dioxide in the air and in the Nordic seas, as well as on the flow of this gas between the sea and the air. This co-operative project is called Carbon Cycling and Convection in the Nordic Seas. The objectives of the project are as follows:

1. To quantify the rate of sequestering of carbon dioxide in the Nordic seas.
2. To improve understanding of the physical, biological, and geochemical processes which are important for carbon dioxide exchange in the Nordic seas.
3. To improve understanding of the mechanisms involved in deep convection and their relation to carbon dioxide and heat fluxes.
4. To assess how possible future climate changes could affect the state of the system.

The role of the Marine Research Institute in this project is to compile annual cycles on the flux of carbon dioxide between the air and ocean, examine how this is controlled by changes which take place in the ecology of the surface layers, and observe what effects

physical factors such as warming and mixing have. In 1993 this research involved journeying 15 times to 5 locations on a section to the west of Iceland and in 1994 data was collected in a similar manner in the Iceland Sea.

Executive Summary

I. Basic data and national circumstances

Iceland is the second largest island in Europe, 103,000 km^2 in area. The land lies in the North Atlantic astride the mid-Atlantic ridge, with its most northerly extremes bounding on the Arctic Circle. Warm and cold ocean and atmospheric currents intersect off the coast and the biosphere is extremely sensitive to any change in the climatic and current systems of the earth. Iceland is a volcanic country, with numerous active volcanoes and extensive geothermal resources.

Some 263 thousand people live in Iceland. The settled areas are primarily along the coast, and is concentrated especially in the capital, Reykjavík, and the vicinity, where about 57% of the nation lives. Outside of this area settlement is sparse, with less than one inhabitant per square kilometre, and most of them living in small communities around the coast of the country. Good transportation and communications are thus extremely important for the rural areas, and the volume of transport, especially road transport, is very substantial in relation to the size of the country's population.

Approximately two-thirds of Iceland is almost or completely devoid of vegetation. Glaciers cover some 11% of the country, and rivers and lakes another 2.2%. There are just over 28 thousand km^2, or about 27% of the land area, of very or fairly well established vegetation, about one-third of which is wetland. About 25 thousand km^2 are considered to be arable land, some 1400 km^2 of which were under cultivation in 1990.

The climate in Iceland is a cold temperate oceanic climate, with relatively mild winters (mean temperatures -2 to 0°C) and cool summers (mean temperatures 8 to 10°C). The weather is constantly changing and precipitation high, but due to the effects of the warm ocean currents (the Gulf Stream), the mean temperature is considerably higher than in most other locations sharing the same latitude.

There are few natural resources in Iceland, the main ones being the bounteous fishing banks and great hydroelectric and geothermal energy potential, together with the unique natural surroundings. According to estimates Icelandic rivers could feasibly be developed to produce 30 TWh of electricity annually, only one-seventh of which has at present been developed. Estimates have placed the geothermal energy potential which could be feasibly developed at around 200 TWh annually for one hundred years, only 1% of which has at present been developed.

Fisheries, encompassing both catching and processing, is the main understay of the national economy, accounting for 15% of GDP and 75% of the nation's goods exports. Agriculture represents only 3% of GDP, but produces sufficient meat and dairy products to satisfy domestic demand and is thus very important. Other significant primary sectors include energy production (of hydroelectric and geothermal energy), industry and tourism.

Per capita energy consumption in Iceland is among the highest in the world. The total domestic energy consumption in 1993 was approx. 89 PJ, which corresponds to the equivalent of roughly 2119 thousand barrels of oil. About 65% of the energy consumed by Icelanders comes from renewable energy sources (hydroelectric and geothermal energy) which cause little or no emissions of greenhouse gases, while the comparable figure for other OECD countries is 2 to 3%.

From 1970 to 1987 very substantial efforts were made in Iceland to establish geothermal heating distribution centres throughout the country, to utilise geothermal resources and reduce oil consumption for domestic heating purposes. Hydroelectric transmission was also extended to reduce oil-fuelled electricity production. This resulted in a reduction in the emission of carbon dioxide (CO_2) from stationary energy production in Iceland from 590 thousand tons in 1973 to only 145 thousand tons in 1990, despite a considerable increase in total energy consumption during the same period. This dramatic reduction in emissions, 445 thousand tons, is the equivalent of 20% of the total emissions in the country in 1990 (see Figure 2.8.1). It is evident that by 1987 the reduction in the emissions of carbon dioxide from stationary energy production had been so extensive that it will not be possible to achieve further substantial progress in this area before the end of this century.

The high proportion of domestic energy already provided by renewable energy supplies is not the only factor which makes it difficult for Iceland to reduce its emissions of greenhouse gases below present levels. The unusually high proportion of mobile sources (automobiles, fishing vessels, domestic aircraft and coastal transport vessels), the emissions of which are difficult to reduce, also presents special difficulties for Iceland with regard to complying with the obligations of the Framework Convention on Climate Change. These sources cause approx. 64% of the total emissions of carbon dioxide in the country, a proportion much higher than in other developed countries.

Another problem is that industrial processes (heavy industry) create relatively high emissions, about 18% of total emissions of carbon dioxide, due especially to the oxidation of carbon and carbon electrodes in ferrosilicon and aluminium production. The only possibility of reducing these emissions is to reduce production, which was relatively low in 1990.

II. Emissions of greenhouse gases

Estimates were made of emissions of anthropogenic greenhouse gases in Iceland in 1990 in accordance with draft guidelines from the Intergovernmental Panel on Climate Change (IPCC).

Total anthropogenic emissions of carbon dioxide in Iceland in 1990 were some 2172 thousand tons. Of these 64% were produced by fishing vessels and transport and 18% from industrial processes. The remaining 18% was the result of fuel consumption by industry and for heating purposes, from geothermal energy production, etc.

Total emissions of methane in 1990 were estimated to be some 23 thousand tons. In 1990 the main sources were refuse dumps, producing some 11 thousand tons,

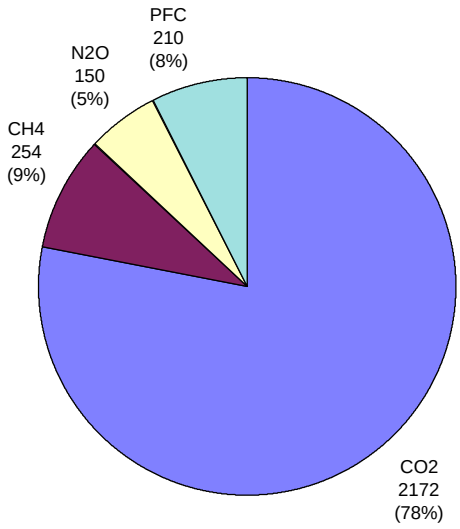
domestic animals and animal fertiliser, which produced approximately 11 900 tons. Other sources produced a total of about 0.2 thousand tons.

Total emissions of nitrous oxide in 1990 were estimated to be some 0.6 thousand tons. The main source was the use of nitrogen fertiliser which accounted for 0.5 thousand tons or 80% of the total. Another prime source was fuel consumption, which contributed about 0.1 thousand tons.

An appreciable quantity of volatile fluorocarbons, estimated at around 45 thousand tons, is thought to have been emitted from the aluminium plant in Straumsvík, the only aluminium smelter in Iceland, although the estimate is subject to a high degree of uncertainty.

If emissions of greenhouse gases in Iceland in 1990 are converted to carbon dioxide equivalents in accordance with methods used by IPCC (based on Global Warming Potential (GWP) 100) the relative importance of the various greenhouse gases can be seen. This is shown in Figure IIa here below.

Figure IIa. *Proportions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorocarbons (CF_4 and C_2F_6) in the total emissions of greenhouse gases in Iceland in 1990, as calculated in thousand equivalent tons of carbon dioxide.*



Source: Ministry of the Environment

III. Policies and measures

The policies and measures involved in Iceland's action programme are divided into two main areas. On the one hand are general and economic measures which are directed at the general public and the main industrial sectors, and on the other hand specific measures, which apply to individual sectors or services in the society.

III.a. General and economic measures

The national government has decided to emphasise incentive measures, public education and economic measures to limit emissions of greenhouse gases in Iceland. It

will seek the co-operation of local authorities, private enterprises, schools and institutions to this end. In addition, the government intends to review the taxation of fuel, linking it more closely to emissions of carbon dioxide in order to have a limiting effect on them. A special CO_2 tax will be considered for this purpose. Taxation of motor vehicles will also be reviewed in order to further encourage purchase of more economical vehicles instead of vehicles with high fuel consumption.

Special rules will be adopted to limit the use of fluorocarbons and other potent and persistent greenhouse gases, as far as possible. The Icelandic government intends to strengthen research and monitoring of greenhouse effects in Iceland to increase knowledge and to reduce the detrimental effects of the changes expected. The main areas of research to be emphasised by the national government are: marine research, meteorological research, monitoring of the atmosphere, investigation of the effects of a rise in sea level, and research in the areas of land reclamation and afforestation. The national government also aims at substantially increasing its contribution to developmental aid in the final years of this century, so that this contribution will amount to at least 0.3-0.4% of GNP by the year 2000. Emphasis will be placed on specialised aid in the area of geothermal development and the reclamation of desertified areas, in addition to projects in the area of fisheries.

The Minister of the Environment will appoint a special "ministerial steering committee", in consultation with other Ministers concerned, to direct the implementation of the action programme of the Framework Convention as described in this status report. In addition, calculations of emissions will be reviewed annually and an assessment made as to whether further measures are needed to comply with the Framework Convention.

III.b. Specific measures

The principal objective of the national government is the limitation of emissions from each economic sector so that wherever possible these will amount to no more in the year 2000 than they were in 1990. Specific measures fall into the following main categories: emissions from fishing vessels, emissions from domestic transportation, emissions from industry, emissions from waste disposal, emissions from agriculture, emissions resulting from the erosion of soil and ground cover, and the sequestration of carbon dioxide as the result of land reclamation and afforestation.

Actions concerning emissions from fishing vessels can be roughly divided into three types: 1) A special working group will be appointed by the Ministry of Industry to prepare a plan to attain the stated objective of reducing emissions of greenhouse gasses from the fishing fleet. 2) The Ministry of Fisheries will promote measures to encourage energy conservation by the fishing fleet in as many respects as possible, e.g. through the use of efficiency encouraging measures. 3) Measures will be introduced to provide for the use of sources of electrical energy ashore by ships in harbour.

Actions concerning emissions from domestic transportation can be divided into five main categories. 1) A working group will be appointed by the Ministry of Transport and Communications, in particular to establish a basis for an overall transport plan for the country having regard to environmental and energy questions. 2) Public transport will be effectively strengthened, in co-operation with local authorities in Iceland. 3)

Provision for pedestrians and cyclists in urban areas will be improved. 4) Rules will be adopted requiring the vendors of new vehicles to provide possible purchasers with standardised data on the fuel consumption of new vehicles offered for sale. 5) The Public Roads Administration will be assigned the task of finding ways to reduce the use of solvents and reduce pollution caused by organic solvents in road construction.

Three main actions are being considered concerning emissions from industry. 1) A fuel and energy conservation campaign will be launched in industrial enterprises. 2) Efforts will be made to further encourage the use of hydroelectric and geothermal energy instead of fossil fuels. 3) A special analysis will be made of ways to reduce emissions of greenhouse gases from industrial processes and from raw materials used in industry.

In the area of waste treatment and disposal three main measures will also be introduced to reduce emissions of greenhouse gases. 1) Concerted efforts will be made to reduce the volume of refuse with the aim of reducing final waste disposal by 50% by the end of the century. 2) Emissions of methane from the refuse grounds of the capital area on Álfsnes will be investigated and ways sought to utilise or eliminate the gas. 3) Open-air combustion of waste will be terminated in Iceland by January 1, 1996.

Measures in connection with agriculture, soil and ground cover erosion, and land reclamation and afforestation can be divided into four main areas: 1) An overall land-use plan for the entire country will be compiled, with emphasis placed on sustainable exploitation and the preservation of vegetation. 2) A special land reclamation programme will be prepared for the entire country, with the aim of halting rapid erosion of soil and ground cover by the end of the century and renew as much of the country's vegetation as possible. 3) A special afforestation programme will be drawn up to increase afforestation work in Iceland. The aim of the programme will be to plant at the end of this century at least four times the number of trees annually as were planted in 1990, while reducing the density of planting at the same time. 4) A special project will be launched with the aim of increasing the sequestration of carbon dioxide in biomass by at least 100 thousand tons annually before the end of this century.

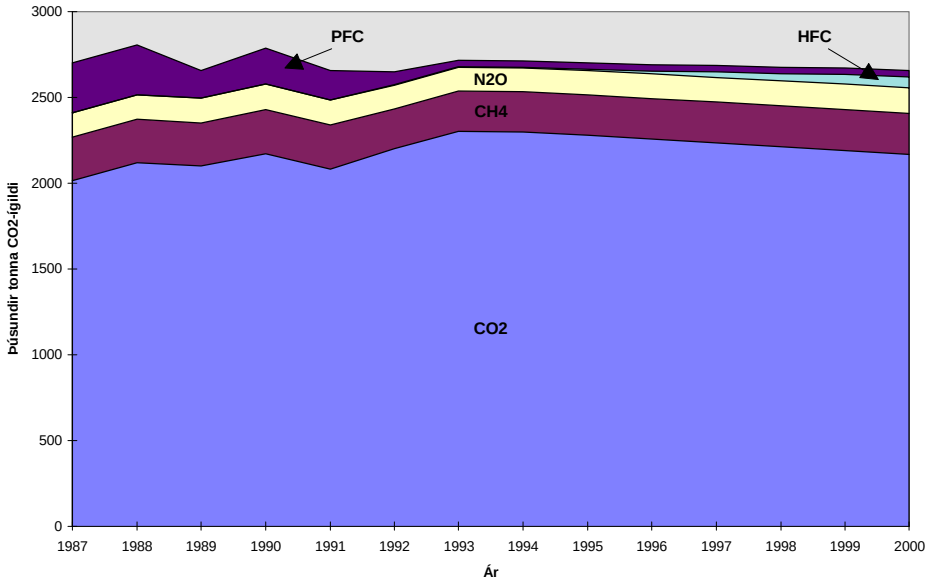
III.c. Future prospects and assessment of measures

Anthropogenic emissions of carbon dioxide are expected to increase by roughly 5% from 1990 to the year 2000, if no measures were taken to counteract this development, which would represent an increase of nearly 110 thousand tons. The policies and measures of the Icelandic government for the Framework Convention are intended to fully counteract this increase. Measures aim at reducing emissions from fuels by 35 thousand tons, reducing emissions from industry by 50 thousand tons with the electrifying of boilers and other measures in industry. In addition, measures in the transportation sector aim at reducing emissions by some 15 thousand tons, and reducing emissions from fishing vessels by around 10 thousand tons. This would provide a total reduction of 110 thousand tons. In addition, extensive measures are proposed in land reclamation and afforestation, which it is hoped will result in an increase of around 100 thousand tons of carbon dioxide absorption in biomass annually.

As far as emissions of methane are concerned, they are expected to decrease during the remaining years of the century due to measures to reduce the numbers of domestic animals and less refuse disposed of as landfill. Emissions of nitrous oxide should not

increase during the remaining years of the century. Emissions of fluorocarbons decreased considerably from 1990 to 1993, and no further significant change is expected in emissions during the remaining years of the century. When emissions of all greenhouse gases in Iceland are converted to carbon dioxide equivalents it is clear that total emissions of greenhouse gases in Iceland will decrease considerably from 1990 to the end of the century. This can be seen in Figure III.a. below.

Figure III.a. *Estimated total emissions of greenhouse gases in Iceland 1987-2000, with the proposed measures, converted to carbon dioxide equivalents (GWP-100).*



Source: Ministry of the Environment

IV. Vulnerability and adaptation

A great deal of uncertainty surrounds the climate changes which may be expected in Iceland in the wake of increasing greenhouse effects. The country is located at the junction of cold and warm air and ocean currents, and possible changes to the current systems and the most common routes of low pressure systems, together with an overall warming, due to the greenhouse effect could thus have very decisive effects. At present it appears most likely that there will be some, even fairly considerable, warming of the country in the next century, which is expected to have in most respects positive effects on the land itself, for agriculture, for instance, although the effects on the nation's most important economic sector, i.e. fisheries, is shrouded in uncertainty. The results of research on the effects of warming on the country's hydroelectric energy production in the coming decades indicates that warming should have a relatively positive effect, especially due to the increasing melting of the glaciers and flow of the glacial rivers.

If a rise in sea level occurs as the result of warming the danger of flooding could increase in some locations in Iceland. This is especially true of harbour areas and several villages which are located close to an unprotected ocean front. It is also conceivable that land erosion could increase due to increased ocean assault following a rise in sea level, especially along the southern coast.

ANNEX I

The Base Year 1990

Table 6A *Summary report for National Greenhouse Gas Inventories 1990.*

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2171.9**	**23.1**	**0.6**	**20.4**	**26.1**	**5.9**	**0.045**	**0**
1 All Energy (Fuel Combustion + Fugitive)	**1777.0**	**0.2**	**0.1**	**20.3**	**24.8**	**3.6**	**-**	**-**
A Fuel Combustion	1698.2	0.2	0.1	20.3	24.8	3.6	-	-
1 Energy and Transformation Industries	5.1	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry (ISIC)	233.3	0.0	-	0.6	0.1	-	-	-
3 Transport	1392.7	0.2	0.0	19.1	24.7	3.6	-	-
- there of Fishing Vessels	655.5	0.0	0.0	14.9	3.8	0.8	-	-
4 Commercial/Institutional	5.7	0.0	0.0	0.0	0.0	-	-	-
5 Residential	59.9	0.0	0.0	0.1	0.0	-	-	-
6 Agriculture/Forestry	-	-	-	-	-	-	-	-
7 Other	1.6	-	-	-	-	-	-	-
8 Biomass		-	-	0.4	-	-	-	-
B Fugitive Fuel Emission	-	-	-	-	-	-	-	-
1 Oil and Natural Gas Systems	-	-	-	-	-	-	-	-
C Geothermal Energy	78.8	-	-	-	-	-	-	-
1 Geothermal Energy Exploitation	78.8	-	-	-	-	-	-	-
2 Industrial Processes	**390.5**	**-**	**-**	**0.0**	**-**	**-**	**0.045**	**-**
A Iron and Steel	203.5	-	-	-	-	-	-	-
B Non-Ferrous Metals	136.5	-	-	-	-	-	0.045	-
C Inorganic Chemicals	-	-	-	0.0	-	-	-	-
D Organic Chemicals	-	-	-	-	-	-	-	-
E Non-Metallic Mineral Products	50.5	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	-
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**2.3**	**-**	**-**
A Paint	-	-	-	-	-	1.1	-	-
B Degreasing and Dry Cleaning	-	-	-	-	-	0.4	-	-
C Chemical Products Manufacture/Processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	0.9	-	-
4 Agriculture	**4.5**	**11.9**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	11.0	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.5	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Forest Clearing & On-Site Burn. of Cleared F.	-	-	-	-	-	-	-	-
B Grassland Conversion	-	-	-	-	-	-	-	-
C Abandonment of Managed Lands	-	-	-	-	-	-	-	-
D Managed Forests [1)]	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**11.0**	**-**	**0.1**	**1.3**	**-**	**-**	
A Landfills	-	11.0	-	0.1	1.3	-	-	-
B Wastewater	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International Transport (Not Incl. in Nat. Totals)	294.1	0.0	0.0	2.5	1.1	0.2	-	-

[1)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

Table 6B *Summary report for National Greenhouse Gas Inventories 1990*

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2171.9**	**23.1**	**0.6**	**20.4**	**26.1**	**5.9**	**0.045**	**0**
1 All Energy (Fuel Combustion + Fugitive)	**1777.0**	**0.2**	**0.1**	**0.3**	**24.8**	**3.6**	**-**	**-**
A Fuel Combustion	1698.2	0.2	0.1	20.3	24.8	3.6	-	-
B Fugitive Fuel Emissions	-	-	-	-	-	-	-	-
C Geothermal Energy	78.8	-	-	-	-	-	-	-
2 Industrial Processes	**390.5**	**-**	**-**	**0.0**	**-**	**-**	**0.045**	**-**
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**2.3**	**-**	**-**
4 Agriculture	**4.5**	**11.9**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	11.0	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.5	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna Clearing	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry [1)]	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
6 Waste	**-**	**11.0**	**-**	**0.1**	**1.3**	**-**	**-**	**-**

[1)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

ANNEX II

Standard Data Tables for the base year 1990

4 AGRICULTURE

Table 4A & 4B *Enteric Fermentation & Animal Wastes*

	Number of Animals	EMISSION ESTIMATES		AGGREGATE EMISSION FACTOR	
		Enteric Fermentation	Animal Wastes	Enteric Fermentation	Animal Wastes
	(1000)	Gg CH_4		kg CH_4 per animal	
4 AGRICULTURE					
A & B Enteric Fermentation & Wastes		10.96	0.94		
1 Cattle					
i Beef	42.654	2.05	0.26	48.00	6.00
ii Dairy	32.249	3.22	0.45	100.00	14.00
3 Sheep	548.599	4.39	0.10	8.00	0.19
4 Pigs	3.135	0.00	0.01	1.50	3.00
5 Horses	72.030	1.30	0.10	18.00	1.40
8 Poultry	214.975	-	0.02	-	0.08

Table 4D *Agricultural Soils*

Source & Sink Categories	Amount of nitrogen applied in fertilizer and manure	Area Cultivated	EMISSION ESTIMATES	AGGREGATE EMISSION FACTOR(S)	
Sector Specific Data				Nitrogen dioxide released per tonne N applied	Amount of biological fixation of nitrogen
	(t N)	(ha)	(Gg N_2O)	(kg N_2O-N)	(t N)
4 AGRICULTURE					
D Agricultural Soils					
Grassland	18.51	136000	0.49	0.03	-

6 WASTE

Table 6A *Landfills*

Source and Sink Categories	ACTIVITY DATA		EMISSION	AGGREGATE EMISSION FACTORS	
Waste Type	Total MSW	MSW Landfilled	CH_4 Emissions	Emission Factor	Qty of CH_4
	(kg per year)	(kg)	(kg)	kg CH_4/kg MSW	kg CH_4
A Landfills	154,756,400	113,504,400	10,782,918	0.09	0

Table 6B *Sewage Treatment*

Source and Sink Categories	ACTIVITY DATA		EMISSION ESTIMATES	AGGREGATE EMISSION FACTORS	
Waste Type	Qty BOD in Wastewater	Qty of CH_4 anaero-bically digested	CH_4 Emissions	Emission factor	Quantity of CH_4 recovered
	(kg)	(kg)	(kg)	(kg CH_4/kg BOD)	(kg CH_4)
B Wastewater					
Municipal	182500	6023	6023	0.03	0
Industrial	-	-	-	-	-

ANNEX III

Summary Report for National Greenhouse Gas Inventories for the Years 1991-1993, 1995 og 2000

Table 6A *Summary report for National Greenhouse Gas Inventories 1991*

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2081.2**	**23.2**	**0.5**	**20.8**	**25.6**	**7.2**	**0.037**	**0**
1 All Energy (Fuel Combustion + Fugitive)	**1719.6**	**0.2**	**0.1**	**20.7**	**24.4**	**3.5**	**-**	**-**
A Fuel Combustion	1640.8	0.2	0.1	20.7	24.4	3.5	-	-
1 Energy and Transformation Industries	5.0	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry (ISIC)	165.3	0.0	-	0.4	0.1	-	-	-
3 Transport	1406.4	0.2	0.0	19.7	24.3	3.5	-	-
- there of Fishing Vessels	685.6	0.0	0.0	15.8	3.7	0.8	-	-
4 Commercial/Institutional	6.8	0.0	0.0	0.0	0.0	-	-	-
5 Residential	55.8	0.0	0.0	0.1	0.0	-	-	-
6 Agriculture/Forestry	-	-	-	-	-	-	-	-
7 Other	1.4	-	-	-	-	-	-	-
8 Biomass	-	-	-	0.4	-	-	-	-
B Fugitive Fuel Emission	-	-	-	-	-	-	-	-
1 Oil and Natural Gas Systems	-	-	-	-	-	-	-	-
C Geothermal Energy	78.8	-	-	-	-	-	-	-
1 Geothermal Energy Exploitation	78.8	-	-	-	-	-	-	-
2 Industrial Processes	**357.3**	**-**	**-**	**0.0**	**-**	**-**	**0.037**	**-**
A Iron and Steel	171.1	-	-	-	-	-	-	-
B Non-Ferrous Metals	139.3	-	-	-	-	-	0.037	-
C Inorganic Chemicals	-	-	-	0.0	-	-	-	-
D Organic Chemicals	-	-	-	-	-	-	-	-
E Non-Metallic Mineral Products	47.0	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	-
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**3.7**	**-**	**-**
A Paint	-	-	-	-	-	1.4	-	-
B Degreasing and Dry Cleaning	-	-	-	-	-	0.4	-	-
C Chemical Products Manufacture/Processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	1.9	-	-
4 Agriculture	**4.3**	**11.7**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	10.8	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.3	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Forest Burn. & On-Site Burn. of Cleared F.	-	-	-	-	-	-	-	-
B Grassland Conversion	-	-	-	-	-	-	-	-
C Abandonment of Managed Lands	-	-	-	-	-	-	-	-
D Managed Forests [1)]	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**11.3**	**-**	**0.1**	**1.2**	**-**	**-**	
A Landfills	-	11.3	-	0.1	1.2	-	-	-
B Wastewater	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International Transport (Not Incl. Nat. Totals)	246.8	0.0	0.0	1.4	0.7	0.1	-	-

[1)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

Table 6A *Summary report for National Greenhouse Gas Inventories 1992*

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2197.9**	**21.0**	**0.5**	**22.0**	**26.0**	**6.8**	**0.016**	**0.000**
1 All Energy (Fuel Combustion + Fugitive)	**1832.9**	**0.2**	**0.1**	**21.9**	**24.7**	**3.6**	**-**	**-**
A Fuel Combustion	1754.0	0.2	0.1	21.9	24.7	3.6	-	-
1 Energy and Transformation Industries	5.0	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry (ISIC)	226.0	0.0	-	0.5	0.1	-	-	-
3 Transport	1461.8	0.2	0.0	20.9	24.6	3.6	-	-
- there of Fishing Vessels	739.7	0.0	0.0	17.0	4.0	0.9	-	-
4 Commercial/Institutional	4.9	0.0	0.0	0.0	0.0	-	-	-
5 Residential	54.8	0.0	0.0	0.1	0.0	-	-	-
6 Agriculture/Forestry	-	-	-	-	-	-	-	-
7 Other	1.5	-	-	-	-	-	-	-
8 Biomass	-	-	-	0.3	-	-	-	-
B Fugitive Fuel Emission	-	-	-	-	-	-	-	-
1 Oil and Natural Gas Systems	-	-	-	-	-	-	-	-
C Geothermal Energy	78.8	-	-	-	-	-	-	-
1 Geothermal Energy Exploitation	78.8	-	-	-	-	-	-	-
2 Industrial Processes	**360.6**	**-**	**-**	**0.0**	**-**	**-**	**0.016**	**0.000**
A Iron and Steel	182.3	-	-	-	-	-	-	-
B Non-Ferrous Metals	134.2	-	-	-	-	-	0.016	-
C Inorganic Chemicals	-	-	-	0.0	-	-	-	-
D Organic Chemicals	-	-	-	-	-	-	-	-
E Non-Metallic Mineral Products	44.2	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	0.000
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**3.2**	**-**	**-**
A Paint	-	-	-	-	-	1.2	-	-
B Degreasing and Dry Cleaning	-	-	-	-	-	0.3	-	-
C Chemical Products Manufacture/Processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	1.6	-	-
4 Agriculture	**4.4**	**11.4**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	10.5	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.4	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Forest Burn. & On-Site Burn. of Cleared F.	-	-	-	-	-	-	-	-
B Grassland Conversion	-	-	-	-	-	-	-	-
C Abandonment of Managed Lands	-	-	-	-	-	-	-	-
D Managed Forests [1)]	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**9.5**	**-**	**0.1**	**1.3**	**-**	**-**	**-**
A Landfills	-	9.4	-	0.1	1.3	-	-	-
B Wastewater	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International Transport (Not Incl. Nat. Totals)	204.9	0.0	0.0	1.9	0.8	0.1	-	-

[1)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

Table 6A *Summary report for National Greenhouse Gas Inventories 1993*

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2300.5**	**21.3**	**0.5**	**22.7**	**25.4**	**6.4**	**0.008**	**0.001**
1 All Energy (Fuel Combustion + Fugitive)	**1887.5**	**0.2**	**0.1**	**22.6**	**24.5**	**3.6**	-	-
A Fuel Combustion	1808.6	0.2	0.1	22.6	24.5	3.6	-	-
1 Energy and Transformation Industries	5.0	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry (ISIC)	249.4	0.0	-	0.6	0.1	-	-	-
3 Transport	1495.6	0.2	0.0	21.5	24.4	3.6	-	-
- there of Fishing Vessels	770.0	0.0	0.0	17.7	4.2	0.9	-	-
4 Commercial/Institutional	6.2	0.0	0.0	0.0	0.0	-	-	-
5 Residential	52.1	0.0	0.0	0.1	0.0	-	-	-
6 Agriculture/Forestry	-	-	-	-	-	-	-	-
7 Other	1.4	-	-	-	-	-	-	-
8 Biomass	-	-	-	0.3	-	-	-	-
B Fugitive Fuel Emission	-	-	-	-	-	-	-	-
1 Oil and Natural Gas Systems	-	-	-	-	-	-	-	-
C Geothermal Energy	**78.9**	-	-	-	-	-	-	-
1 Geothermal Energy Exploitation	78.9	-	-	-	-	-	-	-
2 Industrial Processes	**408.2**	**-**	**-**	**0.0**	**-**	**-**	**0.008**	**0.001**
A Iron and Steel	230.9	-	-	-	-	-	-	-
B Non-Ferrous Metals	139.0	-	-	-	-	-	0.008	-
C Inorganic Chemicals	-	-	-	0.0	-	-	-	-
D Organic Chemicals	-	-	-	-	-	-	-	-
E Non-Metallic Mineral Products	38.3	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	0.001
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**2.8**	**-**	**-**
A Paint	-	-	-	-	-	1.2	-	-
B Degreasing and Dry Cleaning	-	-	-	-	-	0.4	-	-
C Chemical Products Manufacture/Processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	1.2	-	-
4 Agriculture	**4.9**	**11.3**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	10.4	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.9	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Forest Burn. & On-Site Burn. of Cleared F.	-	-	-	-	-	-	-	-
B Grassland Conversion	-	-	-	-	-	-	-	-
C Abandonment of Managed Lands	-	-	-	-	-	-	-	-
D Managed Forests [1)]	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**9.8**	**-**	**0.1**	**0.9**	**-**	**-**	**-**
A Landfills	-	9.8	-	0.1	0.9	-	-	-
B Wastewater	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International Transport (Not Incl. Nat. Totals)	225.1	0.0	0.0	2.7	1.1	0.2	-	-

[1)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

Table 6A *Summary report for National Greenhouse Gas Inventories 1995* [1)]

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2277.4**	**21.4**	**0.5**	**22.0**	**22.3**	**6.1**	**0.008**	**0.003**
1 All Energy (Fuel Combustion + Fugitive)	**1861.2**	**0.2**	**0.1**	**21.9**	**21.7**	**3.4**	**-**	**-**
A Fuel Combustion	1782.3	0.2	0.1	21.9	21.7	3.4	-	-
1 Energy and Transformation Industries	5.0	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry (ISIC)	242.7	0.0	-	0.6	0.1	-	-	-
3 Transport	1489.1	0.2	0.0	20.9	21.6	3.4	-	-
- there of Fishing Vessels	766.8	0.0	0.0	17.6	4.2	0.9	-	-
4 Commercial/Institutional	-	-	0.0	-	-	-	-	-
5 Residential	47.4	0.0	0.0	0.1	0.0	-	-	-
6 Agriculture/Forestry	-	-	-	-	-	-	-	-
7 Other	-	-	-	-	-	-	-	-
8 Biomass	-	-	-	0.3	-	-	-	-
B Fugitive Fuel Emission	-	-	-	-	-	-	-	-
1 Oil and Natural Gas Systems	-	-	-	-	-	-	-	-
C Geothermal Energy	**78.9**	-	-	-	-	-	-	-
1 Geothermal Energy Exploitation	78.9	-	-	-	-	-	-	-
2 Industrial Processes	**411.3**	**-**	**-**	**0.0**	**-**	**-**	**0.008**	**0.003**
A Iron and Steel	228.2	-	-	-	-	-	-	-
B Non-Ferrous Metals	139.0	-	-	-	-	-	0.008	-
C Inorganic Chemicals	-	-	-	0.0	-	-	-	-
D Organic Chemicals	-	-	-	-	-	-	-	-
E Non-Metallic Mineral Products	44.2	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	0.003
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**2.7**	**-**	**-**
A Paint	-	-	-	-	-	1.2	-	-
B Degreasing and Dry Cleaning	-	-	-	-	-	0.4	-	-
C Chemical Products Manufacture/Processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	1.1	-	-
4 Agriculture	**4.9**	**11.4**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	10.5	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.9	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Forest Clearing & On-Site Burn. of Cleared	-	-	-	-	-	-	-	-
B Grassland Conversion	-	-	-	-	-	-	-	-
C Abandonment of Managed Lands	-	-	-	-	-	-	-	-
D Managed Forests [2)]	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**9.9**	**-**	**0.1**	**0.6**	**-**	**-**	**-**
A Landfills	-	9.9	-	0.1	0.6	-	-	-
B Wastewater	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International Transport (Not Incl. Nat. Totals)	225.1	0.0	0.0	2.7	1.1	0.2	-	-

[1)] *National Emissions are Calculated According to Predictions Without Taking Into Account the Effect of the National Climate Change Action Plan.*

[2)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

Table 6A *Summary report for National Greenhouse Gas Inventories 2000* [1)]

Greenhouse Gas Source and Sink Categories	**CO_2** Gg	**CH_4** Gg	**N_2O** Gg	**NO_x** Gg	**CO** Gg	**NMVOC** Gg	**PFC** Gg	**HFC** Gg
Total National Emissions	**2281.8**	**21.8**	**0.6**	**21.1**	**17.5**	**5.8**	**0.008**	**0.020**
1 All Energy (Fuel Combustion + Fugitive)	**1865.6**	**0.1**	**0.1**	**21.1**	**17.2**	**3.1**	**-**	**-**
A Fuel Combustion	1786.7	0.1	0.1	21.1	17.2	3.1	-	-
1 Energy and Transformation Industries	5.0	0.0	0.0	0.1	0.0	0.0	-	-
2 Industry (ISIC)	238.6	0.0	-	0.6	0.1	-	-	-
3 Transport	1522.8	0.1	0.1	20.0	17.1	3.1	-	-
- there of Fishing Vessels	741.7	0.0	0.0	17.0	4.1	0.9	-	-
4 Commercial/Institutional	-	-	0.0	-	-	-	-	-
5 Residential	22.1	0.0	0.0	0.0	0.0	-	-	-
6 Agriculture/Forestry	-	-	-	-	-	-	-	-
7 Other	-	-	-	-	-	-	-	-
8 Biomass	-	-	-	0.3	-	-	-	-
B Fugitive Fuel Emission	-	-	-	-	-	-	-	-
1 Oil and Natural Gas Systems	-	-	-	-	-	-	-	-
C Geothermal Energy	**78.9**	-	-	-	-	-	-	-
1 Geothermal Energy Exploitation	78.9	-	-	-	-	-	-	-
2 Industrial Processes	**411.3**	**-**	**-**	**0.0**	**-**	**-**	**0.008**	**0.020**
A Iron and Steel	228.2	-	-	-	-	-	-	-
B Non-Ferrous Metals	139.0	-	-	-	-	-	0.008	-
C Inorganic Chemicals	-	-	-	0.0	-	-	-	-
D Organic Chemicals	-	-	-	-	-	-	-	-
E Non-Metallic Mineral Products	44.2	-	-	-	-	-	-	-
F Other	-	-	-	-	-	-	-	0.020
3 Solvent Use	**-**	**-**	**-**	**-**	**-**	**2.7**	**-**	**-**
A Paint	-	-	-	-	-	1.2	-	-
B Degreasing and Dry Cleaning	-	-	-	-	-	0.4	-	-
C Chemical Products Manufacture/Processing	-	-	-	-	-	-	-	-
D Other	-	-	-	-	-	1.1	-	-
4 Agriculture	**4.9**	**11.5**	**0.5**	**-**	**-**	**-**	**-**	**-**
A Enteric Fermentation	-	10.6	-	-	-	-	-	-
B Animal Wastes	-	0.9	-	-	-	-	-	-
C Rice Cultivation	-	-	-	-	-	-	-	-
D Agricultural Soils	4.9	-	0.5	-	-	-	-	-
E Agricultural Waste Burning	-	-	-	-	-	-	-	-
F Savanna burning	-	-	-	-	-	-	-	-
G Other	-	-	-	-	-	-	-	-
5 Land Use Change & Forestry	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A Forest Clearing & On-Site Burn. of Cleared F.	-	-	-	-	-	-	-	-
B Grassland Conversion	-	-	-	-	-	-	-	-
C Abandonment of Managed Lands	-	-	-	-	-	-	-	-
D Managed Forests [2)]	-	-	-	-	-	-	-	-
E Other	-	-	-	-	-	-	-	-
6 Waste	**-**	**10.2**	**-**	**0.0**	**0.4**	**-**	**-**	**-**
A Landfills	-	10.2	-	0.0	0.4	-	-	-
B Wastewater	-	0.0	-	-	-	-	-	-
C Other	-	-	-	-	-	-	-	-
International Transport (Not Incl. Nat. Totals)	225.1	0.0	0.0	2.7	1.1	0.2	-	-

[1)] *National Emissions are Calculated According to Predictions Without Taking Into Account the Effect of the National Climate Change Action Plan.*

[2)] *Carbon Sequestration by Plantations is Considerable but is not included in This Summary Report.*

ANNEX IV

Emission Factors

Table IV.i. *Emission Factors for Fossil Fuels and Carbon Sources*

	Types	Conversion Factors GJ/Gg	Carbon Emission Factors kg C/GJ	Fraction Oxidized	Actual CO_2 Emission Factors Gg CO_2/GJ
Liquid Fossil	Gasoline	44800	18.90	0.99	0.0000686
	Jet Kerosene	44590	19.50	0.99	0.0000708
	Kerosene	44750	19.60	0.99	0.0000711
	Gas/Diesel Oil	43330	20.20	0.99	0.0000733
	Residual Fuel Oil	40190	21.10	0.99	0.0000766
	LPG	47310	17.20	0.99	0.0000624
	Naphtha	45010	20.00	0.99	0.0000726
	Bitumen	40190	22.00	0.99	0.0000799
	Lubricants	40190	20.00	0.99	0.0000726
	Petroleum Coke	40190	27.50	0.99	0.0000998
	Refinery Feedstocks	44800	20.00	0.99	0.0000726
*	Waste Oil	20064	23.92	0.99	0.0000868
Solid Fossil	Coking Coal	27440	25.80	0.98	0.0000927
	Steam Coal	28000	25.80	0.98	0.0000927
	Lignite	28000	27.60	0.98	0.0000992
	Sub-bituminous Coal	28000	26.20	0.98	0.0000941
*	Carbon electrodes used in aluminium sm.	31350	31.42	0.98	0.0001129
*	Carbon electrodes uesd in iron & steel ind.	28000	32.14	0.98	0.0001155
*	Carbon electrodes in mineral wool prod.	31350	31.42	0.98	0.0001129
*	Carbon electrodes burned in cement prod.	31350	27.75	0.98	0.0000997
	BKB & Patent fuel	28000	25.80	0.98	0.0000927
*	Coke used in iron and steel industry	28000	29.50	0.98	0.0001060
	Peat	28000	28.90	0.98	0.0001038
Gaseous Fossil	Natural Gas		15.30	0.995	0.0000558
*	Acetylen (C_2H_2)	26413	34.95	0.995	0.0001275
Solid Biomass *	Fuelwood	16720	20.93	0.98	0.0000752
*	MSW	10700	0	1	0.0000244
Liquid Biomass			20.00		

* Conversion Factors and Carbon Emission Factors from National Sources (from actual users).

Table IV.ii. *Emission Factors for various raw materials and MSW*

	Type	Conversion Factors GJ/Gg	Carbon Emission Factors kg C/GJ	Fraction Oxidized	Actual CO_2 Emission Factors Gg CO_2/GJ	NO_x Gg/GJ	CH_4 Gg CH_4/GJ	NMVOC Gg/GJ	CO Gg/GJ	N_2O Gg/GJ
*	Alumina									
*	Cement				0.4402000					
	Incineration (low e.)	10700	24.95	0.98	0.0000897	9.35E-08			9.35E-07	
	Open burning-MSW	10700	24.95	0.98	0.0000897	2.80E-07	6.08E-07		3.93E-06	
	Landfill	10700	6.66	1.00			8.90E-06			
*	Mineral wool				0.108					

* Emission Factors from National sources.

Table IV.iii. *Emission Factors for air transport and marine transport*

TRANSPORT		Fuel Type	Emission factor NO_x Gg/GJ	Emission factor CH_4 Gg/GJ	Emission factor NMVOC Gg/GJ	Emission factor CO Gg/GJ	Emission factor N_2O Gg/GJ
Air Transport	Aeroplanes	Gasoline	0.00000008	0.00000006	0.00000054	0.000024	9E-10
	Jets	Jet Kerosene	0.00000029	0.000000002	0.000000018	0.00000012	
Fishing Vessels	Boats	Gas/Diesel Oil	0.0000016	0.000000005	0.00000011	0.0000005	0.000000002
	Ocean Going Ships	Residual Fuel Oil	0.0000021			0.000000046	0.000000002
Other Vessels	Boats	Gas/Diesel Oil	0.0000016	0.000000005	0.00000011	0.0000005	0.000000002
	Ocean going Ships	Residual Fuel Oil	0.0000021			0.000000046	0.000000002

Table IV.v. *Classification of the Icelandic Vehicle fleet According to its Emission Control Technology types (MOBILE4)*

			Fraction of the National Vehicle Fleet within Each Emission Control Type					
Road Transport		**Emission Control Technology**	**1990**	**1991**	**1992**	**1993**	**1995**	**2000**
Gasoline	Passenger Cars							
		Uncontrolled	0.08	0.03	0.03	0.03	0.03	0
		Non catalyst control	0.92	0.97	0.97	0.97	0.73	0.22
		Advanced catalyst control	0	0	0	0	0.24	0.78
	Light-Duty Trucks							
		Uncontrolled	0.08	0.03	0.03	0.03	0.03	0
		Non catalyst control	0.92	0.97	0.97	0.97	0.73	0.22
		Advanced catalyst control	0	0	0	0	0.24	0.78
	Heavy-Duty Trucks							
		Uncontrolled	0.52	0.22	0.22	0.22	0.3	0
		Non catalyst control	0.48	0.78	0.78	0.78	0.73	0.22
		Advanced catalyst control	0	0	0	0	0.24	0.78
Gas/Diesel Oil	Passenger Cars							
		Uncontrolled	0.52	0.22	0.22	0.22	0.8	0
		Moderate control	0.48	0.78	0.78	0.54	0.44	0.22
		Advanced control	0	0	0	0.24	0.48	0.78
	Light-Duty Trucks							
		Uncontrolled	0.52	0.22	0.22	0.22	0.8	0
		Moderate control	0.48	0.78	0.78	0.54	0.44	0.22
		Advanced control	0	0	0	0.24	0.48	0.78
	Heavy-Duty Trucks							
		Uncontrolled	0.52	0.22	0.22	0.22	0.03	0
		Moderate control	0.48	0.78	0.78	0.54	0.49	0.22
		Advanced control	0	0	0	0.24	0.48	0.78

ANNEX V

Other

Table V.i. *Industrial Production*

	1990 Gg	**1991** Gg	**1992** Gg	**1993** Gg
Ferro-Silicon (75%)	62.792	50.305	54.413	67.374
Aluminium	87.839	89.217	90.045	94.152
Diatomite	26.107	23.015	19.946	17.743
Fertilizer	65.404	63.056	57.324	59.054
Cement	114.1	106.174	99.8	86.419
Mineral Wool	6.15	5.77	5.07	5.29
Fish meal [1)]	155	82	174	195

[1)] Raw material utilisation 17%.

Table V.ii. *Production of Industrial Fertilizers and Animal Wastes 1990-'93*

	1990 kt	**1991** kt	**1992** kt	**1993** kt
Industrial Fertilizer	65.4	63.1	57.3	59.1
- there of quantity of Nitrogen	12.9	12.4	11.1	11.8
Animal Wastes	1764	1771	1740	1733
- there of quantity of Nitrogen	9.2	9.1	8.9	8.8

Note: The following Annex tables are not available electronically:

Annex I

Table 7A, Overview Table for National Greenhouse Gas Inventories 1990

Annex II

Table 1, Energy fuel combustion activities and geothermal energy activities 1990

Table 2, Industrial processes

Table 3, Solvents

Annex IV

Table IV.iv., Emission factors for road transport (MOBILE4)

Table IV.vi., Emission factors for various ovens, kilns etc. in industry, residential, energy, transformation and commercial/institutional use.

Table IV.vii., Emission factors for agriculture

Table IV.viii, Emission factors for sewage treatment

Readers wishing to view the above tables should refer to the original printed document.