Denmark's Third National Communication on Climate Change

Under the United Nations Framework Convention on Climate Change

Danish Environmental Protection Agency

Danish Ministry of the Environment

Contents

Appendices

Weight unit used :
1 Gg (Gigagram) = 10^9 gram =
10^3 tonnes = 1 ktonnes

Exchange rates in 2001 :
1DKK corresponds to 0.1342 EURO or 0.1202 USD

FOREWORD

The ultimate objective of international climate cooperation is described in Article 2 of the UN Framework Convention on Climate Change, namely to achieve a "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

In September 2001, the UN Intergovernmental Panel on Climate Change (IPCC) presented its Third Assessment Report. The report shows that there is now stronger evidence for a human influence on the global climate than previously assumed, and that most of the observed warming at the Earth's surface over the last 50 years is likely to have been due to human activities. The climate changed during the twentieth century, and larger changes are expected in the twenty-first century.

No one knows the exact scope of future climate change. However, today no one can doubt the risk that climate change will affect humans and the environment in both the rich and the poor parts of the world. Taking climate change seriously has become a prerequisite for achieving sustainable development.

The Danish government takes global climate change seriously, and it will fully meet Denmark's international commitments.

Within the framework of the Kyoto Protocol, under the auspices of the EU, Denmark is committed to reducing its emissions of greenhouse gases by 21% in 2008-12 compared to the level in 1990, taking into account the unusually high import of electricity in 1990. This is one of the hardest reduction targets in the world.

Since Denmark issued its First (1994) and Second (1997) National Communication under the UN Climate Convention, the Kyoto Protocol has been adopted, and the Conference of the Parties has taken the decisions necessary on realisation of the Protocol. Denmark ratified the Kyoto Protocol together with the other EU countries on 31 May 2002. The Danish government hopes that the Protocol will enter into force in 2003.

This Third National Communication is the result of extensive work, coordinated by the Danish Environmental Protection Agency, and with the participation of a large number of public institutions. The report contains information on implementation by Denmark, Greenland, and the Faeroe Islands of the commitments under the UN Convention on Climate Change, including emissions and uptake of greenhouse gases, policies and measures, and the expected effects of these.

The report also contains information on the Danish government's new national climate change strategy, which the Danish Parliament, Folketinget, endorsed in March 2003. The strategy's objective is to meet Denmark's Kyoto target by achieving more environment for the money. The strategy therefore combines cost-effective national measures with use of the Kyoto Protocol's flexible mechanisms and the EU system for trading with emissions.

Throughout the 90s, Denmark initiated considerable national efforts within the climate area, and these efforts will continuously contribute to reductions in the future. With regard to total emissions of all greenhouse gases, in 2000 Denmark achieved the target in the Convention on Climate Change to reduce to 1990 levels. Despite significant economic growth, CO_2 emissions have returned to the level in 1990. While electricity export to Scandinavia has increased, CO_2 emissions caused by domestic activities have decreased by more than 13%.

One of the most recent measures introduced is a tax on industrial greenhouse gases (HFCs, PFCs, and SF_6), which entered into force in March 2001. In July 2002 this was followed by rules on phasing out the use of these substances. With some exceptions, phase out will take place over the period 2003-2006.

The climate challenge requires targeted, long-term, and united action in accordance with the principle of common but differentiated responsibilities for countries. The industrialised countries must continue to lead the way with reductions in emissions of greenhouse gases, and grant assistance to the developing countries, including transfers of technology and capacity building. However, economic developments in several countries not listed in Annex I of the Convention on Climate Change are now so favourable that they will soon also be able to make greater contributions to curbing the increasing emissions of greenhouse gases. Not at the expense of their economic development, but to the advantage of it. Today there are many technological opportunities to promote economic development, and at the same time reduce emissions of greenhouse gases. Renewable energy is a good example.

We must initiate a process as soon as possible that builds upon openness and credibility between the Parties, and that aims at further action after 2012 - with a view to meeting our common goal, the ultimate objective of the Convention on Climate Change.

Copenhagen, May 2003

Hans Chr. Schmidt
Minister for the Environment

Introduction

At the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, more than 150 countries signed the UN Framework Convention on Climate Change (the Climate Convention).

On 21 December 1993 the Climate Convention was ratified by enough countries, including Denmark, for it to enter into force on 21 March 1994.

According to decisions made in pursuance of Article 12 of the Climate Convention information by the Parties, the Convention's industrialised countries must sumit a Third National Communication to the Convention secretariat.

In accordance with guidelines under the Climate Convention, this Third National Communication contains a summary (Chapter 1), information on the national circumstances relevant to greenhouse gas emmissions and removals (Chapter 2), greenhouse gas inventory information (Chapter 3), policies and measures affecting greenhouse gas emissions and removals (Chapter 4), projections and the total effect of policies and measures (Chapter 5), vulnerability assessment, climate change impacts and adaptation measures (Chapter 6), financial ressources and transfer of technology (Chapter 7), research and systematic observations (Chapter 8), and education, training and public awareness (Chapter 9).

This report thus contains information about Denmark's implementation of the obligations under the Climate Convention.

Denmark also contributes to the European Union's implementation of the Climate Convention's obligations, including in connection with inventories of the EU greenhouse gas inventory and in connection with the implementation of common and coordinated policies and measures to reduce greenhouse gas emissions, including under the European Climate Change Programme (ECCP).

Further information on the EU's climate policy etc. is to be found in the EU's Third National Communication.

Since Denmark's ratification of the Climate Convention covers the entire Kingdom, this communication also contains information on Greenland and the Faroe Islands. Unlike Denmark's Second National Communication from 1997, it is now possible to show preliminary inventories of Greenland's and the Faroe Islands' greenhouse gas emissions, because such inventories are now included in the annual emission reports to the Climate Convention.

With respect to Denmark's inventories and projections of emissions and removals of greenhouse gases it should be noted that these are shown both in the form that must be used under the Climate Convention and in the form expected to be used under the Kyoto Protocol. Summary inventory information for the economic sectors in Denmark is also shown. Further information and more detailed data combinations are available on the Danish Environmental Protection Agency's website (www.mst.dk).

The Kyoto Protocol was adopted by the Parties to the Convention in November 1997, and after the agreement on the EU Member States' distribution of the burden of the EU's total obligation under the Kyoto Protocol, Denmark and the other EU Member States ratified the Protocol in May 2002. Territorial reservation was taken for the Faroe Islands in connection with Denmark's ratification of the Protocol. It should be noted that only Denmark's greenhouse gas emissions are included in the EU's distribution of the burden under Article 4 of the Protocol because Greenland and the Faroe Islands are not members of the EU.

Besides the Danish Environmental Protection Agency (DEPA), which is in charge of the work, the following institutions have contributed to this Third National Communication:

The National Forest and Nature Agency,
The National Environmental Research Institute,
The National Environmental Research Forest and Landscape Research Institute,
Geological Survey of Denmark and Greenland,
The National Survey and Cadastre,
The Danish Energy Authority,
The Danish Ministry of Foreign Affairs,
The Danish Ministry of Finance,
The Danish Ministry of Transport,
The Danish Meteorological Institute,
The Danish Coastal Authority,
The Danish Ministry of Food, Agriculture and Fisheries,
The Danish Institute of Agricultural Sciences,
Greenland's Home Rule, including the Directorate for Environment and Nature,
The Faroe Islands' Home Rule, including the Ministry of Oil,
Statistics Denmark,
Risø National Laboratory,
University of Copenhagen,
Aarhus University,
Technical University of Denmark,
The Institute of Local Government Studies – Denmark ,
The Royal Veterinary and Agricultural University.

1. Executive Summary

1.1. National circumstances relevant to greenhouse gas emissions and removals

1.1.1. General

The Kingdom of Denmark comprises Denmark, Greenland and the Faroe Islands. The UN Framework Convention on Climate Changes has been ratified on behalf of all three parts of the Kingdom.

Today, Denmark has a population of slightly more than 5.3 million and a total area of 43,000 km^2. More than 60% of the area is used for agricultural purposes, while 11% is forested and 13% is towns, roads and scattered housing, while the rest consists of natural areas, including lakes, bogs, heath, etc.

The Danish climate is temperate with precipitation evenly distributed over the year. The mean annual temperature is 7.7°C and mean annual precipitation is 712 mm.

Since 1993 Denmark has benefitted from considerable economic growth, and Gross National Product (GNP) has risen on average by 2.7% per year. In the year 2000 GNP amounted to over DKK 1,300 billion, corresponding to DKK 245,000 per capita.

1.1.2 Energy, transport and the domestic sector

Denmark is self-sufficient in energy, due primarily to the production of oil and gas in the North Sea, but renewable energy is also increasingly contributing to the country's energy supply. Denmark's total own production of energy has more than tripled during the last decade.

Despite strong economic growth, energy consumption has remained largely unchanged at around 800 PJ in the period in question.

Denmark's dependence on oil and coal has fallen, and particularly within electricity and heat production, Denmark has succeeded in substituting with other fuels. Renewable energy accounts for about 12% of Denmark's actual energy consumption. Actual energy consumption, which amounted to 829 PJ in 2001, was distributed over the following energy sources: oil 366 PJ (44%), natural gas 194 PJ (23%), coal 175 PJ (21%) and renewable energy 96PJ (12%). The net export of electricity was relatively small, corresponding to 2 PJ.

The distribution of gross energy consumption in 2001 was as follows: industry and agriculture accounted for 27%, domestic sector for 27%, transport for 24% and commerce and service for 15%. Refining and non-energy purposes accounted for the remaining 7%.

More than 2/3 of the electricity supply comes from large primary power stations or CHP plants, while the district heat supply covers almost half of the need for heating. The energy sector alone (energy production and supply) accounts for 40% of Denmark's total emissions of greenhouse gases.

Traffic has increased considerably in the last 10 years. Passenger traffic (excl. motor cycle, 2-stroke and bicycle traffic) increased from 64 billion person-kilometres in 1990 to 74 billion in 2001. In the same period, freight transport by road increased from 12 billion tonne-km to14 billion. The transport sector accounts for 18% of Denmark's total greenhouse gas emissions.

The domestic sector accounted for about 6% of Denmark's total emissions of greenhouse gases in 2001.

1.1.3. Business sector and waste

Industry's production value accounts for about 30% of total production. The largest sectors of industry are food and beverages, engineering, electronics and the chemical industry. The total business sector (industry, building and construction, together with public and private services) accounts for about 13% of Denmark's total emissions of greenhouse gases. By far the largest part of these emissions, is CO_2 from energy consumption, but the sector is also a source of emissions of industrial greenhouse gases.

The waste sector's methane emissions account for 2% of the total greenhouse gas emissions. Methane emissions from the waste sector are expected to fall in the future due to the obligation the municipalities have had since 1997 to send combustible waste for incineration. In addition, gas from a number of landfill sites is used in energy production, which helps to reduce both CO_2 and methane emissions.

1.1.4. Agriculture and forestry

In the last 40 years the agricultural area in Denmark has fallen from 72% (30,900 km^2) of the total area in 1960 to 62% (26,756 km^2) in 2001. The number of farms has fallen by 50%, from 119,155 in 1980 to 53,489 in 2001, while the average size of farms has increased by more than 100% in the same period, from 24 ha to 50 ha. At approximately 11%, agricultural exports will account for a considerable proportion of all Danish exports. The agricultural sector accounted for about 20% of Denmark's total emissions of greenhouse gases in 2001.

Approximately 11% of Denmark is forested, and the Forestry Act protects a very large part of the existing forest from other land use. The ambition is to have about 20-25% of Denmark's area forested by the end of the 21st century.

1.1.5. Greenland and the Faroe Islands

Greenland is the world's largest island, with an area of 2.2 million km^2, 85% of which is covered by the ice cap. From north to south, Greenland extends over 2,600 km. Greenland has a population of slightly more than 56,000, and fishing is the main occupation.

Greenland's climate is Arctic, and forests do not grow in Greenland. The warmest recorded temperature since 1958 is 25.5°C, while temperatures can go down below –70 °C on the inland ice.

The Faroe Islands consist of 18 islands with a total area of 1,399 km^2

and have a population of around 47,000. The climate is characterised by mild winters and cool summers and the weather is often moist and rainy. The mean annual temperature is 6.5 °C.

Fish and fisheries account for 98% of the Faroe Island's total export earnings, apart from exports of ships, which vary greatly over the years. Agriculture was the main occupation until the end of the 19th century but now only accounts for 0.7% of gross national product at factor cost. There are more than 1,000 head of cattle and about 70,000 sheep on the Faroe Islands.

1.2. Greenhouse gas inventory information

Denmark's greenhouse gas inventories are prepared in accordance with the guidelines from the Intergovernmental Panel on Climate Change (IPCC) and are based on the methods developed under the European CORINAIR programme.
Table 1.1 shows Denmark's total emissions of the greenhouse gases CO_2, CH_4 and N_2O and the industrial gases HFCs, PFCs and SF_6 from 1990 to 2001, calculated in CO_2 equivalents in accordance with the general rules for inventories under the Climate Convention. Inventory based on the rules under the Kyoto Protocol will involve some changes with respect to base year

Table 1.1 Denmark's total emissions and removals of greenhouse gases 1990-2001
Source: National Environmental Research Institute

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
GREENHOUSE GAS EMISSIONS	(Gg CO_2 equivalent)											
Net CO_2 emissions/removals	49541	60264	54442	56805	60793	58002	71422	62067	56898	54118	49247	50824
CO_2 emissions (without LUCF)	52659	63383	57563	59928	63919	61130	74556	65209	60050	57279	52764	54355
CH_4	5672	5728	5735	5858	5882	5958	6030	5920	5802	5473	5535	5606
N_2O	10843	10737	10068	10193	9976	9903	9758	9343	9382	9314	9090	8749
HFCs	0	0	4	96	141	236	371	392	489	598	705	647
PFCs	0	0	0	0	0	1	3	7	15	20	28	22
SF_6	43	62	89	135	122	107	61	73	59	65	59	30
Total (with net CO_2 emissions/removals)	**66099**	**76791**	**70338**	**73086**	**76913**	**74207**	**87644**	**77803**	**72645**	**69589**	**64664**	**65879**
Total (without CO_2 from LUCF)	**69217**	**79910**	**73459**	**76209**	**80039**	**77335**	**90778**	**80945**	**75797**	**72750**	**68181**	**69410**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(Gg CO_2 equivalent)											
1. Energy	52386	63113	57142	59566	63790	61135	74732	65222	60059	57359	52758	54416
2. Industrial Processes	1049	1240	1393	1541	1581	1655	1823	2012	2000	2085	2246	2164
3. Solvent and Other Product Use	124	122	121	125	119	118	116	115	114	113	112	112
4. Agriculture	14348	14096	13441	13618	13174	13111	12803	12354	12460	12083	11868	11550
5. Land-Use Change and Forestry (net)	-3118	-3119	-3121	-3123	-3126	-3128	-3134	-3142	-3152	-3161	-3517	-3531
6. Waste	1310	1338	1361	1359	1375	1317	1304	1241	1163	1110	1197	1168
7. Other	0	0	0	0	0	0	0	0	0	0	0	0

and removals in connection with land use change and forestry (LUCF). As will be seen from this table, the total emissions in 2000 and 2001 were slightly below the total emissions in 1990. The main reasons for this are explained under the individual greenhouse gases and sectors.

1.2.1 Carbon dioxide, CO_2

Almost all CO_2 emissions come from combustion of coal, oil and natural gas at power stations and in residential properties and industry, although road transport also contributes a considerable proportion – about 20%. The relatively large fluctuations in the emissions from year to year are due to trade in electricity with other countries – primarily the Nordic countries.

The reduction in CO_2 emissions in recent years is due mainly to the fact that many power stations have changed their fuel mix from coal to natural gas and renewable energy. As a result of the reduced use of coal in recent years, most of the CO_2 emissions now come from combustion of oil.

1.2.2 Methane, CH4

The biggest source of man-made methane emissions is agriculture, followed by landfill sites and energy production. The emissions from agriculture are due to the formation of methane in the digestive system of farm animals and the handling of manure. The emissions from agriculture and landfill sites have both fallen by 10-11% since 1990 – in the first case because of a change in farm animal population, with a reduction in the cattle population and an increase in the pig population, and in the second because of increased collection and use of landfill gas in the period in question.

The emissions from energy production are rising because of increasing use of gas engines, which have large

Table 1.2 Denmark's, Greenland's and the Faroe Islands' total emissions and removals of greenhouse gases, 1990 – 2001
Source: National Environmental Research Institute

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(Gg CO_2 equivalent)											
Greenlands CO_2 emissions (without LUCF)	**624**	**609**	**594**	**0**	**494**	**523**	**564**	**575**	**550**	**585**	**659**	**617**
Faroe Islands CO_2 emissions (witout LUCF)	709	682	650	536	544	541	578	559	616	645	699	791
Faroe Islands CH_4 emissions	18	19	19	18	19	19	19	20	19	19	20	20
Faroe Islands N_2O emissions	23	24	24	23	24	25	25	27	26	27	30	31
Faroe Islands Total Emissions without LUCF	**750**	**725**	**693**	**577**	**588**	**585**	**622**	**605**	**661**	**691**	**749**	**843**
The Kingdom's Total Emissions and Removals with LUCF	**66099**	**76791**	**70338**	**73086**	**76913**	**74207**	**87644**	**77803**	**72645**	**69589**	**64664**	**65879**
The Kingdom's Total Emissions and Removals without LUCF	**69217**	**79910**	**73459**	**76209**	**80039**	**77335**	**90778**	**80945**	**75797**	**72750**	**68181**	**69410**
Trend since 1990 (1990=index 100), without LUCF	**100**	**116**	**106**	**111**	**116**	**112**	**133**	**118**	**110**	**105**	**98**	**100**
Trend since 1990 (1990=index 100), with LUCF	**100**	**115**	**106**	**110**	**116**	**112**	**131**	**117**	**110**	**105**	**99**	**100**

methane emissions compared with other combustion technologies.

1.2.3 Nitrous oxide, N_2O

Agriculture is by far the main source of emissions of nitrous oxide because this forms in soil through bacterial conversion of nitrogen in fertiliser and manure. Bacterial conversion of nitrogen also occurs in drain water and coastal water. It will be seen that there has been a considerable fall in nitrous oxide emissions from agriculture since 1990. That is due to less and better use of fertiliser. A small proportion of the nitrous oxide emissions comes from the exhaust of cars fitted with a catalytic converter.

1.2.4 The industrial gases HFCs, PFCs and SF_6

The contribution of industrial greenhouse gases (HFCs, PFCs and SF_6) to Denmark's total emissions of greenhouse gases is relatively modest, but in percentage terms, the emissions of these gases showed the biggest rise during the 1990s. The HFCs, which are primarily used in the refrigeration industry, are the biggest contributor to industrial greenhouse gas emissions. In 2001 industrial gases accounted for about 1% of total emissions of greenhouse gases, corresponding to approximately 700,000 tonnes of CO_2 equivalents. However, in 2001 and 2002 new regulatory instruments, including both taxes and bans, were adopted.

1.2.5 Denmark's, Greenland's and the Faroe Islands' total emissions and removals of greenhouse gases

The total inventories for Denmark, Greenland and the Faroe Islands are reproduced in table 1.2. As will be seen the Climate Convention's goal of reduction of the emissions to the 1990 level in 2000 was achieved. The combined level for Denmark, Greenland and the Faroe Islands in 2000 was 1.1% below the 1990 level.

For the time being, the inventories from Greenland contain only inventories of the CO_2 emissions from combustion of fossil fuels. However, this is regarded as by far the main source of greenhouse gases.

The inventories for the Faroe Islands contain not only the CO_2 emissions from fossil fuel but also the methane and nitrous oxide emissions.

1.2.6 Preliminary inventories under the Kyoto Protocol and the EU's burden-sharing

In accordance with the rules of the Kyoto Protocol, Denmark has chosen 1995 as the base year for industrial greenhouse gases and, in the calculation under the Protocol has – for the time being – included only the removals in forests occurring as a consequence of afforestation since 1990. Denmark's reduction obligation of 21% in 2008-2012 in relation to the base year (1990/95), is related to the EU's total reduction obligation through the so-called burden-sharing agreement. The Faroe Islands are not covered by the Kyoto Protocol because of a territorial reservation taken at the time of the Kingdom of

Denmark's ratification of the Protocol.

The preliminary inventories form the basis for Denmark's climate strategy described in chapter 4.

1.3. Policies and measures

Since the end of the 1980s and up through the 1990s a number of initiatives have been taken to reduce emissions of greenhouse gases. The initiatives have produced important results – particularly with respect to CO_2 – and will also result in further reduction of greenhouse gas emissions in the future.

The initiatives have been, and still are, targeted mainly on the sectors of society in which the activities result in considerable emissions of greenhouse gases and have had the purpose of broad environmental improvements in Denmark.

In February 2003 the government published Denmark's new climate strategy. Cost effectiveness is a vital planning consideration in order to gets more environment for the money. The basis of the strategy is that Denmark must fulfil its international climate obligations under the Kyoto Protocol and according to the subsequent burden – sharing agreement in the EU.

On the basis of the latest projection of Denmark's emissions of greenhouse gases, it is now estimated that, without new initiatives, there will be a shortfall of 20-25 million tonnes of CO_2 equivalents per year in the period 2008-12. The Kyoto Protocol makes it possible to plan climate action that is more flexible and that, globally, gives more environment for the money. The climate strategy combines cost-effective domestic measures with use of the Kyoto Protocol's flexible mechanisms.

For many of the energy producers and a large part of the energy-intensive industry, the coming EU Directive on a Community scheme for trading with greenhouse gas emissions will form the framework for the coming action. The companies that are covered by the scheme, and whose activity will thus be limited by a quota, will be able to plan their climate action themselves. They can choose to reduce their own emissions, when it is most appropriate or buy quotas or credits from project-based emission reductions, when it is deemed most suitable. The companies covered by the scheme will thus have the possibility of ongoing adjustment of their action so that it is always as effective as possible.

Besides quotas and the use of flexible mechanisms, the climate strategy includes a number of national measures, including existing measures that are being continued and new, potential measures that will be considered on the way.

Since the reduction costs in the different sectors are continuously changing, in part due to technology development and changed economic framework conditions, the strategy includes regular evaluation of the action so that the most cost-effective policies and measures are chosen.

In connection with the climate strategy it is estimated that the international price level for quotas/credits is hardly likely to exceed DDK 100 per tonne CO_2 equivalent, with a price level of DKK 40-60 as the most probable. With this price level, it will be considerably cheaper to buy international quotas/credits than to implement most of the national reduction measures.

In a comparison with the national mechanisms it is important to be aware that these must typically be seen in a sector-political context, in which climate is only one among many considerations in the policy being planned. For example, a fundamental consideration in the energy sector is security of supply, which, all else being equal, is improved by lower energy consumption and a multiple energy supply.

An interministerial committee will regularly evaluate the cost effectiveness of the national measures, including new policies and measures. The government has set an economic benchmark of DKK 120/tonne CO_2 equivalent to be used as a basis for implementing national policies and measures outside the area covered by the EU trading scheme. The latest calculations indicate that only relatively few national policies and measures with a significant potential that do not exceed DKK 120/tonne CO_2 equivalent would be able to compete with the price of using the flexible mechanisms. This must also be seen in the light of the fact that Denmark has already done a great deal nationally up through the 1990s, while there is a large, unexploited potential in other countries.

For the national measures, where the analyses show relatively low reduction costs, all in all the potential is not sufficient to remove the Danish shortfall. On the other hand, there is considered to be sufficient potential to buy quotas and credits internationally.

1.3.1 Policies and measures and their effects in Denmark's economic sectors

The energy sector

The energy sector is at the centre of the efforts to reduce the emissions of CO_2. Many initiatives have been taken over a long period of years to reduce the emissions, and work is still going on to find the best and most cost-effective initiatives.

Some measures can bring general pressure to bear on players in the energy sector to reduce their CO_2 emissions. Denmark's Quota Act, which regulates the emissions of CO_2 from the open, market-regulated production of electricity, is an example.

Taxes have also been used for a number of years as measures to reduce the CO_2 emissions from the energy sector – partly with a view to a general reduction and partly to promote the use of fuels with lower CO_2 emissions, mainly biomass. Such taxes are still used.

Increased use of CHP and enlarging the areas receiving district heat have been main elements of the Danish strategy to promote efficient use of energy resources ever since the end of the 1970s.

Renewable energy sources are promoted with economic measures, including the tax system and through direct production grants.

It is estimated that expected rising electricity exports would result in a considerable increase in emissions unless measures were taken to prevent this. However, electricity production is covered by the proposal for an EU Directive on a scheme for emissions trading, and Denmark's climate strategy is thus based on the assumption that electricity production will be covered by the EU's quota scheme from 2005.

The transport sector

Efforts to turn the upward trend in emissions of greenhouse gases in the transport sector have so far failed, in part because it is extremely difficult to reduce the CO_2 emissions in this sector in Denmark, which is not a car-making country, without international initiatives.

The transport sector's possibility, with national measures, of contributing to reduction of Denmark's CO_2 emissions shows that the cost-effectiveness of the measures depends entirely on the side effects. The decision to implement the different measures within the transport sector must therefore to a great extent be evaluated on the basis of the measure's other effects and not simply from the point of view of reduction of CO_2 emissions.

The business sector

The ongoing initiatives to reduce the emissions from the business sector include both promotion of energy savings and energy efficiency improvements, conversion of energy production to cleaner fuels and initiatives to reduce the emissions of industrial gases.

Work to improve energy efficiency in the public sector has been going on for more than 10 years, and considerable savings have been achieved. However, there are still economically viable possibilities for savings. In continuation of the provisions in the Act on Promotion of Savings in Energy Consumption from 2000 and several energy policy agreements, plans are in hand to tighten the action, especially in the public sector.

The regulation of emissions of the industrial greenhouse gases (HFCs, PFCs and SF_6) is 2-phased, consisting partly in a tax and partly in a statutory order on discontinuation of the use of the gases in new installations. The tax is imposed on the substances on importation because none of them is produced in Denmark.

In July 2002 a statutory order on regulation of the industrial greenhouse gases went into force. It includes a general ban on use of the industrial greenhouse gases in a wide range of new installations/products from 1 January 2006, including, for example, domestic refrigerators and freezers, PUR foam, etc.

Agriculture, forestry and fisheries

Within the agricultural sector the following measures have reduced or will reduce emissions: i) ban on burning of straw on fields, ii) the biomass agreement on use of straw for fuel, iii) Action Plans for the Aquatic Environment I and II and Action Plan for Sustainable Agriculture, and iv) the Ammonia Action Plan.

The Action Plans for the Aquatic Environment and the Action Plan for Sustainable Agriculture have, in particular, reduced the emissions of nitrous oxide, and most of the changes in emissions of nitrous oxide from the agriculture sector that have taken place since 1990 can be attributed to these action plans.

2001 brought the adoption of an Ammonia Action Plan, which together with Action Plans for the Aquatic Environment I and II, will reduce ammonia evaporation.

The purpose of banning burning of straw has been to reduce air pollution from this activity. The ban has resulted in greater return of carbon to the soil and increased use of straw as a fuel.

The purpose of the biomass agreement is to increase use of biomass for energy purposes through the establishment or conversion of power stations and CHP plants for use of this fuel. Straw as a fuel substitutes fossil fuels.

The national forest programme includes evaluation of the possibilities offered by the Kyoto Protocol for economically viable CO_2 sequestation in forests. The political goal with the most direct influence on increased carbon sequestation is the declaration of intent from 1989 to double the forested area in Denmark within 100 years. Various measures have been taken towards achieving this goal. For instance, a government grant scheme has been establish that supports private afforestation on agricultural land and the state itself establishes new forests. In addition, some private individuals choose to establish forests on agricultural land without a government grant.

The domestic sector

With a view to reducing both direct and indirect CO_2 emissions from the domestic sector, a wide range of initiatives have been launched. The initiatives promote i) electricity savings, ii) savings in energy consumption for space heating and iii) fuel conversion (from electric heat and oil to district heat, natural gas and renewable energy).

Following up on the climate strategy new energy-saving initiatives are expected, including of standards for products' energy efficiency.

The waste sector

The waste sector's contribution to reduction of greenhouse gas emissions consists mainly in: i) reducing landfilling of organic waste, ii) utilising gas from discontinued/existing landfill sites and iii) using the waste as an energy source.

In 1996 the statutory order on waste was amended to introduce a municipal obligation to assign combustible

TABLE 1.3 DENMARK'S EXPECTED EMISSIONS OF GREENHOUSE GASES

Million tonnes CO_2 equivalents	Base year 1990/95	2001	2008-12	2013-17
CO_2	(52.6*) 52.7	54.3	65.6	64.4
Methane (CH_4)	(5.8*) 5.7	5.6	5.0	4.7
Nitrous oxide (N_2O)	10.8	8.7	8.7	8.7
Industrial gases, HFCs, PFCs, SF_6	0.3	0.7	0.7	0.5
Total emissions	(69.7*) 69.5	69.3	80.1	78.3
Kyoto target: –21%			(55.0*) 54.9	
Shortfall			(25.0*) 25.1	
Electricity export (+)/import(-)	-6.3	+0.3	+9.9	+9.1
Shortfall without electricity export			(15.1*) 15.2	

*Note: The base year data and shortfall calculation used in connection with the climate strategy are shown in brackets.

waste to incineration (corresponding to a ban on deposition of combustible waste). As a result of this, large quantities of combustible waste that used to go to landfill sites are now either recycled or used as fuel in Denmark's incineration plants. Future action will consist mainly in a continued ban on landfilling of combustible waste and implementation of Waste 21.

1.4 PROJECTIONS AND THE TOTAL EFFECT OF POLICIES AND MEASURES

The latest projections from February 2003 cover the period 2001-2017. The calculations for the period 2013-2017, however, must be described as somewhat less certain that the projections up to 2013 because the uncertainty concerning the policies and measures and their expected effect increases with time. In the climate strategy from February 2003, the inventories of how much Denmark is expected to lack in order to meet the obligations entered into on the basis of the existing mechanisms, policies and measures have been calculated both taking account of electricity import in 1990 and not taking account of this.

According to the latest inventories of greenhouse gas emissions, Denmark's legal reduction obligation of 21% means that the emissions must be reduced from 69.5 million tonnes CO_2 equivalents in the base year 1990, to 54.9 million CO_2 equivalents in the period 2008-2012, as shown in table 1.3.

It should be noted that the latest historical inventory of greenhouse gas emissions covers the period 1990-2001, so the projection for 2001 in this report has been replaced with the historical inventory for 2001. Since this new inventory also includes an update of the 1990 figures as a consequence of new knowledge, the base year – and thus also the shortfall – has been changed slightly in relation to the inventory in the climate strategy.

Denmark's expected annual emissions in the period 2008-2012 have been calculated at 80.1 million tonnes CO_2 equivalents. However, the size of the total greenhouse gas emissions depends greatly on CO_2 emissions related to electricity exports, which are expected to account for 9.9 million tonnes CO_2 equivalents per year in 2008 - 2012.

1.5. Vulnerability assessment, climate change impacts and adaptation

1.5.1 Climate development – effects and possibility for adaptation for Denmark

Analyses with global and regional climate models show the following general trend for the climate in Denmark in 2100 in relation to 1990:

- a rise of about 3-5° C in mean annual temperature, greatest in northern areas, in winter and at night;
- a 10-40% increase in winter precipitation, probably a 10-25% fall in summer precipitation and a trend towards more episodes with very heavy precipitation, particularly in autumn;
- a slight increase in storm activity over Denmark and the adjacent waters.

The analyses do not directly give scenarios for future changes in water level, but earlier studies show slightly smaller rises around Denmark than the global rises because of vertical land movements. For example, it is estimated that an average global rise in water level of 0.5 m will lead to a rise of about 0.4 m around Denmark.

The general conclusion has been that the direct impacts in moderate climate scenarios will be moderate for Denmark and can be countered by suitable, ongoing adaptation. Danish studies of – and preparation for – impacts of climate changes have so far been very modest, and there are as yet no actual action plans.

For Danish agriculture, the overall effects are estimated to be advantageous. Changes in cultivation practice can be implemented at short notice, and production is expected to grow with rising temperature and CO_2 concentration.

Danish field and greenhouse studies have shown that climate change will generally promote tree growth, particularly for the species with the northern limit of their spread in Southern Scandinavia. The only species of tree that will show decline is the Norway spruce.

About 1,800 km of the 7,400 km coastline are protected with dikes or other permanent installations, and increasing use is being made of soft solutions, particularly beach feeding.

1.5.2 Climate changes in Greenland and on the Faroe Islands

Analyses with global climate models show the following general trend for the climate in Greenland in 2100 in relation to 1990:

- in South Greenland a rise in mean annual temperature of just over 2°C, slightly more in winter and slightly closer to 2°C in summer, and in North Greenland, a rise in temperature of 6-10°C in winter but only small rises in summer;
- a general increase of 10-50% in precipitation, but little or no increase in Southeast Greenland. In winter, however, a considerably bigger increase in North Greenland, locally up to more than 100%.

Analyses with global climate models show the following general trend for the climate on the Faroe Islands in 2100 in relation to 1990:
- a rise of around 3°C in annual mean temperature, with little difference in the temperature increase in summer and winter
- an approx. 25% increase in winter precipitation but little or no increase in summer.

1.6 Financial resources and transfer of technology

The Danish development cooperation is financed mainly by a facility for assistance to developing countries (DKK 10.5 billion in 2002), the main purpose of which is to promote sustainable development through poverty-oriented growth. Denmark has been in the lead with respect to making funds available for environmental action in the developing countries and the countries of Central and Eastern Europe, partly in the facility for assistance under the Developing Countries Facility and partly through the establishment of the Environment, Peace and Stability Facility (MIFRESTA) as an element of Denmark's follow-up on the Rio Conference in 1992.
Overall, Denmark will continue to provide extensive support for the benefit of the environment in the developing countries, since it is estimated that more than 15% of the facility for assistance to developing countries is used for environmental assistance.

1.7 Research and systematic observations

Research and observations within climate in the broad sense of the word are going on at a number of institutes and organisations and cover a wide range of disciplines, from natural science to evaluation of policies and measures and societal aspects.

Denmark's Meteorological Institute (DMI) carries out observations of climate parameters (atmosphere and ocean), including observations under the World Meteorological Organisation (WMO)'s programmes and subprogrammes. Climate observations, together with climate research, have been one of DMI's main tasks for more than 125 years, with measurement, theory and modelling.

The Danish research competence concerning physical expressions of past climate change is to be found at Geological Survey of Denmark and Greenland (GEUS), which also has competencies in glaciological studies of Greenland's ice cap and its interaction with climate change, and the importance of climate change for water's cycle in nature. Besides research in the climate system, the climate-related research includes research concerning the driving forces for emissions of greenhouse gases and their burden on the environment, the state of the environment – physical, chemical and biological, effects and climate changes and society's possibilities for response and regulation.

The National Environmental Research Institute, the Danish Forest and Landscape Research Institute, the Danish Institute of Agricultural Sciences and Risø National Laboratory are all involved in these climate-related research areas. In addition, several of the country's universities also work with different aspects of climate research.

It is partly only the basis of research competencies in the above-mentioned areas that Denmark also participates actively in IPCC's work. In addition, the Danish climate research contributes to a wide range of international projects under the World Climate Research Programme. Danish climate research increased steadily in the period 1998 to 2001, from 172 man-years in 1998 to 189 man-years in 2001. The budget increased correspondingly from DKK 94 million in 1998 to DKK 114 million in 2001. Of this, foreign funding accounted for just under 30%.

Since the establishment of DMI in 1872 the institute has monitored the main climate parameters. In the climate monitoring programme, classic methods of measurement are used and new, satellite-based observation methods are developed.

DMI operates around 200 automatic measuring stations in the Kingdom (Denmark, Greenland and the Faroe Islands) with a broad measuring programme ranging from automatic water level or precipitation stations that measure only one parameter to stations with a full measuring programme, including automatic cloud height detectors and weather type detectors. For collection of precipitation data DMI also operates a network of 500 manual precipitation stations, which are used mainly for mapping the precipitation climatology.

Besides being of use for national programmes, the observations concern Denmark's international contribution in the form of observation components from Danish territory to the worldwide meteorological observation network WWW (World Weather Watch), GCOS (Global Climate Observing System) and other international programmes for mapping weather and climate.

The meteorological observations are stored in DMI's database, and observations from many Danish stations are available in electronic form right back to 1872, water level measurements back to 1890, and measurements of the surface temperature of the sea back to 1931. In 2001, 75,000 observations were added to the database each day, and the total number of observations in the database is around 245,000,000.

1.8 Education, training and public awareness

In Denmark there is an ongoing public debate in the media and elsewhere about the manmade greenhouse effect and its political reaction in the form of policies and measures. Denmark has a long tradition for involving the public and, in the environment field, this tradition was followed up by an international agreement – the Århus Convention from 1998. A considerable amount of information on climate change and Danish policies is provided on the websites of the Ministry of Environment (www.mim.dk), the Danish Environmental Protection Agency (www.mst.dk), the Ministry of Finance (www.fm.dk), the Ministry of Economic and Business Affairs (www.oem.dk) and the Danish Energy Authority (www.ens.dk).

NERI has prepared a range of climate reports, which, together with other climate information, e.g. climate data, are published on NERI's website www.dmu.dk. DMI has a climate website at www.dmi.dk, providing current and historical climate data, together with a basic description of the climate system and climate processes, and themes on new results from the international scientific literature.

DMI participates in a number of international projects, with support primarily from the EU Commission's framework research programmes, which involve exchange of knowledge and post-graduate training of Danish research scientists. In addition, the Institute contributes to IPCC's work, and the results from that, which are communicated to the public.

A number of initiatives are being carried out to promote environmentally sound behaviour in companies and households, particularly for climate reasons, and with respect to energy use. Labelling schemes, printed matter, information lines, media spots and similar are used to increase public knowledge of possibilities for action and knowledge of less environmentally harmful technologies.

2 National circumstances relevant to greenhouse gas emissions and removals

The Kingdom of Denmark comprises Denmark, Greenland, and the Faroe Islands. The UN Framework Convention on Climate Change has been ratified on behalf of all three parts of the Kingdom, and this report therefore contains information on all three. However, at the present time, more information is available on Denmark than on the other parts of the Kingdom. Where tables, figures, and other information in this report also cover Greenland and/or the Faroe Islands, this is stated.

2.1. Denmark

2.1.1 Form of government and structure of administration

Denmark is a constitutional monarchy, and the power of the state is divided between the legislative branch, the executive branch, and the judicial branch. According to the Kingdom's Constitution, legislative power lies with the Folketing (the Danish Parliament), which consists of 179 members, two of whom are elected on the Faroe Islands and two in Greenland. The members are elected by the population for a period of normally four years.

The executive branch – the government – cannot have a majority of the Folketing against it, and the government is often a majority government. The number of ministers in the government varies. Since 1973 Denmark has had a Minister for the Environment and a Ministry of the Environment. They conduct the international negotiations in the climate area on behalf of Denmark and also have the primary responsibility for coordination of legislation, plans, etc. with respect to climate.

For the last ten years or so, other ministries have also worked with environmental and climate issues. In 1988 the government decided to follow up on the UN report on sustainable development – the Brundtland Report in which one of the main messages of which was the necessity of integrating the environmental issue into the administration within such sectors as transport, agriculture and energy.

For this reason, a number of sector ministries have drawn up action plans in which the environment is an integral element. Examples are sector plans for energy, transport, agriculture, and development assistance. In the climate area, further to the previous government's status report *Climate 2012* from 2000, the government presented a overall status in connection with the presentation of its proposal for ratification of the Kyoto Protocol in April 2002. This status report was followed in February 2003 by a government proposal for a national climate strategy for Denmark, including analyses from the sector ministries, which was adopted by the Folketing on 13 March 2003.

One of the main cornerstones of Danish democracy is autonomous local government, and specific environmental action takes place not only at national level but also at county and municipal level. The state sets the national rules and framework for environmental administration, while the counties and municipalities, working within this framework, plan and decide initiatives that implement and support the national legislation.

The importance of local involvement is stressed in "Agenda 21 – a global agenda for sustainable development in the 21st century", which was adopted at the Rio Conference in 1992. The government supports the popular interest and participation in climate and environmental issues in different ways – including through implementation of the Pan-European Århus Convention and support for the local Agenda 21 work initiated by most of the Danish municipalities.

2.1.2 Population

Today, Denmark has a population of slightly more than 5.3 million. As will be seen from table 2.1, population growth has been relatively small in the last 20 years.

Table 2.1: Population of Denmark
Source: Statistics Denmark

Year	1980	1990	2001
Denmark's population in mill.	5.1	5.1	5.3

The latest forecasts show that population growth will continue to be moderate in the years ahead. For example, the population is expected to reach 5.5 million in 2010, rising to 5.7 million in 2020. The low birth rate in the 1980s means that young people between the ages of 15 and 24 years make up only 11% of the population, while the elderly, between 50 and 64 years of age, account for 19%.

Today, the population density is slightly more than 120 per km^2.

Two-thirds of Danish wage earners are employed in service trades, while 20% are employed in manufacturing.

2.1.3 Geography

Denmark consists of the Jutland peninsula and more than 400 islands. It has a total area of 43,075 km^2 and lies at about 55° N and 11° E.

The whole of the country is lowland. The surface was formed by Ice Age glaciers and glacial streams. The highest hill is approximately 170 metres above sea level.

The coastline has a length of more than 7,400 km. To protect low-lying land against flooding and storm surge, it has been necessary to build dikes or other permanent installations along about 1,800 km of coastline. In addition, sandbags, breakwaters and similar protect other parts of the coastline, which would otherwise erode because they consist of soft materials deposited during the last Ice Age.

A rise in the water level due to climate change would obviously affect the protection of the coasts and create a greater risk of flooding and erosion.

The Danish landscape is indelibly stamped by the high population density. More than 60% of the land is used for agriculture or horticulture. Woodlands take up 11%, while towns, roads and scattered habitation take up 13%. The rest is nature, for example, lakes, bogs, heaths, and dunes.

In relation to its size, Denmark is home to a wide variety of flora and fauna – in all, about 30,000 species.

2.1.4 Climate

Denmark has a temperate climate, with rainfall evenly distributed over the year. The country lies in the zone of prevailing westerly winds, which is characterised by fronts, low pressure, and changeable weather. Compared with other regions on the same latitude as Denmark, the climate is relatively warm due to the warm North Atlantic current that originates in the tropical sea off the east coast of the USA.

As mentioned, Denmark has a distinctly coastal climate, with mild, damp winters and cool, unsettled summers. Average temperatures vary from about half a degree in winter to about 15 degrees in summer. However, the weather in Denmark is greatly affected by the proximity of both the sea and the continent. This means that the weather can change, depending on the prevailing wind direction. The west wind from the sea brings relatively uniform weather in summer and winter: mild in winter and cool in summer. When the wind comes from south or east, the weather in Denmark is more similar to that of the continent: warm and sunny in summer and cold in winter. The weather in Denmark thus depends very much on the wind direction and the season.

Atmospheric pressure

Average atmospheric pressure in Denmark shows seasonal variation, reaching a minimum in November and a maximum in May.

Denmark's highest-ever atmospheric pressure, 1062.5 hPA, was recorded in Skagen on 23 January 1907, while just one month later, on 20 February, the lowest atmospheric pressure in the history of Denmark was also recorded in Skagen, at 943.9 hPa.

Temperature

The annual mean temperature varies from year to year, from below 6°C to more than 9°C, with an average of 7.7°C. The coldest year so far was 1879, with a mean temperature of 5.9°C, while the hottest recorded year was 1990, with 9.3°C. Since 1988, almost every year has been hotter than normal, and the temperature showed a sharply rising trend in the 1990s. Taken over the last 100 years, the temperature in Denmark has risen by about 0.5°C, but the ten hottest years occurred from the 1930s to the 1990s.

Figure 2.1: Annual mean temperature in Denmark 1873-2000, corrected values in °C

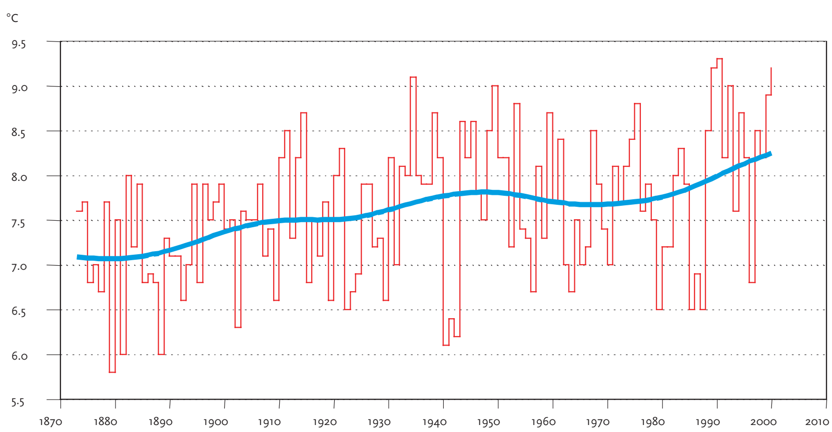


Figure2.2: Denmark's annual precipitation 1874-2000

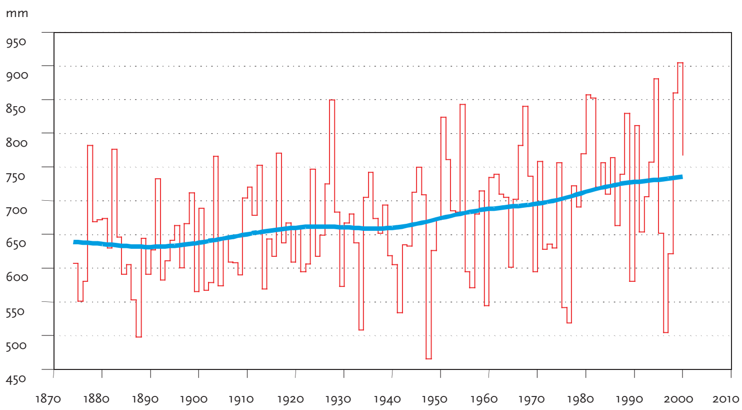


FIGURE 2.3: ANNUAL HOURS OF SUNSHINE IN DENMARK 1920-2000 IN PERCENT

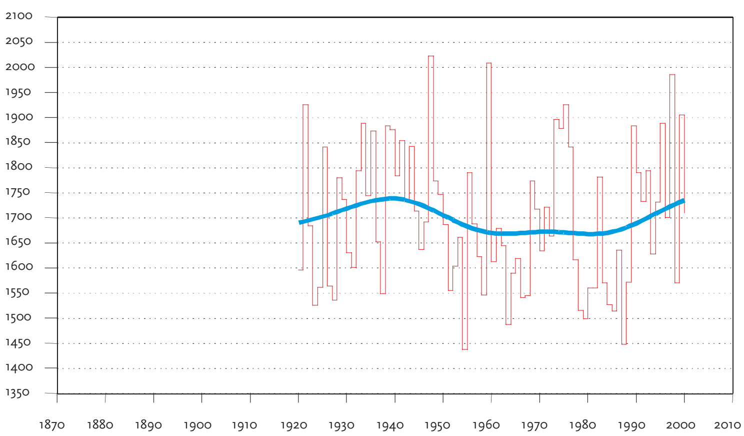
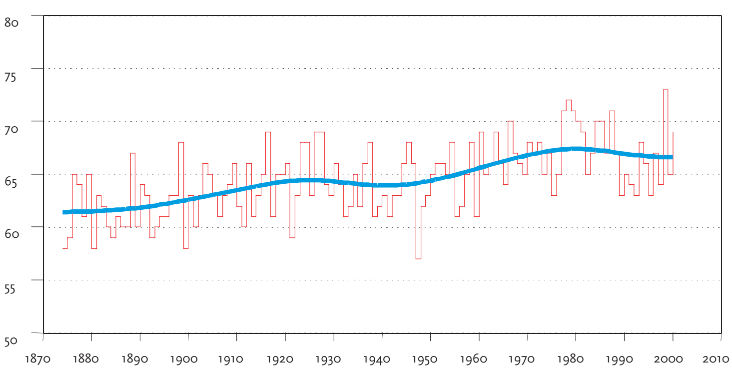


FIGURE 2.4: ANNUAL MEAN CLOUD COVER IN DENMARK 1874-2000
Source: Denmark's Meteorological Institute



The temperature in January and February averages around 0°C but can vary greatly from 12°C to below -31°C. The average temperature in July and August is around 15°C, but again can vary from below -3°C to more than 36°C.

Precipitation
Average annual precipitation varies greatly from year to year and from place to place. The lowest annual precipitation for the country as a whole was 464 mm in 1947, and the highest was 905 mm in 1999, while the average annual precipitation is 712 mm.

The wettest months are normally September, October, and November, while the driest are February to May. In the winter months, the precipitation is sometimes in the form of snow. Annual precipitation in Denmark has on average increased by about 80 mm since 1940.

Hours of sunshine and cloud cover
On average, Denmark as a whole has about 1,701 hours of sunshine annually, but as in the case of the precipitation, this figure varies greatly from year to year. The sunniest year was 1947, with 2,022 hours, and the least sunny was 1954, with 1,437 hours.

December is the least sunny month, with less than 40 hours of sunshine in most places, while June is the sunniest, with an average of 250 hours. Average annual cloud cover is 67%. 146 days are cloudy, i.e. with cloud cover at >80% and only 31 days are clear, with cloud cover at <20%. Since 1980, the trend has been towards more hours of sunshine and less cloud cover.

Wind
Countrywide, annual mean wind velocity is 5.8 m/s, and the wind is most frequently from westerly directions, from which about 25% of all winds come.

The number of days with severe wind (≥10.8 m/s) varies from about 30 in some places inland to almost 170 days at Skagen. On average, storm-force (≥ 24.5 m/s) occurs along the Danish coasts every three to four years. In December 1999 large parts of Denmark were hit by the worst-ever measured hurricane, and in some places mean wind velocities (average over 10 minutes) of more than 40 m/s were recorded, with gusts of up to 50 m/s.

2.1.5 Economy
Since 1993 Denmark has benefited from considerable economic growth, with GNP (Gross National Product) rising at an average of 2.7% per year. In 2000 GNP was more than DKK 1,300 billion, corresponding to DKK 245,000 per capita. (1 Euro equals approximately DKK 7.4).

In 2000 the public debt stood at 47% of GNP, compared with 78% in 1993. In the same period, foreign debt was reduced from 32% of GNP to 17%.

From table 2.2, which shows key figures for the Danish economy, it will be seen that Denmark has a very open – and thus sensitive economy, in which exports account for a substantial part of total demand. In addition, public expenditure accounts for a large part of GNP. Tabel 2.3 shows the business sector's contribution to GNP

Table 2.2: Key figures for the Danish economy. Current prices, year 2000, in DKK mill.
Source: Statistics Denmark

GNP	1,315,500
Imports	488,400
Exports	565,700
Consumer spending	628,100
Public expenditure	325,900
Gross investments	285,600
Public debt as a % of GNP	47.2%
Foreign debt as a % of GNP	16.7%

2.1.6 Energy and the domestic sector
Energy production and energy-consuming activities are the main contributors to the emissions of greenhouse gases in Denmark. The energy sector on its own, i.e. energy production and supply, accounts for 40% of the total emissions of greenhouse gases, mainly CO_2, to which must be added the emissions from the energy-consuming activities in the transport sector, industry and households.

In the energy sector the economic trend, related to domestic energy consumption and the trend in CO_2 emissions have been decoupled, CO_2 emissions have been reduced despite strong economic growth.

Production and supply
Denmark is self-sufficient in energy, see table 2.4. This is mainly due to the production of oil and gas in the North Sea, but renewable energy is also increasingly contributing to the

TABLE 2.3: THE BUSINESS SECTOR'S CONTRIBUTION TO GNP. CURRENT PRICES, YEAR 2000, IN DKK MILL.
Source: Statistics Denmark

Sector	Gross increase in value	%
Agriculture etc.	29,875	2.3
Mining etc.	24,773	1.9
Industry	195,395	14.9
Utilities	23,088	1.8
Building and construction	52,637	4.0
Distribution, hotels, restaurants, etc.	169,405	12.9
Transport, postal services and telecommunication	102,751	7.8
Finance and insurance	62,229	4.7
Housing	95,342	7.2
Leasing and estate agency services and business services	122,290	9.3
Public and personal services	294,044	22.4
Indirectly measured financial services	-39,749	-3.0
(Product taxes minus product subsidies)	183,445	13.9
Gross National Product	1,315,526	100

country's energy supply. As will be seen from table 2.5, Denmark's own production of energy has more than tripled in the last decade.

Today, more than 10% of the demand for energy is supplied by renewable energy. The renewable energy resources are mainly wind energy and biomass, which are used to produce electricity, combined heat and power, or district heating. Internationally, Denmark is among the leading nations in wind energy.

Energy consumption
Despite the economic growth, total energy consumption has remained largely unchanged at approximately 800 PJ in the last ten-year period, cf. tables 2.6 and 2.7.

Denmark's dependence on oil and coal has fallen. Particularly in the production of electricity and heat, oil and coal have been substituted with other fuels. Thus, natural gas, waste and biomass are increasingly being used in small-scale and industrial CHP plants, natural gas and renewable energy is increasingly being used in large scale electricity production, and natural gas is increasingly being used for individual heating of buildings.

Figure 2.5 shows adjusted energy consumption, sector by sector. In the last 20 years relative consumption by the transport sector has risen, whereas relative domestic sector consumption has fallen.

Structure of the market
The structure of the market in the energy sector is characterised by a division between electricity, gas, and district heating supply.

TABLE 2.4: DEGREE OF SELF-SUFFICIENCY IN %
Source: Danish Energy Authority

	1980	1988	1990	1994	1998	2000	2001
Energy, total	5	42	52	76	102	139	137
Oil	2	53	72	111	130	203	197
Oil and natural gas	3	67	85	123	139	189	186

Table 2.5: Energy production in PJ
Source: Danish Energy Authority

	1980	1988	1990	1994	1998	2000	2001
Production, total	40	349	425	635	857	1163	1138
Crude oil	13	202	256	389	492	765	726
Natural gas	0	97	116	182	295	308	318
Renewable energy etc.	28	49	53	64	74	88	94

Table 2.6: Actual energy consumption in PJ
Source: Danish Energy Authority

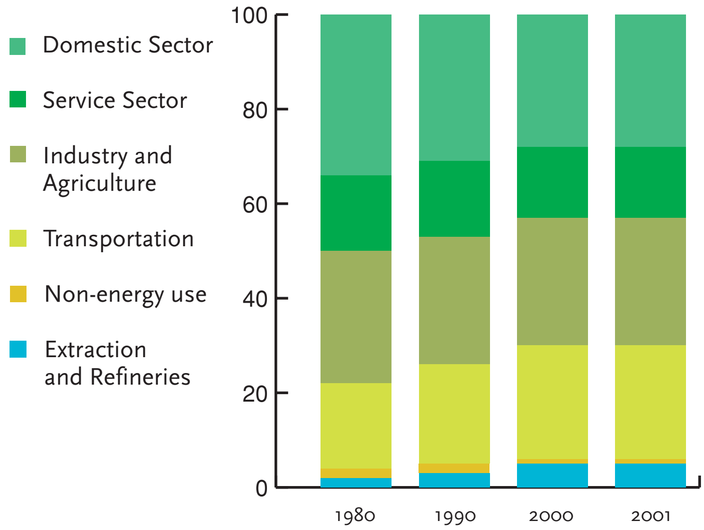
	1980	1988	1990	1994	1998	2000	2001
Energy consumption, total	830	789	752	844	855	812	829
Oil	555	375	343	358	376	367	366
Natural gas	0	67	76	115	179	187	194
Coal	252	282	255	325	236	166	175
Renewable energy etc.	27	49	53	64	80	90	96
Net import of electricity	-4	15	25	-17	-16	2	-2

Table 2.7: Gross energy consumption, breakdown by fuels, adjusted for inter-annual temperature variations and net export in PJ
Source: Danish Energy Authority

	1980	1988	1990	1994	1998	2000	2001
Gross energy consumption, total	816	818	820	829	839	837	831
Oil	548	379	356	346	379	375	369
Natural gas	0	69	83	117	182	193	193
Coal	241	320	326	301	198	177	173
Renewable energy etc.	27	50	55	65	81	92	96

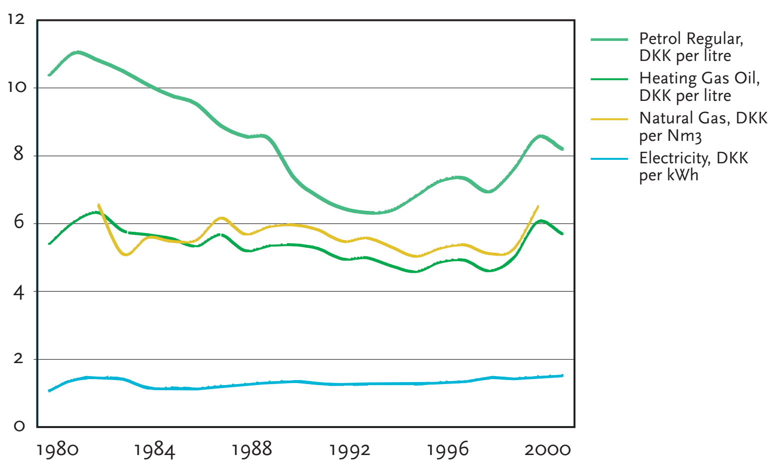
More than two-thirds of Denmark's electricity supply comes from large primary power stations and CHP plants. Just under one-third is supplied by small-scale and industrial CHP plants and wind turbines. The large primary power stations are organised in two companies, which are owned by around 80 regional grid companies whose owners are municipalities, limited liability cooperatives, independent institutions, etc. The small-scale plants are primarily organised in municipally owned and consumer-owned district heating companies. The wind turbines are primarily privately owned or owned by the electricity companies.

Figure2.5: Adjusted energy consumption, breakdown by sector
Source: Danish Energy Authority



In connection with the implementation of the EU Directive on liberalisation of the electricity sector, a reform of the sector has been carried out. As part of the reform, the market was fully opened on 1 January 2003, which means that all electricity customers can now use the electricity supplier of their choice.

Figure 2.6: Energy prices for domestic users in current prices in DKK
Source: Danish Energy Authority



Most production of natural gas and oil is taken care of by a private company, DUC (Dansk Undergrunds Consortium), while the state-owned company DONG (Dansk Olie og Naturgas) takes care of the transportation of natural gas to the shore. DONG also owns and operates the national transmission grid for natural gas and part of the distribution grid. In addition, three regional gas companies under municipal ownership, own and operate regional natural gas grids, with distribution to the end users.

In the gas sector, too, a law reform has been passed to implement the EU Directive on liberalisation of the gas market, and the government's aim is for the gas market to be open for all gas customers from 1 January 2004.

Approximately half of the demand for heating is supplied by district heating. The heat is supplied from primary and small-scale CHP plants, waste incineration plants and biomass-fired district heating stations. Apart from the primary plants, the plants are owned either by municipalities or by local cooperatives that are owned by the consumers. Initially, district heating will not be covered by the liberalisation process, but the government will investigate whether it is possible in the longer term to have a more free choice of supplier in areas with large, interconnected district heating grids.

Prices and taxes

Energy prices are one of the key factors governing energy consumption.

In 2000 total spending on energy, including taxes and VAT, amounted to DKK 118.1 billion. Of this figure, domestic users paid DKK 56.2 billion, manufacturing industries DKK 27.7 billion, and the commercial sector and the service industries, including public services, DKK 24.5 billion. As a general rule, enterprises subsequently receive a full refund of energy taxes and VAT, but not of CO_2 taxes.

Figures 2.6 and 2.7 show the energy prices paid by domestic users. Figure 2.6 shows the current consumer prices, including taxes and VAT. Figure 2.7 shows the development in fixed 2001 prices. The fixed prices have been adjusted for the change in general prices according to the consumer price index.

The prices of heating oil and natural gas follow each other because this is laid down by law. The tax on petrol has varied considerably over time, which has affected the price of petrol.

Measured in fixed prices, the prices of petrol, heating oil and natural gas fell from 1980 until the early 1990s, cf. figure 2.7. The price of electricity remained relatively constant for the whole of the period, although with a rising trend in the later years, primarily because of higher taxes.

As an added incentive to enterprises to improve their energy efficiency, a green tax package with gradually increasing CO_2 and energy taxes was introduced in 1996. Enterprises with a particularly high energy consumption can contract with the Danish Energy Authority on energy-efficiency improvements in return for a discount in the CO_2 taxes.

In 2000 the revenue from energy taxes amounted to DKK 33.0 billion, up

FIGURE 2.7: ENERGY PRICES FOR DOMESTIC USERS. FIXED 2001 PRICES IN DKK
Source: Danish Energy Authority

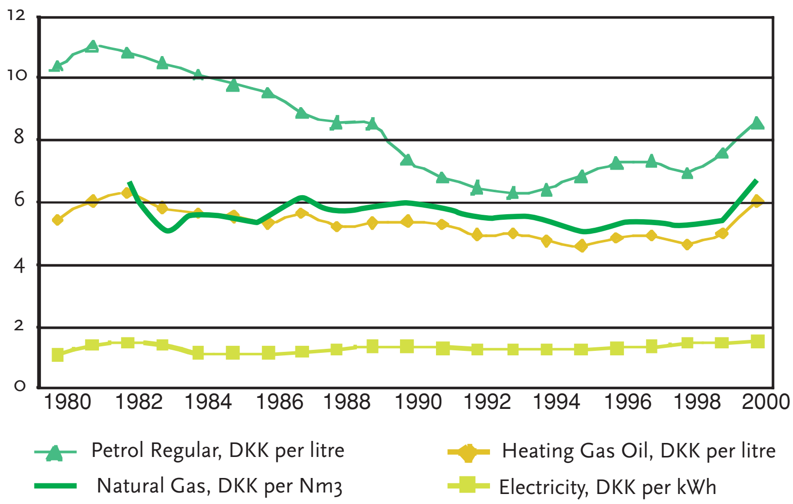
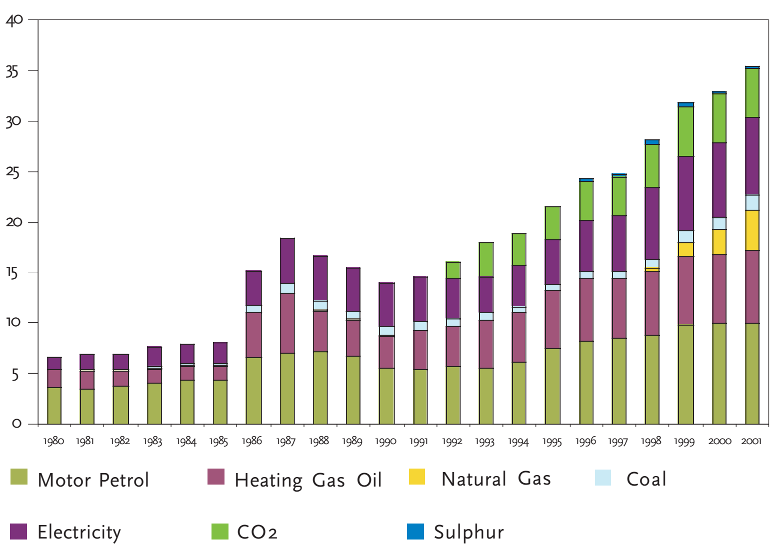


FIGURE 2.8: REVENUES FROM ENERGY, CO_2, AND SULPHUR TAXES. CURRENT PRICES IN BILLION DKK
Source: Danish Energy Authority



from DKK 31.9 billion in 1999. The largest contribution, DKK 10 billion, comes from petrol. Total revenue has increased by 140% in relation to 1990, when there were no CO_2 and sulphur taxes. In 2000 energy taxes accounted for more than 5% of total tax revenue.

Trade

In 2000 net foreign exchange earnings from energy products amounted to DKK 13.1 billion. There was a profit on the trade in oil, natural gas, and electricity, but a loss on the trade in coal.

2.1.7 Transport

Efficient and flexible transportation of goods and persons is a vital element of the foundation of the modern welfare society. At the same time, transport is in itself an important economic sector that contributes to economic growth, employment, and foreign exchange earnings.

The positive effects of the transport sector must be seen against the fact that the sector burdens society in different areas – traffic accidents, air pollution, noise, congestion, and CO_2 emissions. In Denmark, this burden has been reduced in some important areas – primarily in the form of better traffic safety and less air pollution – at the same time as traffic has increased.

However, there has not been a corresponding development with respect to CO_2, and the transport sector has not yet succeeded in decoupling economic growth and greenhouse gas emissions, as has been done in the energy sector. Transport activity, energy consumption and CO_2 emissions within the transport sector have developed largely in step with economic growth. One reason for this is that a number of measures that have been used in other sectors, e.g. the energy sector, including efficiency improvement and substitution of energy sources, have not been directly available or have been associated with heavy costs in the transport sector.

The developments in passager and goods transport activities are shown in table 2.9 and 2.10 respectively
In 2001 the transport sector's CO_2 emissions were approximately 18% higher than the level in 1990.
In 2001 the transport sector account-

Table 2.8: Import and export of energy
Source: Danish Energy Authority

	Import							Export						
	1980	1988	1990	1994	1998	2000	2001	1980	1988	1990	1994	1998	2000	2001
Crude oil 1000 PJ	259	191	174	225	202	159	131	2	83	118	252	356	576	513
Oil products PJ	368	223	177	248	262	256	249	72	123	119	181	137	195	166
Coal PJ	185	261	262	291	204	161	174	0	3	1	1	4	3	4
Natural gas PJo	0	0	0	0	0	0	0	31	39	53	105	121	128	
Electricity GWh	1979	5859	11973	1781	3280	8417	8199	3216	1647	4925	6621	7600	7752	8775

Table 2.9: Trend in passenger transport activity, in bill. person km
Source: Ministry of Transport

	1970	1975	1980	1985	1990	1995	2000	2001
Aircraft	0.2	0.3	0.4	0.4	0.5	0.5	0.4	0.4
Trains	2.8	3.1	4.4	4.8	4.7	4.7	5.4	5.4
Ferries	0.5	0.5	0.5	0.5	0.6	0.6	0.2	0.2
Cars	33.4	37.8	38.6	43.2	50.3	54.0	59.8	59.3
Buses	4.6	5.7	7.3	8.8	7.6	9.1	9.1	9.1
Total	**41.5**	**47.4**	**51.2**	**57.7**	**63.7**	**68.9**	**74.9**	**74.4**
Bicycles				4.5	5.4	5.2		

Table 2.10: Trend in goods transport activity, bill. tonne km
Note: 1 Pipelines not included
Goods transport by air accounts for only a small proportion of total goods transport.
Source: Ministry of Transport

	1970	1975	1980	1985	1990	1995	2000	2001
Freight trains	1.3	1.2	1.2	1.2	0.6	0.6	0.5	0.5
Freighters	1.8	1.7	1.9	1.8	1.9	2.2	1.8	1.8
Lorries	7.8	9.5	8.8	9.4	9.4	9.4	11.1	11,0
Vans					0.4	0.5	0.6	0,7
Pipelines1				0.9	1.9	2.9		
Total	**10.9**	**12.4**	**111.9**	**12.4**	**14.2**	**15.6**	**14,0**	**14,0**

ed for about 22% of Denmark's total CO_2 emissions. Its contribution to Denmark's total greenhouse gas emissions are calculated as a share of the total emissions of greenhouse gases, which include industrial gases, methane, and nitrous oxide. Calculated in this way, the sector is responsible for about 18% of total emissions. The trend in CO_2 emissions in the transport sector is therefore of considerable importance to the total trend in the greenhouse gas emissions.

2.1.8 Business sector

In Denmark the production value of industry is approximately 30% of total national production. Table 2.11 shows that the largest industries in Denmark are the food, drink and tobacco, engineering, electronics, and the chemical industry.

The business sector as a whole (industry, building and construction, and public and private services) accounts for around 13% of Denmark's total emissions of greenhouse gases. CO_2 from energy consumption accounts for by far the largest part of these emissions, but the sector is also a direct source of emissions of industrial greenhouse gases.

In Denmark, the industrial sector's energy consumption accounts for about 20% of total energy consumption. This 20% does not include energy consumption for transport and space heating.

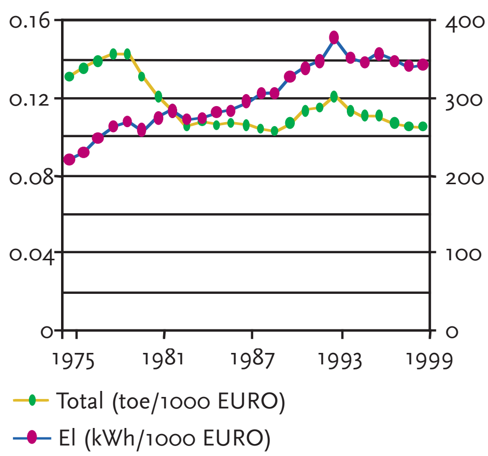
The sector's energy consumption has varied greatly over the last 20 years. Up to 1983, consumption fell considerably due to increases in the price of oil. When oil prices fell in 1986, energy consumption began rising again. In the period 1990-2001 energy consumption in the industrial sector rose by just under 9%, while electricity consumption in the same period increased by almost 22%. From 2000 to 2001 energy consumption rose by just under 2% owing to a considerably higher level of activity. Since 1994 energy consumption per produced unit has fallen, see figure 2.9.

Table 2.11: Turnover by industry in 2002, DKK mill.
Source: Statistics Denmark

All industry	517,551
Mining etc.	2,437
Food, drink and tobacco	131,628
Textiles, clothing and leather	12,687
Timber/wood-working	11,949
Paper and graphic industry	36,849
Mineral oil etc.	14550
Chemical industry	60,543
Rubber and plastics	20,626
Stone, clay and glass	16,529
Metal production and metal-working	40,450
Engineering	62,500
Electronics	61,914
Means of transport	17235
Furniture industry and other industry	27,655

The main action against the industrial sector's energy consumption has hitherto been based on the green tax package for businesses passed by the Folketing in 1995. The package contained a combination of taxes and rebates to enterprises through, among other measures, government grants to promote energy savings by enterprises.

Figure 2.9: Energy and electricity intensity in the industrial sector, based on energy data adjusted for inter-annual temperature variations
Source: Danish Energy Authority and Odyssee



The development in the last few years since the introduction of the green tax package shows that it is possible to increase industrial growth without a corresponding increase in energy consumption and CO_2 emissions. On the contrary, during increased growth it has proven possible to keep energy consumption constant and reduce CO_2 emissions from energy consumption by the industrial sector.

For industrial greenhouse gases (HFCs, PFCs and SF_6), regulation through taxes, and rules on phasing out the use of these substances have been implemented. With certain exceptions, the phasing-out process is expected to take place in the period 2003-2006.

Table 2.12: Key figures for building stock in the year 2001, in mill. m2
Source: Statistics Denmark

Total built-up area	Buildings for all-year habitation	Factories and workshops	Commerce, trade and administration	Institutions and buildings for cultural purposes	Farm buildings
653.6	329.4	52.9	58.9	39.3	130.8

2.1.9 Waste

The waste sector's contribution to the emissions of greenhouse gases consists only of methane. Methane emissions come from the decomposition of organic waste at landfill sites. Emissions of the industrial gases HFC and SF_6 from disposal of, for example, refrigerators and certain thermal glazing, which contain these substances, are included under the business sector.

There are also CO_2 emissions in connection with disposal of oil-based products, e.g. packaging, plastic bags, etc. Since waste incineration in Denmark is included in energy production, these CO_2 emissions must be included under the energy sector in accordance with the inventory rules from the IPCC.

Methane emissions from the waste sector are expected to fall in the future because the municipalities are now obliged to assign all waste suitable for incineration to incineration plants. This means that only a small quantity of organic waste will be deposited at landfills compared with the quantity deposited before the introduction of this obligation in 1997.

In addition, gas from a number of landfills is being used in energy production, which contributes to reducing both CO_2 and methane emissions.

Finally, in connection with incineration, some of the waste is used as an energy source. As many of the incineration plants as possible have been converted to CHP production. In other words, the heat is used to supply district heating, and the electricity is sold to electricity suppliers. In 2001, 32 incineration plants in Denmark converted 25% of the entire waste production and contributed 3% of the entire Danish energy production.

2.1.10 Buildings and urban structure

One-twentieth of the area of Denmark is urbanised. 85% of Danes are town-dwellers, and most enterprises, institutions, etc., are situated in towns. Many pollution problems are therefore concentrated in the towns.

Today, the total built-up area is 654 mill. m^2. Table 2.12 shows the distribution of the area between housing, factories, offices, etc.

Today, about 16,000 homes are built per year, which is one-third of the number built in the first half of the 1970s. House building is expected to remain at this level. In recent years,

Table 2.13: Development in the main forms of heating in buildings, in % of total heated space
Source: Statistics Denmark

Year	1981	1991	2001
Heated space, total	100	100	100
District heating	29.4	38.6	47.5
Central heating with oil	57.2	37.4	23.7
Central heating with natural gas		9.0	15.9
Furnaces fired by oil and similar	2.2	1.5	0.9
Other heating	5.8	5.6	4.5

house building has accounted for slightly more than half of all investment in building activities, and about half of the investment in the housing sector has gone on alterations and extensions. Building for industry and commerce now accounts for around half of all building in towns.

Towns and cities are generally characterised by separation of residential and industrial areas, industrial buildings being situated in specially designated zones on the outskirts of the towns. The growth in the service industries and the growth in manufacturing with a small environmental impact imply new possibilities for integrating industry and housing, thereby reducing the need for transport between home and work.

Approximately two-thirds of the total building space is heated. The main forms of heating are district heating and central heating based on oil and natural gas. Half of the heated space is heated by district heating and, as seen from table 2.13, the use of both district heating and natural gas has increased at the expense of oil.

2.1.11 Agriculture

In the last 40 years the area used for agriculture has fallen from 72% (30,900 km^2) of the total area in 1960 to 62% (26,756 km^2) in 2000. Table 2.14 shows the breakdown by type of crop over the last 30 years. The proportion of agricultural land

Table 2.14: Use of agricultural land, livestock, and nitrogenous fertiliser
Source: Danish Institute of Agricultural Sciences, Danish Research Institute of Food Economics, Statistics Denmark.
* Data for the year 2000

	1970	1980	1990	1999	2001
Grain (%)	59	62	56	55	57
Pulses and industrial seed (%)	2	4	14	8	4
Root crops (%)	10	8	8	5	4
Grass and greenfeed in rotation (%)	17	14	12	16	16
Permanent grass (%)	10	9	8	13	14
Other crops (%)	2	3	2	3	5
Cattle (1000)	2842	2961	2239	1887	1906
Pigs (1000)	8361	9957	9497	11626	12608
Sheep (1000)	70	56	159	143	152
Poultry (1000)	19169	15507	16249	21010	21236
Nitrogen in fertilisers (1000 tonnes N)	271	394	400	263	234
Nitrogen in manure (1000 tonnes N)	-	-	251	237	264*

under grass and greenfeed in rotation and permanent grass fell considerably from 1970 to 1990, but rose considerably during the 1990s, due partly to increasing use of grass fields for dairy farming, and partly to the change in EU subsidy schemes, which means that grass or industrial seed must be grown on set-aside land.

From 1980 to 2001 the number of farms fell from 119,155 to 53,489. In the same period the average size of farms increased from 24 ha to 50 ha. This development has reduced the importance of agriculture to employment and the national economy. However, agricultural production has grown, both in quantity and value, and agricultural exports still make up a large proportion - 11% - of Denmark's total exports.

During the 1990s interest in organic farming increased considerably. In 2001 organic farms accounted for approximately 5% of land under cultivation.

In the last 30 years use of nitrogen by agriculture has varied greatly, cf. table 2.14. Up to 1990 there was a big increase in the use of nitrogenous fertiliser, but during the 1990s use of this type of fertiliser fell considerably, and in 2001 nitrogen consumption was below the 1970 level. The nitrogen content of manure has probably remained approximately unchanged in the entire period in question. Consumption of phosphorus and potassium in fertilisers fell throughout the period.

The cattle population fell by 33% from 1970 to 2001, cf. table 2.14. Most of the cattle are dairy cows. Since milk production remained approximately unchanged throughout the period, the fall in cattle population is due to higher productivity per animal. In the same period, the pig population increased by 51%. The sheep population has doubled in relation to 1970, while after falling during the 1980s, the poultry population is now higher than it was in 1970.

Agriculture was responsible for 20% of Denmark's total emissions of greenhouse gases in 2001. The proportion is expected to be down at 16% in 2010. The gases are mainly methane and nitrous oxides. CO_2 from fuel consumption in the agricultural sector accounts for 3.6% of total Danish emissions.

2.1.12 Forestry

Approximately 11% of Denmark is forested. Originally focus was mainly on the potential of conifers, but in recent years focus has changed towards indigenous, deciduous tree species as offering greater long-term production and nature potential. Denmark's forests are managed as closed canopy forests. The main objective is to ensure sustainable and multiple-use management of the forests and to manage them in line with the overall management of the countryside. Instead of clear-cut systems, forest owners are to a higher degree applying near-to-nature forest management regimes. Unlike our Scandinavian neighbours, Denmark is not a country in which forestry plays an important role in the national econo-

my.
The Danish Forest Act protects a very large part of the existing forests against conversion to other land-uses. Afforestation, for which public subsidies are made available, is as standard protected as forest reserve. In principle, this means that most of the forested land in Denmark will remain as forest.

A target has been set of 20-25% of Denmark being forest landscapes by the end of the 21st century. A considerable increase in the forest area is therefore to be achieved.

Denmark is the only part of the Kingdom in which forestry is practised. Greenland and the Faroe Islands have almost no forest.

2.2 Greenland

2.2.1 Form of government and administrative structure

Greenland has had home rule since 1979. The Home Rule Government consists of a directly elected parliament (the Landsting), comprising 31 members. A general election is held every four years. The Landsting elects a government (the Landsstyre), which is responsible for the central administration under the Prime Minister (the Landsstyreformand). The members of the government head the various ministries.

However, since Greenland is part of the Kingdom of Denmark, some fields of responsibility remain under the state, including the Constitution, the right to vote, eligibility for election to the Folketing, the administration of justice, the concept of citizenship, foreign policy and the National Bank.

The Home Rule Government is responsible for other areas, including transport and communication, and the environment and nature. Greenland is not a member of the EU, but has an OCT scheme (Overseas Countries and Territories scheme) that ensures the country open access to the European market for its fish products.

International agreements entered into by the Danish government also cover Greenland and apply to Greenland to the same extent unless the Home Rule Government specifically requests exemption or deviation from them. Denmark's ratification of the Climate Convention and the Kyoto Protocol both cover Greenland.

2.2.2 Population

Greenland has a population of slightly more than 56,000, 88% of which were born in Greenland. Most of the remainder of the population comes from Denmark.

Fishing is the main industry, and it is estimated that about 2,500 people are directly employed by it. In addition, around 3,000 people work in the fisheries industry and derivative occupations.

2.2.3 Geography

With an area of 2.2 mill. km^2, Greenland is the world's largest island. It extends over almost 24 latitudes. Nordpynten lies only 700 km from the North Pole, and Kap Farvel, 2,600 km further south, is level with Oslo. Towards the south, the height of the sun and thus the length of day and night are almost as in Denmark. Towards the north there is the midnight sun and winter darkness, both lasting for two thirds of the year.

85% of Greenland is covered by a continuous, slightly convex ice cap, which reaches a height of more than 3,000 m above sea level. In a borehole drilled in the central part of the ice cap, the drill reached a depth of 3,030 m in the bedrock.

The remaining 15% of the island is home to Greenland's flora and fauna, and here, on the edge of the ice cap, the people live – mainly in the coastal areas, from which there is access to open water.

2.2.4 Climate
Greenland's northern location and the cold and more or less ice-filled seas that surround it are the main reasons for its cold climate.

Greenland has a mostly arctic climate, and forests cannot grow there. Particularly the northern part of the country is close to the North American continent, separated from it by only a relatively narrow and ice-filled sea. The position of south Greenland, on the other hand, means that the climate here is influenced by the North American continent to the west, and the ocean to the east.

Atmospheric pressure
Atmospheric pressure is generally highest in April/May. The weather in Greenland is most stable at this time of year. After this, in the summer months, the variation in atmospheric pressure is small, but in winter it is much greater, with a generally higher atmospheric pressure towards the north than towards the south, leading to a higher frequency of cold winds from northerly directions and higher wind velocities.

The biggest pressure extremes in Greenland occur in the winter period because of the great temperature contrasts in the atmosphere. The highest atmospheric pressure measured in Greenland was 1059.6 hPa, which was recorded in January 1958. The lowest was 936.2 hPa, recorded in 1986 and 1988.

Wind
Storms typically occur in connection with the passage of low-pressure systems. Between these systems, there are undisturbed periods of varying duration throughout the year, when the wind is governed by local conditions.

An example is the ice cap's katabatic wind system, the extent of which is enormous. A katabatic wind is a wind that blows down an incline, moving from the central part out towards the edge. The wind velocity accelerates with increasing incline of the surface, and the topography can cause channelling, resulting in an extremely high velocity at the edge of the ice.

Greenland has many days with little or no wind. In some places on the east coast this is the case for 60% of the time.

Gusts can be very strong. Gusts of up to 75.1 m/s were measured in Danmarkshavn in 1975, but even stronger gusts undoubtedly occur in connection with the so-called piteraqs. These fall winds, which are katabatic, locally channelled winds from the ice cap, occur in several locations in Greenland, and are characterised by a very abrupt change from light wind to storm. In Greenlandic, piteraq means "that which assaults one".

Figure 2.10 : Annual mean temperature 1873-2000 in °C, stations in Denmark, the Faroe Islands and west Greenland
Source: Danish Meteorological Institute

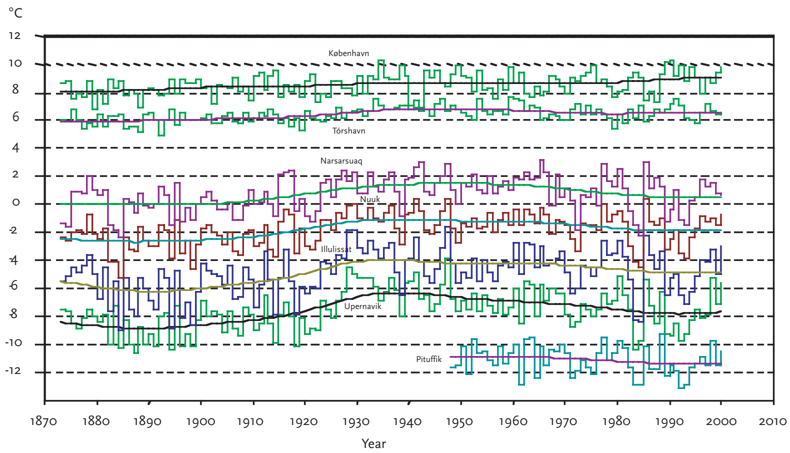
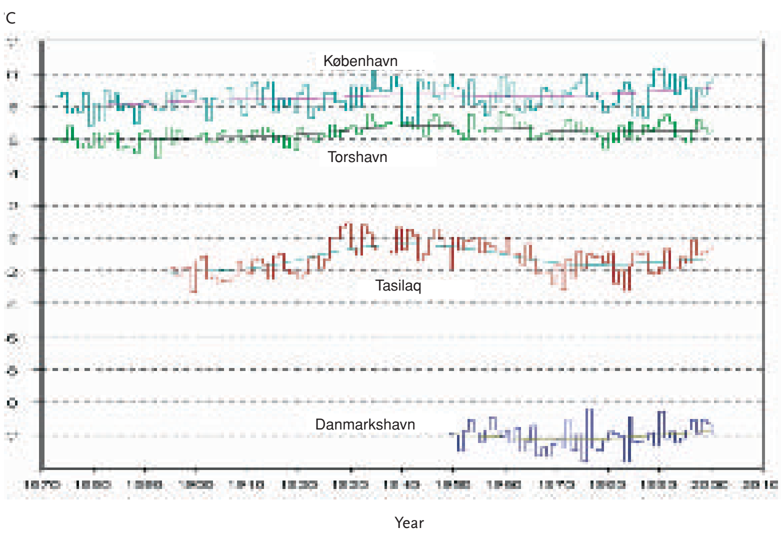


Figure 2.11 : Annual mean temperature 1873-2000 in °C, stations in Denmark, the Faroe Islands and east Greenland
Source: Danish Meteorological Institute



Temperature

The summer temperatures on both the west and the east coast differ by only a few degrees from south to north, despite a distance of more than 2,600 km. The reason for this is the summer midnight sun in north Greenland. Conversely, winter darkness and the absence of warm sea currents mean that the temperature during the winter period differs considerably from north to south.

There is also a big difference in the temperature conditions at the outer coast and inside the fjords. In summer, drift ice and the cold water along the coast can mean that it is warmer inside the fjords, while in winter, on the other hand, the presence of the sea makes it warmer in the coastal areas than inside the fjords.

Foehn winds can disturb this picture in the wintertime. Foehn winds are very common in Greenland, and in winter the hot, dry winds can cause the temperature to rise by 30°C within a relatively short space of time, resulting in melting of snow and ice. The temperature record of 13.9°C from 23 November 1987 in Nuuk is an example of the effect of a Foehn wind.

The highest temperature recorded in Greenland since 1958 is 25.5°C. It was recorded at the "ice cap" station in Kangerlussuaq in July 1990.

In Greenland, frost can occur in all the months of the year except deep inside the fjords at Narsarsuaq Airport and Kangerlussuaq for a couple of the summer months. The "frost-free" period in southern Greenland varies from 60 to 115 days per year.

The coldest place in Greenland is naturally on the ice cap, where the temperature can fall to below -70°C. Temperatures in Greenland have shown a slightly rising trend for the last 125 years, although, on a shorter time scale, temperatures have generally fallen since the 1940s. This has been most marked on the west coast, where a rising trend has only been seen over the last few years. On the east coast, however, there has been a rising trend since the 1970s.

Precipitation
Recorded precipitation in Greenland decreases with rising latitude and from the coast to the inland area. Particularly for southern stations there is considerable seasonal variation.

Right down in the south and particularly in the south-eastern region, precipitation is significant, average annual precipitation ranging from 800 to 2,500 mm along the coasts. Further inland, towards the ice cap, considerably less precipitation is recorded. In the northern regions of Greenland there is very little precipitation, from around 250 mm down to 125 mm per year. In a few places there are "arctic deserts", i.e. areas that are almost free of snow in winter, and where evaporation in summertime can exceed precipitation.

Not surprisingly, snow is very common in Greenland. In fact, at most stations in the coastal region it can snow all year round without snow cover necessarily forming. There are thus many days with snow during the year, mostly in the southern part of the country. The snow depth is greatest in southern Greenland, averaging from one to more than two metres in all the winter months and sometimes reaching up to six metres. In southern Greenland the snow cover can disappear altogether during the winter in connection with warm Foehn winds.

Towards the north, snow cover has already formed in most places by September and normally disappears again in June/July.

Hours of sunshine
The part of Greenland north of the Polar Circle, 66,5°N, has midnight sun and polar night of varying length depending on the latitude. Midnight sun means that the sun is in the sky 24 hours a day, while polar night means that the sun does not rise above the horizon at all.

Despite the polar night, the northern stations have more hours of sunshine than the southern stations. This is due to the "long" day, of course, but also to generally less cloud cover. However, although the surface of the soil receives more solar heat than in the tropics at around the summer solstice because of the long day, a considerable part of the energy is reflected because of the oblique angle of incidence and the snow- and ice-covered surfaces.

2.2.5 Economy

Principal income for the Home Rule Government comes from transfers from the Danish state – the so-called block grant. In addition, the Landsstyre and the municipalities have revenue from personal and corporate taxes, indirect taxes, and licences. There is no VAT. In addition, Greenland receives payment from the EU for access by EU fishermen to Greenland's fishing waters.

Greenland uses the Danish currency, and Danish currency laws apply in connection with the transfer of funds between Greenland and other countries. This means that, in several areas, Greenland is affected by factors, e.g. interest and exchange rates that are determined by external factors.

Exports

87% of Greenland's exports of DKK 2,251 million in 2001 consisted of fish products, 60% of which were prawns. The export value of fish products is heavily dependent on the prices on the world market. Although there was a considerably greater production of prawns in 2001, falling prices on the world market considerably reduced the export value.

Imports

Apart from fishery and hunting products, only a few goods are made in Greenland. Imports therefore include primarily all goods used in households, businesses and institutions, and for investment. In 2001 imports amounted to DKK 2,466 million.

2.2.6 Energy

As in other modern societies, a large part of Greenland's CO_2 emissions come from energy production and supply. Approximately 55% of all energy consumption is used for heating and electricity.

Because of the big distances between towns in Greenland it is neither financially nor technically viable to establish a supply grid connecting them. This means that each town has its own power plant or CHP plant, and each village has its own power plant – so-called island operation. At the same time, the climatic conditions mean that the towns cannot tolerate lengthy interruptions in their electricity supply. It is therefore also necessary to have reserve and emergency plants.

Renewable energy

Up to 1993 all energy production for electricity and district heating was based on diesel-driven power, heating and CHP plants. From 1993, when the hydropower station at Buksefjord went into operation, the capital Nuuk, where around 25% of the Greenland's population live, has been supplied with hydroelectricity for electric heating, lighting, and power. A small hydropower plant is now under construction in east Greenland, and a hydropower plant is planned in South Greenland.

Together with heat utilisation from waste incineration plants, this means that in 2001 about 8% of Greenland's energy consumption (incl. transport, industry, etc.) came from renewable energy sources.

Regular studies have been carried out with a view to utilising other renewable energy sources, but for various reasons, including the high requirements concerning security of supply, the forms of energy utilisation in question have not been of interest so far in Greenland.

Heating

Since 1993 all buildings built with public subsidies in Nuuk have been supplied with electric heating, and electric boilers with interruptible electric heating have been installed in existing district heating stations. The electric boilers operate as long as surplus electricity is available. When it is not, the oil boilers take over. The electricity for this is supplied at a competitive price. In the year 2001, 35% of all electricity produced in Greenland went to permanent and interruptible electric heat in Nuuk.

In 10 towns the residual heat from electricity production is used for district heating. In addition, blocks of flats have their own individual heating plant, while most single-family houses have oil-fired central heating.

In the villages, most of the houses have a central heating furnace or oil stoves.

Electricity

Nuuk's electricity comes from the hydropower station. The electricity in the other towns and villages is produced at diesel-driven power plants. Work is going on to optimise the utilisation of the power plants.

2.2.7 Transport

Passenger transport

All passenger transport to and from Greenland is by air, via either Copenhagen-Kangerlussuaq or Copenhagen-Narsarsuaq. From Nuuk and Kangerlussuaq there is a connection via east Greenland to Iceland.

Between towns and villages in Greenland, passenger transport is by passenger ship, aeroplane, or helicopter. Up through the 1990s both sea and air passenger traffic increased, and the increase in air traffic has resulted in a big rise in consumption of aviation fuel.

There are bus services in the larger towns, while in the smaller ones, passenger transport is by taxi. To get out into the surroundings people usually use sailing boats and dinghies. There are around 5,000 dinghies in Greenland. The use of private cars, which is not deemed to have much effect on Greenland's CO_2 emission, is increasing. In 1990, 1,410 ordinary cars were registered by private owners, while in 2001, the figure rose to 2,097 – a 50% increase.

Goods transport

Almost all goods transport, both to and within Greenland, is by sea. A small proportion, mainly mail and perishable goods, is transported by air.

2.2.8 Business sector

The principal industry in Greenland is fishing/fisheries. In 1996, 25% of the workforce was employed by this industry. In 2001 the fishing fleet and the land-based production facilities for fish, crabs and prawns accounted for about 30% of Greenland's entire energy consumption. The consumption is based mainly on fossil fuels. The industry is very sensitive to market fluctuations and it is therefore difficult to predict how it will develop.

A large part of the rest of trade and industry consists of service enterprises. Except for electricity and district heating, energy consumption and CO_2 emissions are not calculated separately for this part.

Exploration for oil and minerals is under way. If large-scale extraction and production are started up at some time in the future, this could have a big effect on Greenland's CO_2 emissions.

There do not appear to be any enterprises using industrial gases in their production.

2.2.9 Waste

Approximately 30,000 tonnes of waste are produced in Greenland each year. Three incineration plants in towns incinerate about 40% of the waste, while 47 small incineration plants in villages together incinerate 13%. Less than half of the waste is sent to landfills or burnt. Three new incineration plants are expected to go into operation in 2003, which will reduce the amount of waste sent to landfills/burnt to less than 25%.

In the three existing incineration plants in towns, the heat from waste incineration is used for district heating. The heat from the three coming plants will be used in the same way, which means that the energy from more than 60% of Greenland's waste is expected to be utilised in 2003.

The possibilities for reducing the quantity of waste sent to landfills/burnt are being investigated.

2.2.10 Buildings and infrastructure

The government plays a very important role in the housing sector. Most housing is government housing or built with a government grant. Most private housing is built by the owners themselves, and the government offers grants for this purpose. The cooperative housing system was introduced in 1990 with government support.

A large proportion of the houses are more than 15 years old, and a refurbishment programme has been initiated. This modernisation includes reducing the energy consumption of individual houses.

2.2.11 Agriculture

Geographically, Greenland's agriculture is placed in the south and has a very limited impact on CO_2 emissions. It consists mainly of sheep farming, and 25,000-30,000 lambs are produced each year. There are also two farms with domesticated reindeer. The number of sheep has remained relatively constant since 1990, whereas the number of domesticated reindeer has more than halved. The area farmed has increased by 85% since 1990 due to cultivation of a large quantity of coarse fodder.

2.2.12 Forestry

There is no forestry in Greenland apart from four experimental plantations with conifers, with a total area of 100 ha.

Table 2.15 Agriculture in Greenland

Source: Grønlands Statistik and the Home Rule's Department for Trade and Industry

	1990	2001
Agricultural land (ha)	460	852
Sheep (number)	19,929	20,394
Domesticated reindeer (number)	6,000	2,480

2.3 The Faroe Islands

2.3.1 Form of government and administrative structure

The Faroe Islands have home rule status, and their internal affairs are governed by the Faroese parliament (the Lagting). The Faroe Islands are not a member of the EU.

International agreements entered into by the Danish government cover the Faroe Islands and apply to them to the same extent unless the Faroese government specifically requests exemption or deviation from them.

Denmark's ratification of the Climate Convention covers the Faroe Islands as well, but at the request of the Faroese government, geographical exemption was taken for the Faroe Islands in connection with Denmark's ratification of the Kyoto Protocol.

2.3.2 Population

In 2001 the Faroe Islands had a population of slightly less than 47,000 – an increase of 5,000 since 1977. Net immigration was relatively small up to the beginning of the 1980s but increased relatively sharply in the years 1984-89 as a consequence of a high level of economic and employment activity.

In the years 1990-1995 this picture changed to extensive emigration due to a serious deterioration in the economic and employment situation. In 1993 and 1994 alone, net emigration corresponded to 8% of the total population. Since 1996, the population has been growing. In 2001 the capital, Thorshavn, had a population of 18,000, corresponding to slightly less than 40% of the entire population.

2.3.3 Geography

The Faroe Islands consist of 18 small, mountainous islands situated in the North Atlantic at about 62°N and 7°W. The islands extend over 113 km from north to south and 75 km from east to west, and the total area is 1,399 square kilometres. The highest points, almost 890 metres above sea level, are on the northern islands. 17 of the islands are inhabited.

2.3.4 Climate

The climate on the Faroe Islands is strongly affected by the warm North Atlantic current and frequent passage of cyclones, which, depending on the location of the polar front, mainly come from southwest and west. The climate is characterised by mild winters and cool summers and is sometimes very damp and rainy.

The high pressure over the Azores sometimes shifts towards the Faroe Islands. This can result in stable summer weather lasting several weeks, with quite high temperatures. In winter, on the other hand, the low pressure systems can move more southerly around the islands than normal, bringing in cold air from the north and a lengthy period of sunny winter weather.

The maritime climate is also a result of the cold east Iceland current (polar current), which splits into two currents from eastern Iceland towards the Faroe Islands. The mixing of the water masses from this and the warm Gulf Stream causes a relatively big difference in the sea temperatures around the islands, and this in turn causes local variations in the climate.

Atmospheric pressure
The normal atmospheric pressure at sea level in Thorshavn is 1008 hPa on an annual basis, lowest from October to January (1004-1005 hPa) and highest in May (1014 hPa). The lowest atmospheric pressure recorded was 948.6 hPa on 11 January 1986, and the highest was 1046 hPa recorded on 20 February 1965. The islands have long periods with both low pressure and high pressure.

The Faroe Islands lie close to the normal cyclone paths over the North Atlantic, and big and frequent changes in atmospheric pressure, with rises and falls of 20 hPa within 24 hours are common throughout the year. Sometimes, however, such violent cyclones develop that pressure falls of more than 24 hPA/24 hours occur.

Temperature
The annual mean temperature in Thorshavn is 6.5°C. The temperature in January and February is around 3.5°C, and in July and August, around 10.5°C. The annual mean temperature varies from place to place and is lowest at Vága Floghavn, 6.0°C, and highest in Sandur on the island of Sandoy, 7.0°C.

In the 1990s the temperatures in Thorshavn exhibited a slightly rising trend.

Precipitation
Annual precipitation in Thorshavn is 1284 mm, most in autumn and least in summer. There are big geographical variations in precipitation, mainly due to the topography of the islands.

It rains a lot on the Faroe Islands. Indeed, the Hvalvík has as much as 300 days with precipitation, and Thorshavn, 273 days. In the winter, precipitation is often in the form of snow. On average, Thorshavn has 44 days of snowfall per year, mostly in December and January. There is no snow at all in June, July, and August, but there can be snow in September.

Precipitation in Thorshavn has exhibited a distinctly rising trend since the mid-1970s.

Hours of sunshine, cloud cover and relative humidity
Thorshavn has 840 hours of sunshine per year, most in May and June, the average being around 125

hours. In some Decembers there are no hours of sunshine at all. The highest number of hours of sunshine in a calendar month was 232 hours, observed in May 1948 and in May 2000.

The location in the North Atlantic, combined with frequent low-pressure fronts, results in a large number of cloudy days (>80% cloud cover) – 221 days in Thorshavn. The number of hours of sunshine in Thorshavn has remained stable for the last 20 years.

The Faroe Islands have a moist climate, and the relative humidity is very high, 88% on an annual basis in Thorshavn. It is highest around August, and this is also when most fog occurs.

Wind

The mean wind is generally high on the Faroe Islands, particularly in autumn and winter (6-10 m/s). The wind is normally lightest in summer (4.5-6 m/s). There are normally no storms from April to August, while autumn and winter are windy, with many storms, some of which can reach hurricane force.

The highest 10-minute mean winds are about 50 m/s, recorded at Mykines Lighthouse in March 1997 and January 1999. In 1997, gusts of almost 67 m/s were recorded at Mykines Lighthouse.

Although the weather is generally windy, there are also still periods, mostly in summer and mostly of short duration.

2.3.5 Economy

Since 1995 the Faroese economy has grown rapidly, due particularly to strong growth in fisheries. In 2001 exports increased by 12%, while imports fell by just under 4%, resulting in a surplus of DKK 160 million on the balance of trade.
About 80% of exports from the Faroe Islands go to EU countries. Of this, Denmark accounts for 25% and the UK for 18%. In 2001 the Faroe Islands' GNP was DKK 9.36 million.

In the last few years, the Faroe Islands have turned a net foreign debt into a net credit balance, although with a big difference between the private and the public sector. At the end of 2001 the private sector had a net credit balance of more than DKK 5 billion, while the public sector's net foreign debt stood at almost DKK 3 billion. Unemployment has fallen sharply in the last few years and is now around 3%. Table 2.16 shows the development and breakdown by trade and industry, measured in gross national product at factor cost.

In 2001 the surplus on the balance of payments, which, besides the balance of trade, includes services, wages, interest, transfers from the Danish state (approx. DKK 1.2 billion) and Danmarks Nationalbank, amounted to approximately DKK 900 million

The Faroe Islands use the Danish currency and are part of the Danish currency area, although they have their own notes.

2.3.6 Energy

The joint municipal company SEV is responsible for the production and sale of electricity on the Faroe Islands. In 2001, production amounted to about 230 mill. kWh. Of this, more than 30% was based on hydroelectricity, while the remainder was produced at diesel-driven plants. There is not much electricity production based on wind power – only 0.3% or 0.5 mill. KWh in 2001. The

Table 2.16 Gross national product at factor cost, 1997 - 2001, breakdown by sector

Source: Færøernes Landsbank

	1997	1998	1999	2000	2001
			DKK mill.		
Fisheries etc.					
Agriculture	41	47	53	56	57
Fishing	968	1,106	1,017	1,117	1,446
Fish farming	164	180	249	291	302
Whale hunting	10	10	10	10	10
Fishing industry	279	345	394	464	497
Total	**1,462**	**1,688**	**1,723**	**1,938**	**2,312**
Industry, excluding fisheries					
Raw material extraction	12	15	18	21	107
Construction	193	271	321	388	471
Energy and water supply	144	147	150	161	186
Other industrial production	162	173	205	248	290
Total	**511**	**606**	**694**	**818**	**1.054**
Private and public services					
Shipyards, workshops etc	109	138	146	170	198
Trade and hotels	595	692	768	835	959
Shipping	174	184	200	229	267
Other transport	102	129	143	163	193
Post and telecommunications	177	193	201	219	251
Household services	36	43	47	52	55
Financing	364	392	392	422	434
Business services	167	171	187	216	250
Sundry private services	25	39	33	45	52
Public services	1,360	1,436	1,556	1,651	1,800
Housing	709	727	742	756	771
Imported financial services	-327	-363	-373	-401	-413
Total	**3,491**	**3,781**	**4,042**	**4,357**	**4,817**
Total GFI	**5,464**	**6,075**	**6,459**	**7,113**	**8,183**

Table 2.17 Electricity production 1998-2001, in GWh

Source: The Faroe Islands Ministry of Oil

	1998	1999	2000	2001
Hydropower	77.3	70.2	76.0	76.0
Diesel power	113.1	130.6	136.4	154.8
Wind power	0.6	0.6	0.5	0.5
	191	201	213	231

reason for this is partly the very harsh wind conditions on the Faroe Islands, which make special demands on the wind turbines and thus the investment, and partly the fact that it is deemed difficult to adapt the great alternative production of this type to the relatively weak supply grid. Calculations show that there would be room for approximately 4.5 MW wind power in the grid in the area around Thorshavn.

Of the electricity sold in 2001, 33% went to domestic users, 35% to industry, agriculture, and fisheries, 14% to the service sector, and the remainder to street lighting etc.

Since a number of oil finds in British territorial waters close to the Faroese border in the 1990s, there has been a reasonable presumption that there is oil in Faroese territory, and the first licensing round was held in the spring of 2000. The first licences for exploration and production of hydrocarbons in the subsoil off the Faroe Islands were granted in August 2000. The first three exploration wells were drilled in the summer and autumn of 2001. In one of these, oil and gas were found. An evaluation programme is now being carried out to determine whether this find is commercially viable.

2.3.7 Transport

Goods transport between the Faroe Islands and the rest of the world is mainly by sea. Two Faroese shipping companies operate freighter services all year round. Since 1998, the Smyril Line has carried freight in connection with their passenger winter sailings to Denmark. The Icelandic company EMISKIP also operates freight services throughout the year and has an office on the Faroe Islands.

Besides Vagar Airport, the Faroe Islands have 12 helicopter pads. Air services are provided by MAERSK AIR, ICELAND AIR and the Faroese company ATLANTIC AIRWAYS. The number of air travellers to and from the Faroe Islands has risen sharply in the last few years.

Passenger transport by sea takes place mainly in the summer period. There are both regular services (Smyril Line) and cruise liners. The number of foreign passenger ships calling at the Faroe Islands has been increasing in recent years.

For 20-30 years up to the beginning of the 1990s and again over the last few years, major investments have been made in enlarging and modernising the transport infrastructure on the islands and the communication links with the outside world. Constructing roads, tunnels, and harbours is costly because of the difficult topographical conditions. Since an economic downturn at the beginning of the 1990s, the number of motor vehicles has increased by almost 1,000 and now stands at 21,000 motor vehicles, of which 16,000 are cars and 3,500 lorries and vans.

2.3.8 Business sector

Excluding exports of ships, which vary considerably over the years, 98% of the Faroe Islands' export earnings comes from fish and fish products. The fishing industry is therefore of vital importance to earnings and employment on the Faroe Islands. The limited opportunities in other sectors of industry reinforce still further the totally dominant role of the fishing industry. Small villages in particular are almost entirely dependent on fisheries. In 2001 more than 27% of total wages on the Faroe Islands came from the fishing industry. Today, the number of man-years in the fishing fleet itself is estimated to be about 2,000.

Besides the actual fish industry, a number of workshops and industrial enterprises have been built up to make equipment etc. for fishing vessels and the fisheries industry. This group includes shipyards and firms making fishing tackle, and machines and equipment for filleting factories. The last few years have seen the establishment of companies exporting fishing-system solutions to countries in the third world and elsewhere. The absence of a large domestic market, high transport costs for raw materials and finished goods, and – in an international context - a relatively high level of overall costs have hitherto prevented the Faroe Islands from establishing export-oriented industries apart from the fishing industry and the firms supplying it.
The Faroese government supports the development of small industry and manual trades based on sales to the domestic market.

2.3.9 Buildings and urban structure

For many years, the Faroese authorities have made every effort to counteract migration from the small or isolated villages and islands, in particular through a major road-building programme and other transport measures. However, population development is generally poorer in these outlying areas than in other parts of the country.

Housing is predominantly single-family houses, most of which are relatively large and of high standard.

2.3.10 Agriculture

Until the end of the nineteenth century, farming was the Faroe Islands' main industry, but with the economic and industrial development since then, particularly within fisheries, farming today accounts for only 0.7% of the Faroe Islands' gross national income at factor cost.

With a view to increasing the self-sufficiency of the Faroe Islands, the government is providing grants for investments in farming.

With about 5% of the land under cultivation, the Faroe Islands can supply just over half of its total demand for lamb and mutton, most of its demand of milk, a fraction of its demand for beef and eggs, and half of the demand for potatoes. In 2001 the Faroe Islands had 1,170 dairy cows and about 70,000 sheep.

2.3.11 Forestry

There is no commercial forestry on the Faroe Islands, but there are a number of plantations on the islands, which are maintained by the Faroese forestry authority.

3. Greenhouse gas inventory information

3.1 Greenhouse gas inventories

Denmark's greenhouse gas inventories are prepared in accordance with the guidelines from the Intergovernmental Panel on Climate Change (IPCC) and are based on methods developed under the European CORINAIR programme (COordination of INformation on AIR emissions) for calculating national inventories[1].

The inventories follow the method described in CORINAIR's guidelines[2] and IPCC's guidelines[3]. However, in accordance with the latter guidelines, the methods and emission factors have been modified for some of the inventories so that they reflect better Danish conditions.

A description of methods, emission factors and activity data is given in Denmark's national emission inventory reports (NIR)[4] to the Climate Convention. For the last two years these reports have included data in the common reporting format(CRF). The latest NIR and the latest combined Danish inventory of greenhouse gases and other air pollutants can be seen at the National Environmental Research Institute's website[5] and in Illerup et al., 2002.

Preliminary greenhouse gas inventories, for Greenland and the Faroe Islands are included in the annual inventory report to the Climate Convention.

3.2 Denmark's emissions and removals of greenhouse gases

Denmark's emissions of the greenhouse gases CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide) and the so-called industrial gases, which include HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF_6 (sulphur hexafluoride), for the period 1990 to 2001 are shown in tables 3.1-3.4 broken down into IPCC's six main categories and the most relevant sub-categories. The total emissions of these greenhouse gases, calculated in CO_2 equivalents on the basis of the individual gases' global warming potential, is shown in table 3.5. The development 1990-2001, broken down by source in table 10 in the reporting format CRF reported in NIR 2002, is reproduced in Annex A.

3.2.1 Carbon dioxide (CO_2)

Almost all the CO_2 emissions come from combustion of coal, oil and natural gas at power stations and in residential properties and industry, although road traffic also accounts for a considerable part of it.

The relatively large fluctuations in the emissions from year to year is due to trade in electricity with other countries – mainly the Nordic countries. The large emissions in 1991 and 1996 resulted from large electricity exports.

From 1990 to 1996, emissions showed a rising trend, but they have fallen since 1997 because many power stations have changed their fuel mix from coal to natural gas and re-

Table 3.1: Trend in CO_2 emissions 1990 - 2001

Source: National Environmental Research Institute

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
						($Gg\ CO_2$)						
1. Energy	**51530**	**62082**	**56142**	**58492**	**62482**	**59701**	**73051**	**63555**	**58500**	**55764**	**51199**	**52779**
A. Fuel Combustion (Sectoral Approach)	51290	61588	55631	58047	62014	59336	72651	62990	58077	54862	50606	52145
1. Energy Industries	26202	35155	30127	31689	35388	32093	44412	35433	31504	28250	25121	26375
2. Manufacturing Industries and Construction	5605	6012	5873	5804	6300	6705	6888	6763	6081	6129	5823	5909
3. Transport	10404	10896	11021	11202	11642	11775	11976	12102	12125	12182	12046	12077
4. Other Sectors	8959	9238	8470	9115	8432	8511	9198	8520	8162	8119	7505	7688
5. Other	119	287	141	237	252	252	176	171	204	182	111	97
B. Fugitive Emissions from Fuels	240	495	511	445	468	365	400	565	422	903	593	633
1. Solid Fuels	0	0	0	0	0	0	0	0	0	0	0	0
2. Oil and Natural Gas	240	495	511	445	468	365	400	565	422	903	593	633
2. Industrial Processes	**1005**	**1178**	**1300**	**1311**	**1318**	**1311**	**1388**	**1539**	**1436**	**1402**	**1453**	**1464**
3. Solvent and Other Product Use	**124**	**122**	**121**	**125**	**119**	**118**	**116**	**115**	**114**	**113**	**112**	**112**
4. Agriculture	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
5. Land-Use Change and Forestry	**-3118**	**-3119**	**-3121**	**-3123**	**-3126**	**-3128**	**-3134**	**-3142**	**-3152**	**-3161**	**-3517**	**-3531**
6. Waste	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
7. Other	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Denmark's Total Emissions/Removals with LUCF	49541	60264	54442	56805	60793	58002	71422	62067	56898	54118	49247	50824
Denmark's Total Emissions without LUCF	52659	63383	57563	59928	63919	61130	74556	65209	60050	57279	52764	54355
Memo Items:												
International Bunkers	4857	4407	4590	5973	6664	6940	6790	6429	6587	6457	6629	5983
Aviation	1762	1635	1695	1660	1819	1867	1970	2010	2158	2290	2348	2378
Marine	3095	2772	2895	4312	4846	5073	4820	4419	4429	4166	4281	3605
Multilateral Operations	0	0	0	0	0	0	0	0	0	0	0	0
CO_2 Emissions from Biomass	4611	5013	5319	5567	5679	6014	6449	6617	6336	6352	7001	7679

Table 3.2: Trend in CH_4 emissions 1990 - 2001

Source: National Environmental Research Institute

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
						($Gg\ CH_4$)						
Total Emissions	270	273	273	279	280	284	287	282	276	261	264	267
1. Energy	**13**	**15**	**16**	**17**	**25**	**32**	**36**	**39**	**35**	**37**	**36**	**38**
A. Fuel Combustion (Sectoral Approach)	9	10	10	11	17	22	27	29	29	30	30	31
1. Energy Industries	1	2	2	3	6	11	15	16	19	17	17	18
2. Manufacturing Industries and Construction	1	1	1	1	1	1	2	2	1	2	2	2
3. Transport	3	3	3	3	4	4	4	4	4	4	3	3
4. Other Sectors	4	4	4	4	6	6	7	7	5	7	8	8
5. Other	0	0	0	0	0	0	0	0	0	0	0	0
B. Fugitive Emissions from Fuels	4	6	6	6	9	10	9	10	6	8	7	7
1. Solid Fuels	3	4	4	5	6	6	6	7	3	3	3	3
2. Oil and Natural Gas	1	2	2	2	3	3	3	4	3	4	4	4
2. Industrial Processes	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
3. Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
4. Agriculture	**195**	**194**	**192**	**197**	**189**	**189**	**189**	**184**	**186**	**170**	**170**	**173**
A. Enteric Fermentation	152	151	148	150	145	145	145	140	140	130	129	131
B. Manure Management	43	43	44	47	44	45	44	44	46	40	41	42
5. Land-Use Change and Forestry	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
6. Waste	**62**	**64**	**65**	**65**	**65**	**63**	**62**	**59**	**55**	**53**	**57**	**56**
A. Solid Waste Disposal on Land	62	64	65	65	65	63	62	59	55	53	57	56
7. Other	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

newable energy. As a result of the reduced use of coal in the last years, most of the CO_2 emissions now come from combustion of oil.

Emissions from road transport in 2001 accounted for more than 20% of the total CO_2 emissions.

3.2.2 Methane (CH_4)

The man-made emissions of methane (CH_4) come from agriculture, landfill sites and energy production, with agriculture by far the largest source. The emissions from agriculture are due to the formation of methane in the digestive system of farm animals and due to treatment of manure.

The methane emissions from landfill sites are falling because the amount of waste deposited is decreasing year by year as a consequence of the abrupt fall in the quantity of landfilled waste that has occurred since 1997.

The emissions from energy production are rising because gas engines account for an increasing proportion. Gas engines have large emissions of methane compared with other combustion technologies.

3.2.3 Nitrous oxide (N_2O)

Agriculture is by far the biggest source of emissions of nitrous oxide (N_2O) because this gas forms in soil during bacterial conversion of nitrogen in fertiliser and manure. Bacterial conversion of nitrogen also occurs in drain water and coastal water. This nitrogen largely comes from agricul-

Table 3.3: Trend in N_2O emissions 1990 - 2001
Source: National Environmental Research Institute

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(Gg N_2O)											
Total Emissions	35	35	32	33	32	32	31	30	30	30	29	28
1. Energy	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**
A. Fuel Combustion (Sectoral Approach)	2	2	2	2	2	2	3	3	3	3	3	3
1. Energy Industries	1	1	1	1	1	1	1	1	1	1	1	1
2. Manufacturing Industries and Construction	0	0	0	0	0	0	0	0	0	0	0	0
3. Transport	0	1	1	1	1	1	1	1	1	1	1	1
4. Other Sectors	0	0	0	0	0	0	0	0	0	0	0	0
5. Other	0	0	0	0	0	0	0	0	0	0	0	0
B. Fugitive Emissions from Fuels	0	0	0	0	0	0	0	0	0	0	0	0
1. Solid Fuels	0	0	0	0	0	0	0	0	0	0	0	0
2. Oil and Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0
2. Industrial Processes	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
3. Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
4. Agriculture	**33**	**32**	**30**	**31**	**30**	**29**	**29**	**27**	**28**	**27**	**27**	**26**
A. Enteric Fermentation	1	2	2	2	2	2	2	1	2	1	1	1
D. Agricultural Soils	32	31	29	29	28	28	27	26	26	26	25	24
5. Land-Use Change and Forestry (3)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
6. Waste	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Solid Waste Disposal on Land	0	0	0	0	0	0	0	0	0	0	0	0
7. Other	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.4: Trend in HFC, PFC and SF_6 emissions 1990 - 2001

Source: National Environmental Research Institute

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	($Gg\ CO_2$ equivalent)											
Emissions of HFCs - CO_2 equivalent(Gg)	0	0	4	96	141	236	371	392	489	598	705	647
Emissions of PFCs - CO_2 equivalent (Gg)	0	0	0	0	0	1	3	7	15	20	28	22
Emissions of SF_6 - CO_2 equivalent (Gg)	43	62	89	135	122	107	61	73	59	65	59	30

ture's use of fertiliser, and emissions from these sources are therefore included under agriculture. It will be seen from table 3.3 that there has been a considerable fall in N_2O emissions from agriculture since 1990. This is due to less and better use of fertiliser. A small part of the N_2O emissions comes from the exhaust from cars fitted with a catalyser.

3.2.4 The industrial gases HFCs, PFCs and SF_6

The contribution of industrial greenhouse gases (HFCs, PFCs and SF_6) to Denmark's total emissions of greenhouse gases is relatively modest, but has shown the strongest percentage rise during the 1990s. The HFCs, which are primarily used within the cooling industry, con-

Table 3.5: Danish greenhouse gas emissions in CO_2 equivalents 1990 - 2001.

Source: National Environmental Research Institute

Greenhouse gas emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	($Gg\ CO_2$ equivalent)											
Net CO_2 emissions/removals	49541	60264	54442	56805	60793	58002	71422	62067	56898	54118	49247	50824
CO_2 emissions (without LUCF)	52659	63383	57563	59928	63919	61130	74556	65209	60050	57279	52764	54355
CH_4	5672	5728	5735	5858	5882	5958	6030	5920	5802	5473	5535	5606
N_2O	10843	10737	10068	10193	9976	9903	9758	9343	9382	9314	9090	8749
HFCs	0	0	4	96	141	236	371	392	489	598	705	647
PFCs	0	0	0	0	0	1	3	7	15	20	28	22
SF_6	43	62	89	135	122	107	61	73	59	65	59	30
Total (with net CO_2 emissions/removals)	**66099**	**76791**	**70338**	**73086**	**76913**	**74207**	**87644**	**77803**	**72645**	**69589**	**64664**	**65879**
Total (without CO_2 from LUCF)	**69217**	**79910**	**73459**	**76209**	**80039**	**77335**	**90778**	**80945**	**75797**	**72750**	**68181**	**69410**

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	($Gg\ CO_2$ equivalent)											
1. Energy	52386	63113	57142	59566	63790	61135	74732	65222	60059	57359	52758	54416
2. Industrial Processes	1049	1240	1393	1541	1581	1655	1823	2012	2000	2085	2246	2164
3. Solvent and Other Product Use	124	122	121	125	119	118	116	115	114	113	112	112
4. Agriculture	14348	14096	13441	13618	13174	13111	12803	12354	12460	12083	11868	11550
5. Land-Use Change and Forestry (net emissions)	-3118	-3119	-3121	-3123	-3126	-3128	-3134	-3142	-3152	-3161	-3517	-3531
6. Waste	1310	1338	1361	1359	1375	1317	1304	1241	1163	1110	1197	1168
7. Other	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3.1: Danish greenhouse gas emissions in CO_2 equivalents 1990 - 2001

Source: National Environmental Research Institute

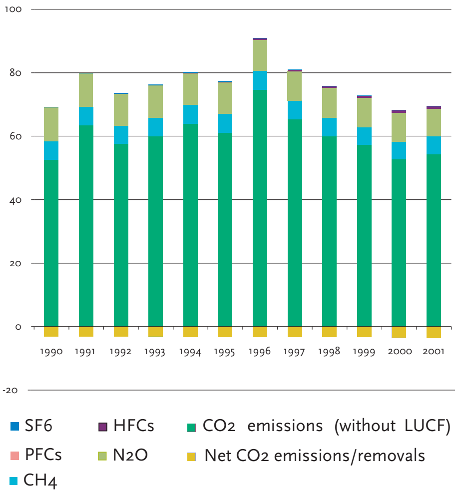
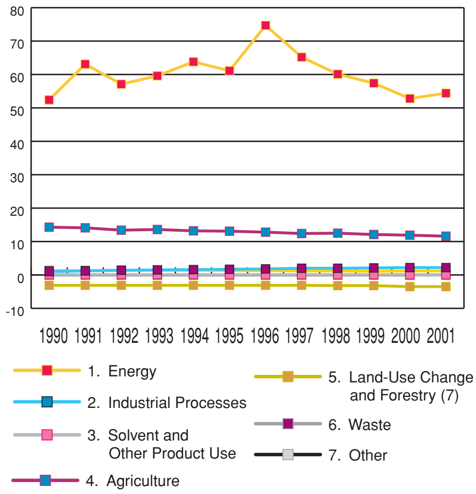


Figure 3.2 Greenhouse gas emissions in Denmark, breakdown by source/sector 1990 - 2001

Source: National Environmental Research Institute



tribute most to the industrial greenhouse gas emissions. In the period 1990 to 2001, HFC emissions rose from 0 tonnes to 647,000 tonnes CO_2 equivalents. There has been a relatively small increase and decrease in PFC emissions, while SF_6 emissions have fallen considerably in the last few years.

3.2.5 Denmark's total emissions and removals of greenhouse gases

Table 3.5, figure 3.1 and figure 3.2 show the trend in Denmark's emissions and removals of greenhouse gases, given in CO_2 equivalents and broken down into gases and sources in accordance with the general rules for inventories under the Climate

Table 3.6. Denmark's, Greenland's and the Faroe Islands' total emissions and removals of greenhouse gases 1990 - 2001

Source: National Environmental Research Institute

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(Gg CO_2 equivalent)											
Greenlands CO_2 emissions (without LUCF)	**624**	**609**	**594**	**0**	**494**	**523**	**564**	**575**	**550**	**585**	**659**	**617**
Faroe Island's CO2 emissions (without LUCF)	709	682	650	536	544	541	578	559	616	645	699	791
Faroe Island's CH_4 emissions	18	19	19	18	19	19	19	20	19	19	20	20
Faroe Island's N_2O emissions	23	24	24	23	24	25	25	27	26	27	30	31
Faroe Island's Total Emissions without LUCF	**750**	**725**	**693**	**577**	**588**	**585**	**622**	**605**	**661**	**691**	**749**	**843**
The Kingdom's Total Emissions and Removals with LUCF	**66099**	**76791**	**70338**	**73086**	**76913**	**74207**	**87644**	**77803**	**72645**	**69589**	**64664**	**65879**
The Kingdom's Total Emissions and Removals without LUCF	**69217**	**79910**	**73459**	**76209**	**80039**	**77335**	**90778**	**80945**	**75797**	**72750**	**68181**	**69410**
Trend since 1990 (1990=index 100), without LUCF	**100**	**116**	**106**	**111**	**116**	**112**	**133**	**118**	**110**	**105**	**98**	**100**
Trend since 1990 (1990=index 100), with LUCF	**100**	**115**	**106**	**110**	**116**	**112**	**131**	**117**	**110**	**105**	**99**	**100**

Convention. CO_2 is the main greenhouse gas, followed by N_2O and CH_4. It will be seen that there was a general fall in these emissions from 1996, when total emissions were(excluding LUCF) 90.8 million tonnes CO_2 equivalents, to 2000, with total emissions of 68.1 million tonnes CO_2 equivalents, while the total emissions in 2001 were 69.3 million tonnes CO_2 equivalents. Of the total greenhouse gas emissions in CO_2 equivalents, CO_2 accounted for 78%, methane for 8%, nitrous oxide for 13% and the industrial gases HFCs, PFCs and SF_6 for 1% in 2001. After deduction of the CO_2 removals in forests, the total net Danish greenhouse gas emissions were 65.9 million tonnes CO_2 equivalents in 2001.

As will be seen from section 3.4, an inventory based on the rules under the Kyoto Protocol means certain changes with respect to base year and removals in connection with land-in-use change and forestry (LUCF).

3.3 Denmark's, Greenland's and the Faroe Islands' total emissions and removals of greenhouse gases

The total inventories for Denmark, Greenland and the Faroe Islands (the Kingdom) are given in table 3.6. As will be seen, the Climate Convention's goal of getting the level in 2000 down to the 1990 level was achieved. In 2000, the total level for Denmark, Greenland and the Faroe Islands lay 1.1% below the 1990 level.

For the time being, the inventories from Greenland contain only inventories of the CO_2 emissions from combustion of fossil fuels, which must, however, be regarded as by far the most important source of greenhouses gases.

The inventories from the Faroe Islands include both an inventory of CO_2 emissions from combustion of fossil fuels and inventories of methane and nitrous oxide emissions from agriculture.

As will be seen from the table, Greenland's and the Faroe Islands' greenhouse gas emissions are small compared with those of Denmark (each about 1% of the total emissions), and they have been almost constant since 1990. The sudden rise in CO_2 emissions in the Faroe Islands in 1999 was due to a relatively big rise in imports of coal briquettes, while a similar rise in Greenland was due to increased sales of arctic gas oil in the towns.

3.4 Preliminary inventories under the Kyoto Protocol and the EU's burden-sharing

In sections 3.2 and 3.3, Denmark's, Greenland's and the Faroe Islands' emissions and removals of greenhouse gases are calculated in accordance with the guidelines under the Climate Convention. Since the rules for inventories under the Kyoto Protocol differ on some points from the rules under the Convention, preliminary inventories are also made in accordance with the rules of the Protocol with a view to following the trend in relation to the obligation under the Protocol.

In accordance with the rules of the Protocol, Denmark has chosen 1995 as the base year for industrial greenhouse gases (HFCs, PFCs and SF_6), and, for the time being, the calculation under the Protocol includes only the removals occurring in forests as a consequence of afforestation since 1990.

Denmark's reduction obligation is related to the EU reduction obligation through the so-called burden-sharing agreement. The Faroe Islands are not covered by the Kyoto Protocol since territorial reservation was made in connection with Denmark's ratification of the Protocol[6].

It was a condition of agreement by Denmark to a reduction contribution of 21% to the EU's total reduction obligation of 8% from 1990 to 2008-2012 that account be taken of Denmark's relatively large electricity import in 1990 by adjusting CO_2 emissions in 1990 so that these corresponded to the national energy consumption. It can thus be seen from Denmark's declaration, given in connection with, that the basis for the 21% reduction contribution has been adjusted. In connection with the EU ratification of the Kyoto Protocol, Denmark gave a legal undertaking to deliver a 21% reduction on the basis of the actual emissions level in 1990. The Council decision on the EU's ratification of the Protocol also refers to the fact that, in connection with the signing of the EU's agreement on the distribution of burdens in June 1998, certain Member States presented assumptions concerning emissions in the base year and common and coordinated policies and measures. In June 1998, Denmark was the only country to present a declaration with written assumptions concerning the base year. In connection with the decision on ratification by the EU, the Council and the Commission agreed on a joint declaration. This stated, inter alia, that the permitted emission levels (measured in tonnes CO_2 equivalents) for the period 2008-2012 should be set taking account of the assumptions concerning emissions in the base year that also appear in the relevant declarations made in connection with the signing of the agreement on the distribution of burdens in June 1998. The permitted emission levels (measured in tonnes) are to be set not later than 2006. The setting of emission levels for the Member States will not affect the EU's total reduction target of 8% measured in tonnes.

Table 3.7 shows the trend in Denmark's emissions and removals under the Kyoto Protocol in relation to the goal of a 21% reduction from the base year (1990/95) to 2008-2012, which Denmark has given a legal undertaking to achieve. To show the importance of the above-mentioned reference and declarations, table 3.7 also shows the trend in relation to a base year in which the CO_2 emissions in 1990 are adjusted for electricity imports.

As far as is known, the trend in Greenland's emissions, calculated

Table 3.7. Denmark's total emissions and removals of greenhouse gases, 1990 – 2001, cf. the Kyoto Protocol and the EU's distribution of burdens

The table is based on data mentioned in section 3.2, the Kyoto Protocol and the Council of Environment Ministers' agreements from June 1998 and March 2002 on a distribution of burdens of the EU's 8% reduction obligation under the Kyoto Protocol, in which Denmark has undertaken a reduction of 21% from the base year to 2008-2012.

Not Adjusted for electricity import in 1990	Base year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	"Legally binding target 2008-2012 (annual emissions)"
Since LUCF includes afforestation since 1990 only, Mt:		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	
- the trend compared with the legally binding commitment under the Kyoto Protocol is, Mt:	69.5	79.9	73.5	76.2	80.0	77.3	90.8	80.9	75.8	72.7	68.1	69.3	54.9
- equal to the following change in % :		14.9	5.7	9.6	15.1	11.2	30.6	16.4	9.0	4.6	-2.0	-0.3	-21
- or in Mt CO_2-equivalent:		10.4	3.9	6.7	10.5	7.8	21.2	11.4	6.2	3.2	-1.4	-0.2	-14.6
Adjusted for electricity import in 1990	Base year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	"Target shown as the reduction burden 2008-2012 agreed in the EU (annual emissions)"
Since LUCF includes afforestation since 1990 only, Mt:		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	
- the trend in compared with Denmark's burden under the Kyoto Protocol agreed in the EU is, Mt:	75.8	79.9	73.5	76.2	80.0	77.3	90.8	80.9	75.8	72.7	68.1	69.3	59.9
- equal to the following change in % :		5.4	-3.1	0.5	5.6	2.0	19.7	6.7	-0.1	-4.1	-10.2	-8.5	-21
- or in Mt													
CO_2-equivalent:		4.1	-2.4	0.4	4.2	1.5	14.9	5.1	-0.1	-3.1	-7.7	-6.5	-15.9

under the Kyoto Protocol, does not differ from the preliminary inventories of CO_2 from use of energy calculated under the Climate Convention and appearing in table 3.6.

The preliminary inventories form the basis for Denmark's climate strategy, as described in chapter 4.

1 A detailed description of the CORINAIR System, which has been used for the Danish emission inventories, is given in Illerup et al., 2000 and Winther et al., 1998.
2 Richardson, 1999
3 Houghton et al., 1997
4 Illerup et al., 2000, 2001 and 2002
5 www.dmu.dk
6 Denmark ratified the Kyoto Protocol on 31 May 2002 and in that connection presented the declaration to the UN Secretariat in New York

4 Policies and measures

4.1 Climate policy and the decision-making process

Since the Brundtland Commission's report "Our Common Future" from 1987, Denmark's climate policy has been developed in interaction with the different sectors of society, international climate policy and the results of related research.

Since the end of the 1980s many initiatives have been taken to reduce the emissions of greenhouse gases. The initiatives have produced important results – particularly with respect to CO_2 – and will lead to further reductions in the emissions of greenhouse gases in the future.

The initiatives have been – and still are – directed primarily towards the sectors of society whose activities are connected with considerable emissions of greenhouse gases.

The initiatives have the objective of broad environmental improvements in society and include environmental taxes and involvement of the population in the debate and the decision-making process in the environmental field.

A new objective is to ensure cost-effective action in order to achieve more environment for the money.

In order to monitor the development of the overall effect of the initiatives on the emissions of greenhouse gases from energy consumption in Denmark, the basis for and follow-up on Denmark's action to reduce the emissions include emission inventories that are adjusted for inter-annual temperature variations and variations in Denmark's import/export of electricity .

International climate objectives
Since 1990 Denmark has undertaken or committed itself to several targets with respect to reducing greenhouse gas emissions:

- In accordance with the Climate Convention, to reduce total emissions of greenhouse gases in Denmark, Greenland and the Faroe Islands to the 1990 level by 2000. This target was met in 2000.
- As its contribution to stabilisation in the EU, Denmark undertook to reduce CO_2 emissions by 5% in relation to the adjusted 1990 level by 2000. This target was also met in 2000.
- In relation to the Kyoto Protocol, the EU has undertaken to get greenhouse gas emissions down in the period 2008-2012 to, on average, 8% below the level in the so-called base year, which is 1990 for CO_2, methane and nitrous oxide and either 1990 or 1995 for the industrial greenhouse gases. Denmark has committed itself to a reduction of 21% as an element of the burden-sharing agreement within the EU.

Section 4.1.1 gives a short description of the general, democratic decision-making processes, to which Denmark's climate policy is also subject.

4.1.1 National action plans

In 1988 the government of that time issued "The Government's Action

Plan for Environment and Development". The plan was a follow-up on the Brundtland Report and was based in principle on striving for environmentally sustainable development. One of the main messages in the plan was the need to integrate environmental considerations in decisions and administration within such sectors as transport, agriculture and energy.

In the years since then a number of ministries have prepared sector action plans in which environment is an integral element. The sector action plans thus deal with the entire development in a sector combined with solutions of environmental problems caused by the sector. The sector plans for energy, transport, forestry, agriculture, aquatic environment, waste, and development assistance are important examples.

The plans from the 1990s all contained specific environmental objectives and, usually, deadlines for achieving them. In addition, there were a number of concrete initiatives that are intended to lead to achievement of the objectives. Progress has been evaluated regularly to check whether the implementation of the plans resulted in achievement of the objectives. The results of the evaluations have been presented in political reports from the sector ministries or in special follow-up reports.

The evaluations and follow-up have often given rise to the preparation of new action plans, either because additional initiatives have been necessary in order to achieve the objectives or because the development of society or the development within the area in question has made it necessary to change both objectives and initiatives.

Major sector plans that have been of importance for the reduction of greenhouse gas emissions are:

- Energy 2000 (1990)
- Action plan for sustainable development in the agricultural sector (1991)
- Strategy for sustainable forest management (1994)
- Strategy 2000 – Danish strategy in the development assistance area (1995)
- Energy 21 (1996)
- Action plan for reduction of the transport sector's CO_2 emissions (1996)
- National sub-strategy for Danish environmental and energy research (1996)
- Action Plan for the Aquatic Environment II (1998)
- Action Plan II – Ecology in Development (1999)
- Waste 21 (1999)
- Action plan for reduction of industrial greenhouse gas emissions (2000)
- Reduction of the transport sector's CO_2 emissions – possibilities, policies and measures, Ministry of Transport (2000)
- Reduction of the transport sector's CO_2 emissions – the government's action plan (2001)
- Denmark's national forest programme (2002)

The sector plans deal with different aspects of the climate problem. In the energy and transport sectors the main environmental concern has been the emissions of the greenhouse gas CO_2. The plans in these sectors were therefore to a great extent concerned with reducing CO_2.

The other sector plans are not primarily focused on reducing greenhouse gas emissions, in part because the sectors are battling with other major environmental problems that efforts have been made to solve through the plans. The main concern in the agricultural sector has been pollution of the aquatic environment. In the waste sector it has been reduction of the volume of waste, and in the industrial sector, reduction of emissions/discharges of harmful substances to the atmosphere/aquatic environment, the use of toxic substances, etc.

However, the implementation of the sector plans has to a great extent also resulted in reduction of greenhouse gas emissions. For example, the reduction in the agricultural sector's nitrogen emissions, which the aquatic environment plans are resulting in, is at the same time reducing the emissions of the greenhouse gas nitrous oxide. The initiatives to reduce waste quantities mean fewer landfill sites and thus less formation and emissions of methane, and the ongoing increase in forested area will mean increased removals of CO_2.

In addition, the energy and transport plans meant that changes were made in the energy and transport areas in all sectors. The initiatives in the energy area have thus resulted in reduced energy consumption and, with that, reduced CO_2 emissions within a wide range of sectors, including the domestic sector and the business sector.

In June 2002 the government's national strategy for sustainable development in Denmark, "*A SHARED FUTURE – balanced development*" was adopted by the Folketing. The strategy must be seen in part as one of Denmark's responses to the challenge of Agenda 21, which was adopted at the UN General Assembly in Rio in 1992. The government lists eight objectives and principles for creating sustainable development:

1. The welfare society must be developed and economic growth must be decoupled from environmental impacts.
2. There must be a safe and healthy environment for everyone, and we must maintain a high level of protection.
3. We must secure a high degree of biodiversity and protect ecosystems.
4. Resources must be used more efficiently.
5. We must take action at an international level.
6. Environmental cosiderations must be taken into account in all sectors.
7. The market must support sustainable development.
8. Sustainable development is a shared responsibility, and we must measure progress.

The strategy is built up with a number of sectors: food production, forestry, industry, transport, energy, urban and housing development, and intersectoral action: climate change, biodiversity, environment and health, resources and resource efficiency, knowledge and policies and measures, the global dimension and public participation.

In order to follow developments in relation to the strategy, regular indicator reports are prepared. The first, from August 2002, contains 14 key indicators – including indicators for economic growth, greenhouse gas emissions, air pollution, employment and discharge of nutrients to the marine environment. In addition, the trend in a wide range of more specific indicators is being monitored. Examples of these indicators are the long term development in average temperatures near ground level globally and in Denmark, the beginning and the size of the pollen season, the incidence of asthma, the thickness of the ozone layer, by-catches of porpoises, the amount of PCB in cod liver and the number of organic farms. The conclusion of the indicator report is that Denmark is on the way to sustainable development since the indicators show that Denmark's stable economic growth has happened without corresponding increases in a number of environmental parameters. For example that energy consumption and greenhouse gas emissionss have not risen in step with the economy, and that the consumption of drinking water and discharges of acid substances have fallen.

On the environment policy front, Denmark has participated actively in improving environmental protection in Europe through the EU cooperation and through bilateral environmental assistance to Central and Eastern European countries. On a number of points, the EU's environmental regulation has put Europe ahead of the rest of world environmentally. There are also many examples of EU rules having helped to strengthen environmental protection in Denmark. With the adoption of the Amsterdam Treaty, sustainable development became a main objective for the EU, and integrating environmental considerations in the EU's sector policies became an obligation.

4.1.2 Denmark's new climate strategy

In February 2003 the government published Denmark's new climate strategy. The basis of the strategy is that Denmark must fulfil its international climate obligations following from the Kyoto Protocol and the subsequent EU burden sharing agreement.

Although many important initiatives have already been launched in order to live up to the climate objective, considerable work still remains before Denmark can live up to its very ambitious Kyoto objective. According to the latest projection of Denmark's emissions of greenhouse gases[1], it is estimated that, unless additional measures are initiated, Denmark will be 20-25[2] million tonnes CO_2 equivalents per year short of achieving its reduction obligation under the Kyoto Protocol in the period 2008-2012.

It is therefore vital in the climate strategy to plan the action cost-effectively.

The Kyoto Protocol offers the possibility of planning climate action that is more flexible and that, globally, gives more environment for the money. The climate strategy combines cost-effective national measures with use of the Kyoto Protocol's flexible mechanisms.

For many of Denmark's energy producers and a large part of the energy-intensive industry, the coming EU Directive on a scheme for trading with greenhouse gas emissions within the Community will form the framework for the coming action. The companies that will be covered by the scheme, and whose activity will be regulated by a quota, will be able to plan their climate action themselves. They can choose to reduce their own emissions when that is most appropriate or to buy quotas or credits from project-based emission reductions when that is deemed most suitable. This means that the companies concerned will be able to adjust their action on an ongoing basis so that it is always as effective as possible.

Reduction is primarily a task for the private sector, but government action can supplement the private sector action and, in the start-up phase, help to get the market for CO_2 credits going.

Besides quota management and use of flexible mechanisms, the climate strategy includes a number of national measures, including initiatives to promote continued energy savings and improve of energy efficiency.

Within the agricultural sector there may also be possibilities for reducing greenhouse gas emissions. However, the potential has not been sufficiently clarified at the present time, and the possibilities for additional cost-effective measures within this sector will be analysed in connection with a coming Action Plan for the Aquatic Environment III.

Within transport the selected analyses carried out show that national solutions for the most part are relatively expensive. However, it is estimated that more efficient and less expensive initiatives may be carried out jointly at EU level.

Since the reduction costs in the different sectors are constantly changing as a consequence of technological development and changed economic framework conditions, the strategy includes regular evaluation of the action in order to ensure that the most cost-effective policies and measures are chosen.

4.1.3 Economic aspects of the climate policy

The picture of potentials and economic reductions in costs that can be given at the present time for selected national measures to reduce greenhouse gas emissions are shown in table 4.1.

In connection with the climate strategy it has been estimated that the international price level for quotas/ credits is hardly likely to exceed

Table 4.1 Reduction possibilities and cost of selected measures to reduce greenhouse gas emissions

Measure	Annual average reduction in the period 2008-2012 '000 tonnes CO_2 equivalents[1]		Economic cost DKK/tonne CO_2 equivalent in 2002 prices	
	Basis for economic analysis	Total potential	With side-effects	Without side-effects
Measures within CO_2 quotas on electricity production:				
Production limited to 14 mill. tonnes CO_2	14,242	28,242	80	100
Change from coal to natural gas	725	5,900	270	310
Heat pumps for displacement of:				
- natural gas-fired district heat	90	200	-190	-160
- natural gas-fired small-scale CHP	190	1,400	-60	-40
- oil-fired district heat	130	600	10	100
- natural gas-fired primary CHP	170	1,200	240	260
- coal-fired CHP	260	3,700	260	290
Conversion to biomass plant	207	2,700	290	290
Injection in oil fields[2]	13,700	13,700	50/160	50/160
Depositing in aquifers	25,170	25,170	310	310
Other supply-side measures:				
Offshore wind farms[3]	496		270	290
Energy savings:				
Codes for oil boilers	27		-590	-560
Codes for gas boilers	40		-500	-270
Codes for windows	164		-550	-510
CO_2 emission from oil/gas production:				
Flare gas recovery	300		-330	-330
Agriculture and forestry:				
Establishment of joint municipal biogas plants	18	500	100	620
Changed feeding of dairy cows	433		590	790
Increased afforestation (1500 ha per year for 20 years)[4]	34		430	920
Transport:				
Increased fuel taxes (DKK 0.3/l)	193		1,250	3,710
Increased fuel taxes (DKK 1/l)	595		1,430	3,910
Use of biofuels[5]	470		980	980
Motor vehicle taxes on lorries	141		-320	1,620
Motor vehicle taxes on private cars	451		1,140	4,410
Discontinuation of mileage allowance[6]	563		650	4,490
Better freight transport logistics in towns	42		-1,050	980
The waste sector:				
Increased collection of methane from landfill sites	93		180	180

Note: A discount rate of 6% has been used. Side-effects in the energy sector are primarily emissions of SO2 and NOX.

1) The figures under "Basis for economic analysis" show the part of the potential for which the economic cost has been calculated. The Figures under "Total potential" show the total potential. There is a considerable element of estimation in the latter figures, which are therefore encumbered with considerable uncertainty. For some measures it has not been possible to give a meaningful total potential.

2) The low cost depends on the countries producing oil in the North Sea agreeing on a distribution of the tax revenue from the increased activity in the North Sea. The high cost covers the case in which only the revenue from the extra tax in the Danish sector accrues to Denmark.

3) Requires displacement of domestic condensing production, which means that the quota must be reduced at the same time.

4) Includes both public and private afforestation projects. At a discount rate of 3% the reduction cost is DKK 220 per tonne CO_2 with side-effects and DKK 500 per tonne CO_2 without side-effects.

5) Marginal costs are rising sharply. More limited action will have significantly lower average costs, particularly in the short term.

6) Estimates underestimate the real economic costs because the negative effects on employment and mobility in the labour market are not included.

DKK 100 per tonne CO_2 equivalents, and will most likely be DKK 40-60, assuming that the USA remains outside the Kyoto system. With this price level it will be considerably cheaper to buy international quotas/credits than to implement most of the national reduction measures. However, to be able to compare the economic unit costs of the national reduction measures with the price of international quotas/credits, the price must first be adjusted with the so-called net tax factor, whereby the cost of acquiring quotas/credits is calculated in consumer prices, which are the comparable quantity across measures. In an economic analysis, the main price estimate for quotas/credits of DKK 40-60 is an expression of costs of DKK 50-70 per tonne CO_2 equivalents.

In a comparison with the national policies and measures, it is important to be aware that these must typically be seen in a sector-political context, in which climate is just one of many considerations in the policy planned. For example, a fundamental consideration in the energy sector is security of supply, which, all else being equal, is improved by a lower energy consumption and a diversified energy supply.

The analyses carried out do not cover every conceivable national measure, and the costs may change in the coming years as a consequence of new knowledge and new technologies. An interministerial committee will regularly evaluate the cost-effectiveness of the national policies and measures, including new ones that are not mentioned in table 4.1. The government has set an economic marker of DKK 120/tonne CO_2 equivalents to be used as a basis for implementing national policies and measures outside the area covered by the EU trading scheme. The analyses show that only relatively few national policies and measures with a significant potential, that do not exceed DKK 120/tonne CO_2 equivalents, would be able to compete with the price of using the flexible mechanisms. This must be seen in the light of the fact that Denmark has already made a massive national effort up through the 1990s, while there is a large, unexploited potential in other countries.
For the national policies and measures, where the analyses show relatively low reduction costs, the potential is, all in all, insufficient to meet the need for making up the Danish reduction shortfall. On the other hand, there is considered to be a considerable potential for buying quotas and credits internationally.

For these reasons, the government's cost-effective strategy for meeting Denmark's reduction obligation is to a certain extent based on the use of flexible mechanisms – emissions trading and the project mechanisms, Joint Implementation and the Clean Development Mechanism. The EU trading scheme will be a key instrument. The actual composition of the action will therefore depend on the extent to which the companies concerned choose to implement their own reduction measures or to buy quotas abroad.

Table 4.2 Aggregation of sources/sectors in the CRF/IPCC format to the six main economic sectors in Denmark

Economic sector		Sources/Sectors in the CRF/IPCC format	
Energy	Includes production, conversion and distribution	1A1	Fuel Combustion in energy Industries
		1B	Fugitive emissions from fuels
Transport	Military included here	1A3	Fuel Combustion in transport
		1A5	Other (Fuel combustion in military transport)
Agriculture and forestry	Fishing included here	1A4c	Fuel Combustion in agriculture, forestry and fisheries
		4	Agriculture
		5	Land-use change and forestry
Business sector	Includes manufacturing, service and trade, together with the industrial gases	1A2	Fuel Combustion in manufacturing, industries and construction
		1A4a	Fuel Combustion in commercial/Institutional
		2	Industrial processes
		3	Use of organic solvents
Domestic sector		1A4b	Fuel Combustion in Residental
Waste	Includes only methane from landfill sites because, according to IPCC, waste incineration with energy utilisation must be included under energy.	6	Waste

Table 4.3 Denmark's emissions of climate gases in 1990/95 and 2001, together with projections, breakdown by economic sector

Source: National Environmental Research Institute

	1990/95 Gg CO_2 equiv.	1990/95 %	2001 Mt CO_2 equiv.	2001 %	Change from 1990/95 to 2001	2008 -2012 Gg CO_2 equiv.	2008 -2012 %	Change from 1990/95 to 2008 -2012	2013 -2017 Gg CO_2 equiv.	2013 -2017 %	Change from 1990/95 to 2013 -2017
Energy	**26.8**	**38.6**	**27.8**	**40.1**	**4%**	**36.9**	**46.1**	**38%**	**34.9**	**44.6**	**30%**
CO_2	26.4	38.0	27.0	39.0	2%	36.0	44.9	36%	34.0	43.4	29%
Methane (CH_4)	0.1	0.2	0.5	0.8	350%	0.6	0.7	372%	0.5	0.7	355%
Nitrous oxide (N_2O)	0.3	0.4	0.3	0.4	3%	0.4	0.5	36%	0.3	0.4	24%
Transport	**10.7**	**15.4**	**12.6**	**18.2**	**18%**	**14.6**	**18.3**	**36%**	**15.1**	**19.3**	**41%**
CO_2	10.5	15.1	12.2	17.6	16%	13.9	17.4	33%	14.4	18.4	37%
Methane (CH_4)	**0.1**	**0.1**	**0.1**	**0.1**	**24%**	**0.0**	**0.0**	**-43%**	**0.0**	**0.0**	**-61%**
Nitrous oxide (N_2O)	0.1	0.2	0.4	0.6	167%	0.7	0.8	347%	0.7	0.9	363%
Agriculture/Forestry	**16.8**	**24.2**	**14.1**	**20.4**	**-16%**	**13.1**	**16.4**	**-22%**	**13.0**	**16.6**	**-23%**
CO_2	2.4	3.5	2.5	3.6	3%	2.3	2.9	-5%	2.2	2.8	-10%
Methane (CH_4)	4.1	5.9	3.7	5.3	-10%	3.2	4.1	-21%	3.2	4.1	-23%
Nitrous oxide (N_2O)	10.3	14.8	8.0	11.5	-23%	7.6	9.5	-26%	7.6	9.7	-26%
Business sector	**8.6**	**12.3**	**9.1**	**13.2**	**7%**	**10.4**	**13.0**	**22%**	**10.8**	**13.8**	**26%**
CO_2	8.1	11.7	8.3	12.0	2%	9.6	12.0	18%	10.1	13.0	25%
Methane (CH_4)	0.0	0.0	0.1	0.1	201%	0.1	0.1	173%	0.1	0.1	187%
Nitrous oxide (N_2O)	0.1	0.1	0.1	0.1	-2%	0.1	0.1	15%	0.1	0.1	23%
Industrial gases	0.3	0.5	0.7	1.0	103%	0.7	0.9	105%	0.5	0.6	44%
Domestic sector	**5.2**	**7.5**	**4.4**	**6.4**	**-15%**	**4.0**	**5.1**	**-23%**	**3.9**	**5.0**	**-26%**
CO_2	5.1	7.4	4.3	6.2	-16%	3.8	4.8	-25%	3.7	4.7	-28%
Methane (CH_4)	0.1	0.1	0.1	0.1	64%	0.2	0.2	199%	0.2	0.2	200%
Nitrous oxide (N_2O)	0.1	0.1	0.1	0.1	-7%	0.0	0.1	-23%	0.0	0.1	-25%
Waste	**1.3**	**1.9**	**1.2**	**1.7**	**-11%**	**0.9**	**1.1**	**-30%**	**0.7**	**0.9**	**-48%**
Methane (CH_4)	1.3	1.9	1.2	1.7	-11%	0.9	1.1	-30%	0.7	0.9	-48%
Total	**69.5**	**100**	**69.3**	**100**	**-1%**	**80.1**	**100**	**15%**	**78.3**	**100**	**13%**
CO_2	52.7	75.7	54.3	78.2	2%	65.6	82.0	25%	64.4	82.3	22%
Methane (CH_4)	5.7	8.2	5.6	8	-1%	5.0	6.2	-12%	4.7	5.9	-17%
Nitrous oxide (N_2O)	10.8	15.6	8.7	13	-19%	8.7	10.9	-19%	8.7	11.2	-19%
Industrial gases	0.3	0.5	0.7	1	103%	0.7	0.9	105%	0.5	0.6	44%

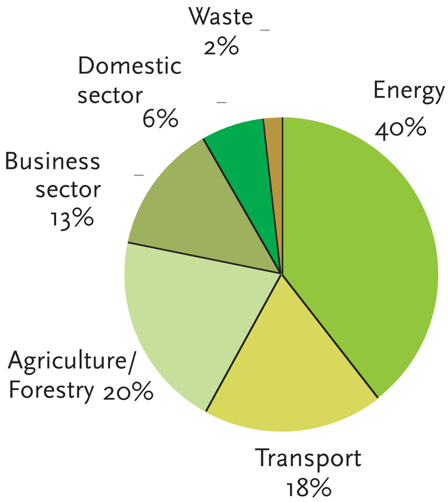
4.2 Policies and measures and their effects in Denmark's economic sectors

In sections 4.2.1 to 4.2.6 below, policies and measures of importance for emissions and removals of greenhouse gases are examined within the following six economic sectors: energy, transport, the business sector, agriculture and forestry, the domestic sector and waste. Table 4.2 shows how the sector classification that is to be used in connection with the annual emission inventories (the CRF/IPCC format) is aggregated to the six economic sectors.

Table 4.3 shows the main result of this aggregation for the base year, 2001, 2008-2012 and 2013-2017.

Figure 4.1 Denmark's emissions of greenhouse gases in 2001, breakdown by economic sector

Source: National Environmental Research Institute and the Danish Environmental Protection Agency



4.2.1 Energy

The energy sector's production, conversion, and distribution of energy account for 40% of Denmark's total greenhouse gas emissions, and mainly the greenhouse gas CO_2 is emitted. 97% of the total greenhouse gas emissions from the energy sector is CO_2, 2% is methane (CH_4) and 1% is nitrous oxide (N_2O).

CO_2

Energy production and energy-consuming activities in the transport sector, industry and the other sectors are the main contributors to the total emissions of CO_2 due to use of large quantities of coal, oil and natural gas.

The energy sector is therefore centrally placed in the efforts to reduce the emissions of CO_2. Many initiatives have been taken over the years to reduce the emissions, and work is still going on to find the best and most cost-effective measures with a view to fulfilling Denmark's international climate obligations.

The focus of this section is energy production and energy supply. The energy-consuming activities and the possibilities for energy savings in the different sectors of society are dealt with in greater detail in the subsequent sections.

Implemented policies and measures

Some policies and measures can bring general pressure to bear on players in the energy sector to get them to reduce their CO_2 emissions. Denmark's national Quota Act, which regulates the emissions of CO_2 from open, market-regulated production of electricity is an example.

The CO_2 Quota Act puts a ceiling on the electricity producers' CO_2 emissions. If the producers exceed a set quota, a penalty tax is imposed on them for every tonne by which the quota is exceeded. The producers can decide for themselves how they keep to the quota – whether by energy efficiency improvements at their plants, by changes in fuel or by reducing production. The Danish producers can also trade quotas among themselves.

Taxes have also been used for many years as an instrument for reducing the CO_2 emissions from the energy sector, since fuels used for heat production have been subject to a CO_2 tax and an energy tax for many years, partly with a view to a general reduction in energy consumption and partly to promote fuels with lower CO_2 emissions – primarily

Table 4.4 Policies or measures in the energy sector

Name of Policy or measure	Objective	Greenhouse gas affected	Type	Status	Initiator/player
Energy sector					
CO_2 quotas for electricity production The Quota Act puts a ceiling on the electricity producers' CO_2 emission. If the quota set is exceeded, a penalty tax is imposed. Quotas can be traded between the producers.	CO_2 reduction	CO_2	Economic, financial	Implemented	Central authorities, energy producers
Biomass Agreement	CO_2 reduction, R&D, demonstration	CO_2	Economic, financial	Implemented	Central authorities, energy producers
Grant for electricity production	CO2 reduction, energy efficiency improvements	CO_2	Economic	Implemented	Central authorities, energy producers
Prioritisation of electricity from CHP plants	CO_2 reduction, improvement of energy efficiency	CO_2	Economic, financial	Implemented	Central authorities, energy producers
Taxes on fuels CO_2 and energy taxes have been imposed on fuels for heat production for many years	CO_2 reduction and energy savings	CO_2	Economic	Implemented	Central authorities
Order to build offshore wind farms	CO_2 reduction, R&D, demonstration	CO_2	Administrative, economic, financial	Implemented	Central authorities, energy producers
Scrapping scheme for old and unfortunately sited wind turbines	Other environmental improvements	CO_2	Economic, financial,	Implemented	Local, regional authorities, interest organisations, energy producers, central authorities
Renewable energy	R&D, demonstration	CO_2	Economic, financial, R&D	Implemented	Consumers, supply companies, interest organisations, local/regional authorities, research institutions, central authorities
Energy research	R&D,	CO_2	R&D	Implemented but regularly adjusted	Central authorities, research institutions
Electricity Saving Trust	Reduction of CO_2 emission, energy savings	CO_2	Economic, financial, information, influencing the market	Implemented	Consumers, supply companies, others
Statutory order with limits on emissions of CH_4 from new gas-fired plants	Reduction of CH_4 emission	CH_4	Administrative	Implemented	Central authorities, energy producers
Prolongation of the CO_2 quota scheme after 2003	Reduction of CO_2 emission	CO_2	Economic, financial	Planned	Central authorities, energy producers

biomass, on which there is no CO_2 tax and, in the case of most applications, no energy taxes either. R&D activities include energy savings, more efficient energy conversion and renewable energy technologies.

Increased use of CHP and enlargement of the areas served with district heat have been main elements of the Danish strategy to promote efficient use of energy resources ever since the end of 1970s. Today, more than half of Denmark's domestic electricity consumption is cogenerated with heat at CHP plants, and the potential for further use of CHP is limited. For this reason, only a small increase in CHP production is expected in the future. Today, CHP is promoted partly by the tax system, partly by electricity production grants for small-scale CHP plants and, lastly, by prioritising electricity from small-scale CHP plants. Plans are in hand to change the last-mentioned, so in future the production from small-scale CHP plants can be sold on market terms too.

Use of renewable energy sources can reduce the emissions of CO_2 from fossil fuels. The proportion of Denmark's gross energy consumption that is covered by renewable energy increased from 6.5% in 1990 to 12% in 2001 and is expected to reach about 14% in 2010.

Renewable energy sources are promoted through economic instruments, including the tax system, and by direct production or establishment grants. Contracts and orders within the electricity and heat sector used to play a role, but use of this instrument has largely ended. Lastly, financing R&D activities is contributing to the continued growth in the proportion of renewable energy.

Substitution of natural gas for coal or oil reduces the emissions of CO_2. The first Danish natural gas was landed from the Danish sector of the North Sea in 1984. From then, natural gas consumption increased to 193 PJ in 2001 and accounted for 23% of gross energy consumption. Growth is now expected to stop, in part because of the relative high price of natural gas. Natural gas is favoured by a lower CO_2 tax than oil and coal because of its lower emissions and will be promoted by the coming EU trading scheme. The ongoing liberalisation of the Danish natural gas sector may also result in lower prices and thus increased use of natural gas.

Additional policies and measures

With the energy sector's big contribution to Denmark's total emissions of greenhouse gases, action in the energy sector is an absolutely vital element of Denmark's new climate strategy. In particular, it is estimated that expected rising electricity exports could result in a considerable increase in emissions if measures are not taken to prevent this.

Electricity production is covered by the proposed EU Directive on emissions trading. The climate strategy is based on the assumption that electricity production will be covered by the EU's scheme from 2005. Since all the EU Member States' electricity producers will be subject to quotas on their fossil electricity production, electricity prices are expected to rise across Europe. That offers the possibility of imposing rather tight CO_2 quotas on the electricity producers so that Denmark's fulfilment of the climate objective is not affected by any high electricity export. In periods with high electricity prices, electricity producers are expected to make considerable use of the flexible mechanisms.

The existing national CO_2 quota regulation of electricity production ends at the end of 2003.

The heat sector is today subject to full CO_2 and energy taxes and is also subject to considerable administrative regulation. In connection with the climate strategy it is therefore believed that there is limited room for further cost-effective reduction measures. In the climate strategy it is proposed that the sector be kept outside the quota regulation for the first period, 2005-2007. After that, according to the present proposal for a trading directive, this sector will also be covered by quota regulation.

Methane, CH_4

Many small sources contribute to the energy sector's methane emissions. The biggest single contribution comes from gas-fired CHP plants, which emit uncombusted natural gas. With a view to minimising the emissions, a statutory order now limits the emissions from new plants, corresponding to about 3% of fuel consumption.

4.2.2 Transport

In 2001 the transport sector accounted for 18% of Denmark's total emissions of greenhouse gases. Of the transport sector's emissions, CO_2 accounts for 96%, corresponding to 12 million tonnes of CO_2, nitrous oxide for 3% or 395,000 tonnes of CO_2 equivalents, and methane for about 1%, corresponding to 70,000 tonnes CO_2 equivalents.

In 2001 the transport sector's energy consumption – mainly oil products – accounted for about 30% of energy consumption in Denmark. Traffic, particularly passenger traffic, has increased steadily in the last few years. In step with the increase, energy consumption and greenhouse gas emissions have also increased. In 2001 greenhouse gas emissions from the transport sector were 17% above the 1990 level. The latest forecast from 2002 indicates that, without additional initiatives, the sector's emissions in 2005 will be 24% above the 1990 level, rising to about 35% in the first commitment period 2008-2012.

CO_2

Efforts to curb the upward trend of greenhouse gas emissions in the transport sector have not yet succeeded, in part because reducing CO_2 emissions in Denmark, which is not a car manufacturing country, is extremely difficult without international initiatives.

As shown in table 4.2, the greenhouse gas emissions from fuel for vehicles, ships and aircraft are included under transport. The contribution from the armed forces consists mainly of CO_2 and accounts for just under 2% of the inventory for the transport sector. The proportion of fuel consumption for multilateral military operations, which is therefore kept out of the total national inventory, is at present regarded as minimal.

Implemented policies and measures

In 2002, working on the basis of the previous trends in passenger and freight traffic, the Danish Road Directorate carried out a projection of road traffic up to 2016. The projection indicates that road traffic will continue to grow. With the chosen assumptions it is estimated that road traffic will grow by more than 25% from 1997 to 2016. In the period 2000 to 2010, growth is expected to lie at about 13%.

A large part of total freight and passenger transport is by road and is expected to increase. The trend in freight and passenger transport by road will therefore determine the transport sector's energy consumption and thus its CO_2 emissions. Table 4.5 shows the existing policies and measures within the transport sector. In the last few years a number of important steps have been taken at international level, and these – supported by targeted and effective Danish action may help to turn the trend for the transport sector's CO_2 emissions.

Additional policies and measures

The transport sector's possibilities for contribution to reduction of Denmark's CO_2 emissions show that the cost-effectiveness of the measures is totally dependent on the side-effects, cf. table 4.1. The decision to implement the various measures within the transport sector must therefore be evaluated on the basis of the measures' other effects and not from a pure CO_2 consideration. The generally high economic shadow prices without side-effects are primarily a consequence of the already high level of taxation in the transport sector. It is thus a common feature of most of the measures that they are directed towards parts of the transport sector that, taken together, pay the full economic cost of transport, since there is a considerable fiscal element in the regular car taxes.

Methane, CH_4

The transport sector's emissions of methane account for about 1% of the sector's greenhouse gas emissions, corresponding to about 70,000 tonnes CO_2 equivalents.

Nitrous oxide, N_2O

Nitrous oxide accounts for 3% of the transport sector's total greenhouse gas emissions, or 380,000 tonnes CO_2 equivalents.

4.2.3 Business sector

The business sector covers industry, building and construction and public and private service.

The sector accounts for about 13% of Denmark's total greenhouse gas emissions. By far the largest part, 93%, is CO_2. The sector is also the only source of emissions of industrial gases. Table 4.6 shows the policies and measures within the business sector.

Table 4.5 Policies or measures in the transport sector

Name of Policy or measure	Objective	Greenhouse gas affected	Type	Status	Initiator/player
Transport sector					
Green owner tax on motor vehicles	Improving efficiency of energy consumption CO_2 reduction	CO_2	Economic	Implemented	
Information campaign on new cars' fuel consumption	Improving efficiency of energy consumption CO_2 reduction	CO_2	Information	Implemented, duration: 2 years	Road Safety and Transport Agency
Low-energy driving techniques	Improving efficiency of energy consumption, CO_2 reduction	CO_2	Information	Part of training for driving licence	
Action for compliance with current speed limits	Improving efficiency of energy consumption, CO_2 reduction	CO_2	Information, economic	Implemented	
Establishment of intermodal installations	Improving efficiency of transport, CO_2 reduction	CO_2	Economic, financial	Ongoing implementation	Ministry of Transport, counties, municipalities, HUR, DSB
Promotion of public transport	Improving efficiency of transport, CO_2 reduction	CO_2	Economic, financial	Ongoing implementation	Ministry of Transport, counties, municipalities, HUR and DSB
Promotion of use of bicycles	Improving efficiency of transport, CO_2 reduction	CO_2	Financial, information	Ongoing	Ministry of Transport, counties, municipalities
Promotion of environment-friendly freight transport	Improving efficiency of transport, CO_2 reduction	CO_2	Economic, financial, information	Implemented	Environmental Protection Agency, hauliers
Promotion of company plans for road safety and environment, together with transport plans	Improving efficiency of transport, CO_2 reduction	CO_2	Administrative, economic, financial	Implemented	HUR and counties/ municipalities
Reduced travelling time for public transport	Improving efficiency of transport, CO_2 reduction	CO_2	Administrative	Ongoing implementation	Ministry of Transport, counties and DSB
Physical planning	Reduction of traffic, CO_2 reduction	CO_2	Administrative	Ongoing implementation	Counties/ municipalities

TABLE 4.6 POLICIES OR MEASURES WITHIN THE BUSINESS SECTOR

Name of the Policy or measure	Objective	Greenhouse gas affected	Type	Status	Initiator/player
Business sector					
Taxes on the sector's energy consumption	CO_2 reduction and energy savings	CO_2	Economic	Implemented	Central authorities
Agreements on energy-efficiency improvements in the business sector	Energy efficiency improvement in energy-intensive companies	CO_2	Voluntary agreement, economic, financial	Implemented	Central authorities
Energy labelling of products	CO_2 reduction and energy savings	CO_2	Information	Implemented	Central authorities
Energy labelling of large buildings – ELO, (includes public buildings)	Savings in energy and water, CO_2 reduction		Information	Implemented	Companies, others
Tax on HFCs, PFCs and SF_6	Reduction of industrial gas emissions	HFC,PFC, SF_6	Economic	Implemented	Central authorities
Regulation of use of HFCs, PFCs and SF_6	Reduction of industrial gas emissions	HFC,PFC, SF_6	Administrative	Implemented	Central authorities
Public service Circular on energy management and energy-efficient procurement for state institutions	CO_2 reduction and energy savings	CO_2	Administrative	Implemented	Central authorities
Electricity Saving Trust – campaigns and A-club for institutions to promote efficient appliances	CO_2 reduction, energy savings	CO_2	Information, influencing the market	Implemented	Institutions, producers
Electricity grid, gas and district heating companies' energy-saving activities	CO_2 -reduktion, energy savings	CO_2	Advice, information, education, campaigns	Implemented	Institutions, retail trade
Tax on energy consumption in public institutions	CO_2 reduction and energy savings	CO_2	Economic	Implemented	Central authorities

The initiatives going on to reduce the emissions from the business sector include both promotion of energy savings and energy-efficient improvements, conversion of energy production to cleaner fuels and initiatives to reduce emissions of industrial gases.

Earlier analyses have shown that there is a big potential for profitable energy efficiency improvements within the business sector, so improving energy efficiency is a vital area of action.

CO_2

Industry, building and construction, trade and private service

Industry is responsible for most of the sectors' emissions of CO_2. The emissions come mainly from energy-consuming activities in industry. Cement and brick production also contributes CO_2, which comes from the raw materials used.

The main measure used to get the business sector's energy consumption down is a green tax package for the business sector, which was introduced in 1995. The package contained a combination of taxes and return of the proceeds to businesses through government grants etc. to promote energy savings in companies. The package led to a higher CO_2 tax and the introduction of a space-heating tax for businesses. At the same time, a scheme was introduced in which companies with a big energy consumption have the possibility of gaining a discount on the taxes in return for entering into an agreement on energy efficiency improvements. The combination of taxes and return of the proceeds was intended to ensure a marked reduction of businesses' CO_2 without affecting their international competitiveness. The grants were also intended to promote the use of more energy-efficient technologies and production methods.

The objective with the green tax package was to get the business sector to contribute to a reduction of Denmark's total CO_2 emissions. The target contribution was about 4% in 2005 in relation to the emissions in 1988.

The green package's overall effect was evaluated in 1999. The main conclusion is that the package has functioned as intended. Considerable environmental gains have been achieved in an economically effective way that takes account of businesses' international competitiveness. The energy package's environmental effects largely live up to the original expectations and the package is thus an important element of the efforts to reduce Denmark's CO_2 emissions.

In the climate strategy from February 2003 it was evaluated whether there was still a potential for relatively cheap emission reductions in the energy-intensive part of industry, which had hitherto paid lower CO_2 taxes than the rest of the business sector and the domestic sector for reasons of competitiveness.

With a common EU trading scheme, some energy-intensive companies could be made subject to tighter CO_2

regulation than hitherto without affecting their competitiveness too seriously. For these companies future regulation is thus expected to be based on implementation of the common EU trading scheme.

This also applies to the product emissions that do not come from energy consumption but that are covered by the EU trading scheme. In Denmark's case, it will be primarily the CO_2 emissions from cement production. These emissions have not previously been regulated.

Co$_2$ emissions from public service
Data on energy consumption in the public sector have been collected for some years as a means of rendering the sector's energy consumption visible. As a consequence there are now complete inventories of energy consumption in county and state institutions, but more limited inventories of the individual municipalities' energy consumption.

The main initiatives to promote energy savings in the public sector are:

- a circular on energy management and energy-efficient procurement for state institutions
- guidelines for procurement in the public sector, e.g. through preparation of environmental guidelines for large buyers in the public sector
- energy labelling and energy-checking of large properties
- A-club for public institutions, introduced by the Electricity Saving Trust. The members of the club undertake only to buy energy-efficient appliances that meet specific requirements given in a positive list
- campaigns by the Electricity Saving Trust on energy-efficient lighting, ventilation and office equipment
- energy advice to institutions by the grid companies.

Work on improving energy efficiency in the public sector has now been going on for more than 10 years, and considerable savings have been achieved. However, there are still economically profitable possibilities for savings. This is illustrated by the fact that there is a very big difference in consumption (per m^2) between comparable institutions.

In continuation of the provisions in the Act on Promotion of Savings in Energy Consumption from 2000 and several energy policy agreements, plans are in hand for further tightening, particularly in the state sector. The circular's requirements will be tightened and so will the obligation concerning energy-afficient procurement.

Co$_2$ emissions from cement production
Cement production results in big emissions of CO_2. The production process itself is very energy-intensive and, a large quantity of CO_2 is emitted in connection with the process. It takes about 4,950 MJ energy to produce 1 tonne of cement.
Cement production in Denmark is concentrated in a single company. In 2001 the total annual emissions of CO_2 from cement production were about 2.6 million tonnes. About half comes from energy consumption and the other half from chalk, which is

one of the raw materials used in the process.

A lot has been done within the cement industry. For example, in the last 20 years the Danish cement producer has reduced its CO_2 emissions by about 13% per tonne cement produced. In addition, cooperation with the Danish Environmental Protection Agency is expected to result in increased use of alternative fuels,which will reduce the CO_2 emissions still further.

The action on the cement industry's energy consumption has also hitherto been based on the green tax package for businesses, with a combination of taxes and agreements on energy efficiency improvements.

In future, regulation of the industry's energy consumption will be based on implementation of the EU emissions trading scheme. As mentioned earlier, this will also apply to product emissions that do not come from energy consumption.

HFCs, PFCs and SF_6

The industrial sector is the only sector with emissions of the industrial gases HFCs, PFCs and SF_6. These gases are used as cooling and foaming agents etc. (HFCs), cooling agents (PFCs) and as insulating gas in high voltage contacts and as noise-damping gas in thermal glazing (SF_6).

The emissions of the industrial greenhouse gases (HFCs, PFCs and SF_6) are regulated in two ways – partly by a tax and partly by a statutory order on discontinuation of use of the gases in new installations.

Since 1 March 2001 a tax has been payable on the industrial greenhouse gases corresponding to their GWP, combined with the Danish CO_2 tax of DKK 0.1/kg CO_2. This means that HFC-134a is subject to a tax of DKK 130/kg because it has a GWP of 1,300. There is a ceiling of DKK 400/kg so although SF_6 has a GWP of 23,900, the tax is only DKK 400/kg and not DKK 2,300/kg.

The tax is imposed on the substances on importation into Denmark because the substances are not produced in Denmark. The tax is payable whether the substances are imported as pure substances or are part of imported products. If the content in the products is not known, the tax is based on a fixed tariff. The tax is payable on a wide range of products, including:

- refrigerating and freezing plant
- air-conditioning plant
- PUR foam for cooling plant, district heating pipes, insulated gates and doors, panels for refrigeration and freezer rooms, extruded polystyrene for insulation (XPS foam) jointing foam
- aerosols
- double glazing.

Table 4.7 Policies or measures used within agriculture, forestry and fisheries to reduce greenhouse gas emissions

Name of Policy or measure	Objective	Greenhouse gas affected	Type	Status	Initiator/player	Emission reduction in 2010, mill. tonnes CO_2 equivalents
Agriculture						
Action Plan for the Aquatic Environment I and II and Action Plan for Sustainable Agriculture	Reduction of nitrogen leaching from agriculture by 100,000 t N/year	N_2O	Regulations, economic information	1987, 1991, 1998	Central and county authorities	2.68
Ban on burning of straw on fields	Reduced air pollution	N_2O	Order	1989	Central and local authorities	?
Ammonia treatment the s-plan	Reduced discharge of ammonia	N_2O	Order	2001	Central and local authorities	0.03
The biomass agreement on use of straw as fuels	Reduced CO_2 emission	CO_2 , N_2O (cf. the energy sector)	Voluntary agreement		State and electricity producers	
Forestry						
Subsidy scheme for private afforestation on agricultural land	Increase in forested area of 450,000-500,000 ha in 100 years' time.*	CO_2	Economic	Grants provided for afforesta-tion in pursuance of the Forest Act	National Forest and Nature Agency	0.3 mill. tonnes **
Promoting near-to-nature management	Convention to promoting near-to-nature management	CO_2	Administrative, economic	An action plan for the state forests and a new Forest Act are being prepared	National Forest and Nature Agency	
The biomass agreement on use of wood chips as fuel	0.2-0.4 mill. tonnes wood chips per year used in primary CHP production	CO_2 neutral	Economic	Implemented with conversion of Herning Power Station and Avedøre II	Danish Energy Authority / Elsam and E2	Through conversion from coal: 247 mill. tonnes CO_2 Through conversion from gas: 148 mill. tonnes CO_2 ***

* Currently, only 1,850 ha forest are established each year (average 1990-2002), compared with the objective of 4,500-5,000 ha.
** The calculation is based on the number of ha forest actually established in the period 1990-2002, which has thus been too little.
***(C) conversion from coal, (G) conversion from gas, Wood chips: 260,000 tonnes: (Herning 200,000 tonnes (G), Måbjerg 20,000 tonnes (G), Ensted 30,000 tonnes (C), Østkraft 10,000 tonnes (C)), pellets: 300,000 tonnes (Avedøre 300,000 tonnes (G))

The tax is also payable on service on existing and new installations/products.

In the spring of 2002 the Danish government issueda revised draft of a statutory order regulating the industrial greenhouse gases for national consultation. A first draft had been sent for notification in the EU in February 2001. The final statutory order entered into force on 15 July 2002.

The regulation includes a general ban on use of the industrial greenhouse gases in a wide range of new installations/products from 1 January 2006, including, for example, domestic refrigerators and freezers, PUR foam, etc. There are certain exceptions from the date for the general ban. For example, the ban will only apply to new commercial cooling plants, air-conditioning plants, etc. from 1 January 2007. Other exceptions are new sound-insulating windows, in which SF_6 has been banned since 1 January 2003, and PFCs, on which there has been a general ban since September 2002. However, some products and applications are exempted from the ban. This applies, for example, to service on existing plants, mobile cooling plants, including mobile air conditioning plants, cooling and air conditioning plants with HFC fillings between 0.150 and 10 kg HFC, electric switches, etc.

4.2.4 Agriculture, forestry and fisheries

The sectors agriculture, forestry and fisheries are generally considered as one single economic sector in Denmark. However, the importance of the individual sectors differs greatly with respect to Denmark's emissions and uptake of greenhouse gases. Agricultural farms have emissions of methane and nitrous oxide. The net uptake of CO_2 in Denmark's forests is included under Forestry. However, CO_2 emissions from energy use in all three sectors are considered under one heading because there is no breakdown of these in the annual energy statistics. Table 4.7 shows policies and measures for emission reductions within agriculture and forestry.

In 2001 agriculture accounted for 20% of Denmark's total greenhouse gas emissions, which consists mainly of methane and nitrous oxide, while a smaller percentage is CO_2.
Measures that are used in the agricultural sector and that have affected or will affect the sector's greenhouse gas emissions include:

- ban on burning of straw on fields
- biomass agreement on use of straw as fuel
- Action Plans for the Aquatic Environment I and II and Action Plan for Sustainable Agriculture
- Ammonia Action Plan.

Methane, CH_4
Methane comes mainly from the agricultural sector. The emissions in 2001 were 173,000 tonnes, corresponding to 3.6 million tonnes CO_2 equivalents. The methane is formed through enteric fermentation in farm animals and from conversion of carbohydrates in manure.

Agriculture's biggest contribution to the methane emissions comes from dairy cows.

In the digestion process, methane is a by-product of the fermentation of feed in the rumen, primarily from grass and green fodder. In addition, methane formed during conversion of manure under anaerobic conditiions if the temperature is sufficiently high. These conditions normally occur in manure stores and housing systems with liquid manure or deep litter.

Methane emissions within agriculture are expected to fall by about 0.4 million tonnes CO_2 equivalents from 2001 to 2012 due to continued efficiency improvements in cattle farming and, to a lesser extent, to more biogas plants.

Nitrous oxide, N_2O
Agriculture is the biggest source of nitrous oxide emissions in Denmark. Of the total emissions of 28,200 tonnes in 2001, 25,500 tonnes or 91% came from agriculture. The nitrous oxide emissions from agriculture correspond to more than 8.0 million tonnes CO_2 equivalents.

Nitrous oxide may be emitted during microbial decomposition of organic matter. The process occurs in some types of manure stores and during conversion of minerally and organically bound nitrogen (e.g. manure and applied wastewater sludge) in the soil. Some of the leached nitrogen is also converted into nitrous oxide. Nitrogen entering the soil with fertiliser and manure and in plant residues is the main cause of nitrous gas emissions. In 2000 agriculture's main contribution to the nitrous oxide emissions consisted of a contribution of 40% from manure and a contribution of 26% from leaching[3].

Ammonia volatilization contributes to the greenhouse effect because some of the ammonia nitrate ends up as nitrous oxide in the atmosphere. Ammonia volatilization into the atmosphere comes almost exclusively from agriculture. In 2000 the NH_3-N emissions from agriculture were slightly more than 84,000 tonnes, with a nitrous oxide contribution corresponding to 4% of agriculture's nitrous oxide emissions[4]. Ammonia volatilizes from manure, fertiliser, sludge, crops and treatment of straw with ammonia.

The emissions occur during handling of manure in animal housing, during application of manure, and from grazing animals.

Implemented policies and measures with effect on the N_2O emissions
Nitrous oxide emissions in agriculture are expected to fall by about 2.7 million tonnes CO_2 equivalents, or 26%, in the period from 1990 to 2008-12. The implementation of the Action Plans for the Aquatic Environment will be the main contribution to this reduction.

Action Plan for the Aquatic Environment I and II and Action Plan for Sustainable Agriculture
One of the main purposes of Action Plan for the Aquatic Environment I and II and the Action Plan for Sus-

tainable Agriculture was to reduce agriculture's emissions of nitrogen to the aquatic environment.

The action plans have been implemented as regulation of farmers' behaviour. The Action Plan for the Aquatic Environment I was initiated in 1987 and The Action Plan for Sustainable Agriculture in 1991. These action plans included particularly requirements concerning winter-green fields and better utilisation of manure.

The Action Plan for the Aquatic Environment II from 1998 contained a number of additional measures, including re-establishment of wetlands, afforestation, agreements on Environment-friendly Agricultural Measures, organic farming on an additional 170,000 ha, improved use of fodder, reduced animal density, use of catch crops, reduced fertilisation norms and stricter requirements concerning the use of nitrogen in manure. The aim was to reduce nitrogen leaching by 100,000 tonnes/year up to the year 2003[5].

These action plans have, in particular, reduced the emissions of nitrous oxide. There have presumably also been small effects on methane emissions from manure stores, particularly as a consequence of increased use of anaerobic fermentation of manure in biogas plants. The increased use of catch crops, larger areas with organic farming and re-establishment of wetlands must also be expected to lead to increased storage of carbon in the soil.

Most of the changes in nitrous oxide emissions from agriculture in the period since 1990 can be attributed to these action plans. On this basis, the reduction in nitrous oxide emissions can be calculated as 1.2 million tonnes CO_2 equivalents/year in 1995, 1.8 million in 2000 and 2.7 million in 2005. There are no estimates of the effect on carbon storage in the soil.

Ammonia Action Plan
Ammonia emitted from agriculture will stimulate emissions of nitrous oxide when it is deposited in other ecosystems. Reducing ammonia evaporation will therefore also result in a reduction of nitrous oxide emissions. In 2001 an ammonia action plan was adopted. This, together with Action Plan for the Aquatic Environment I and II, will reduce ammonia volatilization by 15-20,000 tonnes N/year. This means that ammonia volatilization in agriculture should be reduced from about 90,000 tonnes N in the middle of the 1990s to about 75,000 tonnes N in 2004.

The measures covered by the Ammonia Action Plan are:

1) optimisation of manure handling during housing for cattle, pigs, poultry and fur animals, rules on covering stores of solid manure and liquid manure tanks
2) ban on broad spreading of manure
3) ban on top dressing and reduction of the time from field application of manure to incorporation
4) ban on ammonia treatment of straw.

It is estimated that these measures will together result in a reduction of nitrous oxide emissions corresponding to 34,000 tonnes CO_2 equivalents/year in 2010. Here, the shorter time from application to incorporation has the biggest effect – 13,000 tonnes CO_2 equivalents/year[6].

Ban on burning of straw
The purpose of the ban has been to reduce air pollution from burning of straw. The ban has resulted in more carbon being returned to the soil and greater use of straw as a fuel. Both uses will result in a net reduction in CO_2 emissions. Not burning straw prevents the methane and nitrous oxide emissions associated with the burning. On the other hand, there are some emissions of nitrous oxide in connection with the return of nitrogen to the soil when the straw is mulched.

The measure works by regulating behaviour, and the ban was introduced in 1989. The measure was implemented in the form of a statutory order under the Environmental Protection Act, and compliance is monitored by the local authorities.
There are no estimates of the effect on greenhouse gas emissions.

CO_2
The green tax package and the grant scheme for energy savings in the business sector are resulting in energy savings and thus a reduction in CO_2 emissions from use of energy in agriculture.

Implemented policies and measures with effect on the emissions and the removals of CO_2
The aim is to increase use of biomass for energy purposes by establishing power stations and CHP plants using this fuel.

Straw as a fuel will substitute fossil fuels but will also reduce the amount of carbon returned to the soil. The latter may result in less carbon storage in the soil. At the same time, less nitrogen will be returned to the soil, which will mean a small reduction in nitrous gas emissions from the soil.

In 1990, 720,000 tonnes of straw were used for energy purposes and, in 2000, 900,000 tonnes. However, the use of straw for energy purposes has negative impacts on carbon storage in the soil and presumably on the soil's fertility[7].

Compared with ordinary grain cultivation, it is calculated that cultivation of perennial energy crops corresponding to production of 5 PJ calorific value could reduce CO_2 emissions by 285,000 tonnes/year from substitution of fossil energy, 75,000 tonnes/year from carbon storage in soil, 10,000 tonnes/year from energy saving in cultivation of the crops and 30,000 tonnes/year from reduced nitrous oxide emissions[8].

Forestry is important due to its CO_2 sequestration and emissions being a consequence of trees growing, respiring and decomposing. An average Danish forest contains a considerable store of CO_2 absorbed from the atmosphere. When new forests are es-

Table 4.8 Afforestation area and CO_2 sequestration since 1990 and forecasts[9] for selected years in the next 18 years

CO_2 binding in Gg	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2005	2010	2015	2020
Private afforestation with grants, ha	0	70	70	70	178	178	212	968	547	3304	1800	1899	1496	1370	1370	0	0
CO_2 binding (Gg)	0	0	-0.1	-0.3	-0.4	-0.8	-1.1	-1.9	-4.3	-5.7	-13	-18	-23	-53	-114	-190	-266
Public afforestation, ha	119	312	574	599	702	537	553	681	247	428	276	291	231	460	460	460	460
CO_2 binding, Gg	0	-0.2	-0.8	-2.0	-3.1	-4.5	-6.1	-8.6	-13	-16	-20	-23	-27	-42	-72	-112	-138
Total afforestation, incl. private afforestation without grants, ha	730	993	1255	1280	1491	1326	1376	2260	1405	4343	2687	2801	2238	2441	2441	1071	1071
Total CO_2 binding, Gg	**0**	**-1**	**-3**	**-5**	**-8**	**-10**	**-16**	**-24**	**-34**	**-43**	**-59**	**-73**	**-89**	**-144**	**-279**	**-439**	**-617**

tablished, new CO_2 stores are created. Afforestation is therefore a useful climate policy instrument.

Calculating the total CO_2 accumulation in forests is complicated. Almost all existing forests are established for wood production, e.g. logs and timber. Whether there are net-emissions or net-sequestration of CO_2 from an existing forest depends on many factors, including it's age and species distribution, and the management regime applied.

Compared with other sectors, forestry has very low energy consumption. Green accounting and environmental management are being developed in the sector, partly with a view to determining whether the use of fossil fuels can be reduced.

The national forest programme provides for considering the potential of establishing economic incentives for increasing CO_2 sequestration in forests within the framework of the Kyoto Protocol. Such meausures should be implemented without undermining the Protocol's environmental integrity or counteracting established measures in support of sustainable forest management. The same should also apply to forest projects in connection with CDM and JI. The forests are managed with a

view to multiple-use and sustainability, and carbon sequestration is one of several objectives. The policy objective most likely to increase carbon sequestration is the 1989 target to double Denmark's forested area within 100 years.
There are several measures aiming at achieving this objective. Firstly, a government subsidy scheme has been established that supports private afforestation on agricultural land. Secondly, also state afforestation is taking place, and thirdly some private afforestation is taking place without subsidies.

Primarily the CO_2 balance is affected by these measures. Forests raised on agricultural land accumulate far more biomass than the previous agricultural land-use. The forest biomass contains about 50% carbon, which is absorbed as CO_2 through photosynthesis. Probably, additional carbon is stored in the organic matter in the soil due to a larger supply of dead organic matter and the absence of soil preparation.The effect of afforestation on other greenhouse gases, such as nitrous oxide and methane has not been properly clarified. However, the acidification of nitrogen-rich former agricultural land may stimulate the formation of nitrous oxide, and blocking of drains after afforestation and the resulting water stagnation could increase methane emissions. Increased methane and nitrous oxide emissions could counteract the positive effect of afforestation on CO_2 sequestration. However, since sufficient information is still unavailable on changes in the methane and nitrous oxide emissions, analyses of the consequences are only carried out for CO_2.

The Danish Forest and Nature Agency is responsible for policies on afforestation on private agricultural land and on state-owned land. Through 1990-2002 subsidies were provided for 11,000 ha of private afforestation on agricultural land, catering for an extra sequestration of 68,000 tonnes CO_2. The cost of this afforestation was DKK 620 million. At a discount rate of 6%, the economic shadow price per tonne sequestered CO_2 is DKK 641 without side-effects and DKK 566 with side-effects. At a discount rate of 3%, the shadow price is DKK 303 without side-effects and DKK 237 with side-effects. The side-effects of afforestaion are linked to recreational value, groundwater protection and other factors.

The state, counties and municipalities have established about 5,500 ha of new forest since 1990. Only little is known about private afforestation without subsidies. It is assumed that about 600 ha are planted annually.

The annual quantities of CO_2 sequested as a consequence of subsidised private afforestation, public afforestation and the total afforestation are summed up in table 4.8.

Carbon sequestration in trees after afforestation is calculated by a simple model. Sequestration is obtained as the planted area multiplied by the carbon absorption for the age class of the trees. The absorption is calculated by using Danish increment tables

Table 4.9 Instruments and measures to reduce the emission of greenhouse gases in the domestic sector

Name of instrument or initiative	Objective	Greenhouse gas affected	Type	Status	Initiator/player
Domestic sector					
Taxes on households' and the public sectors' energy consumption	CO_2 reduction, energy savings	CO_2	Economic	Implemented	Central authorities
Energy labelling of small and large buildings	Savings on energy, water, CO_2 reduction	CO_2	Information	Implemented	Consumers, others
Grants for energy savings in pensioners' homes	CO_2 reduction, energy savings and fiscal	CO_2	Economic, financial	Implemented	Central and local authorities, consumers
Electricity Saving Trust – conversion from electric heating	CO_2 reduction, energy savings	CO_2	Economic, financial, information, influencing the market	Implemented	Consumers, supply companies, others
Electricity Saving Trust – efficient appliances	CO_2 reduction, energy savings	CO_2	Information, influencing the market	Implemented	Consumers, retail trade, manufacturers
Energy labelling of electric appliances	CO_2 reduction, energy savings	CO_2	Information	Implemented	Consumers, others
Grid, gas and district heating companies' energy-saving activities	CO_2 reduction, energy savings	CO_2	Advice, information, education, campaigns	Implemented	Consumers, retail trade

for Norway spruce, as representative of conifers, and oak, as representative of deciduous trees[9].
The areas in table 4.3 for the period 1990-2001 are based on the evaluation of the afforestation programme carried out in the period[10] together with a national forest inventory carried out recently[11]. The areas for 2005- 2020 are based on a slightly revised projection[12]. Afforested areas do not include plantations of Norman Christmas trees in short rotation on agricultural land.

The quantities of carbon are obtained by estimating the carbon content of the woody biomass using relevant conversion factors. The stem biomass for conifers and the total above-ground woody biomass for deciduous trees are converted into total aboveground and belowground biomass by multiplying with an expansion factor. An expansion factor of 2 is used, which is somewhat higher than the expansion factors used for forests planted before 1990 – 1.8 for conifers and 1.2 for deciduous trees. The reason for this is that the expansion factor depends on age.

The stem biomass thus constitutes a very small part of the total biomass in entirely young trees. The expansion factor therefore decreases exponentially towards a value between 1 and 2 as the trees grow older[13].

Since there are neither Danish expansion factors nor age-dependent expansion functions, the expansion factor of 2 is being used until better methodologies are available. The total biomass is subsequently converted into tonnes dry matter using the conversion factors 0.38 tonnes dry matter m^{-3} for conifers and 0.56 tonnes dry matter m^{-3} for deciduous trees[14]. The quantity of carbon is calculated by multiplying with the conversion factor 0.5 tonnes C/tonne dry matter. Carbon sequestration in products can be included in the calculations, but the figures presented represent only the quantity of carbon that is sequestered in the forest ecosystem. This quantity of carbon is stored in the total living biomass (incl. roots) of the trees and in slash. The quantity of sequestered carbon is summed by the model for the different year classes of afforested areas since 1990, providing the total carbon sequestration for the differently aged stands in specific years. Studies of soils in a time series of afforested stands have shown that, compared with the biomass carbon pool, there is no great change in the soil carbon pool during the first 30 years after afforestation[15]. It is assumed in the models that the growth of the trees correponds to site index 2 (on a scale decreasing from 1 to 4), and that there is a ratio of 1 to 3 between the area afforested with conifers and deciduous trees[16].

Afforestation offers many other benefits in addition to carbon sequestration. Besides being valuable for outdoor recreation it provides valuable ground water protection and protection of habitats for fauna and flora. Forest is also a highly valued type of nature in terms of cultural values and landscape amenity. In addition to carbon sequestration, afforestation thus contributes to a wide range of values. The above-mentioned shadow price for sequestration of carbon includes side-effects due to, for example, outdoor recreation.

The continued growth of new forests will provide for carbon sequestration on a long-term basis. If the objective of doubling the Danish forested area within 100 years is achieved, the new forests will sequester about 250 million tonnes of CO_2 over the next approximately 120 years. Owing to the legal protection of forest land-use, the sequestration will be permanent. If the objective of doubling the forest area is to be achieved, however, an enhanced rate of planting will be needed.

Danish forest policy is moving towards more near-to-nature forest management. In the long term, this change will increase carbon sequestration in existing forests.

The inventories of the total emissions and removals of greenhouse gases include the emissions of greenhouse gases from fuel sold for fishing vessels. The fishing vessels' contribution to greenhouse gas emissions consist primarily of CO_2. No special initiatives have been put in place concerning this, but the reduction in the number of fishing vessels in recent years has also resulted in a reduction in fuel consumption and thus also in emissions of CO_2.

4.2.5 Domestic sector

The domestic sector's contribution to greenhouse gas emissions, which was 4.4 million tonnes CO_2 equivalents in 2001, consists mainly of CO_2 (97%). There are also small emissions of methane and even smaller emissions of nitrous oxide.

CO_2

The CO_2 emissions come from households' energy consumption, which accounts for almost 30% of total energy consumption in Denmark.

The largest part of the energy consumption is used for heating homes, where burning of oil and natural gas results in a CO_2 emissions. A large part of the space heating is in the form of district heating (about 47%), which results in CO_2 emissions in connection with the production of district heat.

When district heat is produced at CHP plants or with CO_2-friendly fuels, such as natural gas and, particularly, renewable energy, there are big savings overall from use of district heating instead of individual heating based on, for example, oil-fired boilers. CO_2 emissions from the production of district heat are taken into account under the energy sector.

Danish households also have a substantial consumption of electricity, which also means CO_2 emissions from power stations. These emissions are taken into account under the energy sector. Most of the households' electricity consumption is used for electrical appliances and light sources, while just under 25% is used for electric heating. Consumption for electric heating has been decreasing in recent years as a consequence of the work of the Electricity Saving Trust, which has resulted in considerable conversion from electric heating to district heating and natural gas heating.

Households' transport consumption also results in emissions of CO_2. Unlike households' electricity and heat consumption, transport consumption is still increasing considerably.

Households' disposal of waste also contributes to emissions of methane from landfill sites.

The action being taken on households' waste and transport consumption is described in the sections on waste and transport. This section therefore concentrates on the possibilities of reducing the CO_2 emissions through savings in electricity and heating in households and the possibilities for conversion to more environment-friendly forms of heating. The possibilities for reduction in the public energy supply system are described in the section on the energy sector.

In 2001 the domestic sector used in all 156 PJ energy for space heating (climate-adjusted) and 30 PJ electricity for appliances etc. The consumption for heating has been fairly constant for a number of years despite some growth in the number of households and increase in the area heated. Electricity consumption for appliances etc. has risen only slightly since the mid-1990s because the growth in the number of appliances has to some extent been balanced by the fact that appliances and lighting have been more energy-efficient.

Implemented policies and measures

With a view to reducing both the direct and the indirect emissions of CO_2 from the domestic sector, a wide range of initiatives have been launched. The object is to promote:

- electricity savings
- savings in energy consumption for space heating
- fuel conversion (from electric heating to oil or district heating, natural gas and renewable energy).

The initiatives to promote electricity savings include labelling schemes. The EU's obligatory energy labelling scheme for electric appliances, which has gradually been expanded to include new groups of appliances, has been given high priority, and a number of initiatives have been carried out to spread knowledge of the scheme. In addition, work is going on with a voluntary labelling scheme for TVs, videos and office equipment with respect to standby consumption. The labelling schemes have had a considerable impact. Firstly, they work in themselves and, secondly, they have formed the basis for a number of campaigns etc.

The Electricity Saving Trust was established in 1997. Among the Trust's schemes is a grant scheme designed to encourage conversion from electric heating to district heating or natural gas in the domestic sector and the public sector. In addition, the Trust contributes to development, marketing and use of electricity-saving appliances.

Table 4.10 Policies and measures in the waste sector

Policies or measures	Objective	Greenhouse gas affected	Type	Status	Initiator/player
Waste sector					
Obligation to send combustible waste for incineration (in practice a ban on landfilling)	Less landfilling, energy production, more recycling, CH_4 reduction	CH_4		Implemented	Central and local authorities
Waste tax	More recycling, least possible landfilling	CH_4	Economic	Implemented	Local authorities
Weight-based taxes	Waste reduction	CH_4	Economic	Implemented	Central authorities
Grant programme for cleaner products	Waste reduction, pollutants out of the waste	CH_4	Financial	Implemented	Central authorities

The initiatives to promote savings in energy consumption for space heating include energy labelling of small and large properties, campaigns and labelling schemes for low-energy windows, product-directed saving campaigns for efficient boilers and grants for energy savings for pensioners.

The grid, district heating and natural gas distribution companies are required to promote energy savings within their supply areas, and they are carrying out a number of campaigns, information activities, advisory work, etc. These activities are funded via the companies' tariffs. More general measures include regular increases in the CO_2 and energy taxes up through the 1990s. The increases have mainly affected households, helping to reduce their energy consumption.

As a consequence of the initiatives in the domestic sector, energy consumption for space heating is expected to fall slightly even though the number of m^2 housing is rising.

From 2001 to 2010, energy consumption for this purpose is expected to fall by 2%. Relatively speaking, oil consumption will be reduced most, namely by 20%, while electric heat consumption will be reduced by 8%. On the other hand, consumption of district heat, natural gas and biofuels will increase by some per cent. CO_2 emissions will thereby be reduced, particularly when district heat is produced with CHP or with CO_2-friendly fuels.

Electricity consumption for appliances is expected to increase slightly – by 3% – up towards 2012, compared with today's level, which is 30 PJ/year. Although efficiency improvements are expected in many appliances, electricity consumption for this purpose will not fall because households are acquiring more appliances.

Additional policies and measures
As follow-up on the climate strategy, new energy-saving initiatives are expected to be launched, including in the form of codes for products' energy efficiency. The actual implementation of the initiatives has not yet been decided. The extent to which cost-effective energy savings etc. can be initiated will be assessed on an ongoing basis.

4.2.6 Waste

The waste sector's contribution to greenhouse gas emissions consists only of methane from decomposition of organic waste at landfill sites.

Methane, CH_4
Previous years' action in the waste sector has been based on "Action Plan for Waste and Recycling 1993-97", which includes objectives concerning handling of waste up to the year 2000. The plan does not relate directly to the waste sector's contribution to methane emissions (CH_4), but includes a number of initiatives that are of relevance to waste products containing industrial gases (HFCs and SF_6), besides an objective concerning stopping landfilling combustible waste.

The previous government's waste plan, Waste 21, which covers the period 1998-2004, does not relate directly either to the waste sector's possibilities for contributing to solution of the problem of greenhouse gas emissions. The plan is aimed at stabilising the total quantities of waste in 2004, increasing recycling and reducing the environmental burden from the environmentally harmful substances in waste, including the industrial gases. With respect to waste incineration, the objective is to adjust incineration capacity to what is absolutely needed, to ensure best possible energy utilisation, maximum CO_2 displacement and regional self-sufficiency. The plan thus contributes indirectly to reduction of greenhouse gas emissions.

The objective in Waste 21 is for 64% of all waste to be recycled, 24% to be incinerated and not more than 12% deposited. That objective was already reached in the year 2000 according to the Danish Environmental Protection Agency's Waste Statistics 2000 (ISAG). Total waste in that year amounted to about 12.8 million tonnes.

The present government has initiated the preparation of a replacement for Waste 21 in the form of a waste strategy for the period 2005-2008. The strategy is expected to go before the Folketing in May/June 2003.

Implemented policies and measures
The waste sector's contribution to reduction of Denmark's greenhouse gas emissions consist mainly in

- reducing landfilling of organic waste
- utilising gas from closed-down and existing landfill sites
- using the waste as an energy source.

Methane emissions from Danish landfill sites are calculated to have amounted to 64,000 tonnes gross in 1990, rising to a maximum gross emissions of 68,800 tonnes in 1996/1997, corresponding to 1.2 million tonnes CO_2 equivalents.

As a consequence of the ban on landfilling combustible waste from 1 January 1997, methane emissions from Danish landfill sites will fall in the years ahead.

Calculations show that in 2012 the methane emissions will be 47,600 tonnes, corresponding to a 30% reduction in relation to the maximum methane emissions in 1996/1997.

According to the Danish Energy Authority's inventory "Biogas, Production, Forecast and Target Figures", there were in all 25 biogas plants in Denmark in the autumn of 2002. 10,000 tonnes of methane are recovered yearly from these plants. For comparison, only 1,700 tonnes of methane were recovered in 1990.

As a consequence of the new landfilling strategy, only a few biogas plants are expected to be established in the period up to 2012. The maximum quantity of methane recovered is expected to be about 12,000 tonnes in 2002/2003. Thereafter, the quantity of methane recovered is expected to remain at the same level for some years and then to fall steadily over a long period of years.

On the basis of the above-mentioned net emissions of methane (methane produced less methane recovered) from Danish landfill sites are calculated to be 62,400 tonnes in 1990, rising to 65,500 tonnes in 1994, and then falling steadily to 38,500 tonnes in 2012. The average annual net methane emissions in 2008-2012 correspond to about 0.9 million tonnes CO_2 equivalents.

The total quantity of waste incinerated rose from 2,216,000 tonnes in 1994 to 3,221,000 tonnes in 2001, i.e. an approximately 45% increase. The energy produced from the incineration plants is included as part of the renewable energy production in the Danish energy statistics. The international greenhouse gas inventories include greenhouse gases from incineration of the waste's content of oil-based products, such as plastics.

In accordance with the objectives of Energy 21 and Waste 21, efforts are being made to design the incineration plants for maximum energy utilisation.

Besides the direct effect of waste handling on greenhouse gas emissions, the emissions are also affected indirectly through recycling of paper, cardboard, etc. which means less energy consumption and thus less CO_2 emissions during production of new products. With increased recycling of organic waste in biogas plants and use of the methane in biogas engines it is important for the methane emissions from the engines to be reduced either via development of technology or by flaring the flue gas.

The implementation of the government's waste plans and achievement of the objectives set in this area have necessitated the use of a wide range of policies and measures. An amendment of the Statutory order on Waste in 1996 introduced a municipal obligation to refer combustible waste for incineration (corresponding to a ban on landfilling combustible waste). As a result of this instrument, large quantities of combustible waste that used to go to landfill sites are now either recycled or used as fuel in Denmark's incineration plants.

Besides the traditional regulation via legislation, statutory orders, and circulars, the waste sector is regulated by means of a range of policies and measures, including taxes and charges, grant schemes and agreements.

Since the introduction of the waste tax in 1993 the tax has been differentiated to reflect the prioritisation of the different forms of treatment. It thus costs most to deposit waste, less to incinerate it and nothing in tax to recycle it. The size of the tax thus provides an incentive to recycle as much of the waste produced as possible and to use non-recyclable, combustible waste as fuel in energy production instead of depositing it at a landfill site.

Weight-based taxes (e.g. on various packaging, carrier bags and PVC film) encourage a reduction in packaging consumption and thus the quantities of waste. The weight-based tax is based on an index that reflects the environmental burden of the materials used.

Besides the waste tax, which the local authorities collect to finance the public waste treatment, increasing use is being made of fees to finance, for example, return agreements for special waste fractions, including tyres and lead accumulators. The fees are used in this context to finance collection and recycling of the waste.

Under the grant programme "Programme for Cleaner Products etc.", grants are made for projects that reduce the environmental burden in connection with development, production, sale and use of products or in connection with the handling of the waste that is generated during the product's entire life cycle. Grants can also be made for waste projects aimed at reducing the problems in connection with waste disposal.

4.3 Energy policies and measures in Greenland

Until the publication of the Greenland Energy Plan 2010 in 1995, the all-important energy policy objectives in Greenland were security of supply and the energy policy guidelines from 1986, the main focus of which was hydropower.

With Energy Plan 2010, the Home Rule presented a complete review of the energy sector and an action plan for its development for the first time and set up a more differentiated main energy policy objective of "establishing an energy supply that does not compromise security of supply and that ensures the least possible economic and environmental burden for society and the other energy players."

Both before and since 1995, policies and measures have been adopted and implemented in the energy sector that have reduction of greenhouse gas emissions as one, although not in most cases the main, objective. Some of the most important measures are described below.

Act on Energy Supply

With adoption by the Landsting of the Act on Energy Supply in 1997, Greenland got for the first time legislation that deals with energy supply in a broad perspective, since it covers electricity, heat and fuel supply. At the same time, it is the first time that energy efficiency improvement and energy savings have been covered by legislation.

This Act confirms Energy Plan 2010's main objective of promoting the most economic and environment-friendly energy supply. It is stated in the Act that the energy supply shall be planned with a view to economising and saving in energy consumption, the highest possible level of security of energy supply, efficient improvements in the production and supply system and cleaner energy production.

Use of hydropower for energy supply
Since the 1970s the Home Rule has been interested in using hydropower for energy supply. Up through the 1970s and 1980s systematic studies of possible hydro power potentials were carried out. With the presentation of the energy policy guidelines in 1986, it was agreed that hydropower should be a bearing element of the future energy supply system. The first hydropower plants, taken into use in 1993, supplies Nuuk with electricity. Since it was commissioned, the plant has resulted in an annual saving of more than 20,000 m^3 oil, which has resulted in a reduction in CO_2 emissions of around 55,000 tonnes, or about 10% of the total CO_2 emissions in Greenland.

A hydropower plant to supply Tasiilaq is under construction. It will go into use in 2004. The expected oil saving with this hydropower plant is 1,300 m^3, corresponding to 3,446 tonnes CO_2 per year. A third hydropower plant is expected to be built within the next couple of years to supply Qaqortoq and Narsaq in South Greenland, with displacement of oil corresponding to 4,800 m^3. Greenland also has a 10-year plan for further expansion of hydropower.

Waste incineration
Waste incineration plants have been built in three villages and in a number of small communities with waste disposal as the main objective.

At all three plants in the villages, some of the surplus heat from the incineration process is used for district heating. A further three incineration plants are under construction in other villages. There, the heat will also be used for district heating.

The existing waste incineration therefore to some extent replaces fuel oil and results in an unmeasured reduction of methane emissions that would occur if the waste were deposited at landfill sites.

Sector Programme for Renovation with an Environment and Energy Improving Effect in Greenland 2000-2003
In 1999 the Home Rule and the Danish State entered into an agreement on renovation of buildings and supply plants. The agreement covered renovation projects with a positive environmental and energy effect. Projects carried out under the programme include renovation of electricity and heat production plants, including supply grids, revision of the building regulations, renovation of buildings, including the climate envelope, preparation of a new energy plan and behaviour-regulating measures. All the initiatives are expected to help reduce energy consumption and, consequently, CO_2 emissions.

1 Denmark's Greenhouse Gas Projection until 2012, an update including preliminary projection until 2017, Environmental Project No 764, Danish Environmental Protection Agency, Februar 2003.
2 The difference between 20 and 25 million tonnes CO_2 equivalents depends on the outcome of the EU's final setting of the individual EU countries' reductions, which must be done in 2006, and which must take account of Denmark's adjustment of the base year 1990 for electricity import.
3 Olesen et al. 2001a
4 Illerup et al.
5 Grant et al.
6 Olesen et al., 2001b
7 Christensen, 2002
8 Olesen et al., 2001b
9 Møller, 1933
10 National Forest and Nature Agency, 2000
11 Larsen and Johannsen, 2002
12 Danish Energy Authority, 2001
13 Schöne and Schulte, 1999
14 Moltesen, 1988
15 Vesterdal et al., 2002
16 More information on the methods is given in Danish Energy Authority, 2001, and Vesterdal, 2000.

5. Projections and the total effect of policies and measures

5.1 Introduction and overall effect of policies and measures

According to the EU's burdens-sharing agreement, Denmark must reduce greenhouse gas emissions by 21% in the period 2008-2012 in relation to the base year 1990/95 under the Kyoto Protocol.

In connection with the agreement, Denmark took reservation in a declaration for the effects of a large import of electricity from Norway and Sweden in the base year 1990, which resulted in Denmark emitting 6.3 million tonnes CO_2 less than would have been the case if the electricity had been produced in Denmark. The Danish position was, and is, that a fortuitous event such as a large electricity import in a single year should not mean that Denmark's reduction obligation in relation to the EU should be calculated on the basis of the random low emissions in 1990. In March 2002 Denmark had to accept a Council decision that binds Denmark legally to a reduction of 21% in relation to the emissions in the base year, which has not been adjusted for the electricity import.

Denmark was, however, assured in a political declaration from the EU Council of Ministers and the European Commission that the assumptions relating to base year emissions will be taken into account in connection with fixing the permitted amount of emissions in 2006, measured in tonnes of CO_2 equivalents. The government will therefore work to ensure that Denmark's reduction burden in 2008-2012 corresponds to 21% of the 1990 level adjusted for electricity import, corresponding to 5 million tonnes CO_2 equivalents per year.

The shortfall in respect of fulfilling Denmark's obligations with the existing policies and measures has been calculated partly for a situation in which account is taken of the electricity import in 1990 and partly for a situation in which account is not taken of this.

The projections are based on a number of sector-specific projections of the domestic emissions for this period. These emissions depend on the scope of economic activity in all sectors of society, energy prices, technological development and the legislation regulating the various activities with respect to environment, energy efficiency, etc. The main assumptions include the Ministry of Finance's estimate concerning economic development[1] and the IEA's expectations concerning future energy prices[2]. In addition, the projections are based on already adopted regulation of various sectors, including the environmental regulation of agriculture and the energy sector.

According to the latest inventories of greenhouse gas emissions, Denmark's reduction obligation of 21% means that the emissions must be reduced from 69.5 million tonnes CO_2 equivalents in the base year 1990/95 to 54.9 million in the period 2008-2012.

The latest projections from February 2003 cover the period 2001-2017

and are reproduced in Appendix B. However, the calculations for the period 2013 - 2017 must be described as somewhat less certain than the projections up to 2013, in part because of the uncertainty concerning the policies and measures and their expected effect increases with time. In addition, new projections have not been carried out for the agricultural sector after 2012. The projection is a "with measures" projection that includes initiatives that can be expected with reasonable certainty to be implemented without further political action in the form of legislation, political agreements or similar. The projection must therefore not be confused with the most probable development because it does not take account of new political initiatives that could be taken according to the government's climate strategy, February 2003, which was adopted by the Folketing on 13 March 2003.
It should be noted that the latest historical inventory of greenhouse gas emissions covers the period 1990-2001, for which reason the projection for 2001 in this report has been replaced by the historical inventory for 2001.

Since this new inventory also includes an update of the 1990 figures as a consequence of new knowledge, the base year – and thus also the shortfall – has been changed slightly in relation to the inventory in the climate strategy.

Denmark's expected annual emissions in the period 2008-2012 have been calculated to be 80.1 million tonnes CO_2 equivalents. As will be seen from table 5.1, the size of the total greenhouse gas emissions depend greatly on CO_2 emissions asso-

Table 5.1. Denmark's expected greenhouse gas emissions

Mill. tonnes CO_2 equivalents	Base year 1990/95[1]	2000	2001	"2010"[2]	"2015"[3,4]
CO_2	(52.6*) 52.7	52.8	54.3	65.6	64.4
Methane (CH_4)	(5.8*) 5.7	5.8	5.6	5.0	4.7
Nitrous oxide (N_2O)	10.8	9.1	8.7	8.7	8.7
Industrial gases HFC_s, PFCs, SF_6	0.3	0.8	0.7	0.7	0.5
Total emissions	**(69.7*) 69.5**	**68.4**	**69.3**	**80.1**	**78.3**
Kyoto objective: –21%				**(55.0*) 54.9**	
Shortfall				**(25.0*) 25.1**	
Electricity export (+)/import(-)	**-6.3**	**-0.3**		**+9.9**	**+9.1**
Shortfall without electricity export				**(15.1*) 15.2**	

* Note: The base-year data and shortfall estimated in connection with the climate strategy are shown in brackets.

1 The base year for CO_2, methane and nitrous oxide is 1990. In accordance with the Kyoto Protocol, 1995 has been selected as the base year for the industrial gases.

2 "2010" is used to express the average emissions in the period 2008-2012.

3 "2015" is used to express the average emissions in the period 2013-2017

4 A new projection of agriculture's emissions of methane and nitrous oxide has not been carried out for the period 2013-2017. Here, the emissions for the period 2008-2012 are kept.

ciated with electricity export, which is estimated to be 9.9 million tonnes CO_2 equivalents per year in the period 2008-2012.

5.2. Energy, including transport and the domestic sector

In this section the projection of the emissions of CO_2, CH_4 and N_2O from combustion of fuels and from gaseous emissions from fuels is described. The projection includes all fuel-consuming sectors, including the transport sector and industry. The projection is based on a projection of the development in energy consumption in the period 2002-2017. The emissions of CO_2, CH_4 and N_2O have been calculated by multiplying the energy consumption by emission factors.

The projection of energy consumption is based on the initiatives described in sections 4.2.1 - 4.2.3 and 4.2.5 being implemented and on no further initiatives being implemented. It should therefore be seen as a "with measures" projection. Figure 5.1 and table 5.2 show the development of total energy consumption (excl. fuels for non-energy purposes) with this assumption, broken down by sector.

In years with ample precipitation Denmark is a net importer of electricity produced at Norwegian and Swedish hydropower stations, while

Figure 5.1 Gross energy consumption 1990-2017, 1990-2001 observed
Source: Danish Energy Authority

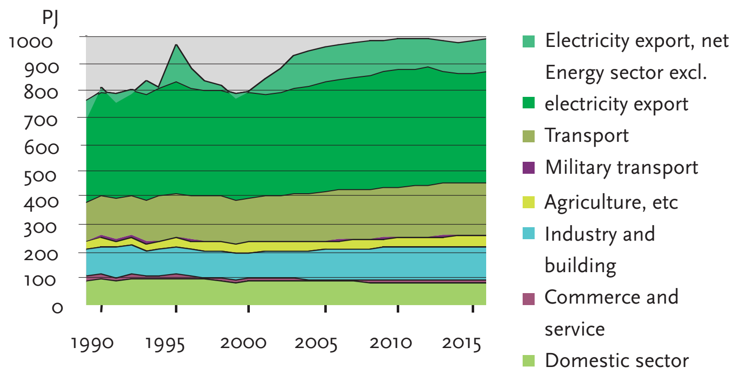
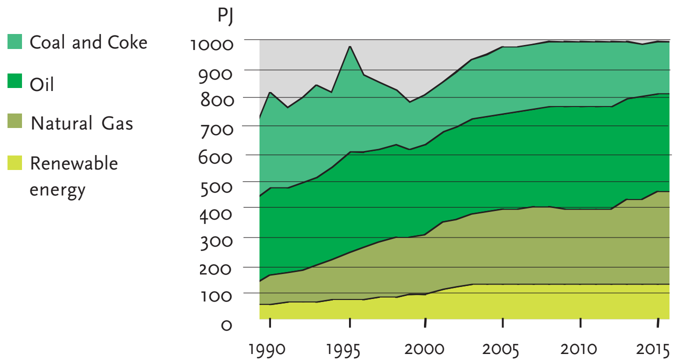


Table 5.2 Gross energy consumption 1990-2017, 1990 and 2001 are observed
Source: Danish Energy Authority

PJ	1990	2001	2005	2010	2015
Energy sector excl. electricity export	377.4	398.8	406.9	435.1	421.6
- of which flaring	4.2	10.8	10.1	10.1	9.4
Electricity export, net	-67.7	4.1	123.7	119.0	112.9
Transport excl. international air transp.	141.6	164.0	174.9	187.0	192.4
Military transport	1.6	1.3	2.0	2.0	2.0
Agriculture, etc.	33.9	36.2	38.6	39.9	40.6
Industry and building	98.7	95.0	100.8	110.6	118.8
Commerce and service	21.2	15.7	16.5	17.3	17.9
Domestic sector	85.2	83.9	82.1	S79.9	77.9
Total	**692.1**	**799.0**	**945.5**	**990.7**	**984.0**
Total excl. electricity export	**759.8**	**794.9**	**821.8**	**871.7**	**871.1**

TABLE 5.2 GROSS ENERGY CONSUMPTION 1990-2017, 1990 AND 2001 OBSERVED



in years with scanty precipitation, it is a net exporter of electricity to Norway and Sweden. This has resulted in large fluctuations in the observed Danish gross energy consumption in the period 1990-2001.

Energy consumption is expected to grow within most business sectors and transport in the next 15 years, but to fall slightly in the domestic sector. The energy sector's consumption has been calculated excluding fuels for production of electricity for export because this consumption figures separately, but the calculation includes flaring. Domestic electricity consumption is expected to grow, which is also reflected in the gross energy consumption in the energy sector up to 2013. Thereafter, the sector's energy consumption falls because a number of primary coal-fired stations are expected to be replaced by new, more efficient CHP plants, about half of which are expected to use natural gas as fuel.

As will be seen, the big increase in total energy consumption in the first part of the projection period is due to a big increase in electricity exports. This increase is expected partly because the price of electricity on the Nordic electricity market is expected to rise and partly because the existing national CO_2 Quota Act for the electricity sector only has an effect up to and including 2003. With that, it will be more attractive for the electricity sector to export electricity.

Figure 5.2 shows the development of total energy consumption, broken down by fuels, which determine the size of CO_2 emissions because the fuels have very different emission factors.

The increase in the quantity of renewable energy up to the year 2004 is due primarily to expansion of wind turbines, while the increase in oil consumption can be attributed mainly to growth in the transport sector. With the new power stations, natural gas consumption increases from 2014 at the expense of coal consumption. This change means a reduction in CO_2 emissions because natural gas has far lower emission factors than coal.

As will be seen later, with the expected development of energy consumption the CO_2 emissions from Danish territory will exceed the Kyoto objective for 2008-2012. An EU Directive on trading with CO_2 emissions from electricity and heat production, together with fuel consumption in certain sectors of industry, is expected to play a vital role in cost-effective achievement of Denmark's Kyoto target. Table 5.3 shows the resulting emissions of CO_2, CH_4 and N_2O from the energy sector in the "with

Table 5.3 "With measures" projection, 1990-2001 observed

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003, 2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003 and Danish Energy Agency

Greenhouse gas emissions in '000 tonnes CO_2 equivalents	1990	2000	2001	2005	2010	2015
CO_2 – combustion of fuels						
Energy production	26202	25121	26375	33629	35401	32986
Industry and building & construction	5605	5823	5909	6454	7121	7687
Transport	10381	12046	12174	13098	13977	14366
Other sectors (commerce and service, households and agriculture, forestry and fishery)	8959	7505	7688	7380	7359	7290
Other	119	111	97	230	223	217
CO_2 – gaseous emission from fuels						
Flaring	240	593	633	573	573	537
CO_2 – total emission from energy and transport	**51530**	**51199**	**52779**	**61134**	**64431**	**62865**
CH_4 – total emission from energy and transport	**273**	**763**	**807**	**889**	**866**	**832**
N_2O – total emission from energy and transport	**583**	**797**	**831**	**1103**	**1197**	**1177**
Total greenhouse gas emission from energy and transport	**52386**	**52728**	**54416**	**63126**	**66495**	**64874**

measures" projection. The emissions of CH_4 and N_2O calculated as 1000 tonnes are CO_2 equivalents. Appendix B contains detailed tables showing the results of the projections.

5.3. Business sector

Besides the greenhouse gas emissions mentioned in section 5.2, industrial processes include a number of activities that emit greenhouse gases. This section covers emissions connected with production of cement, chalk and bricks, together with emissions of the industrial gases HFCs, PFCs and SF_6.

The projection of the emissions is based on implemented and adopted policies and measures, described in chapter 4, including a statutory order on phasing out certain industrial gases. This statutory order will result in a reduction in greenhouse gas emissions of, on average, 1.1 million CO_2 equivalents per year in the period 2008-2012. It is covered by a ban on the use of HFC as a coolant in the retail trade and stationary A/C systems from 1 January 2007, except for refilling of existing systems, and as a foaming agent in PUR foam from 1 January 2006.

5.4 Agriculture

16% of Denmark's greenhouse gas emissions in 2001 consists of methane and nitrous oxide, which are primarily emitted by agriculture. The methane and nitrous oxide emissions are not taxed and are only regulated indirectly via the regulation of the effect on the aquatic environment of nitrogen losses from agriculture, e.g. in the Action Plan for the Aquatic Environment II. Further possibilities for reduction of the methane and nitrous oxide emissions in the agricultural sector have not been sufficiently identified at present. More knowledge is needed on both technical possibilities for reduction and the associated costs.

Owing to the EU's milk quotas and the increasing productivity within dairy farming, the cattle population is expected to fall by 1.8% per year to 524,000 dairy cows in 2010. In pig farming, on the other hand, production is expected to rise by 1.5 % per year. This will result in increased production of fatteners to just over 26 million in 2010. In total, the fall in cattle population and the rise in pig population are expected to result in a small increase in the total quantity of manure.

Total agricultural land is expected to fall by 0.3% per year. In addition, the planned afforestation area has been deducted. It is also assumed that agricultural land used for organic farming will reach 220,000 ha in 2010. The area with set-aside crops according to the EU's subsidy schemes is estimated to be 7% of the total agricultural area in the entire projection period.

5.4.1 Methane

Increasing productivity of individual cows means a rise in the emissions coefficient for methane from dairy cows from 102 kg methane/cow/year in 1990 to 117 kg methane/cow/year in 2010. However, this is more than balanced by the fall in the population of dairy cows, and the result is a fall in methane emissions (table 5.6).

5.4.2 Nitrous oxide

The fall in nitrous gas emissions shown in table 5.7 can be attributed particularly to reduced use of nitro-

Table 5.4 Industrial greenhouse gas emissions (HFCs, PFCs and SF_6), 1990-2001 observed.

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003, 2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

1000 tonnes CO_2 equivalents	1995	2000	2001	2005	2010	2015	2020
HFCs, PFCs and SF_6	344	793	700	808	702	507	230

Table 5.5 Emissions from cement, chalk and brick production, 1990-2001 observed

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003, 2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

1000 tonnes CO_2	1990	2000	2001	2005	2010	2015
Cement, chalk and brick production	1005	1453		1456	1458	1420

Table 5.6 Methane emissions from agriculture in the period 1990 to 2015, 1990-2000 observed

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003,
2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

1000 tonnes CO_2 equivalents	1990	2000	2001	2005	2010	2015
Enteric Fermentation	3189	2715	2747	2641	2509	2459
Manure Management	900	861	884	707	690	674
Total Methane Emissions	**4089**	**3575**	**3632**	**3348**	**3199**	**3133**

Table 5.7 Nitrous oxide emissions from agriculture in the period 1990 to 2015

1. Calculations have not been carried out of the emissions within the agricultural sector after the first obligation period 2008-2012.

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003,
2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

1000 tonnes CO_2 equivalents	1990	2000	2001	2005	2010	2015[1]
Nitrous oxide from agriculture, total	10259	8293	7918	7501	7553	7553

gen fertilisers and a fall in nitrogen leaching and ammonia evaporation, which are effects of the action plans for the aquatic environment area. It is assumed that the aquatic environment action plans (Action Plans for the Aquatic Environment I and II) will be fully implemented in 2003.

5.5 Forestry

The projections for CO_2 sequestration in forests are based on an assumption that the present subsidy structure and financing are maintained until the end of 2012. So far, financing has been made available until the end of 2003, and political commitment for public financing and/or access to alternative sources of financing for private afforestation may be available even beyond 2003. Table 5.8 shows the expected rate of afforestation in selected years up to 2020. Indeed, the rate of private afforestation will depend on the economic conditions in the agricultural sector, and, as the marginal agricultural localities are planted over time, a saturation point may be reached where the existing subsidies no longer provide an incentive for further afforestation.

5.6 Waste

The objective of the waste plan – Waste 21 – is to reduce the proportion of waste going to landfill sites from 2.1 million tonnes (16%) in 1997 to 1.5 million tonnes (12%) in 2004. As mentioned earlier, this target was already achieved in 2000. The net methane emissions (produced methane less recovered methane) from Danish landfill sites is calculated to be 62,400 tonnes in 1990, rising to 65,500 tonnes in

Table 5.8 Afforestation area and CO_2 sequestration since 1990 and forecasts for selected years over the next 20 years[3]

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003

CO_2 binding in Gg	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2005	2010	2015	2020
Private afforestation with grants, ha	0	70	70	70	178	178	212	968	547	3304	1800	1899	1496	1370	1370	0	0
CO_2 binding (Gg)	0	0	-0.1	-0.3	-0.4	-0.8	-1.1	-1.9	-4.3	-5.7	-13	-18	-23	-53	-114	-190	-266
Public afforestation, ha	119	312	574	599	702	537	553	681	247	428	276	291	231	460	460	460	460
CO_2 binding, Gg	0	-0.2	-0.8	-2.0	-3.1	-4.5	-6.1	-8.6	-13	-16	-20	-23	-27	-42	-72	-112	-138
Total afforestation, including private afforestation without grants, ha	730	993	1255	1280	1491	1326	1376	2260	1405	4343	2687	2801	2238	2441	2441	1071	1071
Total CO_2 binding, Gg	**0**	**-1**	**-3**	**-5**	**-8**	**-10**	**-16**	**-24**	**-34**	**-43**	**-59**	**-73**	**-89**	**-144**	**-279**	**-439**	**-617**

Table 5.8 Methane emissions from landfill sites in the period 1990 to 2012, 1990-2001 observed.

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003,
2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

Tonnes methane, CH_4.	1990	2000	2001	2005	2010
Methane emissions from landfill sites (gross)	64,000	67,800	67,000	61,200	57,700
Recovery of methane from landfill sites	1,700	10,800	10,000	11,400	9,700
Methane emissions from landfill sites (net)	**62,400**	**57,500**	**57,000**	**49,800**	**45,000**

1994 and then steadily falling to 38,900 tonnes in 2012. The average annual net methane emissions from landfill sites in 2008-2012 correspond to about 0.9 million tonnes CO_2 equivalents. There are no emissions of methane from wastewater in Denmark because wastewater is treated with aerobic processes.

5.7 Total emissions

5.7.1 Total carbon dioxide (CO_2) emissions

Table 5.9 shows the expected development of CO_2 emissions, while Appendix B gives a more detailed projection. The biggest source of CO_2 emissions in Denmark is combustion of fossil fuels, including electricity and heat production and transport. The transport sector has had the biggest increase in CO_2 emissions since 1990, and the emissions are expected to continue rising for the whole of the projection period. The CO_2 emissions from the transport sector were 10,404 Gg in 1990 and rose to 12,077 Gg in 2001, while in the period 2008-2012 it has been calculated that the average annual CO_2 emissions will be 13,727 Gg. The emissions from energy production,

Table 5.9 Projection of Denmark's CO_2 emission 2000-2017 and observed emission in 1990, 2000 and 2001

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003, 2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

	1990	2000	2001	2005	2008-12	2013-17
GREENHOUSE GAS SOURCE AND SINK CATEGORIES				(Gg CO_2)		
1. Energy	**51530**	**51199**	**52779**	**61134**	**64394**	**63370**
A Fuel Combustion Activities (Sectoral Approach)	51290	50606	52145	60561	63821	62822
1 Energy Industries	26202	25121	26375	33629	35405	33475
2 Manufacturing Industries and Construction	5605	5823	5909	6454	7111	7681
3 Transport	10404	12046	12077	12869	13727	14153
4 Other Sectors	8959	7505	7688	7380	7355	7295
5 Other (Here: Military mobile and in projections other off road)	119	111	97	230	223	217
B Fugitive Emissions from Fuels	240	593	633	573	573	548
1 Solid Fuels	0	0	0	0	0	0
2 Oil and Natural Gas	240	593	633	573	573	548
2. Industrial Processes	**1005**	**1453**	**1464**	**1456**	**1458**	**1420**
3. Solvent and Other Product Use	**124**	**112**	**112**	**60**	**68**	**68**
4. Agriculture	**0**	**0**	**0**	**0**	**0**	**0**
5. Land-Use Change and Forestry (LUCF)	**-3118**	**-3517**	**-3531**	**-1063**	**-1199**	**-1360**
6. Waste	**0**	**0**	**0**	**0**	**0**	**0**
7. Other	**0**	**0**	**0**	**0**	**0**	**0**
Total Emissions/Removals with LUCF	49541	49247	50824	61587	64722	63499
Total Emissions without LUCF	52659	52764	54355	62650	65921	64859
Memo Items:						
International Bunkers	4857	6629	5983	6376	6835	7321
Aviation	1762	2348	2378	2758	3218	3704
Marine	3095	4281	3605	3618	3618	3618
Multilateral Operations	0	0	0	0	0	0
CO_2 Emissions from Biomass	4611	7001	7679	0	0	0

including conversion and distribution, fluctuated in the period 1990-2001 due to greatly varying electricity export/import. The CO_2 emissions from energy production were 26,202 Gg in 1990 and 26,375 Gg in 2001, while for the period 2008-2012 it has been calculated that the average annual CO_2 emissions will be 35,405 Gg, of which 9,900 Gg can be attributed to electricity production for export.

The total CO_2 emissions without land-use change and forestry (LUCF) was 52,659 Gg in 1990 and 54,355 Gg in 2001, while for the period 2008-2012 it has been calculated that the average annual CO_2 emissions will be 65,921 Gg.

5.7.2 Methane, CH_4

Most of the methane emissions come from farm animals' digestive systems. The reduced emissions from 1990 to 2001 and continued reduction in the projection period can be attributed mainly to a smaller cattle population. The second-largest source of methane emissions are landfill sites, where emissions also decreased from 1990 to 2001. However, the energy sector's methane emissions increased considerably in the same period due

Table 5.10 Projection of Denmark's methane emissions 2002-2017, 1990-2001 observed

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003, 2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

	1990	2000	2001	2005	2008-12	2013-17
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(CH_4 in Gg CO_2 equivalent)					
Total Emissions	5672	5535	5606	5281	4979	4656
1. Energy	**273**	**763**	**807**	**889**	**866**	**839**
A Fuel Combustion Activities (Sectoral Approach)	180	625	660	612	585	569
1 Energy Industries	1	4	3	17	17	14
2 Manufacturing Industries and Construction	17	38	40	32	34	36
3 Transport	0	0	0	0	0	0
4 Other Sectors	0	0	0	0	0	0
5 Other (Here: Military mobile and in projections other off road)	0	0	0	1	1	1
B Fugitive Emissions from Fuels	93	138	147	276	281	270
1 Solid Fuels	72	64	69	97	101	91
2 Oil and Natural Gas	0	0	0	0	0	0
2. Industrial Processes	**0**	**0**	**0**	**0**	**0**	**0**
3. Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**0**
4. Agriculture	**4089**	**3575**	**3632**	**3348**	**3200**	**3133**
A. Enteric Fermentation	3189	2715	2747	2641	2509	2459
B. Manure Management	900	861	884	707	690	674
5. Land-Use Change and Forestry (LUCF)	**0**	**0**	**0**	**0**	**0**	**0**
6. Waste	**1310**	**1197**	**1168**	**1045**	**914**	**684**
1 Managed Waste Disposal on Land	1310	1197	1168	1045	914	684
7. Other	**0**	**0**	**0**	**0**	**0**	**0**

to increased use of gas engines. Total methane emissions were 5,672 Gg CO_2 equivalents in 1990 and 5,606 CO_2 equivalents in 2001, while in the period 2008-2012, is has been calculated that the average annual emissions will be 4,979 CO_2 equivalents.

5.7.3 Nitrous oxide, N_2O

Agriculture is by far the biggest source of emissions of nitrous oxide because this can form in soil through bacterial conversion of nitrogen in fertiliser and manure spread on fields. The main reason for the reduction in total nitrous oxide emissions from 10,843 Gg CO_2 equivalents in 1990 to 8,749 Gg CO_2 equivalents in 2001 is a combination of the Action Plans for the Aquatic Environment I and II and the Action Plan for Sustainable Agriculture. In the period 2008-2012 calculations indicate average annual emissions of 8,738 CO_2 equivalents. The contribution from the transport sector and the energy sector to nitrous oxide emissions is expected to rise, while the contribution from agriculture is expected to fall slightly in relation to 2001.

5.7.4 Industrial gases HFCs, PFCs and SF_6

In accordance with the possibilities offered in the Kyoto Protocol, Denmark has chosen 1995 as the base year for emissions of the industrial gases HFCs, PFCs and SF_6. The total emissions of these gases were 344 Gg CO_2 equivalents in 1995 but double that – 793 Gg CO_2 equivalents – in 2000. In 2001 the emissions fell to 700 CO_2 equivalents.

Table 5.11 Projection of Denmark's nitrous oxide emissions 2002-2017, 1990-2001 observed

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003
2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003

	1990	2000	2001	2005	2008-12	2013-17
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(N_2O in Gg CO_2 equivalent)					
Total Emissions	10843	9090	8749	8604	8738	8738
1. Energy	**583**	**797**	**831**	**1103**	**1191**	**1185**
A Fuel Combustion Activities (Sectoral Approach)	582	793	827	1101	1190	1184
1 Energy Industries	275	263	280	358	374	340
2 Manufacturing Industries and Construction	54	57	57	61	67	72
3 Transport	147	379	393	592	658	681
4 Other Sectors	106	93	95	88	88	88
5 Other (Here: Military mobile and in projections other off road)	1	1	2	2	2	2
B Fugitive Emissions from Fuels	1	3	3	2	2	2
1 Solid Fuels	0	0	0	0	0	0
2 Oil and Natural Gas	1	3	3	2	2	2
2. Industrial Processes	**0**	**0**	**0**	**0**	**0**	**0**
3. Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**0**
4. Agriculture	**10259**	**8293**	**7918**	**7501**	**7547**	**7553**
A. Enteric Fermentation	462	440	442	723	747	750
B. Manure Management	9797	7853	7477	6779	6800	6803
5. Land-Use Change and Forestry (LUCF)	**0**	**0**	**0**	**0**	**0**	**0**
6. Waste	**0**	**0**	**0**	**0**	**0**	**0**
7. Other	0	0	0	0	0	0

Table 5.12 Projection of Denmark's industrial gas emission 2002-2017, 1990, 2000 and 2001 observed

Source: 1990-2001: National Emission Report (NIR), National Environmental Research Institute, April 2003,
2002-2017: Environmental Project No. 764, Danish Environmental Protection Agency, February 2003
Environmental Project No. 761, Danish Environmental Protection Agency, February 2003

	1995	2000	2001	2005	2008-12	2013-17
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(HFCs, PFCs and SF_6 in Gg CO_2 equivalent)					
Total Emissions of HFCs, PFCs and SF_6	344	793	700	809	706	497
2. Industrial Processes	**344**	**793**	**700**	**809**	**706**	**497**
C Metal Production	**36**	**21**	**0**	**0**	**0**	**0**
1 Iron and Steel Production	0	0	0	0	0	0
2 Ferroalloys Production	0	0	0	0	0	0
3 Aluminium Production	0	0	0	0	0	0
4 SF_6 Used in Aluminium and Magnesium Foundries	36	21	0	0	0	0
SF_6 Used in Aluminium Foundries	0	0	0	0	0	0
SF_6 Used in Magnesium Foundries	36	21	0	0	0	0
5 Other	0	0	0	0	0	0
F Consumption of Halocarbons and Sulphur Hexafluoride	**308**	**771**	**700**	**809**	**706**	**497**
1 Refrigeration and Air Conditioning Equipment	55	551	468	576	541	338
2 Foam Blowing	182	166	186	206	115	55
3 Fire Extinguishers	0	0	0	0	0	0
4. Aerosols/ Metered Dose Inhalers	0	14	12	0	0	0
5 Solvents	0	0	0	0	0	0
6. Semiconductor Manufacture	0	0	0	0	0	0
7. Electrical Equipment (SF_6)	4	11	13	12	14	15
8 Other	68	29	22	15	37	89
C3F8 (PFC used as detergent)	0	2	4	0	0	0
SF_6 (Window plate production, research laboratories and running shoes)	68	27	18	15	37	89
Total Emissions of HFCs	**236**	**705**	**647**	**764**	**638**	**374**
Total Emissions of PFCs	**1**	**28**	**22**	**17**	**18**	**19**
Total Emissions of SF_6	**107**	**59**	**30**	**27**	**50**	**104**

Table 5.13 Greenland's actual CO_2 emissions from combustion of fossil fuels and expected CO_2 emissions from electricity and district heat production
Source: Nukissiorfiit.

Year	1990	1995	2000	2003	2005	2008	2009	2010	2011
CO_2 emission from combustion of fossil fuels (1000 tonnes)	626	525	661						
Of which CO_2 emissions from electricity and district heat production in towns and villages (1000 tonnes)		125*	135	137	136	126	121	121	121

The main reasons for this were the introduction of a tax and legislation on phasing out import, production, and use of these gases. For the period 2008-2012 calculations indicate total average annual industrial gas emissions of 706 CO_2 equivalents. Thereafter, a considerable reduction is expected in HFCs, which are the largest contributor to industrial gas emissions, and overall this will result in a considerable reduction of industrial gas emissions after the first commitment period.

5.8 Greenland and the Faroe Islands

With respect to the expectations concerning future greenhouse gas emissions in Greenland, the projections cover only electricity and district heat production.

The projections for CO_2 emissions from electricity and district heat production are based on a projected increase in energy consumption of 1% up to 2005 and then stagnation. The projections are also based on the fact that a hydropower station is under construction and expected to go into operation in 2004 and that a further hydropower station is planned, which will go into operation in 2006. There are not at the present time any estimates of future greenhouse gas emissions on the Faroe Islands.

5.9 Methods used in the projections

The projection of energy consumption in the business sector and the public service sector is based on an ADAM/EMMA projection, while the domestic sector is projected on the basis of the bottom-up principle.

EMMA is a macro model that describes the final energy consumption broken down into a number of sectors and seven types of energy. It is based on historical experience with the behaviour of businesses and households and is documented in satellite models for ADAM, NERI Technical Report No. 148, DMU 1995.

In EMMA, energy consumption in the business sector is determined by three factors: production, energy prices/taxes and energy efficiencies/trends. Increased production will increase the demand for energy input, whereas increased energy prices and taxes will pull in the direction of a more limited demand for the fuels. Improved energy efficiency will mean that production can be maintained using less energy, and in EMMA this results in reduced energy consumption.
The projection of production is based on the ADAM projection in the *Economic Report, January 2002,* covering the period 2000-2010. For the period 2011-2017 figures from the *Financial Report 2001* have been used.

The domestic sector's energy consumption has been determined using the bottom-up models: the Electricity model for households and the Heating model for households. The projection is based on, among other things, expectations concerning growth in the housing stock and expectations concerning the development in the number of electric appliances.

The projection of electricity and heat production is based on the Danish Energy Authority's RAMSES model, using as the basis the demand for electricity and district heat according to the projection of the consumption sectors. In the projection, electricity and heat production is divided between existing and possible new production plants on the basis of technical and economic parameters. Industrial and local mini-CHP production is not projected in the RAMSES model so a separate (bottom-up) projection has been made of this production.

Table 5.14 Average annual rate of growth in real production value of business in % in relation to the previous year

Note: The rates of growth for 2001 have been taken from Danmarks Statistik's National Accounts, April 2002, the rates of growth for 2002-2010 from Economic Report, January 2002, and the rates of growth for 2011-2017 from Financial Report 2001.

Annual rate of growth in per cent	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Primary industry	2.3	2.1	0.0	1.3	1.0	1.0	0.9	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8
Building and construction	-2.5	1.8	3.3	1.4	1.6	1.7	1.8	1.9	1.9	1.9	1.6	1.6	1.5	1.4	1.2	1.2	1.2
Manufacturing	2.3	0.9	3.2	1.6	2.1	2.1	2.0	1.9	2.0	2.0	1.7	1.7	1.7	1.7	1.7	1.6	1.7
Public service	1.6	1.3	0.8	0.9	0.9	0.4	0.4	0.4	0.4	0.5	0.7	0.7	0.6	0.7	0.7	0.7	0.7
Commerce	0.5	1.4	3.4	2.8	2.8	2.8	2.6	2.6	2.4	2.5	1.8	1.8	1.8	1.7	1.7	1.7	1.7
Financial services	1.4	0.4	0.5	0.4	0.2	0.2	0.3	0.3	0.3	0.3	1.4	1.4	1.4	1.4	1.4	1.3	1.3
Other, Services	6.4	2.1	2.6	2.2	2.3	2.3	2.2	2.2	2.2	2.2	2.5	2.5	2.5	2.4	2.4	2.4	2.4
Average	2.3	1.4	2.4	1.7	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6
BVT growth	1.2	1.5	2.3	1.7	1.9	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7

The projection of road transport, rail transport, domestic ferries and freighters, together with domestic air transport is documented in the report "The transport sector's energy consumption and emissions", Danish Road Directorate, 2002. The projection is based on, among other things, the same economic assumptions as the EMMA projection above.

The armed forces' consumption of transport energy is kept at a level corresponding to the average for 1998-2001. International shipping and border trade with diesel are kept at the 2001 level.

Tables 5.14, 5.15 and 5.16 show a number of key figures and key assumptions for the projection.

Additional information on the methods used in the projections is available in Environmantal Project No 764, published by the Danish Environmental Protection Agency in February 2003.

Table 5.15 Development of energy prices, excl. taxes, deflated

Annual growth %	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Price of crude oil	-6.8	-7.9	-7.3	-0.1	0.0	0.0	0.0	0.0	0.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7
Price of gas	-9.6	-7.3	-7.6	-3.7	0.0	0.0	0.0	0.0	0.0	1.0	1.8	1.8	1.8	1.8	1.7	1.7
Price of coal	-15.1	3.3	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Price of electricity	9.1	2.1	-1.2	-2.2	-0.8	-1.3	-1.2	-0.7	-0.4	-0.5	-0.4	0.0	0.0	0.0	0.0	0.0
Price of district heat	-11.2	-0.4	-0.6	-0.9	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.8	0.8	0.8	0.8	0.8

Table 5.16 Index of growth in households and housing unit area in Denmark

1 Economic Report, Ministry of Finance, January 2002, and Financial Report 2001 from the Ministry of Finance

2 World Energy Outlook 2002, IEA

3 The forecast is based on afforestation continuing as hitherto up to 2012.

Year	Households	Housing unit area
2001	100	100
2005	102	102
2012	106	107
2030	114	117

6. Vulnerability assessment, climate change impacts and adaptation measures

6.1 Climate in the future

Future climate change as a consequence of man-made impacts through increased greenhouse effect, depletion of the ozone layer and aerosol emissions are evaluated by means of climate models. Climate models, which are based on the laws of physics and ascertained relationships, are mathematical descriptions of the components of the climate system: atmosphere, ice, ocean, and snow, land surfaces and the biosphere. The calculations are performed in a large computer system and the models are becoming increasingly complex.

6.2 Climate trend in Denmark

6.2.1 The latest developments

Denmark is situated on the west side of the European continent, between the mainland and the Scandinavian peninsular in a marine area and therefore has a coastal climate. DMI's statistics[1] show that the average mean temperature in the 1990s was slightly more than 8°C after having risen just under 1°C since 1870. The mean temperature is almost 16°C in the summer quarter and around 0.5°C in the winter quarter.

Average annual precipitation (measured values before precipitation adaptation) in the 1990s was about 735 mm and has thus risen by almost 100 mm since 1870. There are, however, significant regional differences. West and Southern Jutland have most precipitation (over 900 mm) and the Eastern islands less (slightly more than 500 mm).

The water level in Danish waters has generally risen in the last 100 years, but after adjustment for land movements, there has been no general rise in water level in Danish waters. However, since Denmark tilts, the water level in the southern part of the country is rising by about 1 mm per year. Unfortunately, the region in question has many low-lying, vulnerable areas.

6.2.2 Projected climate changes in Denmark

For several reasons, the basis for evaluating the impacts of the man-made increase in the greenhouse effect is uncertain. Serious problems are that the magnitude of future greenhouse gas emissions is uncertain and that the climate models are encumbered with uncertainty.

DMI/Denmark's Climate Center (in cooperation with, inter al., Max Planck Institut für Meteorologie in Hamburg) has carried out global and regional calculations for several scenarios for future emissions of greenhouse gases and aerosols – namely, IPCC's IS92a-Business-as-Usual scenario and the new A2 and B2 scenarios from IPCC's special report – SRES-2000 – on emissions scenarios[2].

Calculations with global and regional climate models show the following trend for the climate in Denmark in 2100 compared with 1990:

- A rise in the annual mean temperature of 3-5°C, depending on the

chosen scenario. Greatest warming in winter and at night. This would mean generally smaller daily and seasonal variations. There would be only a slight difference in the temperature rise in summer and winter.
- An increase of 10-40% in winter precipitation and presumably a slight fall of 10-25% in summer precipitation. A tendency towards lengthy periods of drought in summer and more episodes with very heavy precipitation, particularly in autumn because the amount of precipitation falling in showers with an intensity of more than 15 mm/day would increase by about 50%.
- A tendency towards a general increase in westerly winds at the same time as the storm courses over the North Atlantic shift slightly eastward, leading to a small increase in storm activity over Denmark and the adjacent waters. Although very uncertain, the following calculations with storm flood models show that the highest water level in the biggest storm floods could rise by 5-10% in relation to today[3].

There would be a combined effect on the run-off, i.e. the water running in watercourses. For Denmark, there would be an increase of the order of 10% in the period December to April. A generally larger run-off of storm water in the Baltic region could make the surface water in the inner Danish waters less saline. This could affect fish stocks.

The calculations carried out do not directly provide scenarios for future changes in the water level around Denmark, but previous studies[4] show that the rises in water level around Denmark would be slightly smaller than the average global rises because of vertical land movements. For example, it is estimated that an average global rise in water level of 0.5 m would lead to a rise of about 0.4 m around Denmark. These figures do not account for the regional impact on water level of changed ocean currents, flow, temperature, and wind conditions. The wind effect alone gives a rise of 3-5 cm[5]. IPCC estimates that the global water level would rise 0.1-0.9 m in the period up to 2100 in the SRES scenarios. In Danish impact and vulnerability studies, rises in water level of 0.25-0.50 m are usually used.

6.2.3 Impacts and Denmark's possibilities for adaptation

Earlier evaluations

The impacts of possible climate changes in Denmark have been evaluated several times since 1988 and most recently with various aspects in the report: "Climate Change Research – Danish Contributions" edited by A.M.K. Jørgensen, J. Fenger and K. Halsnæs in a cooperative project between DMI, NERI and Risø and published by DMI in 2001, and have been treated in greater detail in the report "Danish adaptation to a changed climate" (J. Fenger and P. Frich), published by NERI in 2002.

The general conclusion has been that the direct impacts in moderate climate scenarios would be modest and could be countered by suitable ongoing adaptation. Danish studies of – and preparations for – impacts from climate changes have been very limited in their scope, and no action plans yet exist. However, the Danish Nature Council recommended in a report from 2000 (Vismandsrapport 2000) that preparedness be built up against the consequences of climate change for nature. It is suggested that the preparedness be based on technical reports and that relevant monitoring of nature follow it.

There have not as yet been any evaluations of secondary impacts for Denmark in the form of changed tourist destinations, environmental refugees, etc. or any evaluations of impacts from changed conditions in other countries on a little, open economy like Denmark. For an export-oriented industry like Danish agriculture, such secondary impacts could easily be more important than the primary impacts.

Water resources

The quantity of water resources is affected by both the availability of water from nature and water consumption. With the prospect of summers that may be both hotter and drier, an increased demand for water for several purposes can be expected:

- Domestic consumption would rise, in part because of garden watering unless restrictions were imposed.
- Farmers' need to irrigate their fields would increase significantly, and the present problems in the form of conflicts of interest between agriculture and the environment must be expected to increase.
- Nature's need for water to maintain wetlands etc. would be affected. However, the individual wetlands can be expected to behave differently, depending on, among other things, the local geological conditions.

There is a fundamental difference between free groundwater reservoirs, where the formation of groundwater depends on the net precipitation, and artesian reservoirs, where the formation of groundwater depends mainly on pressure differences between upper and lower reservoirs. Moraine areas are generally less vulnerable to climate change than areas with sandy soil. Besides this, however, a permanent climate change can be expected to affect land use (other crops, longer growing season) and, through this, the size of the evapotranspiration. Similarly, a change in the pattern of precipitation in the form of increased intensity could affect the run-off pattern and thus also the formation of groundwater.

Just as important as the quantity of groundwater is its quality, and here, the climate plays a role, albeit an indirect one. In Denmark, almost all fresh water is produced in potable water quality and from groundwater. Salt (NaC1) in the water is normally due to deposits in the subsoil. Only in a few areas does penetration of seawater play an important role such as small islands, e.g. Langeland and Samsø, and near low-lying coasts, e.g. along Køge Bay. With a rising sea level, salt penetration would increase and can be expected to reduce water recovery in slightly more places than is the case today.

Agriculture

The combined impacts are expected to benefit Danish agricultural productivity. Changes in cultivation practice can be implemented at short notice, and production is expected to increase with rising temperature and CO_2 concentration. There is at present a trend towards less cattle production and more pig and grain production. The projected climate changes could reinforce this trend because market constraints in the dairy sector would limit production and more land and grain would be available for pig production at competitive prices.

However, higher temperatures would increase the risk of pests and plant diseases resulting in an increased demand of pesticides. At the same time, increased production would require more fertilisers, which, together with more precipitation and higher winter temperatures, would increase the risk of nitrate leaching. Here, it might be necessary to change the environmental legislation to ensure a cost-effective agricultural sector and protect water resources in a changed future climate.

Forestry

Danish forestry is characterised by a long duration of production determined by the rotation age of the trees, which is between 50 and 180 years. Long-term planning based on the most suitable species and genotypes in an optimal forest structure is therefore necessary.

Danish field and greenhouse studies have indicated that the projected climate change would promote tree growth, particularly for species with natural distribution having its northern limit in Southern Scandinavia. The only tree species expected to show decline is Norway Spruce, which has its natural distribution southwest of Denmark, but which has become the most common tree species in Denmark through planting. After the wind fall in December 1999 new planting of other species has become more widespread.

Forests are important carbon sinks, and reforestation, deforestation, and afforestation figure in the national CO_2 inventories. The planned doubling of forest land in Denmark during the next 100 years could sequester around 5% of the national emissions.

Natural ecosystems

Denmark is centrally situated in a natural vegetation area with temperate deciduous forests, and this will not change significantly. However, many species of fauna and flora have the limit of their dispersal in or around Denmark, and a northward shift could therefore be expected. Not all alien species are equally welcome, particularly in agriculture. The Colorado beetle has its northern limit just south of Denmark. The progress of the Iberian forest snail in recent years may be connected with a generally milder winter climate. The spread of new species is made difficult by the fact that the landscape is very fragmented. This may mean a reduction in species diversity for a time but can be remedied by Denmark's intensive nature preservation and management of nature.

Freshwater ecosystems are sensitive to the quantity of water and can be burdened by reduced precipitation in the summertime. The effect may be intensified if increased leaching of nutrients occurs.

Coastal protection
The Danish coastline consists of raised beaches and wide foreshores in the northern part of the country and an archipelago to the south. The coastline is relatively long, about 7,400 km for an area of 42,000 km^2. 80% of a population of 5.33 million (1.1.2000) live in urban areas connected to the coast. The vulnerable areas are particularly raised seabed, marshlands, and reclaimed land, where 60-70,000 properties are situated.

Around 1,100 km of the coastline are protected by dikes and 700 km by other permanent installations. Increasing use is being made of soft solutions – particularly beach feeding. As yet, direct planning for rising water levels beyond the present secular rise is extremely modest and purely qualitative.

However, some thought has been given to the possible impact on coastal ecosystems, particularly salt marsh and dune areas. Here, the pattern of action will depend on the attitude to – and weighing up of – economic, sociological and biological interests and possibilities. The general strategy seems to be in the direction of preservation of a natural coastline – at the cost of agricultural land if necessary[6].

Infrastructure
In connection with the construction of coastal infrastructure, including bridges, harbours, sewerage installations, etc. the general attitude has been "wait and see". Economic evaluations have been unofficial or lacking altogether.
However, in connection with the planning of the new metropolitan district "Ørestad" on the partially reclaimed land on the island of Amager near Copenhagen, a rise in water level of around 0.5 m was taken into account for the stairs leading down to Metro stations.

Fisheries
Higher temperatures and lower salinity in Danish waters would affect the survival, growth, and reproduction of the present fish population. It would also result in a longer growth season for plankton and thus favour species that directly live from plankton. This could include sardines[7].

Energy consumption
Denmark has a reasonably cool climate now and no tradition for air conditioning (although many new cars are now fitted with an air-conditioning system). Less need for heating would therefore presumably mean lower energy consumption.

Health and well-being
In the next 100 years the projected climate change would hardly give Denmark a climate that differs significantly from today's climate in, for example, Northern France. Direct health impacts in the form of a higher risk of heat stroke or a reduced risk of colds can therefore not be expected.

On the other hand, a number of indirect impacts can be predicted. A considerably larger amount of pollen and a several weeks' earlier start to the pollen season have already been observed. This could be the reason for the increase in allergy cases. In addition, vector-borne diseases could occur with invasion by, for example, malarial mosquitoes.

Infection via refugees (possibly environmental refugees) and immigrants would increase the risk not only of "southern" diseases, but also of diseases that are at present under control in Denmark – e.g. tuberculosis.

A warmer climate could also increase the risk of photochemical air pollution, which, in Denmark, is mainly due to long transport from Central Europe and elsewhere.

Greenhouse gas emissions
A changed climate could in many cases mean changes in greenhouse gas emissions and thus a feedback effect on the climate system. Possible sources affected, besides energy production and forestry, are different forms of agricultural activities, including livestock (methane) and use of manure (nitrous oxide). The consequences of going over to organic farming have been discussed, although without any clear conclusions.

6.3 Climate changes in Greenland

Greenland has an arctic climate. 82% of the land is covered by the up to 3km-thick ice cap, while the ice-free land areas are limited to a coastal strip up to some hundred kilometres wide. However, furthest south, the climate is sub-Arctic with a mean temperature of more than 10°C in the warmest month, while the climate in the rest of Greenland can be divided into a low-Arctic zone and a high-Arctic zone. The low-Arctic zone, which extends northward to Melville Bay on the west coast and to Scoresbysund on the east coast, is characterised by relatively mild winters with a lot of snow and periods of thaw and summers with a mean temperature of 5-10°C in the warmest month and frequent rain. This description applies particularly to the maritime coastal zone, while, inland, Southwest Greenland has a winter climate that is more like high-Arctic

The high-Arctic region, which covers the entire northern and north-eastern part of Greenland, has a continental climate with very cold winters (more than 50 degrees of frost occur in North Greenland), in which the temperature rarely rises above zero from September to May, and in which winter precipitation is limited. Parts of North Greenland have a desert-like climate with only about 25 mm precipitation per year, or about 1% of the precipitation at the southern point of Greenland. The continental climate in high-Arctic Greenland is due to field ice, which often constitutes a several-hundred-kilometre wide belt of tightly packed polar ice that drifts down along the east coast and so to speak "extends" the land out to sea. The climate in high-Arctic Greenland is therefore greatly influenced by precisely the amount of field ice.

Calculations with global climate models[8] show the following general trend for the climate in Greenland in 2100 in relation to 1990:

- A rise in the mean annual temperature in South Greenland of about 2°C, slightly more in winter than in summer. In North Greenland temperatures would rise by 6-10°C in winter, but only slightly in summer.
- A general increase of 10-50% in precipitation, but little or no increase in summer in South Greenland. However, in winter, the increase would be considerably bigger in North Greenland, locally up to more than 100%.

Almost the entire population of Greenland live in towns and villages in the low-Arctic part of the country, with most living in South-west Greenland, which has the mildest climate, and where the main industry is fisheries. Only in the southernmost part of the high-Arctic region, in Thule towards the northwest and in Scoresbysund on the east coast, are there small communities that live to some extent from hunting mammals and birds.

A description is given in the following two sections of what could or would happen on land and in the marine environment as a consequence of the expected climate changes. The description is based exclusively on general evaluations[9] with the present extremely limited knowledge concerning factors determining the welfare of the species and ecosystems in question[10].

6.3.1 Impacts and adaptations in terrestrial ecosystems

The very big differences between the climate in the low-Arctic and high-Arctic parts of Greenland are reflected in marked differences in the natural conditions in the two parts. Low-Arctic Southeast and West Greenland are characterised by luxuriant vegetation with bushes and often thick plant cover. In winter the snow often lies deep and soft from November to some time in May. Unlike this, in Northeast and North Greenland, the plant cover is usually only a few centimetres high, and increasingly large areas are entirely without vegetation as one moves northward. This is because of the poor snow cover, with many areas blown free of snow for most of the winter, while the rest is covered by often tightly packed snow that does not disappear until the end of June or the beginning of July.

The Arctic fauna and flora, which, compared with the situation in more southern climate zones, are poor in species, are adapted to the extreme climatic conditions. Some plants, invertebrates, and mammals depend on stable snow cover to protect them from the cold. However, many other species are dependent on the snow disappearing early – or being blown away altogether in winter. The distribution, duration, and thickness of the snow cover are therefore just as important factors as the temperature in the general conditions of life for many plants and animals in Greenland.

The importance of the snow cover
As a consequence of earlier snow melting in low-Arctic Greenland, higher summer temperatures and more summer precipitation, a long growth season can be expected and thus a more extensive and vigorous plant cover. Immigration of species from the south can be envisaged, but would be impeded by barriers in the form of the waters and competition from already established species. Conversely, species with a more northerly dispersal could disappear from southern areas.

In high-Arctic Greenland, more ample precipitation in both summer and winter, together with slightly higher summer temperatures, would presumably mean increased growth and more extensive plant cover, and it can be envisaged that large parts of this zone would change character in the direction of low-Arctic conditions. However, the increased snow cover would delay melting, which would impede plant growth and delay plant reproduction or make it completely impossible. There would be a risk of more northerly species, such as sabine ranunculus, disappearing altogether.

The increased UV-B radiation as a consequence of the depletion of the ozone layer, which is expected to continue for a couple of decades, would presumably cause problems in Arctic plants that are adapted to low UV-B radiation. The extent to which the plants would be able to adapt to the greater radiation is not known.

The carbon balance and the permafrost
Increased microbial activity and thicker active strata (the part of the earth that dries up on top of the permafrost) would also release more greenhouse gases, but in the case of carbon dioxide, this would be counteracted by a bigger uptake in the plants as a result of the increased growth. Owing to Greenland's very hilly landscape, there are not the very large layers of peat that are so widespread in parts of Siberia and Canada. For this reason, Greenland's contribution to the feared release of enormous quantities of carbon dioxide from such peat layers would presumably be modest.

Mammals
A great deal of Greenland's fauna would presumably also benefit from a milder climate and consequently more luxurious and widespread plant growth, although there are important exceptions. Many of the species in high-Arctic Greenland are dependent on the low-precipitation continental climate. This applies, for example, to the musk ox, where thicker snow cover and more frequent periods of thaw in winter (with the formation of ice crusts in the snow) could make it difficult for the animals to forage. Examples of this are al-

ready known with the present climatic conditions, and reindeer died out for the same reason in the whole of high-Arctic Greenland during a snowy period more than 100 years ago. The artificially established population of musk oxen in South-west Greenland are hardly likely to suffer similar problems. On the contrary, both reindeer and musk oxen might thrive even better in the continental low-Arctic region.

Birds

Another "risk group" is the high-Arctic waders, which are the dominant bird group in Greenland. Nine out of ten of Greenland's 11 species of wader are only found in – or have their main dispersal in the high-Arctic part. They are totally dependent on the sparse vegetation. Later melting of snow would also impede their reproduction since they are entirely dependent on early snow melting both in order to procure sufficient food, mainly in the form of early active arthropods and in order to be able to lay eggs on such large snow-free areas that the foxes cannot find all the nests. On top of this there is the prospect of the large wading areas that these birds make outside the breeding time in temperate and tropical climate zones being permanently flooded as a consequence of the expected rise in sea level.

Immigration of new animal species

Many insects and other arthropods could spread northwards, and new species, particularly of mobile insects and birds, could immigrate from the south, but they would undoubtedly come from regions where they are already common and would thus from a global point of view be unable to replace any loss of high-Arctic species, which would be definitive.

Humans

Seen from the point of view of local society, the changes mentioned in the terrestrial ecosystems would be of limited practical importance and perhaps even an advantage in the form of more plant growth, more reindeer and musk oxen and perhaps better possibilities for farming in South Greenland. The increased thawing of the permafrost could bring problems in areas where houses and other structures are founded in the permafrost, but since the vast majority of structures in Greenland stand on solid rock, the problem would only be a local one. Increased melting of the ice cap would provide more water – for hydropower for example – but this resource is not generally a constraint today. The cost of heating in winter would be reduced and there would be generally fewer problems in connection with hard frost.

The possible loss of biodiversity, for example in the form of bird species in the high Arctic, would mean a loss of experiential quality, not only there but also in the birds' resting and wintering grounds. There would thus be a risk of most of the high-Arctic zone disappearing together with the special fauna and flora that are adapted to precisely this zone. Most of the continental high-Arctic areas are in North and North-east Greenland and on the northern Canadian islands.

6.3.2 Impacts and adaptations in marine ecosystems

In North-east Greenland the expected climate change would result in the thickness of the ice halving in the fjords and a doubling of the ice-free period. As a result, about 60% more light would penetrate down in the water column, which would stimulate the production of both plankton algae and bottom-living algae. However, the increased precipitation (snow) would impair the light conditions in the ice in early spring and probably have an adverse effect on the production of sea-ice algae and the animals that benefit from the early production. All in all, however, production would increase.

Algae, water copepods, mussels, and walruses

An increased fresh water supply as a consequence of increased precipitation and melting of the ice cap in the inner parts of the fjords would increase the water exchange in the fjords and bring more nutritious water in from the open sea and thus contribute still further to increased primary production. The increased production would have a powerful effect in the top levels of the food chain. Today, water copepods (crustaceans that live on algae) are limited by food, and stimulation of plankton production would immediately mean increased grazing and growth of copepods. Sedimentation of the copepods' faeces would therefore increase, thereby increasing the quantity of food for bottom-living animals. This would, for example, increase growth in mussels, which are today very limited by food.

The increased mussel growth would benefit walruses. Rising winter temperatures would mean that the ice did not reach the same thickness as today and would therefore break up more easily in spring and that the walruses could seek food on the mussel banks for longer periods.

Problems for polar bears

The polar bear, on the other hand, is facing an uncertain future in East Greenland. If the ice disappeared it would reduce the bears' hunting grounds and they would probably follow the ice northwards. Seals, which are attached to the ice, would presumably become concentrated in smaller areas with ice and would therefore be more easily accessible to the bears, but in the longer term, the number of bears would decrease. In addition, the polar bear is not good at hunting seals in water. The ice conditions on the west coast of Greenland would probably not change as much as on the east coast, and the polar bears off the west coast would therefore be less affected by the climatic changes than those off the east coast.

Fish

Rising surface temperatures would also have a major effect on the composition of fish in the high-Arctic zone. In the case of rock trout, reproduction ceases when the temperature rises above 5°C because the enzymes in the egg sacs denature when the temperature is just a little over 5°C. As a result, the eggs rot in the body and the fish dies. At the same time, a number of Arctic fish species would be more exposed to parasites and bacterial and fungal attack, and their immune defence system would be reduced with rising temperatures.

For many of Greenland's fish species, the seas off Greenland limit their dispersal, for example, cod, Norway haddock, striped catfish, halibut and herring, which have their northern limit there. Conversely, too high sea temperatures set a southern limit for the dispersal of Arctic species, such as polar cod, and Arctic roc. Therefore, relatively small variations in the temperature of the sea could result in considerable fluctuations in the dispersal of many fish species. The trend in cod fishing largely follows the average sea temperature. In the last 30 years, cod and a number of other boreal fish species have largely disappeared as a consequence of a generally colder climate in South and West Greenland. Today, more cold-adapted populations of prawn, crab, and halibut constitute the main commercial fishing resources in Greenland.

A change in sea currents and a rise in temperature as a consequence of the climate changes would probably improve the conditions of life for cod and some other commercially exploited fish species in these areas. However, a larger cod population would have an adverse effect on the prawn population due to predation. It can therefore be envisaged that there would be a change in the fishing resources from dominance by prawns today to dominance by cod towards the end of this century.

Crabs, copepods, and sea birds

There are no crabs in areas with temperatures below 0.5°C, which characterises large areas off East Greenland. The temperature rises in the future would perhaps mean that crabs would migrate into the area and thus distinctly change the composition of bottom-living animals.

Another marked change that could happen is a change in currents, so that North Atlantic sea water containing a smaller species of copepod (*Calanus finmarchicus*) could penetrate areas that are today dominated by polar water with larger and longer-living species of copepod (*C. Glacialis and C. hyperborus*).

If *C. finmarchicus* ousted the larger species it would have very serious consequences for little auks, which breed in their millions in the Thule area and around Scoresbysund, and which are specialised in foraging along the edges of ice with high concentrations of food animals. The little auk lives almost exclusively from the large species of copepod and could not get enough energy out of the little copepod. Polar guillemots, among other sea birds, would perhaps have more difficulty in West Greenland, but the populations there have already been reduced to some few per cent of the natural population by hunting, so the climate would undoubtedly be of secondary importance. Conversely, the Atlantic guillemot would be able to immigrate in large numbers in South-west Greenland, just as a number of other sea bird species would benefit from the increased marine production and the reduced ice cover.

Whales
Whales, which are associated with sea ice, such as the narwhale, the white whale, and the Greenland whale, would have reduced living areas in the winter months, while new areas would become available to them in the summer months. However, the reduced drift ice would mean reduced areas with concentrated food along the edges of the ice in the same way as for the little auk. In winter, the whales would get increased competition for food from other marine mammals. Other species of whale that use the Arctic and north boreal waters in summer would be able to use more northern areas.

Our knowledge about the way the ecosystems function is constantly improving, but in the case of such large changes in such a short space of time, we as yet know too little to make precise predictions. One of the biggest uncertainties in connection with the marine environment in South Greenland is the extent to which the sea currents and thus sea temperatures follow changes in air temperature. The balance between the part of the seawater in Southwest Greenland that comes from the cold East Greenland Current and the part that comes from the warm North Atlantic drift (a branch of the Gulf Stream, which bends westward, south around Iceland), and the cold water masses in Baffin Bay and Davis Strait, thus totally determine the ecological conditions off Southwest Greenland, where most of Greenland's population live.

Humans
For Greenland society, a warmer climate would probably mean increased fishing in the form of more cod, Norway haddock and other species, but fewer prawns. The possibilities for hunting ring seals and polar bears would probably be reduced, while the occurrence of several other game animals would depend more on the pressure of hunting itself. Communication conditions would be much better because the period of open water would be longer, making it easier for boats to call at many towns and villages. There would be far less field ice, but on the other hand, a reduced possibility of using the ice to get from place to place.

Retraction of glaciers and the ice cap, together with less "Arctic wilderness" could adversely affect the tourist industry, but the improved communication – including a longer summer season – could have a beneficial effect.

6.4 Climate changes on the Faroe Islands

Calculations with global climate models[11] show the following general trend for the climate on the Faroe Islands in 2100 compared with 1990:

- A rise of about 3°C in the annual mean temperature. There would be only a slight difference in the temperature rise in summer and winter.
- An approx. 25% increase in winter precipitation, but only a small or no increase in summer.

6.4.1 Impacts and adaptation in terrestrial and marine ecosystems

Only minor changes in terrestrial ecosystems are expected. The isolation of the Faroe Islands in the Atlantic Ocean may have the consequence that climate-induced changes in plant and animal life will be unbalanced. Thus, the rate of possible species loss from terrestrial ecosystems may not be counterbalanced by a similar immigration rate, resulting in reduced species diversity.

The greatest changes are expected at sea, although the uncertainty is also greatest here as long as the fate of the North Atlantic Current has not been clarified. Warmer deep water could result in a redistribution of pelagic and benthic communities.

Impacts on plankton would be similar to those mentioned for Greenland. Fish species that settle in shallow waters in the early spring such as flatfish, lumpfish, and species with pelagic drifting eggs and larvae would have a high risk of UV-B induced damage.

Effects on marine mammals and sea birds are expected mainly to concern spatial shifts in areas of food production and primary productivity (changes in upwelling sites), nesting and rearing sites, and increases in diseases and oceanic biotoxin production (from both temperature increase and current changes).

The reappearance of cod seems highly dependent on what happens to sea currents. That there have been three to four times as many storms as normal in recent years has contributed to the disappearance of the cod by blowing the fry towards waters too cold for their survival. A reduction in water arriving from the south would worsen the present lack of the fry's favourite food.

1 Cappelen, 2000
2 Christensen, 2000; Stendel et al., 2000; Stendel et al., 2001; Christensen and Christensen, 2001; May,1999; May, 2001; Andersen et al., 2001
3 Kaas et al. 2001
4 Duun-Christensen, 1992
5 Kaas et al, 2001
6 Fenger, J., Buch, E. and Jakobsen, P. P., 2001
7 MacKenzie, B. R., Visser, A. W., Fenger, J., Holm, P., 2002
8 May, 1999; Stendel et al., 2000
9 The evaluations were carried out by Hans Meltofte and Søren Rysgaard, DMU, and Søren Anker Pedersen, Greenland Institute of Natural Resources, March 2003.
10 Vibe, 1967; Heide-Jørgensen and Johnsen ,1998; Petersen et al., 2001; Meltofte, 2002; Rysgaard et al., 2003.
11 May, 1999; Stendel et al., 2000

7 Financial resources and transfer of technology

7.1 Danish development policy

Denmark's vision for regional and global sustainable development is a world with economic development, social welfare, and greater protection of the environment. It includes a world market with free trade based on high environmental and social standards, and it includes respect for human rights, democratisation, transparency, and responsibility in administrations.

Through both foreign policy and environment policy, Denmark will work actively to promote international action. Danish international assistance is still well above the UN objective of 0.7 per cent of GNI. Denmark attaches importance to ensuring coherence between development, environment, and trade policy.

Denmark wants a strong global structure to promote all elements of global sustainable development, including a stronger structure for promotion of international environmental cooperation and environmental regulation.

The effort to promote national sustainable development is closely linked to the global challenges for sustainable development – and vice versa. Growing trade and international capital flows, conflicts and refugee flows, together with the increasing pressure on natural resources, have made individual countries ever more dependent on the outside world. Denmark therefore has a great interest in contributing to sustainable development through national efforts and through the EU, the UN, the WTO, the OECD, and the international financial institutions, including the World Bank and the International Monetary Fund.

The world is facing many regional and global challenges. Of the world's approximately 6 billion people, 2.8 billion live on less than 2 dollars a day and 1.2 billion live on less than 1 dollar a day. The challenge therefore consists primarily in eradicating poverty and creating better conditions of life for the poor people of the world. For example, one fifth of the world's people do not have access to clean water and sanitation, and this particularly affects women, children, indigenous peoples, and other particularly exposed population groups.

The battle for scarce natural resources is in some cases the cause of violent conflicts, creating immense refugee problems, particularly in the developing countries. Analyses from the Intergovernmental Panel on Climate Change (IPCC) show that climate change is very probably already a reality, and it is in the developing countries that the greatest adverse effects of climate changes are expected. Biodiversity is under increasing pressure, and nature's resources are often used on an unsustainable basis. The use of dangerous chemicals is a growing problem, both for human health and for fauna and flora.

There is often a close correlation between poverty and environmental problems. It is often the poorest people that are worst affected by the deterioration of the environment. At the same time, poverty limits the possibilities for sustainable utilisation of natural resources because limited resources are available for investment in protection of the environment. For example, poverty is contributing to soil exhaustion and desertification in Africa. Conversely, uncontrolled economic growth in developing countries and the slightly more developed countries in the East and South often leads to increased use of natural resources and burdens the environment.

In its entire international work for global sustainable development, Denmark attaches importance to the need to integrate and balance the economic dimension (poverty-oriented growth), the social dimension (promotion of such social sectors as education and health) and the environmental dimension (protection of the environment).

Denmark will continue working for global sustainable development by
- decoupling economic growth, resource consumption and deterioration of the natural resource base integrating environmental considerations in policies and decisions
- ensuring continued progress in the global environmental agenda
- promoting economic cooperation and partnership for development, including combating global poverty and regulating trade and investments
- contributing to international peace and stability and working to promote democracy and human rights
- working for continued development and democratisation of the international cooperation with the emphasis on openness and participation; including participation by weaker groups
- developing an environmental policy that promotes realistic international cooperation on reducing pollution in a cost-effective manner
- promoting mutually obligating partnerships with the private sector.

7.1.1 Development cooperation

Since the change of government in Denmark in November 2001, the government has reviewed Denmark's development assistance and environmental assistance to developing countries with the objective of prioritising it, focusing it, and making it more effective.

The agreed changes to the assistance on this basis mean, among other things, that more is required of the governments in the cooperation countries with regard to respect for human rights and democracy. Systematic and lasting violations of human rights and democratic rules of play will no longer be accepted. This has led to Denmark ending its assistance cooperation with Eritrea, Malawi, and Zimbabwe. This leaves Denmark with 15 programme cooperation countries – Bangladesh, Benin, Bhutan, Bolivia, Burkina Faso, Egypt, Ghana, Kenya, Mozambique, Nepal, Nicaragua, Tanzania, Uganda, Vietnam, and Zambia.

The Danish development cooperation is financed mainly by the facility for assistance to developing countries (DKK 10.5 billion in 2002), the main purpose of which is to promote sustainable development through poverty-oriented growth. Equal participation by women and men in the development process, consideration for the environment and democratisation are of vital importance to combating poverty and are therefore integrated in all aspects of Denmark's assistance.

In 1999 Denmark was awarded top marks in OECD's regular reviews of assistance to developing countries. The latest OECD review of Danish assistance took place in the spring of 2003, and the result of the review is pending.

Thorough environmental analyses will play an essential role in the coming years' revision of the country strategies for Denmark's programme cooperation countries. Another important task will be to seek better integration of the objectives of international environmental agreements in the bilateral assistance cooperation. In the Appropriations Act for 2003 the government has chosen to prioritise a number of areas and to earmark further resources for them. The areas include good governance, assistance to refugees in local areas, environment, industrial development, women, and trade and development.

Denmark seeks actively to get the many countries – including the EU countries – whose development assistance is below the UN objective of 0.7% of GNI to increase their assistance. Denmark will continue in the absolute lead in development assistance, with Denmark's assistance expected to be around 0.9% of GNI at factor cost in 2003.

7.1.2 New and additional assistance funds

Bilateral action

Denmark is at the leading edge with respect to making funds available for environmental action in the developing countries and in Central and Eastern Europe. It makes funds available partly through assistance under the facility for assistance to developing countries, which, as mentioned in the foregoing, has combating poverty in the developing countries as its main objective, and partly through the establishment of the Environment, Peace and Stability Facility (MIFRESTA) as an element of the follow-up on the Rio Conference in 1992. Through the latter, considerable funds have been spent on environmental action in developing countries, Central and European countries and the Arctic since 1993. Under MIFRESTA, Denmark is also engaged in the refugee area and prevention of conflict.

In the poorest of the developing countries, assistance is aimed particularly at relieving poverty-related pressure on the environment and nature, and in close cooperation with the recipient countries, Denmark provides considerable assistance to areas of relevance to sustainable development. This applies, for example, to the drinking-water area, where the action is helping to ensure millions of poor people access to water and to

Table 7.1 Danish total development and environmental assistance 1997-2000

	Contribution mill. DKK				
	1997	1998	1999	2000	2001
Bilateral development assistance	5,226.96	5,421.37	5,520.70	6,160.72	6,409.41
Of which environmental assistance	290.25	207.19	311.03	287.05	336.36
MIFRESTA[1]	311.4	374.9	486.4	508.2	903.5

protect sources of water – e.g. by tree planning and by building up capacity for sustainable management. In the energy area Denmark provides support for sustainable energy supply – e.g. supporting poor women in planting trees for fuel, which provides the women with an income and at the same time, protects the environment. Within nature resources, Denmark is working to strengthen sustainable management and production with a view to preventing soil exhaustion and desertification. In the richer developing countries with growing economic activity, the assistance is aimed at helping the countries with environment and nature protection, primarily by strengthening their own capacity to solve the problems and by increasing environmental awareness.

In Central and Eastern Europe, Denmark's environmental assistance is aimed at solving acute environmental problems and at getting the EU's environmental rules implemented in the candidate countries. Since 1990 many concrete environmental projects have been carried out that improve the state of the environment in Denmark's neighbouring areas. In the Arctic, transboundary pollution is being monitored. Transboundary pollution is an indicator of regional and global pollution since the polar region is very environmentally sensitive. A number of projects are also being carried out in Greenland. Environmental assistance is mainly provided bilaterally – from Denmark directly to another country.

Denmark's special environmental assistance under the MIFRESTA Facility increased up to 2002. Since then, however, this assistance has been considerably reduced because of increased requirements to the recipient countries to take more responsibility for the action, and the number of countries that can receive this assistance has been cut. The MIFRESTA countries are now Botswana, South Africa, Namibia, Mozambique, Tanzania, Vietnam, Cambodia, Thailand, and Malaysia, while assistance to Swaziland, Lesotho, Malawi, Zimbabwe, Zambia, and Laos has been cut altogether.

Overall, Denmark will continue to provide extensive assistance for the benefit of the environment in the developing countries, since it is estimated that more than 15% of the facility for assistance to developing countries is spent on environmental assistance.

Table 7.2 Danish bilateral and regional assistance in 1997 in relation to implementation of the Climate Convention (DKK mill.)

	Mitigation						Adaptation		
Recipients Country/ region	Energy	Transport	Forestry	Agriculture	Waste	Industry	Capacity building	Coastal zone manage ment	Other
Burkina Faso	0.1								
Egypt	12				2		7	4	21
Malaysia			9.5				7.7		
Nepal			7.36	3.89					
Nicaragua			76				7		
Regional			2						
Thailand	12.3					4.2	7.5		
Vietnam			3						
Zimbabwe			4						

Table 7.3 Danish bilateral and regional assistance in 1998 in relation to implementation of the Climate Convention (DKK mill.).

	Mitigation						Adaptation		
Recipients Country/ region	Energy	Transport	Forestry	Agriculture	Waste	Industry	Capacity building	Coastal zone manage ment	Other
Bhutan			1.04			0.43			
Bolivia									20
Burkina Faso	2.5								
Egypt	89						12	2	8
Laos			1						
Lesotho							12		
Malaysia						3.2	5	12	
Nepal			3.78	2.94					
Swaziland			3				7		
South Africa							3		
Thailand	2.9		6.4			1.5	5		
Vietnam			4.8						

Table 7.4 Danish bilateral and regional assistance in 1999 in relation to implementation of the Climate Convention (mill. DKK).

	Mitigation						Adaptation		
Recipients Country/ region	Energy	Transport	Forestry	Agriculture	Waste	Industry	Capacity building	Coastal zone manage ment	Other
Bhutan			2.60			2.20			
Bolivia				18					
Burkina Faso	1.7								
Egypt	139				17		11		10
Laos			1.2				4.5		
Malaysia	13.7		2.2	2		1	13.2		
Mozambique								3	
Namibia			2						
Nepal	3.66		17.24	2.13		6.26			
Nicaragua			1	2			16		
South Africa	7					3	2		
Southern Africa							6		
Tanzania			5				4		
Thailand			3.5				0.5		
Vietnam							2.5		

Table 7.5 Danish bilateral and regional assistance in 2000 in relation to implementation of the Climate Convention (mill. DKK).

	Mitigation						Adaptation		
Recipients Country/ region	Energy	Transport	Forestry	Agriculture	Waste	Industry	Capacity building	Coastal zone manage ment	Other
Benin			5.5						
Bhutan			2.47			2.18			
Bolivia				9					
Burkina Faso	4.5								
Cambodia			2.2				2.5		
Egypt	134				8		6	3	4
Laos							1.2		
Malawi	20								
Malaysia	19.1	13				1	3	2.2	
Nepal	16.05		30.67	2.21		14.55			
Nicaragua				10			19		4
Niger			10.3			2.6			
South Africa	4		1				9		
Tanzania			5						
Thailand	20.7					1	7		
Vietnam				37.4		3		20	

Table 7.6 Danish bilateral and regional assistance in 2001 in relation to implementation of the Climate Convention (mill. DKK).

	Mitigation						Adaptation		
Recipients Country/ region	Energy	Transport	Forestry	Agriculture	Waste	Industry	Capacity building	Coastal zone manage ment	Other
Benin			6.7						
Bhutan			1.66			1.86			
Bolivia				8					8
Burkina Faso	5.3								
Cambodia						10		4	
Egypt	50				1	10	5	6	6
Laos						1.9			
Malaysia	14.9		3				4	5	
Nepal	20.23		36.13	2.44		26.34			
Nicaragua				5			11		20
Niger			3.7			2.3			
South Africa	7		4				27		
Thailand	38.5		4	3					
Vietnam				2			6		
Zambia	4								

Denmark's environmental assistance under the MIFRESTA Facility comprises a number of activities that are an important element of Denmark's overall international profile. In the light of the Johannesburg Summit, the coming entry into force of the Kyoto Protocol, and the enlargement of the EU, the government has decided to review the entire MIFRESTA assistance in the spring of 2003. The result of the review is expected to be incorporated in the Finance and Appropriations Act for 2004.

Multilateral action

Denmark has worked – mainly through the EU – for binding and effective regulation of international environmental problems through the regional and global environment conventions. This applies, for example, to the conventions on biodiversity, climate change, combating desertification, the Basel Convention on cross-border transportation of hazardous waste and the conventions regulating chemicals, the Stockholm Convention on Persistent Organic Pollutants and the IMO Convention on toxic primers. Denmark has worked to get the conventions coordinated and enforced effectively and for the precautionary principle to have a central role in the rules. Denmark is a considerable contributor to the Montreal Protocol's fund for financing the phasing-out of ozone-depleting substances in developing countries.

In addition, Denmark supports sustainable energy through so-called 'trust fund contributions' to the World Bank and the Asian Development Bank.

Denmark's contribution to sustainable development includes considerable support for international organisations, particularly the UN system, in which all countries in the world participate on an equal footing. Here, Denmark is working to strengthen the Commission for Sustainable Development, CSD. Denmark is also working to make the UN more efficient so that the division of work between the organisations becomes better and overlapping is avoided.

In the environment area, Denmark is working to strengthen the Global Environment Facility (GEF) financially and organisationally. The Danish contribution to GEF's replenishment for the years 2002-2005, the largest

Table 7.7 Danish contribution to GEF 1997-2001

Contribution mill. DKK					
Year	1997	1998	1999	2000	2001
GEF	33.8	33.2	22.0	58.2	48.3

to date, is about 50% larger than in the previous replenishment. Denmark, together with other EU Member States, has made an extra, voluntary contribution to the third replenishment.

Measured per capita, Denmark is one of the biggest contributors to the UN's environment programme UNEP. Besides the annual contribution to the programme's Environment Fund, Denmark makes both technical and financial contributions to a number of special UNEP activities, particularly those taking place at the special cooperation centres for energy and the environment (at Risø National Laboratory, started in 1991) and for water and the environment (at the Danish Hydraulic Institute, started in 2002). The Risø National Laboratory, in particular, does a great deal of work on climate-related questions and sustainable energy and has, for example, made valuable contributions to the sections on adaptation in the IPCC's Third Assessment Report. The centre's work programme for the coming years includes many activities concerning the Kyoto Protocol's Clean Development Mechanism and contributions to the IPCC Fourth Assessment Report. Table 7.8 shows Denmark's support for the two centres and for other cli-

Table 7.8 Danish contributions to multilateral institutions, NGOs, and programmes

Institution or programme	Contribution (mill. DKK)				
	1997	1998	1999	2000	2001
1. World Bank	665.3	644.5	698.7	835.7	1048.6
2. International Finance Corporation	-	2.4	5.8	11.9	20.5
3. African Development Bank	0.2	5	71.6	72.0	12.5
4. Asian Development Bank	-	15.9	7.4	11.4	24.5
5. European Bank for Reconstruction and Development	7.8	6.5	16.1	19.1	26.0
6. Inter-American Development Bank	16.0	20.8	10.1	20.9	15.3
7. United Nations Environment Programme – specific programmes	16.0	15.0	13.8	13.8	15.5
8. United Nations Development Programme – specific programmes	610.9	649.5	519.3	513.7	525.6
9. UNFCCC – Supplementary Fund	-	3.8	0.1	-	0.5
10. Risø National Laboratory	4.8	11.0	9.2	11.8	6.4
11. DHI	-	-	-	-	3.8
12. IUCN	18	18	18	18.5	20
13. IIED	4	5	5	5	6

mate-related activities, primarily under UNEP.

From the facility for assistance to developing countries, Denmark also contributes to international NGOs involved in the work with climate changes. This applies to the IUCN/World Conservation Union and the International Institute for Environment and Development (IIED). The contributions can be seen from the following table, which also shows Denmark's contribution to multilateral institutions and programmes.

The least developed countries are among the countries that are most vulnerable to climate change. Denmark therefore attaches particular importance to helping these countries adapt to climate change. For this reason, in 2002 Denmark made its first contribution of DKK 11.4 mill. to the fund for the least developed countries (the LDC Fund) under the Climate Convention. The contribution is intended to finance the least developed countries' work with National Adaptation Plans of Action (NAPAs).

7.1.3 Assistance through the private sector

Denmark has the following assistance instruments and measures for assistance to developing countries through the private sector:

Mixed credits

Mixed credits can be provided in connection with projects within both the public and the private sector. Restricted mixed credits are interest-free loans for development projects in credit-worthy developing countries with per capita GNP of not more than USD 2,380 (2002/2003) and are thus not reserved for programme cooperation countries. The loans are made from a Danish bank to a credit-worthy borrower in the recipient country. The interest expense, export credit premium, etc. are paid via the assistance funds. The project's assistance relevance is evaluated on the basis of Danida's ordinary rules for project evaluation. In the period 1997-2001 assistance was granted with mixed credits for 75 projects with a total contract sum of DKK 3.6 bill. and a grant for interest payments, export credit premium, premium etc., totalling DKK 1.4 bill. (see table 7.9). Approximately one fifth of these projects concern renewable energy – particularly wind turbines.

In addition to the existing restricted mixed credit scheme, a new scheme – for unrestricted mixed credits – was introduced in 2002. The unrestricted scheme largely corresponds to the existing restricted scheme. The main difference between the two is that the support possibilities in the unrestricted scheme are not limited to Danish suppliers and that there is no requirement concerning the origin of the supplies. Besides this, the unrestricted scheme can only be used in Denmark's programme cooperation countries and in South Africa.

Table 7.9 Number of projects and total cost under the scheme for mixed credits 1997-2001

	1997	1998	1999	2000	2001	Total
Number of projects	12	11	20	18	14	75
Contract sum (mill. DKK)	949	323	947	929	418	3,566
Total cost (mill. DKK)	**371**	**128**	**396**	**345**	**141**	**1,381**

The private sector programme

Denmark supports cooperation between the private sector in the recipient countries and in Denmark, including – particularly – cooperation projects between companies. Some of the projects are environment-related, e.g. projects relating to renewable energy and energy saving through transfer of cleaner technologies. Table 7.10 shows the support provided for these projects.

Table 7.10 PSP and Company-to-Company expenses,1997-2001

	1997		1998		1999		2000		2001	
Type of cooperation	Number	Amount	Number	Amount	Number	Amount	Number	Amount	Number	Amount
Initiation facilities	13	5.8	65	31.6	64	30.4	50	24.1	31	51.2
Partnerships	24	45.7	29	69.3	47	106.2	29	73.8	37	86.2
Total	**37**	**51.5**	**94**	**100.9**	**111**	**136.6**	**79**	**97.9**	**68**	**137.3**

Table 7.11 Annual amount granted for interest support etc.

	1997	1998	1999	2000
Interest support etc. granted, total mill. DKK	412	142	435	379

The Industrialisation Fund for Developing Countries (IFU) invests in joint ventures in the developing countries, including joint ventures on renewable energy. The IFU can also make grants for training of personnel in companies in developing countries. The IFU administers funds from Danida's Environment and Training Fund.

7.1.4 Assistance to developing countries that are particularly vulnerable to climate changes

Small Island Development States (SIDS) are particularly vulnerable to global environmental impacts, including climate change, and Denmark attaches great importance to supporting SIDS in accordance with Agenda 21 and the Barbados Action Plan. At the UN's special general assembly in September 1999 on these countries Denmark emphasised the prioritisation of the poorest developing countries among SIDS and weighting action in favour of women and the poorest target groups. In 1999 Denmark held a large NGO conference on renewable energy and small island states. In addition, Denmark provides support for SIDS through multilateral assistance to regional projects in the climate and energy areas and to projects on the Maldives, partly through the regional organisation "South Pacific Regional Environment Programme" (SPREP) and partly through UNEP.

From 1998 to 2002 Danida supported a SPREP project on knowledge and capacity building in the climate area for governments, NGOs, and regional organisations on the Pacific islands. In addition, Danida is financing a supplementary capacity building project that UNEP is implementing on wind and other renewable energy technology in the electricity systems on the Pacific islands. In 2003 a new project on sustainable energy is being planned for the benefit of SIDS.

7.1.5 Activities in connection with technology transfer

Examples of Danish-supported activities leading to transfer of technology include the energy sector in Malaysia and the establishment of a large wind farm in Egypt.

The main purpose of the Danish support for the energy sector in Malaysia is to help the country develop a strategy for sustainable energy and identify ways of increasing energy efficiency.

The project in Egypt has included support for the establishment of a wind farm in the Red Sea area with a capacity of 60 MW. This is one of the largest plants of its kind in the developing countries. More information on these projects is given in Appendix C.

Table 7.12 The main action areas for projects aimed at reducing energy consumption and CO_2 emissions in Central and Eastern Europe

Technology	Greenhouse gas reduction in tonnes CO_2 equivalents	Total investment in mill. DKK	DANCEE grant in DKK	DANCEE share of financing
Geothermal and district heat	349,724	489.5	40.3	8.2 %
Cement industry	42,138	35.9	8.0	20.0 %
District heat and CHP	289,662	549.5	77.8	14.2 %
Wind turbines	4,710	35.9	13.3	37.1 %
Bio fuels	61,682	176.1	50.2	28.5 %
Total:	**747,916**	**1,290.8**	**189.6**	**14.7 %**

7.2 Cooperation with Central and Eastern Europe

7.2.1 MIFRESTA Facility

Since 1989 Denmark has been supporting the Central and East European countries' efforts to build up well-functioning democracies, which are now, after a number of turbulent years, characterised by economic growth and ever-stronger democratic institutions. The Danish assistance programme for Central and Eastern Europe has played an essential role in this process.

Environmental activities have long constituted by far the largest part of all Danish assistance to Central and Eastern Europe.

DANCEE has made grants for a number of projects aimed at reducing energy consumption and CO_2 emissions. The total reduction of CO_2 emissions through already completed and ongoing projects is now estimated to be about 0.75 million tonnes per year. Table 7.12 shows the main action areas.

Table 7.13 Examples of support projects for Central and Eastern Europe with CO_2 reduction

Project	**Emission reduction in tonnes CO_2 per year**
Sawdust for heat supply, Tasca, Romania	1,000
Renovation of district heating system, Kiev, Ukraine	7,100
3 natural gas-fired CHP plants, Decin, Czech Republic	140,000
Geothermal district heat supply for Zakopane and Nowy Targ, Poland	210,000
Wood chip firing for district heating plant, Petroffskoye, Russia	9,900

Table 7.14 Contributions via the Environmental Investment Facility

	Contribution (mill. DKK)			
	1997	1998	1999	2000
Share capital	66.5	18.3	67.2	10.2
Project loans	60.7	0.3	49.0	80.1

Table 7.13 shows some concrete examples of projects with CO_2 reduction. More information on these projects is given in Appendix C.

The Danish Environmental Investment Facility for Central and Eastern Europe is contributing to a number of environmental projects in Central and Eastern Europe. The contributions, which are shown in table 7.14, are made as share capital or project loans and can thus not be regarded as real development assistance.

7.2.2 Strategy for Danish assistance to Central and Eastern Europe 2002-2003

In April 2002 the government presented its strategy for Danish assistance to Central and Eastern Europe in the years 2002-2003. DKK 700 mill. has been earmarked for environmental projects in the years in question, including DKK 130 mill. for Joint Implementation.

Under the previous environmental support programme for Central and Eastern Europe, projects were implemented that have in all resulted in CO_2 reductions of about 0.75 million tonnes per year.

Cooperation agreements have been entered into with Slovakia and Rumania on cooperation with a view to Joint Implementation projects and negotiations on cooperation agreements have also been held with Estonia, Latvia, Russia, Ukraine, Poland, and the Czech Republic.
The planned action in 2002-2003 includes projects that will result in a considerable reduction in CO_2 emissions, and Denmark will seek to credit this to the Danish climate account. Further agreements are expected to be entered into in 2003 with, among other countries, Rumania, Slovakia and Poland.

In addition, the countries will be provided with technical assistance in building up the capacity that will be needed to enter into Joint Implementation projects.

8. Research and systematic observation

8.1 Climate research and observations in general

Research and observations within climate in the broad sense of the word take place at a number of institutes and organisations and cover a wide range of disciplines from natural science to evaluation of instruments and sociological aspects.

Denmark's Meteorological Institute (DMI) carries out observations of climate parameters (atmosphere and ocean) under the World Metrological Organisation's (WMO) programmes and sub-programmes: World Weather Watch Programme (WWW), Global Atmosphere Watch (GAW), Global Observing System (GOS), Global Climate Observing System (GCOS) and Global Ocean Observing System (GOOS).

Together with climate research, climate observations have been one of the DMI's main tasks for more than 125 years, with measurement, theory, and modelling. The establishment of the Danish Climate Center at the DMI in 1998 strengthened the area, and raised its public profile in national and international cooperation.

Danish research competence concerning the physical expressions of past climate changes is to be found particularly at the Geological Survey of Greenland and Denmark (GEUS), the University of Copenhagen (KU) and Århus University. GEUS also has competencies in glaciological studies of the Greenland ice cap and the ice cap's interaction with climate change and in the effect of climate change on the water cycle in nature. The Geophysical Department and the Geological Institute at KU and the Geological Institute at Århus University have very great expertise in palaeoclimate data, and the climate group at KU is known worldwide for its ice core drilling and analyses.

Besides research on the climate system, the Institute's climate-related research includes research concerning the driving forces for emissions of greenhouse gases and their impact on the environment, the state of the physical, chemical and biological environment, effects of climate change and society's possibilities for response and regulation. Denmark's National Environmental Research Institute (NERI), the Danish Forestry and Landscape Research Institute (FSL), the Danish Institute of Agricultural Sciences and Risø National Laboratory are all involved in these climate-related fields of research. In addition, several of Denmark's universities work on different aspects of climate research.

The DMI has published an overview, parts of which describe current Danish research on climate changes[1].

It is on the basis of research competencies in the above-mentioned areas that Denmark also participates actively in IPCC's work. For example, Danish authors have been involved in IPCC's evaluation reports.

The Copenhagen Global Change Initiative (COGCI) is a recently established and formalised cooperation in the form of a research network and a PhD school between three Danish institutions (GEUS, DMI, and NERI) and the University of Copenhagen. The COGCI covers all relevant scientific and interdisciplinary disciplines within global, regional, and local environmental impacts and climate problems.

Danish climate research contributes to a wide range of international projects under the World Climate Research Programme, such as the Arctic Climate System Study (ACSYS), Climate Variability and Predictability (CLIVAR), the Global Energy and Water Cycle Experiment (GEWEX), Stratospheric Processes and their Role in Climate (SPARC) and the World Ocean Circulation Experiment (WOCE).

8.2 Research

8.2.1 Research policy and funding

Climate-related research in Denmark is characterised by having grown up within an already existing framework as a natural development of institutions' activities. Denmark has not previously had a general national research programme for climate changes and global changes. However, as follow-up on *Climate 2012*, a committee was appointed to look at the possibilities for improving coordination of Danish research work on climate. This committee completed its work in December 2002. The work consisted primarily in mapping Danish climate research[2] and making recommendations on that basis.

Mapping was largely based on a questionnaire-based survey in which all known research centres with climate or climate-related research were contacted. Besides the narrowly focused scientific climate research, the survey has provided information on a broad section of climate-related research in Denmark.

The mapping exercise showed that there is great diversity in relatively extensive climate-relevant research. The research is primarily concentrated on basic knowledge, consequences of climate change and mitigation of manmade climate change, whereas there has been very little research in adaptation to climate change.

Table 8.1 Resources used in Danish climate research 1998-2001

Main group	Manyears				PhD students				Budget DKK mill.				Reviewed publ.			
	1998	1999	2000	2001	1998	1999	2000	2001	1998	1999	2000	2001	1998	1999	2000	2001
Knowledge background	66	77	80	79	17	22	25	30	41	46	46	51	99	97	109	166
Consequences	43	39	40	42	13	14	13	13	18	18	16	15	38	43	45	65
Mitigation	62	66	64	64	19	24	23	22	34	36	42	47	46	54	51	54
Adaptation	1	2	3	4	1	1	2	2	1	1	2	1	0	1	2	10
Robustness etc.	1	1	1	1	0	0	0	0	0	0	0	0	7	5	5	10
Total	**172**	**184**	**187**	**189**	**49**	**61**	**63**	**67**	**94**	**101**	**107**	**114**	**190**	**200**	**212**	**305**

The research is funded by the institutions' basic grants, programme grants, and the EU Commission's framework programmes for research and technological development, and by the Danish research councils.

In the period 1998 to 2001 Danish climate research increased steadily, from 172 man-years in 1998 to 189 man-years in 2001. The budget increased correspondingly from DKK 94 million in 1998 to DKK 114 million in 2001, with foreign funding accounting for just under 30%.

Besides the resources shown in table 8.1, a number of players are working with activities related to climate research, including activities under the Danish Energy Research Programme, the Nordic Energy Research Programme, PSO funds and Risø National Laboratory's Wind Energy Department, see section 8.2.6. In 2001 these spent DKK 379 mill. on activities indirectly or partially related to activities concerning mitigation of man-made climate changes.

On the basis of the mapping exercise, the committee recommended a general, combined evaluation to determine which areas within climate research should receive larger grants from the government research councils or from other public support schemes. In addition, the committee presented the following proposals for special action areas to strengthen the entire Danish research in the area:

- Climate research focused on the North Atlantic region
- Adaptation and vulnerability in relation to nature and environment
- Emissions in the agricultural sector with a view to reducing greenhouse gas emissions
- Analysis of extreme events in relation to the greenhouse effect
- Development of climate models focused on feedback processes
- Long-term stabilisation of atmospheric greenhouse concentrations and targets for greenhouse gas emissions
- The effect of climate change on renewable energy

Lastly, the committee's research representatives proposed that more attention be paid in future to interdisciplinary cooperation, building up national and international networks, and disseminating the results, and that climate research be given a clearer place in the government's research policy.

The government will consider the possibilities for following the committee's recommendations.

Danish climate-related research is described in detail in the following sections, while a number of on-going research projects are listed in Appendix D.

8.2.2 Climate processes and studies including palaeoclimatic studies

At the DMI work is going on within atmospheric and coupled atmospheric-oceanic processes, which are important in connection with global climate change. These process studies, which are going on in several international projects, include natural atmospheric-oceanic interplay on time scales from years to decades and the main processes of importance for deep water formation in the North Atlantic.

Through assimilation of atmospheric reanalyses in atmospheric models, several studies are being carried out of atmospheric processes that are important partly for developing improved atmospheric models and partly for detecting changes in the external climate impacts. In addition, trends and variations in the latest tropospheric temperature observations from satellites (primarily MSU data) and radio soundings are being analysed and compared.

At the DMI work is going on to improve models for describing the thinning of the stratospheric ozone layer. This area is important, not only in relation to the Vienna Convention concerning protection of the stratosphere's ozone layer, but also in a climate context, because there is interaction with the greenhouse effect.

The DMI has participated in all major European-American Arctic ozone campaigns in the 1990s, such as EASOE, SESAME, THESEO, and THESEO-2000/SOLVE. The research is based on analyses of a broad range of available observations compared with analyses of the meteorological conditions in the stratosphere. It includes analyses of the dispersal of ozone-depleted air from the Polar regions to intermediate latitudes, experimental and theoretical model work concerning the formation of polar-stratospheric clouds, and modelling of the propagation of localised mountain waves. The work, which is receiving support from the EU Commission's framework research programmes, is aimed at better understanding and modelling of the processes that lead to chemical depletion of the ozone layer.

The Geophysical Department under the Niels Bohr Institute for Astronomy, Physics and Geophysics at the University of Copenhagen is working mainly on global and general problems, such as the natural variability of the climate in all time scales and the role of basic physical/chemical processes in the climate system. Examples of projects are the international ice core projects, the aim of which is to analyse ice cores through Greenland's ice cap in order to obtain a climate series that covers as long a period of time as possible and to obtain information about the end of the last ice age 11,500 years ago, and about the last warm period 130,000 years ago.

At Odense University research is going on within the areas of the climate system's stability, the role of the ocean in the climate system and the chemical and biological development of the atmosphere and the ocean. The newly established Center for Planet Research undertakes climate research in a more general sense – for example, it studies ice deposits not only on earth but also in the solar system.

GEUS works with the physical expressions of past climate changes, including ecosystems' response, temperature variations, changes in precipitation and rises in water level. Another research topic is past variations in the circulation of the North Atlantic sea currents and their importance for climate changes. GEUS also works with mass balance studies of Greenland's ice cap, including its interaction with climate change and its effect on changes in water level.

8.2.3 Climate modelling and the climate of the future

With substantial support from the European Commission, the DMI/Denmark's Climate Center are working closely together with research institutions in Europe on analyses of the climatic consequences of increased greenhouse effect, depletion of the stratospheric ozone layer and variations in solar activity. The main emphasis is on Denmark and the European region, but global research is also being carried out. The work includes both developing models and using the models for scenario calculations of the climate of the future. The models include:

- Relatively simple empirical models for describing local climate change and variations (downscaling) and for use in seasonal forecasting.
- A regional dynamic atmosphere-climate model for calculating regional/local climate change and variations. The main focus is on Denmark, Europe, and Greenland.
- Finely meshed global dynamic atmospheric climate models for calculating global/regional climate change and variations.
- Global dynamic coupled atmosphere-ocean-sea ice models, which are used for calculating climate change (primarily as a consequence of increased greenhouse effect) and internal variations in the climate on a 5-100 year time scale.

In 2000 both global and regional scenario calculations were carried out[3] based on IPCC's so-called SRES emission scenarios – more specifically, scenarios A2 and B2, and the results have been used in the IPCC's Third Assessment Report. For Denmark it is particularly changes in (extreme) precipitation, soil moisture and storm activity that are important. For Greenland it is particularly changes in the simulated snow accumulation on the ice cap that are of interest.

In the European climate project PRUDENCE, which is being coordinated by the DMI, researchers are working with several climate models to reduce and quantify the uncertainty in climate projections and interpretation of the results in relation to European strategies for mitigating climate change and adapting to it.

The research on ozone as a greenhouse gas includes the influence of ozone on circulation in the stratosphere, together with radiation forcing and climate effects caused by changes in the ozone concentration. In the research in this area, use is made of a global climate model and a more simple radiation convection model.

Research at the Geophysical Department of the University of Copenhagen includes experimental/field-related, theoretical, and modelling aspects and helps to indicate methods that can be used for evaluating the climate of the future.

8.2.4 Effects of climate change

The effects of climate change on nature and ecosystems are covered by research at GEUS, NERI, the Danish Forest and Landscape Research Center (FSL), the Danish Institute of Agricultural Sciences and Risø National Laboratory.

FSL carries out research on the direct effect of changed CO_2 concentration on Danish forests through its cooperation with the Royal Veterinary and Agricultural University.

NERI has research competence concerning toleration limits for air pollution for particularly sensitive ecosystems on agricultural land.

NERI works with climate change in Greenland, where adverse effects can be expected. NERI is carrying out a standardised biological/ecological monitoring programme covering a broad spectrum of processes, fauna, and flora. In connection with this project the institute is carrying out research projects aimed at increasing knowledge of basic Arctic ecosystems. In the last five years NERI has built up competence focused on the Arctic marine ecosystem's function and dynamics and is investigating an Arctic fjord system and, within that, relationships between production and nutrient conversion.

GEUS has competence concerning long-term variations in ecosystems in Denmark and Greenland and on the Faroe Islands caused by the climate. The institute is investigating how the ecosystems react to climate change in lakes and marine environments in Denmark and Greenland and in forests in Scandinavia. It also registers changes in sea level and their effect on the water cycle, including the formation of groundwater.

The Danish Institute of Agricultural Sciences works with the interaction of climate and agriculture, including effects of climate and atmospheric CO_2 on processes in the soil-plant system. Other aspects being studied include factors affecting greenhouse gas emissions from agriculture, e.g. energy consumption in the agricultural sector, biomass for energy purposes, production and handling of manure, biogas, and NH_3 volatilization, and greenhouse gases in relation to feeding strategies, manure handling, and soil tillage.

Risø National Laboratory's work includes a number of sub-projects on effects of climate change in developing countries, where the centre's activities include both analyses of vulnerability to climate change and adaptation strategies. The activities cover the energy, industrial, forestry, agricultural, transport, and waste sectors.

There is not at the present time special competence concerning the effects on humans and their conditions of life and health, which are particularly relevant in those areas in the world where dramatic climate effects are expected/seen. An element of

NERI's work programme for 2000 and 2001 was a pilot study of the equality problem between developing countries and industrial countries.

The Geographical Institute at the University of Copenhagen is doing research on soil-forming processes in relation to climate and vegetation that are of significance for, amongst other things, the exchange of greenhouse gases between soil and the atmosphere.

8.2.5 Economic research, including evaluation of climate change and possibilities for mitigation

It is important to take account of the economic consequences of the different ways of reducing greenhouse gas emissions.

NERI's Center for Analysis of Environment, Economy and Society has general competence in setting up and evaluating mechanisms for reducing emissions and special competence within the agricultural, energy and transport sectors. In addition, it possesses general knowledge of the different aspects of the Kyoto Protocol, including research competence concerning Joint Implementation.

Risø National Laboratory is involved in various research activities, primarily relating to policy and mechanisms for reducing greenhouse gas emissions, and relating to emission scenarios for greenhouse gases. The activities include development and implementation of international method standards for cost and sustainability analyses of reduction policies, discussion and testing of baseline approaches and various project and sector studies for the energy, transport, and agricultural sectors. The research activities have also included support for the Climate Secretariat and capacity and training programmes in developing countries. In addition, Risø has research activities concerning the Kyoto Protocol's flexible mechanisms, Emission Trading (ET), Joint Implementation (JI) and Clean Development Mechanism (CDM).

Research at Aarhus University is concentrated on the regulatory aspects of the climate problem. The Center for Social Science Research on the Environment (CeSam) at Aarhus University thus has general competence in research in mechanisms – particularly in the effects of economic instruments (taxes and quotas) and voluntary agreements. In addition, the centre has thorough knowledge of environment and energy policy, including climate policy in the industrialised countries.

The University of Southern Denmark in Odense carries out research in climatic, ecological and anthropogenic impacts on marine environments, particularly the North Sea and the Baltic Sea in the period 1500-2000.

At the University of Copenhagen the main focus of climate research is the scientific aspects, but research is also being conducted in the climate field in an economic context, at the Economic Institute, for example.

At Roskilde University Center, research is going on concerning scenario building within climate-stabilising policies, together with life cycle analyses as a tool in economic evaluation of climate-stabilising strategies.

8.2.6 Research and development of technologies to reduce greenhouse gas emissions and to adapt to climate change

At the Technical University of Denmark (DTU), the energy/environment group and the group for urban ecology base their research on sustainable energy development and sustainable urban change, with energy savings and renewable energy as central parameters.

The Energy Research Programme (EFP) has hitherto supported a large number of research and development activities in the energy field. The activities have ranged all the way from social science research on the interaction between the energy sector and the rest of society to research in such advanced energy technologies as super-conductors and fuel cells. In 2002 funding for the programme was reduced from the previous annual sum of between DKK 200 mill. and DKK 250 mill., and at the same time, the action areas were narrowed. However, the energy research effort will increase again from 2003, mainly within renewable energy, with a pool administered under the Ministry of Science, Technology and Innovation. The EFP contributes to Danish energy research with a long-term perspective, and industry is also involved. Statistics on research projects show that private companies, together with energy and research institutions, contribute almost 50% of the financial support for the research projects.

NERI concerns itself with the main forces behind greenhouse gas emissions from the energy sector, the agricultural sector, and the transport sector. FSL has competence in forestry, afforestation, etc. Together, these two institutions cover the aspects of land use in the open countryside for agricultural purposes, forestry and nature. In this connection, both institutions are studying problems related to use of biomass from agriculture and forestry as an energy source.

NERI makes general inventories of atmospheric emissions from all sectors and activities, including the greenhouse gases. The institution has special research competence in inventories from the agricultural sector, the transport sector, and the energy sector. FSL seeks generally to quantify how forestry and changes in land use in relation to forests affect the forest ecosystems' carbon sinks and thus the potential binding of CO_2 in biomass and soil.

NERI also has research competence in modelling of the dispersal of greenhouse gases locally and regionally, with special focus on Denmark, Europe, and Greenland. The Department for Atmospheric Environment is developing a CO_2 model (DEHM) for dispersal, transport, and surface movements. The model can be used to determine the size of sources and drains for CO_2 in Europe over specific areas and for estimating whether these areas comply with the Kyoto Protocol.

GEUS is researching impacts from earlier eras on the environment, and the driving forces for natural climate variations in long-term perspectives.

In cooperation with seven other countries, GEUS is the project manager for the EU-funded GESTCO project, in which the possibilities for finding geological storage possibilities near the European power stations and large industrial CO_2 point sources are being studied. Also in this project a technical-economic model is being developed for planning and price calculations of different combinations of sources of CO_2 emissions, transport, and types of geological stores. Several geological formations in Denmark are known to be suitable for deposition. Publication of the results will be followed up by public hearings.

GEUS is also participating in the international research project SACS, in which CO_2 deposition from the Norwegian Sleipner gas field is being further developed. GEUS is studying the geological conditions for the store, including the spread of the sand formation, the tightness of the clay seal and the chemical effects of storing CO_2 in the form of carbonic acid where the acidity is very low.

Under the Danish Electricity Supply Act, the system operator is responsible for ensuring the research and development projects that are needed for use of environmentally sound electricity production technologies. In 2000 and 2001 a sum of around DKK 100 mill. per year was used for this purpose, including research and development within wind power, biomass and waste, other renewable energy, CHP and use of gas and system-fitting.

Risø National Laboratory is carrying out research projects on the driving forces, emissions and possibilities for reduction, particularly in the developing countries.

Research at the Danish Institute of Agricultural Sciences focuses on the agricultural sector's possibilities for adapting to climate change by changing the cultivation system, including changes in fertilisation and the use of pesticides and adapting soil tillage methods. The aim is to develop adaptation options that also reduce greenhouse gas emissions from the sector.

8.3 Systematic climate observations

8.3.1 Atmospheric climate observations, including measurements of the atmosphere's composition

Since its establishment in 1872 the DMI has monitored the main climate parameters. In the climate monitoring programme classic methods of measurement are used and new, satellite-based methods of observation are being developed.

The DMI operates around 200 automatic measuring stations in the Kingdom (Denmark, Greenland and

Table 8.2. Average data accessibility in 2000

Type	2000
Automatic weather stations, incl. Greenland and the Faroe Islands	96%
Satellite reception	98%
Weather radar	98%
Radio sounding, Denmark/Faroe Islands	99%
Radio sounding, Greenland	96%
Storm flood stations	99%

the Faroe Islands) with a broad measuring programme ranging from automatic water-level or precipitation stations that measure only a single parameter to stations with a full measuring programme, including automatic cloud-height detectors and weather-type detectors. Since 2001 a separate network for climate observations has not been operated because of technological convergence between the weather networks and the climate networks and a need to rationalise the measuring network.

The manual measuring network is now being replaced by automatic measuring stations at the fastest possible rate, the aim being to eliminate human sources of error, to realise any rationalisation potential and to enable a considerably higher observation frequency. Observations were previously taken every three hours, but, today, observations are required at 10-minute intervals from the new stations, which cannot be done manually. The purpose is to achieve convergence between the different types of stations so that the number of station types and spare parts can be reduced as much as possible without loss of quality.

To collect precipitation data the DMI also operates a network of 500 manual precipitation stations, which are mainly used to map the precipitation

Table 8.3. The network of surface observation stations

Type	**DMI**			**Cooperation partners**		
	Denmark	Greenland	Faroe Islands	Denmark	Greenland	Faroe Islands
Manual or semi-manual weather stations	6	4				
Automatic weather stations	50	25	4	15	11	1
Manual precipitation stations	489	1	5			17
Automatic precipitation intensity stations	4			70		
Sun stations	33	6	2			
Automatic water level stations	15	1	1	60		

climatology. 100 stations report daily via an automatic telephone service called "Tast-Selv", and 400 monthly by postcard. Besides being used in national programmes, the observations are part of Denmark's international contribution in the form of observation components from Danish territory to the worldwide meteorological observation network WWW (World Weather Watch), GCOS (Global Climate Observing System), and other international programmes for mapping weather and climate.

As will be seen from table 8.2, the Danish observation network is characterised particularly by high average data accessibility.

The meteorological observations are stored in the DMI's database, and observations from many Danish stations are available in electronic form right back to 1872, water level measures from 1890 and measurements of sea surface temperature from 1931. In 2001 the number of daily observations was 75,000, and the total number of observations in the database is around 245,000,000.

The meteorological observation systems that are of most interest in a climate context are:

- the surface observation system
- the radio sounding network
- the weather radar network
- the ice observation service.

Each of these systems is described in the following, together with the DMI's stratospheric observations and oceanographic observations.

The surface observation network

For historical and practical reasons, the surface observation network consists of many different types of station. Except in the case of the manual precipitation and hours of sun stations, the stations have been gradually automated since the 1970s at an increasing rate, and by the end of 2000, Denmark had an almost 100% automated network of weather stations. Table 8.3 shows the station network. DMI is receiving a growing number of observations from cooperation partners in all parts of the Kingdom, so these are included in table 8.3.

Besides the observations from the Danish land areas, the DMI has an observation agreement with about 50 Danish, Greenlandic and Faroese ships, which carry out systematic observations in the North Sea, the Baltic Sea, the North Atlantic and the waters around Denmark. In addition, Denmark is a partner in the EGOS cooperation on collection of weather observations from drifting weather buoys in the North Atlantic, since the DMI has strategically well placed satellite reception facilities in Kangerlussuaq (Greenland) and in Copenhagen. The siting of weather stations in Denmark and Greenland and on the Faroe Islands, together with precipitation stations in Denmark, is shown in Appendix E (the GCOS Report).

Radio sounding network

In radio sounding, a small, fully automatic weather station is sent up by balloon. The balloon can reach a height of about 35 kilometres, and all the way up it sends observations of temperature, pressure, humidity, and wind velocity via radio to a receiving station. Radio soundings provide measurement of the atmosphere's vertical profile for use in analyses of the condition of the atmosphere. They also enable measurement of ozone and radioactivity.

The DMI operates radio-sounding stations in Copenhagen, in Thorshavn on the Faroe Islands and in Danmarkshavn, Illoqqortoormiit, Tasiilaq, Narsarsuaq, and Aasiaat in Greenland. Soundings are also received from two so-called ASAP (Automated Shipboard Aerological Programme) containers, which are portable radio sounding stations designed for use on ships. The DMI has had an agreement for many years with a Greenland shipping company on ship-borne radio soundings in the North Sea and the North Atlantic. The radio sounding stations and the ASAP units take two daily soundings, although the ASAP units do not take a sounding if they are near a land radio sounding station, such as the one in Thorshavn. The total number of soundings per year is in the order of 5,800.

Weather radar network
With radars in Sindal and on Stevns, Rømø and Bornholm, Denmark's network of weather radars provides almost 100% coverage. It also has an extremely closely meshed network of land-based precipitation stations.

The weather radar network has supremely high spatial resolution and is therefore able to provide precipitation climatological information with a very high degree of detail nationally, regionally, and locally. By calibrating radar data against surface-based point-precipitation measurements, the latest research results show that good absolute accuracy can be achieved. The present radar network has a data frequency of six data sets per hour and the spatial resolution is 2x2 km^2.

Satellite data
Denmark contributes to space-based observations through membership of the European space organisation ESA and the European meteorological satellite organisation EUMETSAT, and DMI has facilities for receiving satellite data in Denmark and Greenland.

In cooperation with EUMETSAT, NERI is managing the development of a so-called satellite application facility (SAF) for use of GPS data for weather and climate monitoring and is also participating in the development of SAFs for oceanography and sea ice, together with ozone and UV radiation.

8.3.2 The ice observation service
The DMI is responsible for systematic monitoring of the ice conditions in the waters around Greenland. Observations of the ice conditions have been collected for about 125 years, and there is a very large quantity of data in graphic form in the way of monthly surveys, ice maps, etc. Since 1956 the waters south of Kap Farvel, in particular, have been intensively monitored with a view to making shipping in the area safer. Ice maps

are prepared several times a week with detailed information on relevant ice conditions. All new ice maps are in vector-graphic form. Since 2000 weekly maps have been prepared showing the ice conditions all the way round Greenland. The maps are based on satellite data and are essentially an automatically produced product that is primarily intended as a basis for analyses of climatic conditions for Greenland and the surrounding waters.

8.3.3 Stratospheric observations

The DMI monitors the stratospheric ozone layer, taking daily earth-based measurements of the thickness of the ozone layer from Copenhagen and Kangerlussuaq (Søndre Strømfjord) with Brewer spectrometers, together with daily measurements from Pituffik (Thule Air Base) in the spring and autumn months with a SAOZ spectrometer. The DMI also takes weekly measurements of the vertical ozone profile by means of balloon-borne soundings from Illoqqortoormiit. The measurements are reported to the databases under Network for the Detection of Stratospheric Change (NDSC) and World Ozone and UV-radiation Data Center under the WMO programme Global Atmosphere Watch. Ozone soundings are also carried out on a campaign basis from Pituffik and Illoqqortoormiut in the winter and spring months, often as an element of major international campaigns. Balloon-borne experiments are also going on for studies of polar-stratospheric clouds from Greenland and Scandinavia. Data from the research campaigns are reported to the Pan-European data centre at NILU in Norway.

The DMI's stratospheric observatories in Pituffik and Kangerlussuaq are primary and secondary Arctic stations, respectively, in Network for the Detection of Stratospheric Change, a worldwide network of measuring stations equipped with standardised instrumentation of verified high quality for monitoring the condition of the stratosphere and the processes that lead to chemical depletion of the ozone layer. Besides ozone and NO_2 observations, the DMI in Pituffik takes measurements of the level of UV-B radiation. Besides the DMI's instrumentation, the NDCS stations include lidars for measuring stratospheric aerosol and cloud particles (Italy and USA) and an infrared spectrometer (USA) for measuring a wide range of stratospheric trace substances.

8.3.4 Reanalyses and climate databases

The DMI cooperates with the Pan-European meteorological forecasting centre in the UK, European Centre for Medium-Range Weather Forecasts, on building up and using so-called global reanalyses, which are a fundamental set of data for understanding climatic variations and changes based on all measurements globally over a 40-year period. In addition, databases of the climate trend in the past 100 years or so are created and maintained, cf. 8.3.1.

8.3.5 Oceanographic climate observations

Together with the Danish Coast Directorate, the DMI monitors the water level in a number of Danish localities.

In cooperation with the Greenland Institute of Natural Resources, the DMI carries out annual oceanographic observations on standard sections of the west coast of Greenland for the purpose of monitoring climate changes in the Greenland marine environment with a view to use in fishery evaluations.

The DMI also participates in special measuring campaigns in, for example, the North Atlantic. For instance, in 1999, the DMI took over the management of the research vessel DANA's expedition in the Greenland Sea, the purpose of which was to investigate the importance of this sea for global ocean circulation and its influence on the global climate.

8.3.6 Terrestrial observations related to climate changes

Monitoring of snow cover, sea ice and surface radiation is reported in sections 8.3.1 and 8.3.2. Denmark does not carry out further terrestrial observations that can be related to climate change, but Denmark's climate-related research (cf. 8.2) includes monitoring and studying the effect of terrestrial conditions.

8.3.7 Development assistance for establishment and maintenance of observation and monitoring systems

Since September 1997, the DMI has participated in a development project together with the Ghanaian meteorological institute (Meteorological Services Department – MSD). The purpose of the project includes re-establishing a network of meteorological stations in the country, thereby ensuring collection of data. At the same time, work is going on to improve communication and use of the collected data. According to plan, the project will run until the end of 2003. At the end of the project, MSD is intended to have an efficient network of around 300 observation stations registering the usual meteorological parameters.

The DMI is also participating in the project "Use of climatic seasonal forecasts to improve cultivation strategies for crops in West Africa". The purpose of this project is to examine the possibilities for adapting cultivation practice for a selected agricultural crop (peanuts) in Ghana, using the best available seasonal forecasts for the climate. The project is funded by the Council for Developing Country Research (RUF).

Finally, the DMI is participating in a knowledge-building initiative within use of regional climate scenarios in developing countries.

1 Climate Change Research – Danish Contributions, Jørgensen et al., 2001.
2 Mapping of Danish climate research and proposals for strengthening action areas. Prepared for the Working Group for a Danish Climate Research Programme, ECON Center for Economic Analysis, December 2002.
3 The climate of the 21st century: Transient simulations with a coupled atmosphere-ocean general circulation model, Stendel et al. 2000.

9 Education, training and public awareness

In Denmark there is an ongoing public debate in the media and elsewhere on the anthropogenic greenhouse effect, its extent, and the political reaction in the form of policies and measures. In 2002 the government published its strategy for sustainable development. The Danish climate policy must be seen in the light of the action to make the development of Danish society sustainable. The strategy includes involvement of the public and transparency concerning the basis for decisions and analyses. Denmark has a long tradition for involving the public, and in the environmental area this was followed up with an international agreement – the Århus Convention from 1998. In the international UN negotiations on a common effort to mitigate the effect of climate changes, both Danish industry, and green and development-oriented organisations were represented in the Danish delegation. The websites of the Ministry of Environment (http://www.mim.dk/), the Danish Environmental Protection Agency (www.mst.dk), the Ministry of Finance (www.fm.dk), the Ministry of Economic and Business Affairs (www.oem.dk) and the Danish Energy Authority (www.ens.dk) provide considerable information about climate change and Denmark's policy in this area.

The Danish Environmental Protection Agency has also initiated mapping of information obligations and activities in the climate area. The main purpose of the mapping project is to contribute to a basis for decisions on future information activities in the climate area on the basis of Denmark's formal commitments, the initiatives of Denmark and others, and general activities up to the present time.

9.1 Education and post-graduate education programmes

Climate change is a central theme at Copenhagen Global Change Initiative (COGCI), which is a PhD school and research network established in cooperation between the University of Copenhagen, the DMI, NERI, and GEUS. The school has 25 PhD students registered at present. The programme comprises general and specialist courses, together with seminars and theme days. Seminars and theme days are open to the public, and plans are in hand to offer the courses to other institutes and the business community as supplementary training.

The universities disseminate widely the result of research – for example, the Niels Bohr Institute's activities are published at the website http://www.fys.ku.dk/hco/presse/Formidling2002.htm. A large part of this work concerns climate, both specifically and more generally.

The DMI arranges lectures for, for example, upper secondary school pupils, teachers, researchers, and other interested persons. In addition, employees from a number of institutions participated in the Danish Natural Science Festival in 1998 and 2000, holding lectures around the country.

For upper secondary school pupils and pupils taking the higher preparatory examination, the Ministry of Environment, together with the Ministry of Foreign Affairs has prepared material for teaching about the environment. This project, which is called "The Global Environment" has climate as one of its main themes. The material is Internet-based (www.globalemiljoe.dk) and is supplemented by a textbook.

In connection with the many projects initiated under the Danish Environmental Protection Agency's (DEPA) Programme for Cleaner Products, reports are required, and these are made publicly accessible. In addition, articles are prepared for various technical journals so that the relevant target groups learn about the results.

9.2. Climate information

The DEPA website is regularly updated with the latest relevant information within the climate area, either directly in the form of press releases, documents, reports, etc. or through links to the actual players.

NERI has prepared a number of reports. Technical Report No. 401 contains an evaluation of Denmark's need and possibilities for adapting to future climate changes. The report features on NERI's website www.dmu.dk. A number of NERI's reports on climate are also designed for use in the education sector, including Theme Report 29/1999 "Where does air pollution come from?" and Theme Report 31/2000 "CO_2, where, why, how much?".

The DMI's website, http://www.dmi.dk/, provides current and historical climate data, together with a thorough description of the climate system and climate processes and themes on new results from the international scientific literature. The DMI also communicates through lectures and popular articles in newspapers and trade journals, through books and series of reports, and at theme days and in the magazine KlimaNyt (Climate News), which is published electronically two to four times a year. In 2001 the DMI published the book "Climate Change Research – Danish Contributions", edited in cooperation with Risø National Laboratory and NERI. The book provides a general introduction to the problem of man-made climate changes and describes research projects and results at a number of institutions in Denmark. The reports, KlimaNyt and the climate book can be obtained at www.dmi.dk. IPCC's results in the "Third Assessment Report" (TAR) in Danish have been disseminated in part through publication of a book, "Global Warming – Mitigation and Adaptation".
Another website of interest is http://www.glaciology.gfy.ku.dk/, which is regularly updated.

9.3 Danish participation in international climate activities

The DMI participates in a number of international projects with support primarily from the European Commission's framework research programmes. In addition, the Institute contributes to the IPCC's work. Partly in cooperation with the Max Planck Institut für Meteorologie in Hamburg, the DMI has carried out analyses of the development of climate for two of the IPCC's SRES emission scenarios with a coupled atmosphere-ocean model system.

These scenarios are available for effect studies in the IPCC's scenario database. Employees at the DMI have also participated in the preparation of the IPCC's Third Assessment Report (TAR) – one was coordinating author, another contributing author and several participated as expert reviewers.

The Danish Institute of Agricultural Sciences has contributed to the IPCC through an EU Concerted Action concerning effects of climate changes and adaptation to a changed climate in Europe.

Risø National Laboratory also participates at expert level in the IPCC. The UNEP Centre at Risø has contributed to the TAR WG III Report with five authors and a coordinating author. The UNEP Centre participates in a wide range of information activities in that connection with different policy possibilities in cooperation with the DMI, NERI, and others.NERI works in different ways to popularise and communicate the content of TAR, the latest research results on climate effects, etc.

9.4. Public campaigns

Campaigns

A number of initiatives are being carried out for companies and private households with a view to promoting environmentally sound behaviour, particularly for climate reasons and in relation to energy use. Denmark uses labelling schemes, printed material, information lines and media spots to increase public knowledge of possibilities for action and least environmentally harmful technology.

In the last few years environment policy has increasingly focused on the fact that we all share responsibility for environmental problems and for helping to solve them. This strategy is now also penetrating in the transport sector, and in the last three to four years, two large nationwide environmental traffic campaigns have been implemented. "We cycle to work" and "Environmental Traffic Week", which is an element in the European car-free day on 22 September and European Mobility Week, in which more than 1,000 towns all over Europe participated in 2002. In "We cycle to work" the Danish Cyclists' Federation has established good cooperation with many citizens and companies and has particularly communicated the health benefits of cycling as a form of transport. In "Environmental Traffic Week" the emphasis was on demonstrating more environment-friendly transport habits (use the car less, buy an energy-efficient car, drive together with others, use the bike for short trips, use public transport as much as possible, etc.). Emphasis was also on discussing traffic habits with the public in open dialogue and without reproach. In this way greater public engagement in the cause of environmental traffic can be established and help to create greater understanding of new ways of organising urban transport systems.

Another reason for the increased campaign and information activities is that a combination of measures affecting attitudes and behaviour and other forms of encouragement, such as economy and accessibility without a car are needed to promote more environment-friendly traffic habits.

Evaluations[1] show that both "We cycle to work" and the "Environmental Traffic Week" have had a good effect and have been well received by municipalities, interest and grassroots organisations, and companies, all of which were in charge of most of the actual activities. The Ministry of Transport and the Ministry of the Environment have so far provided funding of DKK 4-5 million for Environmental Traffic Week each year in order to support and co-fund the work of the municipalities. The present government co-funding ends in 2003, after which it will be up to the Danish municipalities themselves to finance any participation in European Mobility Week.

In the years ahead the growing public focus on lifestyle diseases and obesity will probably provide good opportunities for marketing non-motorised forms of transport, such as cycling and walking, in public health campaigns drawing people's attention to the health benefits of using a bike more often, walking to the shops, leisure activities, etc.

1 See, for example, Environment News No. 57, 2001, DEPA

Appendix A: Greenhouse gas inventories 1990-2001

This appendix contains five tables summarising the results of the latest greenhouse gas inventories for Denmark 1990-2001 and tables showing the preliminary inventories of Greenland's CO_2 emissions from energy use 1990-2001and the Faroe Islands' emission of CO_2, methane (CH_4) and nitrous oxide (N_2O) 1990-2001. The tables have been reproduced from the annual report to the Climate Convention from April 2003 (The National Inventory Report – NIR, including the Common Reporting Format - CRF).

Table A.1 (10-1): Denmark's carbon dioxide (CO_2) inventories 1990-2001

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(Gg CO2)												
1. Energy		**51530**	**62082**	**56142**	**58492**	**62482**	**59701**	**73051**	**63555**	**58500**	**55764**	**51199**	**52779**
A. Fuel Combustion (Sectoral Approach)		51290	61588	55631	58047	62014	59336	72651	62990	58077	54862	50606	52145
1. Energy Industries		26202	35155	30127	31689	35388	32093	44412	35433	31504	28250	25121	26375
2. Manufacturing Industries and Construction		5605	6012	5873	5804	6300	6705	6888	6763	6081	6129	5823	5909
3. Transport		10404	10896	11021	11202	11642	11775	11976	12102	12125	12182	12046	12077
4. Other Sectors		8959	9238	8470	9115	8432	8511	9198	8520	8162	8119	7505	7688
5. Other		119	287	141	237	252	252	176	171	204	182	111	97
B. Fugitive Emissions from Fuels		240	495	511	445	468	365	400	565	422	903	593	633
1. Solid Fuels		0	0	0	0	0	0	0	0	0	0	0	0
2. Oil and Natural Gas		240	495	511	445	468	365	400	565	422	903	593	633
2. Industrial Processes		**1005**	**1178**	**1300**	**1311**	**1318**	**1311**	**1388**	**1539**	**1436**	**1402**	**1453**	**1464**
A. Mineral Products		1005	1178	1300	1311	1318	1311	1388	1539	1436	1402	1453	1464
B. Chemical Industry		0	0	0	0	0	0	0	0	0	0	0	0
C. Metal Production		0	0	0	0	0	0	0	0	0	0	0	0
D. Other Production		0	0	0	0	0	0	0	0	0	0	0	0
E. Production of Halocarbons and SF_6													
F. Consumption of Halocarbons and SF_6													
G. Other		0	0	0	0	0	0	0	0	0	0	0	0
3. Solvent and Other Product Use		**124**	**122**	**121**	**125**	**119**	**118**	**116**	**115**	**114**	**113**	**112**	**112**
4. Agriculture		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Enteric Fermentation													
B. Manure Management													
C. Rice Cultivation													
D. Agricultural Soils [2]		0	0	0	0	0	0	0	0	0	0	0	0
E. Prescribed Burning of Savannas													
F. Field Burning of Agricultural Residues													
G. Other													
5. Land-Use Change and Forestry [3]		**-3118**	**-3119**	**-3121**	**-3123**	**-3126**	**-3128**	**-3134**	**-3142**	**-3152**	**-3161**	**-3517**	**-3531**
A. Changes in Forest and Other Woody Biomass Stocks		-3118	-3119	-3121	-3123	-3126	-3128	-3134	-3142	-3152	-3161	-3517	-3531
B. Forest and Grassland Conversion													
C. Abandonment of Managed Lands		0	0	0	0	0	0	0	0	0	0	0	0
D. CO_2 Emissions and Removals from Soil		0	0	0	0	0	0	0	0	0	0	0	0
E. Other		0	0	0	0	0	0	0	0	0	0	0	0
6. Waste		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Solid Waste Disposal on Land													
B. Waste-water Handling													
C. Waste Incineration													
D. Other													
7. Other		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Emissions/Removals with LUCF [4]		**49541**	**60264**	**54442**	**56805**	**60793**	**58002**	**71422**	**62067**	**56898**	**54118**	**49247**	**50824**
Total Emissions without LUCF[4]		**52659**	**63383**	**57563**	**59928**	**63919**	**61130**	**74556**	**65209**	**60050**	**57279**	**52764**	**54355**
Memo Items:													
International Bunkers		**4857**	**4407**	**4590**	**5973**	**6664**	**6940**	**6790**	**6429**	**6587**	**6457**	**6629**	**5983**
Aviation		1762	1635	1695	1660	1819	1867	1970	2010	2158	2290	2348	2378
Marine		3095	2772	2895	4312	4846	5073	4820	4419	4429	4166	4281	3605
Multilateral Operations		0	0	0	0	0	0	0	0	0	0	0	0
CO_2 Emissions from Biomass		4611	5013	5319	5567	5679	6014	6449	6617	6336	6352	7001	7679

[1] Fill in the base year adopted by the Party under the Convention, if different from 1990.

Table A.2 (10-2): Denmark's methane (CH_4) inventories 1990-2001

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
					(Gg CH4)								
Total Emissions		270	273	273	279	280	284	287	282	276	261	264	267
1. Energy		13	15	16	17	25	32	36	39	35	37	36	38
A. Fuel Combustion (Sectoral Approach)		9	10	10	11	17	22	27	29	29	30	30	31
1. Energy Industries		1	2	2	3	6	11	15	16	19	17	17	18
2. Manufacturing Industries and Construction		1	1	1	1	1	1	2	2	1	2	2	2
3. Transport		3	3	3	3	4	4	4	4	4	4	3	3
4. Other Sectors		4	4	4	4	6	6	7	7	5	7	8	8
5. Other		0	0	0	0	0	0	0	0	0	0	0	0
B. Fugitive Emissions from Fuels		4	6	6	6	9	10	9	10	6	8	7	7
1. Solid Fuels		3	4	4	5	6	6	6	7	3	3	3	3
2. Oil and Natural Gas		1	2	2	2	3	3	3	4	3	4	4	4
2. Industrial Processes		0	0	0	0	0	0	0	0	0	0	0	0
A. Mineral Products		0	0	0	0	0	0	0	0	0	0	0	0
B. Chemical Industry		0	0	0	0	0	0	0	0	0	0	0	0
C. Metal Production		0	0	0	0	0	0	0	0	0	0	0	0
D. Other Production													
E. Production of Halocarbons and SF_6													
F. Consumption of Halocarbons and SF_6													
G. Other		0	0	0	0	0	0	0	0	0	0	0	0
3. Solvent and Other Product Use													
4. Agriculture		195	194	192	197	189	189	189	184	186	170	170	173
A. Enteric Fermentation		152	151	148	150	145	145	145	140	140	130	129	131
B. Manure Management		43	43	44	47	44	45	44	44	46	40	41	42
C. Rice Cultivation		0	0	0	0	0	0	0	0	0	0	0	0
D. Agricultural Soils		0	0	0	0	0	0	0	0	0	0	0	0
E. Prescribed Burning of Savannas		0	0	0	0	0	0	0	0	0	0	0	0
F. Field Burning of Agricultural Residues		0	0	0	0	0	0	0	0	0	0	0	0
G. Other		0	0	0	0	0	0	0	0	0	0	0	0
5. Land-Use Change and Forestry		0	0	0	0	0	0	0	0	0	0	0	0
A. Changes in Forest and Other Woody Biomass Stocks													
B. Forest and Grassland Conversion		0	0	0	0	0	0	0	0	0	0	0	0
C. Abandonment of Managed Lands													
D. CO_2 Emissions and Removals from Soil													
E. Other		0	0	0	0	0	0	0	0	0	0	0	0
6. Waste		62	64	65	65	65	63	62	59	55	53	57	56
A. Solid Waste Disposal on Land		62	64	65	65	65	63	62	59	55	53	57	56
B. Waste-water Handling		0	0	0	0	0	0	0	0	0	0	0	0
C. Waste Incineration		0	0	0	0	0	0	0	0	0	0	0	0
D. Other		0	0	0	0	0	0	0	0	0	0	0	0
7. Other		0	0	0	0	0	0	0	0	0	0	0	0
Memo Items:													
International Bunkers		0	0	0	0	0	0	0	0	0	0	0	0
Aviation		0	0	0	0	0	0	0	0	0	0	0	0
Marine		0	0	0	0	0	0	0	0	0	0	0	0
Multilateral Operations		0	0	0	0	0	0	0	0	0	0	0	0
CO_2 Emissions from Biomass													

Table A.3 (10-3): Denmark's nitrous oxide (N_2O) inventories 1990-2001

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(Gg N2O)												
Total Emissions		**35**	**35**	**32**	**33**	**32**	**32**	**31**	**30**	**30**	**30**	**29**	**28**
1. Energy		**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**
A. Fuel Combustion (Sectoral Approach)		2	2	2	2	2	2	3	3	3	3	3	3
1. Energy Industries		1	1	1	1	1	1	1	1	1	1	1	1
2. Manufacturing Industries and Construction		0	0	0	0	0	0	0	0	0	0	0	0
3. Transport		0	1	1	1	1	1	1	1	1	1	1	1
4. Other Sectors		0	0	0	0	0	0	0	0	0	0	0	0
5. Other		0	0	0	0	0	0	0	0	0	0	0	0
B. Fugitive Emissions from Fuels		0	0	0	0	0	0	0	0	0	0	0	0
1. Solid Fuels		0	0	0	0	0	0	0	0	0	0	0	0
2. Oil and Natural Gas		0	0	0	0	0	0	0	0	0	0	0	0
2. Industrial Processes		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Mineral Products		0	0	0	0	0	0	0	0	0	0	0	0
B. Chemical Industry		0	0	0	0	0	0	0	0	0	0	0	0
C. Metal Production		0	0	0	0	0	0	0	0	0	0	0	0
D. Other Production													
E. Production of Halocarbons and SF_6													
F. Consumption of Halocarbons and SF_6													
G. Other		0	0	0	0	0	0	0	0	0	0	0	0
3. Solvent and Other Product Use		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
4. Agriculture		**33**	**32**	**30**	**31**	**30**	**29**	**29**	**27**	**28**	**27**	**27**	**26**
A. Enteric Fermentation													
B. Manure Management		1	2	2	2	2	2	2	1	2	1	1	1
C. Rice Cultivation													
D. Agricultural Soils		32	31	29	29	28	28	27	26	26	26	25	24
E. Prescribed Burning of Savannas		0	0	0	0	0	0	0	0	0	0	0	0
F. Field Burning of Agricultural Residues		0	0	0	0	0	0	0	0	0	0	0	0
G. Other		0	0	0	0	0	0	0	0	0	0	0	0
5. Land-Use Change and Forestry		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in Forest and Other Woody Biomass Stocks													
B. Forest and Grassland Conversion		0	0	0	0	0	0	0	0	0	0	0	0
C. Abandonment of Managed Lands													
D. CO_2 Emissions and Removals from Soil													
E. Other		0	0	0	0	0	0	0	0	0	0	0	0
6. Waste		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Solid Waste Disposal on Land													
B. Waste-water Handling		0	0	0	0	0	0	0	0	0	0	0	0
C. Waste Incineration		0	0	0	0	0	0	0	0	0	0	0	0
D. Other		0	0	0	0	0	0	0	0	0	0	0	0
7. Other		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Memo Items:													
International Bunkers		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Aviation		0	0	0	0	0	0	0	0	0	0	0	0
Marine		0	0	0	0	0	0	0	0	0	0	0	0
Multilateral Operations		0	0	0	0	0	0	0	0	0	0	0	0
CO_2 Emissions from Biomass													

Table A.4 (10-4): Denmark's inventories for the industrial greenhouse gases (HFCs, PFCs and SF_6) 1990-2001

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(Gg CO2) Actual emissions												
Emissions of HFCs CO2 equivalent (Gg)		**0**	**0**	**4**	**96**	**141**	**236**	**371**	**392**	**489**	**598**	**705**	**647**
HFC-23		0	0	0	0	0	0	0	0	0	0	0	0
HFC-32		0	0	0	0	0	0	0	0	0	0	0	0
HFC-41		0	0	0	0	0	0	0	0	0	0	0	0
HFC-43-10mee		0	0	0	0	0	0	0	0	0	0	0	0
HFC-125		0	0	0	0	0	0	0	0	0	0	0	0
HFC-134		0	0	0	0	0	0	0	0	0	0	0	0
HFC-134a		0	0	0	0	0	0	0	0	0	0	0	0
HFC-152a		0	0	0	0	0	0	0	0	0	0	0	0
HFC-143		0	0	0	0	0	0	0	0	0	0	0	0
HFC-143a		0	0	0	0	0	0	0	0	0	0	0	0
HFC-227ea		0	0	0	0	0	0	0	0	0	0	0	0
HFC-236fa		0	0	0	0	0	0	0	0	0	0	0	0
HFC-245ca		0	0	0	0	0	0	0	0	0	0	0	0
Emissions of PFCs CO_2 equivalent (Gg)		**0**	**0**	**0**	**0**	**0**	**1**	**3**	**7**	**15**	**20**	**28**	**22**
CF_4		0	0	0	0	0	0	0	0	0	0	0	0
C_2F_6		0	0	0	0	0	0	0	0	0	0	0	0
C_3F_8		0	0	0	0	0	0	0	0	0	0	0	0
C_4F_{10}		0	0	0	0	0	0	0	0	0	0	0	0
$c\text{-}C_4F_8$		0	0	0	0	0	0	0	0	0	0	0	0
C_5F_{12}		0	0	0	0	0	0	0	0	0	0	0	0
C_6F_{14}		0	0	0	0	0	0	0	0	0	0	0	0
Emissions of SF_6 CO_2 equivalent (Gg)		**43**	**62**	**89**	**135**	**122**	**107**	**61**	**73**	**59**	**65**	**59**	**30**
SF_6		0	0	0	0	0	0	0	0	0	0	0	0

Table A.5 (10-5): Denmark s total emissions and removals of greenhouse gases (GHGs) in the period 1990-2001

GREENHOUSE GAS EMISSIONS	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO2 ækvivalenter (Gg)												
Net CO_2 emissions/removals		49541	60264	54442	56805	60793	58002	71422	62067	56898	54118	49247	50824
CO_2 emissions (without LUCF) [6]		52659	63383	57563	59928	63919	61130	74556	65209	60050	57279	52764	54355
CH_4		5672	5728	5735	5858	5882	5958	6030	5920	5802	5473	5535	5606
N_2O		10843	10737	10068	10193	9976	9903	9758	9343	9382	9314	9090	8749
HFCs		0	0	4	96	141	236	371	392	489	598	705	647
PFCs		0	0	0	0	0	1	3	7	15	20	28	22
SF_6		43	62	89	135	122	107	61	73	59	65	59	30
Total (with net CO_2 emissions/removals)		**66099**	**76791**	**70338**	**73086**	**76913**	**74207**	**87644**	**77803**	**72645**	**69589**	**64664**	**65879**
Total (without CO_2 from LUCF) [6]		**69217**	**79910**	**73459**	**76209**	**80039**	**77335**	**90778**	**80945**	**75797**	**72750**	**68181**	**69410**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO_2 equivalent (Gg)												
1. Energy		52386	63113	57142	59566	63790	61135	74732	65222	60059	57359	52758	54416
2. Industrial Processes		1049	1240	1393	1541	1581	1655	1823	2012	2000	2085	2246	2164
3. Solvent and Other Product Use		124	122	121	125	119	118	116	115	114	113	112	112
4. Agriculture		14348	14096	13441	13618	13174	13111	12803	12354	12460	12083	11868	11550
5. Land-Use Change and Forestry [7]		-3118	-3119	-3121	-3123	-3126	-3128	-3134	-3142	-3152	-3161	-3517	-3531
6. Waste		1310	1338	1361	1359	1375	1317	1304	1241	1163	1110	1197	1168
7. Other		0	0	0	0	0	0	0	0	0	0	0	0

[6] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO_2 emissions and removals from Land-Use Change and Forestry.
[7] Net emissions.

Table A.6 :
Greenland's preliminary inventories for CO_2 from energy use, Faroe Island's preliminary inventories for CO_2 , methane (CH_4) and nitrous oxide (N_2O) and the totals for Denmark, Greenland and Faroe Islands 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	(Gg CO_2 equivalent)											
Greenlands CO_2 emissions (without LUCF)	**624**	**609**	**594**	**0**	**494**	**523**	**564**	**575**	**550**	**585**	**659**	**617**
Faroe Island's CO2 emissions (without LUCF)	709	682	650	536	544	541	578	559	616	645	699	791
Faroe Island's CH_4 emissions	18	19	19	18	19	19	19	20	19	19	20	20
Faroe Island's N_2O emissions	23	24	24	23	24	25	25	27	26	27	30	31
Faroe Island's Total Emissions without LUCF	**750**	**725**	**693**	**577**	**588**	**585**	**622**	**605**	**661**	**691**	**749**	**843**
The Kingdom's Total Emissions and Removals with LUCF	**66099**	**76791**	**70338**	**73086**	**76913**	**74207**	**87644**	**77803**	**72645**	**69589**	**64664**	**65879**
The Kingdom's Total Emissions and Removals without LUCF	**69217**	**79910**	**73459**	**76209**	**80039**	**77335**	**90778**	**80945**	**75797**	**72750**	**68181**	**69410**
Trend since 1990 (1990=index 100), without LUCF	**100**	**116**	**106**	**111**	**116**	**112**	**133**	**118**	**110**	**105**	**98**	**100**
Trend since 1990 (1990=index 100), with LUCF	**100**	**115**	**106**	**110**	**116**	**112**	**131**	**117**	**110**	**105**	**99**	**100**

Appendix B: Projections of Denmark's greenhouse gas emissions and removals up to 2017

This appendix contains the result of the latest "with measures" projections of Denmark's emissions and removals of greenhouse gases published in Denmark's Greenhouse Gas Projections until 2012, an update including a preliminary projection until 2017, Environmental Project No. 764, Danish Environmental Protection Agency, 2003. "With measures" means that only the effects of implemented measures have been taken into account in the projections. The effects of further possible measures and their costs are described in chapter 4.

The result for each greenhouse gas and the combined result are presented in tables showing the source and sector breakdown in the IPCC/UNFCCC-CRF format, which is also used in connection with the annual reporting of the historical inventories of emissions and removals of greenhouse gases.

Table B.1: CO_2 projections 2002-2017 in IPCC/UNFCCC-CRF format

CO2 projections (Gg)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	55892	58126	61925	62503	64034	64308	64997	65503	65672	65892	66125	66089	64412	63912	63773	63888	65638	64415
Denmark's Total KP Removals	-88	-110	-127	-147	-169	-189	-220	-246	-286	-321	-343	-397	-400	-441	-479	-503	-283	-444
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	54976	57210	61009	61587	63118	63392	64081	64587	64756	64976	65209	65173	63496	62996	62857	62972	64722	63499
Denmark's Total Emissions without LUCF	55980	58236	62052	62650	64203	64497	65217	65749	65958	66213	66468	66486	64812	64353	64252	64391	65921	64859
1. Energy	54453	56713	60533	61134	62692	62989	63692	64222	64431	64685	64941	64997	63323	62865	62763	62902	64394	63370
A Fuel Combustion Activities (Sectoral Approach)	53943	56169	59960	60561	62118	62416	63118	63649	63858	64111	64367	64426	62764	62328	62227	62365	63821	62822
1 Energy Industries	27994	29853	33348	33629	34857	34819	35213	35448	35401	35449	35513	35397	33575	32986	32723	32697	35405	33475
a Public Electricity and Heat Production	25159	26851	29976	30145	31373	31335	31729	31964	31917	32011	32097	32136	30504	29961	29721	29695	31944	30403
b Petroleum Refining	987	987	987	987	987	987	987	987	987	987	987	987	987	987	987	987	987	987
c Manufacture of Solid Fuels and Other Energy Industries	1848	2015	2385	2497	2497	2497	2497	2497	2497	2451	2428	2273	2083	2038	2015	2015	2474	2085
2 Manufacturing Industries and Construction	6090	6213	6324	6454	6585	6716	6849	6984	7121	7241	7358	7472	7582	7687	7785	7882	7111	7681
3 Transport	12204	12450	12654	12869	13080	13277	13461	13628	13753	13851	13940	14017	14083	14149	14220	14297	13727	14153
a Civil Aviation	156	164	171	179	184	190	196	202	209	215	221	227	233	240	246	253	208	240
b Road Transportation	11582	11833	12043	12265	12470	12662	12840	13000	13120	13211	13295	13365	13425	13484	13549	13619	13093	13488
c Railways	204	204	203	202	202	202	202	202	202	202	202	202	202	202	202	202	202	202
d Navigation	261	248	236	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223
4 Other Sectors	7417	7418	7401	7380	7370	7376	7370	7365	7359	7348	7335	7321	7306	7290	7283	7275	7355	7295
a Commercial/Institutional	844	859	873	886	898	910	920	931	940	948	955	962	970	977	985	992	939	977
b Residential	4152	4104	4044	3985	3944	3922	3888	3858	3827	3796	3764	3734	3702	3670	3648	3626	3827	3676
c Agriculture/Forestry/Fisheries	2421	2455	2485	2508	2528	2545	2562	2577	2592	2605	2616	2625	2634	2642	2650	2657	2590	2642
5 Other (please specify: Military mobile and in projections other off road)	238	236	233	230	228	227	226	224	223	222	221	219	218	217	215	214	223	217
b. Mobile	238	236	233	230	228	227	226	224	223	222	221	219	218	217	215	214	223	217
B Fugitive Emissions from Fuels	509	544	573	573	573	573	573	573	573	573	573	571	560	537	537	537	573	548
1 Solid Fuels																		
2 Oil and Natural Gas	509	544	573	573	573	573	573	573	573	573	573	571	560	537	537	537	573	548
Flaring	509	544	573	573	573	573	573	573	573	573	573	571	560	537	537	537	573	548
2. Industrial Processes	1454	1454	1455	1456	1456	1457	1457	1458	1458	1459	1459	1420	1420	1420	1420	1420	1458	1420
A Mineral Products	1454	1454	1455	1456	1456	1457	1457	1458	1458	1459	1459	1420	1420	1420	1420	1420	1458	1420
1 Cement Production	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343
2 Lime Production	110	111	111	113	112	114	113	115	114	116	116	77	77	77	77	77	115	77
F Consumption of Halocarbons and Sulphur Hexafluoride																		
1 Refrigeration and Air Conditioning Equipment																		
2 Foam Blowing																		
4. Aerosols/ Metered Dose Inhalers																		
7. Electrical Equipment (SF6)																		
8 Other (please specify)																		
C3F8 (PFC used as detergent)																		
SF6 (Window plate production, Research laboratories and Running shoes)																		
3. Solvent and Other Product Use	73	69	64	60	55	51	68	68	68	68	68	68	68	68	68	68	68	68
A Paint Application	37	35	32	30	28	25	34	34	34	34	34	34	34	34	34	34	34	34
D Other (please specify: Other Products, Manufacture and Processing)	37	34	32	30	28	25	34	34	34	34	34	34	34	34	34	34	34	34
4. Agriculture																		
A Enteric Fermentation																		
B Manure Management																		
D Agricultural Soils																		
5. Land-Use Change and Forestry (LUCF)	-1004	-1026	-1043	-1063	-1085	-1105	-1136	-1162	-1202	-1237	-1259	-1313	-1316	-1357	-1395	-1419	-1199	-1360
A Changes in Forest and Other Woody Biomass Stocks	-1004	-1026	-1043	-1063	-1085	-1105	-1136	-1162	-1202	-1237	-1259	-1313	-1316	-1357	-1395	-1419	-1199	-1360
2 Temperate Forests	-1004	-1026	-1043	-1063	-1085	-1105	-1136	-1162	-1202	-1237	-1259	-1313	-1316	-1357	-1395	-1419	-1199	-1360
6. Waste																		
A Solid Waste Disposal on Land																		
1 Managed Waste Disposal on Land																		
7. Other (please specify)																		
Memo Items (not included above):																		
International Bunkers	6098	6201	6287	6376	6464	6552	6645	6738	6838	6930	7025	7122	7220	7319	7420	7525	6835	7321
Aviation	2480	2584	2670	2758	2847	2935	3027	3121	3220	3313	3408	3505	3602	3701	3802	3908	3218	3704
Marine	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618	3618
Multilateral Operations																		
CO2 Emissions from Biomass																		
CO2 Emissions related to Net Electricity Import	-4457	-6930	-10250	-10301	-11194	-10764	-10774	-10552	-9862	-9365	-9106	-8865	-9040	-8908	-9450	-9044	-9932	-9061

Table B.2 CH_4 projections 2002-2017 in IPCC/UNFCCC-CRF format

CH4 projections (Gg CO2 equivalents)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	5488	5402	5334	5281	5225	5175	5112	5059	5009	4905	4809	4782	4719	4646	4591	4544	4979	4656
Denmark's Total KP Removals																		0
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	5488	5402	5334	5281	5225	5175	5112	5059	5009	4905	4809	4782	4719	4646	4591	4544	4979	4656
Denmark's Total Emissions without LUCF	5488	5402	5334	5281	5225	5175	5112	5059	5009	4905	4809	4782	4719	4646	4591	4544	4979	4656
1. Energy	869	870	880	889	888	887	874	870	866	861	857	856	851	832	828	827	866	839
A Fuel Combustion Activities (Sectoral Approach)	612	612	616	612	611	606	595	590	585	579	576	574	569	567	567	568	585	569
1 Energy Industries	293	293	296	293	293	291	281	279	277	273	270	269	266	265	265	266	276	266
a Public Electricity and Heat Production	279	278	279	275	275	272	263	261	259	255	252	253	250	250	250	251	258	251
b Petroleum Refining	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
c Manufacture of Solid Fuels and Other Energy Industries	13	14	16	17	17	17	17	17	17	17	17	15	14	14	14	14	17	14
2 Manufacturing Industries and Construction	30	31	31	32	32	33	33	34	34	35	35	36	36	36	37	37	34	36
3 Transport	52	50	48	46	43	40	37	34	30	29	27	25	23	21	20	19	31	22
a Civil Aviation	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1
b Road Transportation	51	49	47	45	42	39	36	33	30	28	26	24	22	20	19	18	31	21
c Railways	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
d Navigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 Other Sectors	236	238	239	241	242	242	242	242	242	243	243	243	244	244	245	245	242	244
a Commercial/Institutional	20	20	20	20	20	21	21	21	21	21	21	21	21	22	22	22	21	22
b Residential	173	174	175	176	177	176	176	176	176	176	176	176	176	176	177	177	176	177
c Agriculture/Forestry/Fisheries	43	44	45	45	45	45	45	45	46	46	46	46	46	46	46	46	46	46
5 Other (please specify: Military mobile and in projections other off road)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
b. Mobile	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
B Fugitive Emissions from Fuels	257	258	264	276	277	280	279	280	281	281	282	282	282	266	261	260	281	270
1 Solid Fuels	78	78	85	97	97	101	100	101	101	102	102	103	103	86	81	80	101	91
2 Oil and Natural Gas	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179
Flaring	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2. Industrial Processes																		
A Mineral Products																		
1 Cement Production																		
2 Lime Production																		
F Consumption of Halocarbons and Sulphur Hexafluoride																		
1 Refrigeration and Air Conditioning Equipment																		
2 Foam Blowing																		
4. Aerosols/ Metered Dose Inhalers																		
7. Electrical Equipment (SF6)																		
8 Other (please specify)																		
C3F8 (PFC used as detergent)																		
SF6 (Window plate production, Research laboratories and Running shoes)																		
3. Solvent and Other Product Use																		
A Paint Application																		
D Other (please specify: Other Products, Manufacture and Processing)																		
4. Agriculture	3463	3418	3383	3348	3317	3286	3257	3228	3199	3171	3144	3133	3133	3133	3133	3133	3200	3133
A Enteric Fermentation	2734	2697	2669	2641	2614	2587	2561	2535	2509	2484	2459	2459	2459	2459	2459	2459	2509	2459
B Manure Management	729	721	714	707	703	699	696	693	690	688	685	674	674	674	674	674	690	674
D Agricultural Soils																		
5. Land-Use Change and Forestry (LUCF)																		
A Changes in Forest and Other Woody Biomass Stocks																		
2 Temperate Forests																		
6. Waste	1157	1113	1071	1045	1021	1002	981	962	944	873	808	793	735	681	630	583	914	684
A Solid Waste Disposal on Land	1157	1113	1071	1045	1021	1002	981	962	944	873	808	793	735	681	630	583	914	684
1 Managed Waste Disposal on Land	1157	1113	1071	1045	1021	1002	981	962	944	873	808	793	735	681	630	583	914	684
7. Other (please specify)																		
Memo Items (not included above):																		
International Bunkers	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	4	5
Aviation	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3
Marine	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Multilateral Operations																		
CO2 Emissions from Biomass																		
CO2 Emissions related to Net Electricity Import																		

Table B.3: N_2O projections 2002-2017 in IPCC/UNFCCC-CRF format

N2O projections (Gg CO2 equivalents)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	8777	8473	8555	8604	8644	8670	8700	8727	8750	8754	8759	8763	8738	8730	8728	8731	8738	8738
Denmark's Total KP Removals																		0
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	8777	8473	8555	8604	8644	8670	8700	8727	8750	8754	8759	8763	8738	8730	8728	8731	8738	8738
Denmark's Total Emissions without LUCF	8777	8473	8555	8604	8644	8670	8700	8727	8750	8754	8759	8763	8738	8730	8728	8731	8738	8738
1. Energy	946	999	1067	1103	1132	1148	1168	1185	1197	1201	1206	1211	1185	1177	1175	1179	1191	1185
A Fuel Combustion Activities (Sectoral Approach)	944	997	1065	1101	1131	1147	1166	1183	1196	1199	1205	1209	1183	1175	1173	1177	1190	1184
1 Energy Industries	294	315	353	358	370	369	372	375	376	373	373	373	344	332	327	326	374	340
a Public Electricity and Heat Production	277	298	334	338	350	349	353	355	356	354	354	354	326	315	309	309	354	323
b Petroleum Refining	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
c Manufacture of Solid Fuels and Other Energy Industries	10	11	13	14	14	14	14	14	14	13	13	12	11	11	11	11	13	11
2 Manufacturing Industries and Construction	58	59	60	61	62	64	65	66	67	68	69	70	71	72	73	74	67	72
3 Transport	502	532	561	592	608	624	638	652	662	667	672	675	678	681	684	687	658	681
a Civil Aviation	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	2	3
b Road Transportation	493	524	553	584	600	615	630	643	654	659	663	667	669	672	675	678	650	672
c Railways	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
d Navigation	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4 Other Sectors	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88
a Commercial/Institutional	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9
b Residential	46	45	45	44	44	44	44	43	43	43	42	42	42	42	42	41	43	42
c Agriculture/Forestry/Fisheries	34	35	35	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37
5 Other (please specify: Military mobile and in projections other off road)	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
b. Mobile	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
B Fugitive Emissions from Fuels	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2
1 Solid Fuels																		
2 Oil and Natural Gas	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2
Flaring	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2
2. Industrial Processes																		
A Mineral Products																		
1 Cement Production																		
2 Lime Production																		
F Consumption of Halocarbons and Sulphur Hexafluoride																		
1 Refrigeration and Air Conditioning Equipment																		
2 Foam Blowing																		
4. Aerosols/ Metered Dose Inhalers																		
7. Electrical Equipment (SF6)																		
8 Other (please specify)																		
C3F8 (PFC used as detergent)																		
SF6 (Window plate production, Research laboratories and Running shoes)																		
3. Solvent and Other Product Use																		
A Paint Application																		
D Other (please specify: Other Products, Manufacture and Processing)																		
4. Agriculture	7832	7474	7488	7501	7512	7522	7532	7543	7553	7553	7553	7553	7553	7553	7553	7553	7547	7553
A Enteric Fermentation																		
B Manure Management	716	712	717	723	728	734	739	745	750	750	750	750	750	750	750	750	747	750
D Agricultural Soils	7116	6763	6771	6779	6784	6788	6793	6798	6803	6803	6803	6803	6803	6803	6803	6803	6800	6803
5. Land-Use Change and Forestry (LUCF)																		
A Changes in Forest and Other Woody Biomass Stocks																		
2 Temperate Forests																		
6. Waste																		
A Solid Waste Disposal on Land																		
1 Managed Waste Disposal on Land																		
7. Other (please specify)																		
																	0	0
Memo Items (not included above):																		
International Bunkers	91	92	93	94	94	95	96	97	97	98	99	100	101	101	102	103	97	101
Aviation	21	22	22	23	24	24	25	26	27	28	28	29	30	31	32	32	27	31
Marine	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71
Multilateral Operations																		
CO2 Emissions from Biomass																		
CO2 Emissions related to Net Electricity Import																		

Table B.4: HFCs projections 2002-2017 in IPCC/UNFCCC-CRF format

HFCs emissions (Gg CO2 equivalents, actual emissions)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	704	724	746	764	703	712	704	682	656	606	542	500	429	374	308	262	638	374
Denmark's Total KP Removals																		0
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	704	724	746	764	703	712	704	682	656	606	542	500	429	374	308	262	638	374
Denmark's Total Emissions without LUCF	704	724	746	764	703	712	704	682	656	606	542	500	429	374	308	262	638	374
1. Energy																		
A Fuel Combustion Activities (Sectoral Approach)																		
1 Energy Industries																		
a Public Electricity and Heat Production																		
b Petroleum Refining																		
c Manufacture of Solid Fuels and Other Energy Industries																		
2 Manufacturing Industries and Construction																		
3 Transport																		
a Civil Aviation																		
b Road Transportation																		
c Railways																		
d Navigation																		
4 Other Sectors																		
a Commercial/Institutional																		
b Residential																		
c Agriculture/Forestry/Fisheries																		
5 Other (please specify: Military mobile and in projections other off road)																		
b. Mobile																		
B Fugitive Emissions from Fuels																		
1 Solid Fuels																		
2 Oil and Natural Gas																		
Flaring																		
2. Industrial Processes	704	724	746	764	703	712	704	682	656	606	542	500	429	374	308	262	638	374
A Mineral Products																		
1 Cement Production																		
2 Lime Production																		
F Consumption of Halocarbons and Sulphur Hexafluoride	704	724	746	764	703	712	704	682	656	606	542	500	429	374	308	262	638	374
1 Refrigeration and Air Conditioning Equipment	518	535	549	558	570	580	573	558	540	500	447	416	364	321	266	229	524	319
2 Foam Blowing	181	189	198	206	133	132	131	124	116	106	95	84	65	52	41	33	115	55
4. Aerosols/ Metered Dose Inhalers	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Electrical Equipment (SF6)																		
8 Other (please specify)																		
C3F8 (PFC used as detergent)																		
SF6 (Window plate production, Research laboratories and Running shoes)																		
3. Solvent and Other Product Use																		
A Paint Application																		
D Other (please specify: Other Products, Manufacture and Processing)																		
4. Agriculture																		
A Enteric Fermentation																		
B Manure Management																		
D Agricultural Soils																		
5. Land-Use Change and Forestry (LUCF)																		
A Changes in Forest and Other Woody Biomass Stocks																		
2 Temperate Forests																		
6. Waste																		
A Solid Waste Disposal on Land																		
1 Managed Waste Disposal on Land																		
7. Other (please specify)																		
Memo Items (not included above):																		
International Bunkers																		
Aviation																		
Marine																		
Multilateral Operations																		
CO2 Emissions from Biomass																		
CO2 Emissions related to Net Electricity Import																		

Table B.5: PFCs projections 2002-2017 in IPCC/UNFCCC-CRF format

SF6 projections (Gg CO2 equivalents, actual emissions)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
Denmark's Total KP Removals																		0
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
Denmark's Total Emissions without LUCF	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
1. Energy																		
A Fuel Combustion Activities (Sectoral Approach)																		
1 Energy Industries																		
a Public Electricity and Heat Production																		
b Petroleum Refining																		
c Manufacture of Solid Fuels and Other Energy Industries																		
2 Manufacturing Industries and Construction																		
3 Transport																		
a Civil Aviation																		
b Road Transportation																		
c Railways																		
d Navigation																		
4 Other Sectors																		
a Commercial/Institutional																		
b Residential																		
c Agriculture/Forestry/Fisheries																		
5 Other (please specify: Military mobile and in projections other off road)																		
b. Mobile																		
B Fugitive Emissions from Fuels																		
1 Solid Fuels																		
2 Oil and Natural Gas																		
Flaring																		
2. Industrial Processes	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
A Mineral Products																		
1 Cement Production																		
2 Lime Production																		
F Consumption of Halocarbons and Sulphur Hexafluoride	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
1 Refrigeration and Air Conditioning Equipment																		
2 Foam Blowing																		
4. Aerosols/ Metered Dose Inhalers																		
7. Electrical Equipment (SF6)	11	12	12	12	13	13	13	13	14	14	14	15	15	15	15	16	14	15
8 Other (please specify)	18	17	15	15	15	15	15	15	15	47	93	102	114	100	72	56	37	89
C3F8 (PFC used as detergent)																		
SF6 (Window plate production, Research laboratories and Running shoes)	18	17	15	15	15	15	15	15	15	47	93	102	114	100	72	56	37	89
3. Solvent and Other Product Use																		
A Paint Application																		
D Other (please specify: Other Products, Manufacture and Processing)																		
4. Agriculture																		
A Enteric Fermentation																		
B Manure Management																		
D Agricultural Soils																		
5. Land-Use Change and Forestry (LUCF)																		
A Changes in Forest and Other Woody Biomass Stocks																		
2 Temperate Forests																		
6. Waste																		
A Solid Waste Disposal on Land																		
1 Managed Waste Disposal on Land																		
7. Other (please specify)																		
Memo Items (not included above):																		
International Bunkers																		
Aviation																		
Marine																		
Multilateral Operations																		
CO2 Emissions from Biomass																		
CO2 Emissions related to Net Electricity Import																		

Table B.6: SF_6 projections 2002-2017 in IPCC/UN-FCCC-CRF format

SF6 projections (Gg CO2 equivalents, actual emissions)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
Denmark's Total KP Removals																		0
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
Denmark's Total Emissions without LUCF	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
1. Energy																		
A Fuel Combustion Activities (Sectoral Approach)																		
1 Energy Industries																		
a Public Electricity and Heat Production																		
b Petroleum Refining																		
c Manufacture of Solid Fuels and Other Energy Industries																		
2 Manufacturing Industries and Construction																		
3 Transport																		
a Civil Aviation																		
b Road Transportation																		
c Railways																		
d Navigation																		
4 Other Sectors																		
a Commercial/Institutional																		
b Residential																		
c Agriculture/Forestry/Fisheries																		
5 Other (please specify: Military mobile and in projections other off road)																		
b. Mobile																		
B Fugitive Emissions from Fuels																		
1 Solid Fuels																		
2 Oil and Natural Gas																		
Flaring																		
2. Industrial Processes	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
A Mineral Products																		
1 Cement Production																		
2 Lime Production																		
F Consumption of Halocarbons and Sulphur Hexafluoride	29	29	27	27	28	28	28	28	28	61	107	117	129	115	87	72	50	104
1 Refrigeration and Air Conditioning Equipment																		
2 Foam Blowing																		
4. Aerosols/ Metered Dose Inhalers																		
7. Electrical Equipment (SF6)	11	12	12	12	13	13	13	13	14	14	14	15	15	15	15	16	14	15
8 Other (please specify)	18	17	15	15	15	15	15	15	15	47	93	102	114	100	72	56	37	89
C3F8 (PFC used as detergent)																		
SF6 (Window plate production, Research laboratories and Running shoes)	18	17	15	15	15	15	15	15	15	47	93	102	114	100	72	56	37	89
3. Solvent and Other Product Use																		
A Paint Application																		
D Other (please specify: Other Products, Manufacture and Processing)																		
4. Agriculture																		
A Enteric Fermentation																		
B Manure Management																		
D Agricultural Soils																		
5. Land-Use Change and Forestry (LUCF)																		
A Changes in Forest and Other Woody Biomass Stocks																		
2 Temperate Forests																		
6. Waste																		
A Solid Waste Disposal on Land																		
1 Managed Waste Disposal on Land																		
7. Other (please specify)																		
Memo Items (not included above):																		
International Bunkers																		
Aviation																		
Marine																		
Multilateral Operations																		
CO2 Emissions from Biomass																		
CO2 Emissions related to Net Electricity Import																		

Table B.7: Combined greenhouse gas (GHG) projections 2002-2017 in IPCC/UNFCCC-CRF format

GHG projections (Gg CO_2 equivalents)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-12	2013-17
Denmark's Total national Emissions and Removals (KP Net Emissions) in the base scenario ("with measures", i.e. implemented and adopted measures)	70910	72771	76604	77198	78651	78911	79558	80017	80134	80236	80360	80269	78446	77795	77505	77517	80061	78306
Denmark's Total KP Removals	-88	-110	-127	-147	-169	-189	-220	-246	-286	-321	-343	-397	-400	-441	-479	-503	-283	-444
Denmark's Total Emissions/Removals with LUCF (CC Net Emissions)	69994	71855	75688	76282	77735	77995	78642	79101	79218	79320	79444	79353	77530	76879	76589	76601	79145	77390
Denmark's Total Emissions without LUCF	70997	72881	76731	77345	78820	79100	79778	80263	80420	80557	80703	80666	78846	78236	77984	78019	80344	78750
1. Energy	56267	58582	62480	63126	64712	65024	65733	66277	66495	66747	67004	67064	65360	64874	64766	64908	66451	65394
A Fuel Combustion Activities (Sectoral Approach)	55499	57779	61640	62275	63860	64169	64879	65422	65639	65890	66148	66209	64516	64070	63967	64110	65595	64574
1 Energy Industries	28581	30461	33998	34280	35519	35478	35866	36102	36055	36095	36156	36039	34184	33582	33314	33290	36055	34082
a Public Electricity and Heat Production	25716	27427	30589	30758	31997	31956	32344	32580	32533	32619	32703	32743	31080	30525	30280	30255	32556	30977
b Petroleum Refining	994	994	994	994	994	994	994	994	995	995	995	995	995	995	995	995	995	995
c Manufacture of Solid Fuels and Other Energy Industries	1871	2040	2414	2528	2528	2528	2528	2528	2528	2481	2458	2301	2109	2063	2040	2040	2504	2110
2 Manufacturing Industries and Construction	6178	6303	6415	6547	6679	6812	6947	7083	7222	7344	7463	7578	7689	7795	7895	7992	7212	7790
3 Transport	12758	13032	13263	13506	13731	13941	14136	14313	14446	14547	14639	14717	14785	14851	14924	15003	14416	14856
a Civil Aviation	158	166	174	181	187	193	199	205	212	218	224	230	237	243	250	257	211	243
b Road Transportation	12127	12406	12644	12893	13112	13317	13506	13677	13803	13898	13984	14055	14116	14176	14243	14314	13773	14181
c Railways	206	206	205	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204
d Navigation	266	253	241	228	228	228	228	228	228	228	228	228	228	228	228	228	228	228
4 Other Sectors	7740	7744	7729	7709	7700	7707	7701	7696	7690	7679	7666	7652	7637	7622	7615	7608	7686	7627
a Commercial/Institutional	872	887	901	915	927	939	949	960	969	978	985	993	1000	1008	1015	1023	968	1008
b Residential	4370	4323	4263	4205	4165	4142	4108	4077	4046	4014	3983	3952	3920	3888	3866	3844	4046	3894
c Agriculture/Forestry/Fisheries	2498	2534	2565	2589	2608	2626	2643	2659	2674	2687	2698	2708	2717	2726	2734	2741	2672	2725
5 Other (please specify: Military mobile and in projections other off road)	242	239	236	233	231	230	229	228	226	225	224	223	221	220	219	217	226	220
b. Mobile	242	239	236	233	231	230	229	228	226	225	224	223	221	220	219	217	226	220
B Fugitive Emissions from Fuels	768	803	839	851	852	855	854	855	856	856	857	855	843	804	799	798	856	820
1 Solid Fuels	78	78	85	97	97	101	100	101	101	102	102	103	103	86	81	80	101	91
2 Oil and Natural Gas	690	725	754	754	754	754	754	754	754	754	754	752	741	718	718	718	754	729
Flaring	512	546	576	576	576	576	576	576	576	576	576	574	562	539	539	539	576	551
2. Industrial Processes	2206	2225	2245	2265	2203	2214	2206	2186	2160	2144	2126	2055	1997	1927	1834	1773	2165	1917
A Mineral Products	1454	1454	1455	1456	1456	1457	1457	1458	1458	1459	1459	1420	1420	1420	1420	1420	1458	1420
1 Cement Production	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343
2 Lime Production	110	111	111	113	112	114	113	115	114	116	116	77	77	77	77	77	115	77
F Consumption of Halocarbons and Sulphur Hexafluoride	752	771	791	809	748	757	750	728	703	685	667	635	577	507	414	353	706	497
1 Refrigeration and Air Conditioning Equipment	534	552	566	576	588	597	590	575	558	518	465	434	382	340	285	248	541	338
2 Foam Blowing	181	189	198	206	133	132	131	124	116	106	95	84	65	52	41	33	115	55
4. Aerosols/ Metered Dose Inhalers	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Electrical Equipment (SF6)	11	12	12	12	13	13	13	13	14	14	14	15	15	15	15	16	14	15
8 Other (please specify)	20	18	15	15	15	15	15	15	15	47	93	102	114	100	72	56	37	89
C3F8 (PFC used as detergent)	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF6 (Window plate production, Research laboratories and Running shoes)	18	17	15	15	15	15	15	15	15	47	93	102	114	100	72	56	37	89
3. Solvent and Other Product Use	73	69	64	60	55	51	68	68	68	68	68	68	68	68	68	68	68	68
A Paint Application	37	35	32	30	28	25	34	34	34	34	34	34	34	34	34	34	34	34
D Other (please specify: Other Products, Manufacture and Processing)	37	34	32	30	28	25	34	34	34	34	34	34	34	34	34	34	34	34
4. Agriculture	11295	10893	10871	10849	10828	10808	10789	10770	10752	10724	10697	10686	10686	10686	10686	10686	10746	10686
A Enteric Fermentation	2734	2697	2669	2641	2614	2587	2561	2535	2509	2484	2459	2459	2459	2459	2459	2459	2509	2459
B Manure Management	1445	1433	1431	1429	1431	1433	1435	1437	1440	1438	1435	1424	1424	1424	1424	1424	1437	1424
D Agricultural Soils	7116	6763	6771	6779	6784	6788	6793	6798	6803	6803	6803	6803	6803	6803	6803	6803	6800	6803
5. Land-Use Change and Forestry (LUCF)	-1004	-1026	-1043	-1063	-1085	-1105	-1136	-1162	-1202	-1237	-1259	-1313	-1316	-1357	-1395	-1419	-1199	-1360
A Changes in Forest and Other Woody Biomass Stocks	-1004	-1026	-1043	-1063	-1085	-1105	-1136	-1162	-1202	-1237	-1259	-1313	-1316	-1357	-1395	-1419	-1199	-1360
2 Temperate Forests	-1004	-1026	-1043	-1063	-1085	-1105	-1136	-1162	-1202	-1237	-1259	-1313	-1316	-1357	-1395	-1419	-1199	-1360
6. Waste	1157	1113	1071	1045	1021	1002	981	962	944	873	808	793	735	681	630	583	914	684
A Solid Waste Disposal on Land	1157	1113	1071	1045	1021	1002	981	962	944	873	808	793	735	681	630	583	914	684
1 Managed Waste Disposal on Land	1157	1113	1071	1045	1021	1002	981	962	944	873	808	793	735	681	630	583	914	684
7. Other (please specify)																		
Memo Items (not included above):																		
International Bunkers	6193	6297	6384	6473	6563	6652	6745	6839	6939	7033	7129	7226	7325	7425	7527	7633	6937	7427
Aviation	2503	2607	2694	2783	2873	2962	3055	3149	3250	3343	3439	3536	3635	3735	3837	3943	3247	3737
Marine	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690	3690
Multilateral Operations																		
CO_2 Emissions from Biomass																		
CO_2 Emissions related to Net Electricity Import	-4457	-6930	-10250	-10301	-11194	-10764	-10774	-10552	-9862	-9365	-9106	-8865	-9040	-8908	-9450	-9044	-9932	-9061

Appendix C: Description of selected programmes/projects for promotion and/or financing of technology transfer to other countries

Part I

Description of selected programmes or projects for promotion and/or financing of technology transfer to developing countries

Programme/project title: Capacity Building in Government and Related Agencies, Malaysian Energy Centre (PTM)			
Objective: To enhance a wider implementation of sustainable energy solutions, renewable energy and energy efficiency, in Malaysia.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Malaysia	Energy	DKK 10.0 mill.	3
Description: The overall strategy is to design a training programme on integrated resource and energy planning targeting the relevant PTM staff, as well as participants from government agencies and related institutes and companies. The necessary tools for implementation of integrated resource and energy planning(including a computer-model and a database) will be established and hands-on training will be provided. The following main results have been achieved: - The capacity of PTM staff, related agencies, and selected universities in energy-sector modelling has been enhanced - A data collection system and a database have been developed - A set of customised integrated energy sector analysis tools has been developed - A set of integrated analyses has been performed - A website has been developed including a database			
Indicate success factors: Capacity developed among relevant members of staff.			
Technology transferred: Danish experience in modelling and analysis methodology has been provided.			

Programme/project title: Support for Development of a Strategy for Renewable Energy as the Fifth Fuel in Malaysia			
Objective: To improve the environmental sustainability of energy supply by increased utilisation of renewable energy sources, including improvement of the use of energy efficiency in the end use sectors of industry and buildings. The project aims at supporting the Ministry of Energy, Communications and Multimedia in developing implementation plans for the national strategies on energy efficiency (EE) and renewable energy (RE). The EE and RE strategies will be implemented within the context of the 8th Malaysia Plan.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Malaysia	Energy	DKK 4.7 mill.	1 year Completed in 2000
Description: i) The project developed a policy on RE incorporated in the 8th Plan and a legal and financial framework for RE. This includes access to the electricity grid on transparent and acceptable terms. The project also looked into financial and fiscal incentives and provided a strong organisational support and increased the level of awareness on the benefits of utilising RE. ii) In addition the project achieved the development of a Malaysian Energy Management Programme which included the role of the public administration in Malaysia as a catalyst for establishment of a market for EE technology and promotion of RE in an open electricity market as well as a visit to Denmark for high-level decision makers in Malaysia.			
Indicate success factors: An objective of 5% energy supply from renewable energy sources was implemented in the 8th Malaysian Plan			

Programme/project title: Support for Development of an Energy Efficiency Strategy in Malaysia			
Objective: To improve the efficiency of the use of energy in the end use sectors of industry and buildings.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Malaysia	Energy	DKK 2.0 mill.	Completed in 2000
i) **Description:** The achieved establishment of financial support for EE activities comprising a comprehensive fiscal package and the establishment of an Energy Business Fund which can disburse funds efficiently and expeditiously to EE and RE Projects in Malaysia. Another result was an implementation plan for a Malaysian Energy Management Programme that gives EE due recognition in government procurement, and energy management of government facilities			
Indicate success factors: The project recommendations are reflected in the 2001 Budget and 8th Malaysia Plan and an energy efficiency strategy was developed.			

Programme/project title: Centre for Education and Training for Renewable Energy and Energy Efficiency			
Objective: Renewable energies and energy efficiency are regarded as viable means for Malaysia to reduce dependence on fossil fuels and improve the environment. The objective of the project is to increase the role and utilisation of renewable energy and energy efficiency in public schools and universities.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Malaysia	Energy	DKK 9.5 mill.	3 years
Description: The project aims to establish a Centre for Education and Training for Renewable Energy (RE) and Energy Efficiency (EE) in Malaysia. This will be equipped with publicity materials, training modules, portable exhibition kit, a website and necessary office equipment to carry out training and dissemination activities in RE and EE. The project will also develop education and training materials in RE and EE for schools and universities.			
Indicate success factors: The project has suggested initiating the establishment of a long-term plan to serve as an input for the scheduled mid-term review of 8th Malaysian Plan in second half of 2003. This is reflected in the 2001 Budget and 8th Malaysia Plan.			

Programme/project title: Energy Efficient Building Design for MECM as Key Demonstration Building for Energy Use Performance and Environmental Qualities in Malaysia			
Objective:			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Malaysia	Energy	DKK 9.5 mill.	3 years
Description: The Ministry of Energy, Communications and Multimedia (MECM) will move to a new building in the new Federal Government Administrative Centre, Putrajaya by the end of 2003. It is the intention of the MECM that the MECM Building in Putrajaya is to be a model building with leading-edge communications and multimedia facilities, low energy consumption and with minimal impact upon the environment. The focus is on energy use performance and environmental qualities. This means that the building design process will be based on an energy-conscious concept, taking into consideration the various aspects of building design, such as geographical orientation, the choice of outer layer of the building, energy efficient lighting and cooling system and overall integrated control and monitoring of the building utilities, functions, etc.			
Indicate success factors: The team consisting of the CTA, local consultants and one short-term Danish expatriate, has worked successfully with the team of the developers of MECM Building. The project has been extended with a second phase and the building is under construction to be completed by end 2003. On the awareness side, the project has created a lot of interest among public institutions and private building practitioners, architects, engineers, and building developers. This was evident from their active participation in the various workshops conducted during the project. A request for additional follow-up activities has been approved.			
Technology transferred: Danish experience and methodology on building design features, energy saving features etc.			

Programme/project title: Zafarana wind farm in Egypt			
Objective: To contribute to Egypt's economic development by means of environmentally sound electricity production based on wind power.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Egypt	Energy	Contribution DKK 253 mill. Credit scheme DKK 175 mill.	6
Description: The project is the first commercial wind farm in Egypt. It followed up on preliminary Danish assistance projects that included a wind atlas, planning of wind turbine centres and the construction of a demonstration wind farm. The wind farm, which has a total capacity of 60 MW, is divided into two phases. Phase 1, 30 MW, was built in 1999-2001 and phase 2 began at the end of 2002.			
Technology transferred: Danish wind power technology.			
Effect of emissions on greenhouse gases/sinks (if possible): Substitution of fossil fuels with wind power.			

Programme/project title: Adjustments to the Building Energy Code, Thailand.			
Objective: The project is intended to help create a qualified basis for adjustment of the part of Thailand's building regulations that concerns the energy consumption from buildings.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Thailand	Energy	DKK 11.8 mill.	3
Description: The project is intended to provide support to those responsible for the part of Thailand's building regulations that concerns energy consumption in order to create a qualified basis for adjustment of the regulations. Account is taken of the latest developments within building design and technological and climatic differences across the country – factors that have so far been neglected. The revised building regulations on energy consumption will be designed to enable their incorporation in future comprehensive building regulations covering all technical aspects of the building sector. The results of analyses and studies of energy-efficient building design will be made available to all relevant parties within the building sector in order to increase awareness of the possibilities for energy savings in buildings.			
Technology transferred: Danish experience with administration and regulation in the building sector and means of checking compliance with the building regulations will be made available to the Thai authorities.			
Effect on emissions of greenhouse gases/sinks (if possible): By reducing energy use in buildings, which is largely based on fossil fuels, CO_2 emissions is reduced.			

Programme/project title: Provincial Programme for Sustainable Energy in Thailand.			
Objective: To identify, plan and implement renewable energy solutions at provincial and village level and to strengthen NGOs, educational institutions, and authorities in their use of renewable energy.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Thailand	Energy	DKK 8.8 mill.	3
Description: Geographically, the target area is the Isaan region in northeast Thailand. Project activities include collection of data, preparation of RE plans at village level, implementation of RE projects, training in RE technology, information on renewable energy, seminars on renewable energy and establishment of three renewable energy and environment centres. Renewable energy technology will be promoted through support for actual projects showing alternatives to centralised fossil-based energy production.			
Effect on emissions of greenhouse gases/sinks (if possible): By promoting alternatives to fossil fuel-based energy production, greenhouse gas emissions will be reduced.			

Part II

Description of selected DANCEE projects or programmes for promotion and/or financing of technology transfer to Central and Eastern European countries concerning environmentally sustainable technologies

Programme/project title: Kiev District Heating Rehabilitation			
Objective: To reduce energy consumption and thus CO_2 through replacement of equipment at 33 substations with modern, mainly Danish-made, energy-efficient equipment.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Ukraine	Energy	Danish Environmental Protection Agency DKK 10 mill. Kyivenergo approx. DKK 5 mill.	20 years
Description: In connection with a major renovation of the transmission grid and the construction of new CHP plants, the Danish Environmental Protection Agency demonstrated the possibilities for energy savings in this part of the production-transmission-distribution grid through the establishment of 33 energy-efficient substations. As a result, Kyivenergo now wants to redirect some of a USD 200 mill. World Bank loan to investments in the distribution grid, including a large number of new substations based on the Danish model. The Environmental Assistance scheme financed consulting services and equipment, while Kyivenergo paid for design, installation, etc. Besides the work on the distribution grid, CO_2-foamed (Danish) district heating pipes were supplied to some of the apartment buildings affected.			
Indicate success factors: The biggest possible energy saving to convince Kyivenergo that it is right to implement energy savings in the distribution grid.			
Technology transferred: Equipment for substations in the district heating grid and supply of district heating pipes.			
Effect on emissions of greenhouse gases/sinks (if possible): Documented CO_2-displacement: 7,100 t/year			

Programme/project title: Establishment of three natural gas-fired CHP plants in Decin			
Objective: To reduce emissions of CO_2, SO_2, $NO_{X,}$ and particulate, improve the health situation in the town and improve security of supply.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Czech Republic	District heating/ energy	DKK 130 mill.	Bynov 1996 Zelenice 1997 CZT 2001/2002
Description: Closure of many coal-fired district-heating plants in the town of Decin, which has a population of about 70,000. Establishment of three natural gas-fired CHP plants covering the need for heat in the town's three districts. The plant in Bynov was the Czech Republic's first natural gas-fired CHP plant. It was opened in October 1996 by Mr. Skalicky, the Czech Minister for the Environment at that time. The event attracted a lot of media attention. Besides the CHP plants, the town's district heating grid was renovated with Danish district heating pipes. The switch to natural gas and the establishment of two of the CHP plants have resulted in a big reduction in dust emissions, with directly measurable effects on the population's health. Before the project Decin had the Czech Republic's highest child mortality and the largest number of people with respiratory diseases – more than twice the average number. Total support: DKK 23 mill.			
Indicate success factors: Better public health			
Technology transferred: Natural gas-fired CHP plants, pre-insulated district heating pipes, other equipment, client consultancy, invitation for tenders			
Effect on emissions of greenhouse gases/sinks (if possible): Reduction of 65,000 tonnes lignite per year and 2,400 tonnes heavy fuel per year. The reductions, including the CZT plant, are as follows: CO_2 140,000 tonnes/year SO_2 480 tonnes/year Smog 130 tonnes/year			

Programme/project title: Establishment of woodchip-fired plant at Petroffskoye District Heating Plant			
Objective: Reduction of emissions of CO_2, SO_2, NO_X and particulates, together with deposition of coal ash. Development of the local economy on the basis of utilisation of local biomass to replace fossil fuels from other regions of Russia.			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Russia	District heat/energy	DKK 5.2 mill.	2001
Description: An old, inefficient, coal-fired district heating plant has been replaced by a modern, fully automatic woodchip-fired plant (4 MW) made in Denmark. DANCEE grant: DKK 4.2 mill. The plant is not completely financially viable because of considerable price subsidies for heating purposes in Russia. For oil-fired plants, changing to woodchip firing is viable, but lack of financing possibilities and big import taxes on woodchip firing equipment is preventing further spread of the technology for the time being. Use of local biomass waste from the timber industry is contributing to economic growth and employment in the local area.			
Technology transferred: Equipment for firing with wood waste in district heating boilers with dust filters and monitoring equipment.			
Effect on emissions of greenhouse gases/sinks (if possible): Expected CO_2 displacement: 9,900 tonnes			

Programme/project title: Use of sawdust for heat supply in Tasca, Rumania			
Objective: To establish a heat supply for the village of Tasca and solve a waste problem – sawdust			
Recipient country	**Sector**	**Total funding**	**Year(s) in function**
Rumania	Energy Waste	Approx. DKK 8.5 mill.	1999
Description: In Rumania sawdust is generally regarded as waste and a great deal of it is deposited unlawfully in the countryside and often along riverbanks. The village used to receive district heat from a nearby cement factory, but when the factory was privatised to a German group, it was announced that the district heat supply was going to be discontinued. A new, sawdust-fired boiler plant with a capacity of 2.5 MW was therefore established, together with a new district heating grid with pre-insulated district heating pipes connecting the boiler plant to all consumers. Connection units for production of hot utility water for the individual buildings were supplied and fitted. A structure was established for collecting sawdust from the small sawmills in the district. Total cost of Danish consultancy and equipment: DKK 8,380,737.			
Indicate success factors:			
Technology transferred: Complete boiler plant, pre-insulated district heating pipes and exchange units for connection of consumers			

Programme/project title: Establishment of a geothermal plant for supplying district heat to Zakopane and Nowy Targ in southern Poland

Objective: Reduction of emissions in the area, closure of existing coal-fired district heating plants and private cup burners, and utilisation of a local, clean source of energy

Recipient country	Sector	Total funding	Year(s) in function
Poland	District heat/energy	USD 95 mill.	Peak load plant 1999 Geothermal plant 2001

Description: In 1980 hot groundwater was discovered at a depth of 2,000 metres in connection with exploratory drilling for oil. After a number of teething problems the Danish Environmental Protection Agency became involved in the project in 1992 and, among other things, provided support to make the project viable, both technologically and financially. Various feasibility studies, preliminary design, design, establishment of organisation, equipment supplies, etc. have been carried out. When completed, the plant is intended to supply heat to the main towns Zakopane and Nowy Targ and villages between them, in all to about 80,000 people. At the present time, with the peak-load plant supplying Zakopane with district heat, there is already a visible improvement of the environment, which is important because the town is Poland's largest winter sports area.
Total Danish support: DKK 24 mill.

Indicate success factors: Improved public health and a clean town mean more tourists (now 3 million per year)

Technology transferred: Equipment, pre-insulated district heating pipes, exchangers, which are called Redan in the area, etc., design, financial analyses, building up of organisation, etc.

Effect on emissions of greenhouse gases/sinks (if possible):
CO_2 210,000 tonnes/year
SO_2 1,200 tonnes/year
NO_X 800 tonnes/year
Particulates 540 tonnes/year

Programme/project title: Establishment of natural gas-fired CHP plant in the town of Põlva in Estonia

Objective: To contribute to sustainable energy use through demonstration of natural gas-based CHP (through transfer of technology and know-how)

Recipient country	Sector	Total funding	Year(s) in function
Estonia	Energy	DKK 5,600,000 mill.	2

Description: The project was the establishment of a small-scale natural gas-fired CHP plant in the town of Põlva (1 MW electricity and 1.2 MW heat). The project included a feasibility study, installation of a CHP plant, contracting for access to the electricity grid and sale of electricity to third parties, together with dissemination of knowledge about possibilities for establishing CHP in Estonia (through a seminar and a brochure).

Indicate success factors: High-efficiency CHP plant established. The plant has been in operation for two years. The project has resulted in the following reduction of emissions: CO_2 7,849 tonnes/year, SO_2 111 tonnes/year, NO_X 3.2 tonnes/year, particulates 60 tonnes/year and ash 5,551 tonnes/year.

Technology transferred: CHP plant established

Effect on emissions of greenhouse gases/sinks (if possible): Yearly reduction in CO_2 emission: 7,849 tonnes/year

Programme/project title: Demonstration and training project on use of wind energy

Objective: To support the construction of a Russian resource base for handling wind energy and to promote expansion of wind energy in Russia

Recipient country	Sector	Total funding	Year(s) in function
Russia	Energy	DKK 9 mill.	2

Description: A wind farm comprising 20 x 225 kW turbines was established under Danish supervision. An intensive training programme was carried out at the same time for knowledge transfer concerning establishment of wind farms, turbine operation, connecting to the electricity system, etc.

Indicate success factors: A functioning wind farm making a CO_2-less contribution to Kaliningrad's electricity supply and a Russian resource base of trained technicians within wind energy utilisation

Technology transferred: Danish wind turbines and know-how

Effect on emissions of greenhouse gases/sinks (if possible): It is assumed that the displaced electricity in Yantarenergo's supply region came from an oil-fired power station (built in 1935) with an electrical efficiency of 30%. The wind farm, which comprises 20 turbines and has a total capacity of 4.5 MW, is designed to yield almost 2,000 full-load hours/year with an electricity production of around 9,000 MWh/year. CO_2 displacement will be about 7,900 tonnes/year.

Programme/project title: Assistance to Estonia's Ministry of Economic Affairs in connection with preparation and implementation of the EU SAVE Directive 93/76

Objective: To contribute to sustainable energy use through the establishment of effective programmes for energy efficiency improvement in end use (households, public buildings and industry)

Recipient country	Sector	Total funding	Year(s) in function
Estonia	Energy	DKK 1,700,000	1

Description: The project comprised assistance to the Energy Department of the Estonian Ministry of Economic Affairs in connection with the preparation and implementation of the EU SAVE Directive 93/76: Establishment of energy inspection and energy management programme for industry and establishment of a programme for energy labelling of buildings. The EU Directive, which is based on the Climate Convention, is aimed at reducing Member States' CO_2 emission through improved energy efficiency. The energy saving potential in end consumption in Estonia is estimated to be around 30%. The project did not include equipment.
The project was completed in 2002.

Indicate success factors: Establishment of energy saving programmes that are resulting in energy savings and thus in reduced CO_2 emission.

Technology transferred: Transfer of know-how and knowledge

Effect on emissions of greenhouse gases/sinks (if possible): The project has a big potential for reducing CO_2 emissions.

Programme/project title: Energy inspection at Smolensk CHP Plant No. 2.

Objective: Feasibility study to demonstrate potential for savings at power stations

Recipient country	Sector	Total funding	Year(s) in function
Russia	Energy	DKK 400,000	2

Description: The project identified 10 different savings measures – six in the electricity sector and four in the heat sector. The potential for electricity savings is in the order of 180,000 – 7,500,000 kWh/year, while the potential for heat savings ranges from 4,000 GJ to 190,000 GJ per year. The payback times range from about one month to 11_ years, with an average payback time of 2_ years for all 10 measures. The total investment for implementation of the proposed measures has been calculated at approximately USD 930,000.

Indicate success factors: It has been proven that, as expected, big savings and very short payback times can be achieved.

Technology transferred: Transfer of know-how and knowledge

Effect on emissions of greenhouse gases/sinks (if possible): If implemented, all the saving measures investigated will result in a reduction in CO_2 emission.

Appendix D List of current climate-related research projects

The Danish Meteorological Institute (DMI)

The following research projects for the period 2002-2003 are being financed by the EU Commission's research programme EUMETSAT and national research councils and programmes.

- DEMETER. "Development of a European Multi-model Ensemble system for seasonal to interannual prediction".
- PREDICATE. "Mechanisms and predictability of decadal fluctuations in Atlantic-European climate".
- DETECT. "Detection of changing radiative forcing over the recent decades"
- PROMISE. "Predictability and variability of monsoons, and the agricultural and hydrological impacts of climate change".
- PRISM. "Programme for Integrated earth System Modelling".
- PRUDENCE. "Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects".
- STARDEX. "Statistical and Regional Dynamical downscaling of Extremes for European regions".
- CAL. "Coupling of Atmospheric Layers".
- GLIMPSE. "Global Implications of Arctic climate processes and feedbacks".
- CWE. "Climate, Water and Energy".
- SAT-MAP-CLIMATE. "Satellite based bio-geophysical parameter mapping and aggregation modelling for CLIMATE models". (The Wind Energy Department at Risø National Laboratory is also participating.)
- "Application of seasonal climate forecasts for improved management strategies for crops in Western Africa".
- "Consequences of climate change for the oceanic environment near Greenland".
- CONWOY. "Consequences of weather and climate changes for marine and freshwater ecosystems".
- PSC Climate. "Polar stratospheric clouds and ozone depletion: The role in global climate change".
- MAPSCORE. "Mapping of polar Stratospheric Clouds and Ozone levels relevant to the Region of Europe".
- SAMMOA. "Spring-to-Autumn Measurements and Modelling of Ozone and Active species".
- CANDIDOZ. "Chemical and Dynamical Influences on Decadal Ozone Changes".
- GREENICE. "Greenland Arctic shelf ice and climate experiment".
- MOEN. "Meridional Overturning Exchange with Nordic Seas".
- CONVECTION. "Greenland Sea Convection Mechanisms and their Climatic Implications".
- EUMETSAT OZON and UV SAF. "The development and implementation of certain activities of a EUMETSAT Satellite Application Facility on ozone monitoring".
- GRAS SAF. The development of a EUMETSAT Satellite Application Facility for GRAS meteorology, including a visiting scientist programme.
- Ocean and Sea Ice SAF. "The development of a EUMETSAT Ocean and Sea Ice Satellite Application Facility".

Geological Surveys of Denmark and Greenland - GEUS

- "Ice-edge monitoring" Collection of time series of melting from the ice cap in southern Greenland. Will presumably be expanded with a Dancea project". Project period: 2003-2006.
- "Lake-climate interactions in space and time". Studies of lake data to understand the processes linking the state of lakes with climate variations. Project period 2003.
- "Green Ice". Studies of the sea ice north of Greenland to determine changes in thickness etc. caused by climate changes. Project period: 2003-2006.
- "Euro Clim". Establishment of monitoring and warning system for climate changes based on ice and water data in Greenland. Project period: 2001-2004.
- "Cryosat". Participation in establishment of the programme for the CRYOSAT satellite for monitoring ice caps, glaciers and sea ice. Project period: 2003.
- "Holocene Greenland". Identification of Holocene palaeohoydrographic changes in the Greenland fjords and coastal areas in relation to climate changes. Project period: 1999-2003.
- "Norse – Climate". Studies of the natural conditions in the period 1000-1500 BC in order to cast light on the Northman's living conditions in Greenland. Project period: 2001- 2003.

- "History of the ice cap". Studies of the spread of the ice cap during the last Ice Age in the northern part of West Greenland. Project period 2002-2003.
- DART." Quantify the dynamics of forest-tundra ecotone response to climate and land-use changes". Project period: 2000-2003.
- "Effects of climate changes". Development of a concept for monitoring climate changes in Denmark, the Faroe Islands, Greenland and adjacent areas. Project period 2003.
- "METROL". Investigations of methane emission from the seabed in the North Sea and Danish inland waters with a view to possible climate impacts. Project period: 2002-2005.
- "PACLIVA". Comparison of the climate system in the North Atlantic in the relatively cold year 2000 with the climate system that prevailed from 8,000 to 6,000 years ago. Project period 2002-2004.

Aarhus University (Geological Institute)

- The EU project HOLSMEER. "Late Holocene Shallow Marine Environments of Europe". The focus of the project is climate changes in the last 2,000 years. The investigations are being carried out on, inter alia, drilled marine cores from Portugal in the south to the coastal areas of Iceland and Norway in the north. Project period: 2001-2003.
- The EU project PACLIVA. "Patterns of Climate Variability in the North Atlantic". The project compares the climate system in the recent relatively cold year 2000 with the climate system that prevailed from 8,000 to 6,000 years ago, i.e. with the warmest period we have had in the last 11,500 years. Project period: 2002-2004.
- KRONPAL. "Chronology and paleoclimate: Integration of marine cores from Iceland with AMS ^{14}C datings, ash chronology and ice cores". The project examines large and small oceanographic shifts in the North Atlantic in the last 15,000 years and problems concerning exact dating of these. Project period: 2003-2005.
- "Varvige, Holoene and interglacial lake sediments in Denmark". Lake sediments from the last 11,500 years from interglacial periods with rhythmic stratifications (year strata, layers of glacial deposit) are being studied with a number of detailed stratigraphic methods. One of the aims is to determine how quickly the land environment and the aquatic environment have reacted to climate changes in the past. Project period: 2003-2005.

Danish Institute of the Agricultural Sciences (DJF)

- DINOG. "Dinitrogen fixation and nitrous oxide losses in organic grass-clover pastures: An integrated experimental and modelling approach". The purpose is to quantify nitrogen fixation and nitrous oxide emission from grasslands through monitoring, laboratory tests and modelling of nitrification and denitrification. Project period: 2001-2004.
- MIDAIR. "Greenhouse gas mitigation for organic and conventional dairy production". The purpose of this project is to identify and quantify the main sources of greenhouse gas emission from organic and conventional milk production and to indicate strategies for mitigating these emissions. Project period: 2001-2004.
- GREENGRASS. "Sources and Sinks of Greenhouse Gases from managed European Grasslands and Mitigation Strategies". The purpose of this project is to quantify exchange of carbon dioxide, nitrous oxide and methane from grassland in Europe through monitoring and modelling, and to evaluate the potential for mitigation in selected operating strategies. Project period: 2002-2004.
- PRUDENCE. "Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects". The purpose of this project is to improve the basis for projecting climate effects through modelling and to interpret predictions and uncertainties in relation to the EU's policy for adaptation to and mitigation of climate changes. Project period 2002-2004.
- "Knowledge synthesis on energy in organic farming". Purpose: to gather knowledge about energy consumption, possible savings and energy production in organic farming and to evaluate the possibilities for reducing fossil energy in organic production. Project period: 2002-2003.

University of Copenhagen

Geophysical Department

Projects are in progress within the following areas:

- Ice cores and climate parameters, datings
- The carbon cycle/the ocean's circulation and physical properties
- The stability of the climate
- Atmospheric CO_2 transports
- Large-scale meteorology
- Statistical analyses of climate data

Geological Institute

- Projects are in progress within the following areas:
- Long lake cores from Denmark and this and the previous interglacial period
- Correlation between Greenland ice cores and lake cores in Denmark by means of well-dated ash strata from Iceland or the Eifel area in Germany

Geographic Institute

- FITES. "Fire in Tropical Ecosystems". FITES has studied the distribution, controls/causes and effects, including climatic ones, of savannah fires in the Sudanian and south-Sahelian zone of Africa. Project period: 1986-2003.
- INTEO. "Integration of Earth Observation Data in Distributed Hydrological Models". INTEO studies the use of Earth Observation data for running, calibrating and validating hydrological models, at the scale of large river basins, allowing assessment of the effect of climatic change on water resource availability. Project period: 1996-2005.
- "Land use and carbon cycle in Senegal". The project is studying the impact of land use change on carbon storage in vegetation and soils in Senegal. Project period: 1999-2002. (Extension of the project is under negotiation).
  NECC. "Nordic Centre for Studies of Ecosystem Carbon Exchange and its interaction with the climate system". The interaction between CO_2 and climate is being studied over selected Nordic ecosystems, ranging from agricultural areas on Zealand to the tundra in North Sweden. Project period: 2003-2007.
- EO-FLUX. "Earth observation data for upscaling carbon Flux and water Budget at Zealand". CO_2 and H_2O exchange over Zealand is being studied on the basis of satellite data, CO_2 measurements and hydrological modelling. Project period: 2001-2003.

Institute of Molecular Biology

- "Forest Carbon – Nitrogen Trajectories (FORCAST)". The objective is to investigate carbon and nitrogen pools and fluxes in European forest ecosystems. Project period: 1999-2003.

Institute of Chemistry. The Atmosphere Group

- "Establishment of relevant physical and chemical quantities: IR absorption spectra, velocity and photolytic constants, uptake coefficients, formation of CCN (Cloud Condensation Nuclei) etc." Project period: ongoing

Botanical Institute

- "Biogeochemistry in the Arctic – processes, controls and sensitivity to global change". Measurement of drivers and controls of biogeochemical nutrient and carbon cycling in arctic ecosystems and probable impacts on the cycles of a predicted climate change. Project period: 2000-2002.
- "Processes in the plant-microbe-soil interface: Implications for ecosystem function". Experimental assessment of probable impact of future projected climate change on processes in the plant-microbe-soil system in Arctic ecosystems that have been manipulated to mimic future changes in environmental conditions. Project period: 2003–2005.
- FITES - Fire in Tropical Ecosystems. Studies of the effect of fire on decomposition of matter, biodiversity and greenhouse gas emission in savannah ecosystems. The Botanical, Geographic and Zoological Institutes and the Botanical Museum are participating in the project.

Risø National Laboratory

Department for Plant Research

- EU project CarbonEuroflux. Exchange of CO_2 between the atmosphere and the forest ecosystem. Project period: Project period 1996 - ? (depending on project renewal).
- EU project CORE. "Climate –Atmosphere Interaction". Its goal is to produce continuous field measurements on atmosphere-biosphere interactions at six field research stations run by four participants (University of Helsinki, Finnish Meteorological Institute, National University of Ireland, Galway, and Risø National Laboratory. Project period: 2000-2003.
- The EU project VULCAN. "Effect of heating and drying out on heath ecosystems' function, biodiversity and plant composition". In the project experimental heating and drying out of semi-natural ecosystems are being carried out in six European countries to study the effects on the ecosystems. Project period: 2001-2004.
- EU project GREENGRASS. "Sources and sinks of greenhouse gasses from managed European grasslands and mitigation scenarios". The purpose is to acquire detailed knowledge about CO_2, CH_4 and N_2O fluxes from grassland along European climate gradients and under varying forms of use and cultivation with a view to evaluating possible "mitigation options" by changing cultivation and use practice. Project period: 2001-
- EU-project NOFRETTE. "Nitrogen oxide emissions from European forest ecosystems". The project covers emission of NO and N_2O from forest ecosystems. Its purpose is partly to

determine the size of these emissions and partly to describe the fundamental process that drive the NO/N_2O emission from European forest ecosystems under the influence of geographically determined variations in nitrogen deposition, climate and soil conditions and types of forest. Project period: 2001 –

- "Greenhouse gas emission and nitrogen fixation in clover". The project is intended to help cast light on nitrous oxide (N_2O) emission from cropped clover areas and determine the proportion of the biologically fixated nitrogen that is given off as N_2O. Project period: 2000-2004
- "Recovery of forest ecosystems from acidification – impacts of climate change". In this project model calculations are being carried out of the effect of climate changes on the "recovery" processes for soil acidification under the agreed protocols for reduction of sulphur and nitrogen emission. Project period 2001-2003
- "UV impacts on the vegetation in Zackenberg, Greenland". The main purpose of the project is to establish a relatively simple and robust method for continuous monitoring of the effects of UV radiation on selected Arctic species of plant in Zackenberg, Greenland. Project period: 2001-2004.

Energy System Group

- "Assessment and Dissemination activity on major Investment Opportunities for renewable electricity in Europe using the REBUS tool - Admire Rebus". Financed by the EU's ALTERNER programme. Project period: 2002-2003.
- "Green-X Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market". The core objective of this project is to facilitate significantly increased electricity generation from renewable energy sources (RES-E) in a liberalised electricity market with minimal costs to European citizens. To identify most important strategies, the dynamic toolbox Green-X will be developed. Project period 2002-2004**.**

Department for Wind Energy

- SAT-MAP-CLIMATE. "Satellite-based bio-geophysical parameter mapping and aggregation modelling for CLIMATE models". The purpose of the project was to extract information from satellite pictures of surface roughness over land, sea and land temperatures, albedo and plant cover and to utilise the resulting maps in weather forecasting and climate models. Project period: 1999-2002. (the DMI also participated.)
- WATERMED. "Water use Efficiency in natural vegetation and agricultural areas by remote sensing in the Mediterranean basin". The purpose of the project is to map water balance and vegetation in the Mediterranean area, in both Europe and Africa, on the basis of satellite pictures and modelling. Project period: 2000-2003.
- EO-FLUX-BUDGET. "Earth Observation data for upscaling carbon FLUX and water BUDGET at Zealand". The purpose of the project is to determine the CO_2 and water balance for a region (Zealand) on the basis of satellite pictures and modelling. The results complement point measurements of CO_2 and water balance in a climate context. Project period 2000-2004
- The EU project AutoFlux. The objective of the AutoFlux project has been to develop an instrumentation system "AutoFlux" for routine unattended use on Voluntary Observing Ships or unmanned buoys, for monitoring climate relevant surface fluxes over the oceans. Project period: 1998-2002.
- NEAREX. "Modelling and measuring the transport of CO_2 to the Greenland Sea from Eastern/Central Europe. Project period: 1998-2002.
- NECC. "Nordic Centre for Studies of Ecosystem Carbon Exchange and its interaction with the climate system". Project period: 2003-2007.
- CarboEuroflux. Exchange of CO_2 and water vapor between the atmosphere and the forest ecosystem. The project, which is EU funded covers a range of biomes from the Mediterranean to the boreal region. Project period 1996 - ? (depending on project renewal). Contribution to the global carbon cycle through FLUXNET.
- RS-model "Remote Sensing based Crop Simulation and Soil-Vegetation-Atmosphere-Transport modelling. Project period: 1996-1999 plus 2001-2004. (Danish funding).
- Carbon uptake in the Greenland Sea- AMAP-project. The CO2 exchange between the sea and the atmosphere in the sub polar area will be investigated and quantified. Previous measurements in the Greenland Sea is used as a basis for the development of a detailed model of the transport of CO2 across the air/water interface and the vertical transport and transformation of carbon in the water column. The project will focus on the interaction of physical and biological processes influencing the marine carbon uptake. The project is a corporation between NERI, department of Marine Ecology and Risoe National Laboratory, department of Wind Energy. Project period 2003/2004

Department of Marine Ecology

- MARINBASIS. "Environmental monitoring in Zackenberg". Marine monitoring of abiotic and biotic reactions on year-to-year variations and long-term climate changes with a view to being able to predict and document the effects of the expected climate changes. Project period: 1995 – and following decades.
- ANOXIA IN SEA ICE: Importance for C and N cycling in the Arctic – Implications of reduction in sea ice distribution and thickness on nitrogen and carbon transformations. Project period: 2001-2003.
- NARP "The bio production and energy transfer in the Nordic Seas, the role of key zooplanktons in a system with rapid climate changes". Project period: 2001-2003.
- CASES. "Canadian Arctic Shelf Exchange Study". Central goal: To understand and model the response of the Mackenzie Shelf ecosystem to atmospheric, oceanic and continental forcing of sea-ice cover variability. Project period: 2003-2007+.
- CANABA. "Carbon flux and ecosystem feed back in the northern Barents Sea in an era of climate change". Project period: 2003-2006.
- "Consequences of climate changes on Greenlandic marine ecosystems". Project period: 2001-2003.
- "Functional diversity of bacteria and phytoplankton in the Disco Bay, Greenland" Project period: 2001-2003.

Department for Arctic Environment

- "The biological monitoring programme BioBasis, in Zackenberg, Northeast Greenland". Monitoring of biotic reactions on year-to-year variations and long-term climate changes with a view to being able to predict and document the effects of the expected climate changes. Project period: 1995 and following decades.
- "The natural geographic monitoring programme GeoBasis in Zackenberg, Northeast Greenland". Monitoring of abiotic reactions on year-to-year variations and long-term changes in the climate with a view to being able to predict and document the effects of the expected climate changes. Project period: 1995 and following decades.
- Environmental monitoring in Zackenberg – Marine Basis. Project period 1995 and following decades.
- "Anoxia in sea ice: Importance for C and N cycling in the Arctic". Project period: 2001-2003.
- "Effect of climate on Arctic marine ecosystems". Project period: 2001-2003.
- "The bio production and energy transfer in the Nordic Seas, the role of key zooplanktons in a system with rapid climate changes". Project period: 2001-2003.
- "The Collared Lemming (Dicrostonyx groenlandicus) in Greenland: Population Dynamics and Habitat Selection in Relation to Food Quality". The study is focused on the collared lemming's food biology and habitat selection in relation to the 4-year cyclical fluctuations in population. Project period: 1999-2002.
- "Carbon balance for a High-Arctic ecosystem". The purpose of the project is to estimate the annual carbon exchange in the Zackenberg area. Project period: 2002-2005.

-Department for System Analysis

- "Projection models for greenhouse gases". Models are being set up at a level of detail that makes it possible to project emission in relation to technological development and political measures. Project period: 2003
- "Inventory of Denmark's greenhouse gases for the Climate Convention and the EU". Denmark's total greenhouse gas emission is being calculated and reported in accordance with current guidelines. Project period: 1990 onwards.
- "Decoupling CO_2 emissions from economic indicators: A Nordic industrial sector analysis". The project is being carried out for the Nordic Council of Ministers in cooperation with the University of Iceland. Project period: 2003-2005.

Department for Terrestrial Ecology, Soil ecology and Ecotoxicology

- "Evolutionary and Physiological Adaptations to Climate Change". Study of genetic variation and physiological adaptation in soil-living animals to extreme climate conditions. Project period: 2002-2005.
- "Effect of increased freeze-thaw cycles in Arctic soil ecosystems"-. The effects of artificially increased freeze-thaw cycles are being studied in field tests (Abisko, Sweden). The focus of this PhD project is how microarthropods react to this artificially increased stress and what consequences it might have on the conversion of organic matter in the soil. Project period: 2001-2004.
- "Synergetic interactions between climate and pollution". An evaluation of the synergetic effects that can occur when soil-living animals are exposed to toxic stress and climate stress at the same time. The results of the project may be of importance for risk assessment of chemical substances taking account of varying climatic conditions. Project period: 1999-2004.

Department for Atmospheric Environment

- The EU project AERCARB. "Airborne European Regional Observations of the Carbon Balance". The objective of AEROCARB is to demonstrate the feasibility of an integrated approach to estimate and monitor the net European carbon balance as a mean to corroborate EU-wide controls of CO_2 emission. Closely connected to this, is the study of spatial and temporal variations of the CO_2 sources and sinks over the European continent.

Technical University of Denmark

- "Solar activity and terrestrial climate: An analysis of some purported correlations". The project's critical analyses revealed serious (misleading) errors in a number of scientific articles concerning the sun's effect on the earth's climate. Project period: 2001- 2003.

Danish Forest and Landscape Research Institute (FSL)

- The EU project AFFOREST. "Afforestation management in north-western Europe - influence on nitrogen leaching, groundwater recharge, and carbon sequestration".
  Environmental effects of afforestation on agricultural land, including binding of carbon in soil and biomass. Project period: 2000-2004.
- "Spreading of wood-chip ash in Danish forestry – ecological consequences". The ecological consequences of ash recirculation under different conditions are being evaluated on the basis of experiments with spreading of ash. Project period: 1999-2004.
- The EU project CNTER. "Carbon Nitrogen Interactions in Forest Ecosystems". Methods for calculating carbon binding in forest soil. The importance of nitrogen deposition for carbon binding in forest soil. Project period: 2001-2004.
- "Biomass removal for energy purposes – return and storage of nutrients in forest ecosystems". Release of nutrients from bags of ash laid out in different localities and in different species of tree is being studied and the ability of the ash to compensate for taking nutrients out of the forest evaluated. Project period: 1999-2003.
- The EU project WOOD-EN-MAN. "Wood for energy - a contribution to the development of sustainable forest management". Research-based development of operational recommendations for sustainable forest operation using woodchips for energy purposes (economy, social economy and ecology), together with policy recommendations on increased use of forest biomass for energy purposes. Project period: 2001-2005.
- NORDBIO. "Nutrient removals with biomass in Norway spruce stands". Development of biomass equations and nutrient models for calculation of biomass and nutrient removal in Norway Spruce in the Nordic countries – particularly with a view to use for energy purposes. Project period: 2001-2004.
- The EU project VULCAN. "Vulnerability assessment of shrubland ecosystems in Europe under climatic changes". The effects of climate changes on the function of vulnerable ecosystems are being studied in six European countries. The project is intended to provide knowledge for politicians, decision-makers, land managers and farmers on the interaction between the climate of the future and the function of the ecosystems. Project period: 2001-2004.
- "Pre-treatment of wood ash and ash spreading in the forests". Project period: 2002-2004
- "Storm fall and energy wood – supply consequences". Wood fuel resources from Danish forests over _ ha – inventory and forecast 2002. Project period: 2002-2003.
- The EU project BIONORM. Pre-normative work on sampling and testing of solid biofuels for the development of quality assurance systems. Project period: 2002-2004.
- "Greenhouse Gas Balances of Biomass and Bioenergy Systems". IEA Bioenergy Programme TASK 38. Analysis of the country-level, regional and global potential of bioenergy, afforestation and other biomass-based mitigation strategies. Project period: 2001-2003.
- "Conventional Forestry Systems for Sustainable Production of Bioenergy". IEA Bioenergy Programme TASK 31. To synthesise and transfer to stakeholders important knowledge and new technical information concerning conventional forestry systems for sustainable production of bioenergy. Project period: 2001-2003.

Institute of Local Government Studies

- "International trade and CO_2". The purpose is to analyse the effect on the national CO_2 emission of trade between countries and the possibilities for reducing the global CO_2 emission by changing the pattern of trade. The project is intended to deliver results of value to the officials attending international climate negotiations. Project period: 2003.

The Royal Veterinary and Agricultural University

- EO-FLUX-BUDGET. "Earth Observation data for upscaling carbon FLUX and water BUDGET at Zealand". In this project the CO_2 and water balance for a region (Zealand) are being determined on the basis of satellite pictures and modelling. The results complement point measurements of CO_2 and water balance in a climate context. Project period: 2000-2004.
- EPN: "European Phenological Network". Thematic Network on the analysis of phenological information in relation to climate variability/ change and exploration of possibilities to predict climate-change effects on the timing of life cycle events. Project period: 2000-2003.
- "Plant community context and reproduction of Sorbus torminalis along a large-scale gradient in Europe - analysing the species' response to climatic change". Project period: 2001- 2004.
- EC Karnal Bunt: 'Pest Risk Assessment for Karnal Bunt - Tilletia indica'. Project period: 2000-2004.

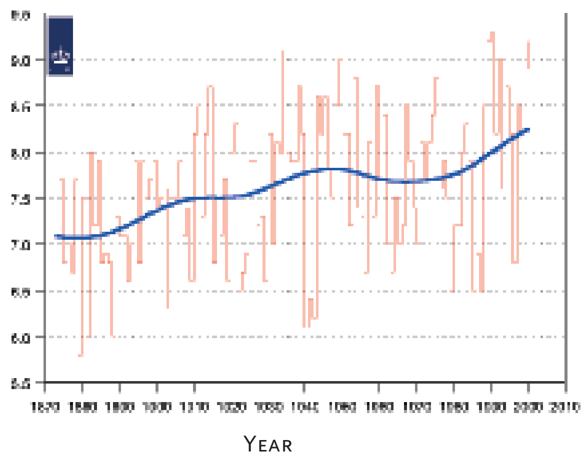
National Survey and Cadastre

- The EU project SITHOS. "Sea Ice Thickness Observing System". Project period: 2002-2005.
- The EU project GREENICE. "Greenland arctic shelf Ice and Climate Experiment". Project period: 2003-2006.
- CRYOSAT. "Cal/val and preparation for ESA's cryosphere monitoring satellite CryoSat". Project period: 2001-2004.
- The EU project GOCINA. "Geoid and Ocean Circulation in the North Atlantic Region". Project period 2002-2005.
- The EU project ESEAS. "European Sea Level Service - monitoring of sea-level changes by satellite". Project period: 2002-2005.

E Denmarks's report on systematic observations for the Global Climate Observing System (GCOS)

DENMARK'S REPORT ON SYSTEMATIC CLIMATE OBSERVATIONS FOR THE GLOBAL CLIMATE OBSERVING SYSTEM (GCOS) FOR THE THIRD NATIONAL COMMUNICATION TO THE CONFERENCE OF THE PARTIES TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

Yearly mean Temperature, Denmark, 1873-2000



Editor: Lillian Wester-Andersen (DMI)

This report is prepared to give a status on the Danish contribution to the systematic climate observations for the Global Climate Observing System (GCOS). The report is part of the Third National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

Climate research and the generation of climate-related observations are carried out by various government departments in order for them to meet their responsibilities. Currently, no national plan exists for the whole area of climate research and observations.

Systematic observations

Many agencies in Denmark engage in the systematic observation of elements of the climate system. Invariably the capture, quality control and archiving of such data are designed to meet the integrated needs of these agencies, deriving from their overall missions.

Typically the drivers for long-term systematic observation of environmental or ecological characteristics arise from an operational, regulatory or research need. Examples of the former are to be found in the capture of meteorological data for predictive and statistical services by the Danish Meteorological Institute (DMI). The resulting observation programmes tend to be long term, but the resulting individual data may be seen as perishable and focus might not always be on maintaining stability and reliability in the records.

The general need for systematic and reliable time series is increasingly understood in the scientific community and incorporated in the collection and data handling procedures.

Data Availability

In this report relevant climate observations for Denmark, Greenland and the Faroe Islands will be described. In general the data are available from the institution operating the observing station / collecting the data, but many can also be found on the web, for instance www.dmi.dk. Where data such as contributions to GCOS are submitted to the appropriate Data Centres, they are also available from these centres.

Additionally, all meteorological data and products that are produced by WMO Members (national meteorological services) to the WMO programmes such as the WWW are available under the terms of WMO Resolution 40 (WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities). Such data are "freely" available "without charge" (i.e. at no more cost than the cost of reproduction and delivery, without charge for the data and products themselves and with no condition on their use).

Similarly hydrological data and products are covered under WMO Resolution 25. Further the IOC are expected to adopt a data policy which provides for free and open access to data that are collected, produced or exchanged as part of oceanographic programmes conducted in association with the IOC.

Chapter 2 Meteorological and Atmospheric Observations

Contributing to GCOS

Denmark participates fully in the GCOS Surface Network (GSN) and the GCOS Upper Air Network (GUAN), and in the Global Ozone Observing System (GO3OS) as part of the Global Atmosphere Watch (GAW).

GCOS Surface Network / GSN Stations

The designated 7 GSN stations in Denmark, Greenland and on the Faroe Islands are all run by DMI and consists of:

- Greenland: Upernavik, Godthaab / Nuuk, Narsarsuaq, Danmarkshavn, Ammassalik;
- The Faroe Islands: Torshavn;
- Denmark: Copenhagen.

All of these currently meet the GCOS standard for surface observing.

GCOS Upper Air Network / GUAN Stations

Only one GUAN station is designated for Denmark, Greenland and the Faroe Islands and it is situated in Narsarsuaq, Greenland. The station is run by DMI and is operated to GCOS standard. A survey of the performance in 2000 shows that 92% of the soundings reached an altitude of 30 hPa.

GCOS Global Atmospheric Watch / GAW Stations

Denmark contributes to the Global Ozone Observing System (GO3OS) as part of the GAW programme with three stations in Greenland and one in Denmark. The stations in Kangerlussuaq (Greenland) and Copenhagen (Denmark) are equipped with Brewer spectrometers, the station in Pituffik (Greenland) is equipped with a Dobson and a SAOZ spectrometer and the station in Illoqqortoormiut (Greenland) is equipped with a SAOZ spectrometer. The spectrometer in Illoqqortoormiut is operated by Service d'Aeronomie (France) in cooperation with DMI while all other spectrometers are operated by DMI. All data are available from DMI.

Table 1. Participation in the global atmospheric observing systems
1 The Danish participation is in the GO3OS of GAW

	GSN	GUAN	GAW[1]
How many stations are the responsibility of the Party?	7	1	4
How many of those are operating now?	7	1	4
How many are operating to GCOS standard now?	7	1	4
How many are expected to operate in 2005?	7	1	3
How many are providing data to international data centres now?	7	1	4

Other National and Meteorological and Atmospheric Observations:

Surface Climatological/ Meteorological Network

DMI operates and receives data from a network of approximately 100 automatic meteorological stations in Denmark, Greenland and on the Faroe Islands. Measurements are made in accordance with the WMO recommendations.

Figure 1: Meteorological Observing Stations, Denmark

As from 2001 a special dedicated network of (manual) stations for climatological observations has been discontinued, due the convergence of the different network technologies. The objectives behind this decision are to eliminate human errors, to benefit from potential savings in the rationalisation and to reach a higher observation frequency. Climatological data are now obtained from the automatic network described above. Climatological data are collected to

Figure 2: Meteorological Observing Stations, Greenland

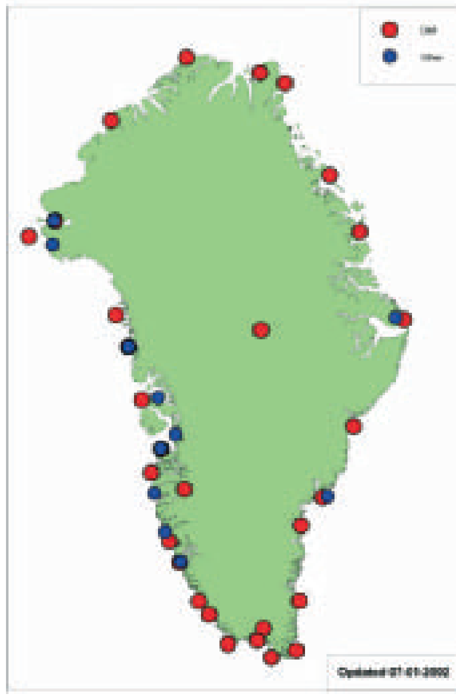
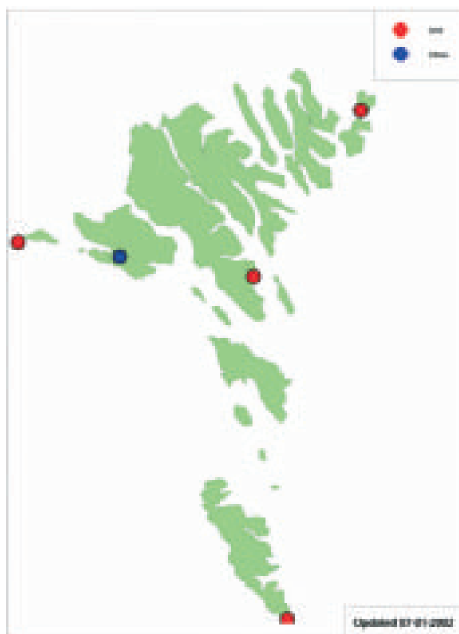


Figure 3: Meteorological Observing stations, The Faroe Islands



define the climate in Denmark, Greenland and on the Faroe Islands and to create a national database for a wide range of enquiries and research activities. Most climatological work involves the production of annual or monthly statistics including means, percentiles and standard deviations.

Long records are needed to establish reliable averages and trends. In 2001 the daily inflow of data from Denmark, Greenland and the Faroe Islands was 75,000 and in all 245,000,000 observations are currently stored in the database. The observations are stored in a central database at DMI, where data from several meteorological stations are stored as far back as 1872.

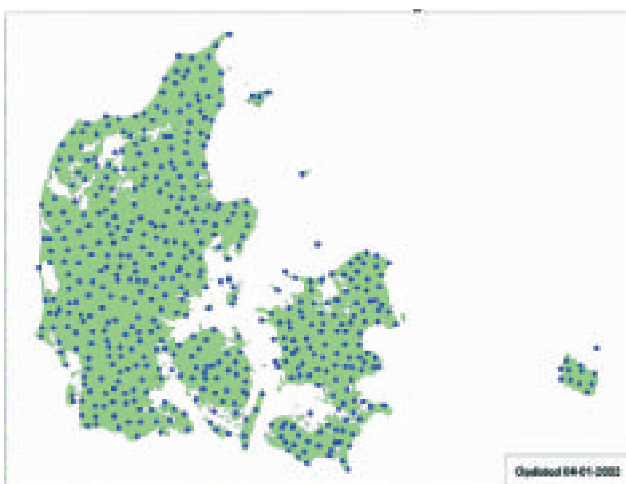
A monthly summary is prepared for three stations in Denmark, one on the Faroe Islands and 8 in Greenland on the CLIMAT format. These data are routinely submitted on the GTS.

Rainfall Observing Network (Stations and Radar)

The need for rainfall data is greater than what is generated from the overall surface climatological and meteorological network described in the above paragraph. In Denmark the rainfall network consists of approximately 575 stations. Roughly 75 of these provide continuous data on rainfall intensity. They are operated jointly by DMI and The Water Pollution Committee of the Society of Danish Engineers (SVK). The remaining 500 stations collect daily values on rainfall and from approximately 100 of these data are transmitted to DMI on a daily basis, whereas the remaining data are received as monthly sums.

Figure 4: Automatic Precipitation Stations, (Detailed for Copenhagen)

Figure 5: Manual Precipitation Stations



On the Faroe Islands a rainfall network of 22 stations collects daily information about the precipitation. Information on precipitation can also be obtained from weather radar data. In Denmark DMI runs a network of three weather radars which provides nearly 100% coverage. In the early part of 2002, an additional radar on the island of Bornholm will further improve this coverage. The network has an unsurpassed high spatial resolution, and hence provides very detailed climatological information about precipitation both on national, regional and local scale. By calibrating radar data against point-measurements of precipitation the latest scientific results show a high absolute accuracy. The present radar network has a data frequency of 6 pictures / hour, and a spatial resolution of 2 km x 2 km.

Surface Radiation and Sunshine Observing Network

Regarding observations of hours of bright sunshine DMI runs a network of 30 stations in Denmark, 6 in Greenland and one on the Faroe Islands.

Radiation is measured at 23 stations in Denmark, of which 15 are operated by DMI and 8 by the Danish Institute of Agricultural Sciences (DIAS). The measurements of radiation are carried out as 10- minute mean values of global radiation at the DMI operated stations and as hourly mean values of global radiation at the stations operated by DIAS.

Solar Ultraviolet Radiation and Stratospheric Ozone stations

The Solar Ultraviolet (UV) radiation at different wavelenghts is measured by DMI at two sites in Greenland, namely Pittufik and Kangerlussuaq.

Besides the GO3OS described earlier weekly ozone soundings are made at Illoqqortoormiut and sporadic ozone soundings are made during the winter months in Pituffik by DMI.

Upper Air Measurements
- Radiosounding Observations

DMI runs radiosounding stations in the following 7 locations: Copenhagen (Denmark), Tórshavn (the Faroe Islands), Danmarkshavn, Illoqqortoormiit, Tasiilaq, Narsarsuaq and Aasiaat (Greenland). Two soundings are made every day at these stations.

From all 7 radiosounding stations a monthly summary (CLIMAT TEMP) is prepared and transmitted routinely on the GTS.

Ice Observations

DMI has the responsibility of systematic surveillance of the sea ice conditions in the Greenland waters. Observations on the ice conditions have been collected for approximately 125 years and an extensive volume of data is available in a graphic format as monthly summaries, ice maps etc.

Since 1959 special emphasis has been put on the waters south of Cape Farewell (the southern tip of Greenland) in order to improve the navigation safety. Ice maps are prepared more than weekly containing detailed information on the relevant ice conditions. Recent maps are available on vector graphic format.

Since 2000 weekly summaries of the ice conditions for all Greenland waters have been prepared. These summaries are based on satellite data and are generated automatically and are primarily intended for analysis of the climatology in the Greenland waters.

Climatological data sets

Over the years several long term climatological series have been established by DMI representing Denmark, Greenland and the Faroe Islands.

The main accomplishments in this area in recent years are: - Observed Daily Precipitation, Temperature and Cloud Cover for Seven Danish Sites, 1874-2000 (DMI technical report no. 01-10) and Observed Daily Precipitation, Maximum Temperature and Minimum Temperature from Ilulissat and Tasiilaq, 1873-2000 (DMI technical report no. 01-11).

Both reports (incl. datasets) are available at DMI's website (http://www.dmi.dk/eng/f+u/index.html) under the headings Publications / Technical Reports.

Air Quality Monitoring

Automatic monitoring takes place near ground level in both urban and rural locations across Denmark. A monitoring network is operated by the National Environmental Research Institute (NERI), Denmark, and measures a wide range of pollutants:

- Oxides of Nitrogen (NOX)
- Nitrogen dioxide (NO_2)
- Ozone (O_3)
- Sulphur dioxide (SO_2) is measured 1/2 hourly and daily basis
- Total Suspended Particulate matter, TSP (PM10)
- Elements (in particulate matter)
- Nitrogen compounds ((NH_3+NH_4+), (HNO_3+NO_3-))
- Carbon monoxide (CO)

Figure 6 shows the types and distribution of air quality monitoring stations across Denmark and in table 2 the measurements taken at the different stations are listed.

Besides the above measured ozone DMI operates an ozone measurement station at Jægersborg a sub-urban environment near Copenhagen. Real-time hourly data are presented on DMI's website (http://www.dmi.dk). Data with a time resolution of 10 minutes are available from DMI. It is intended to establish one more real-time ozone measurement station in 2002.

Figure 6: Air quality monitoring stations across Denmark

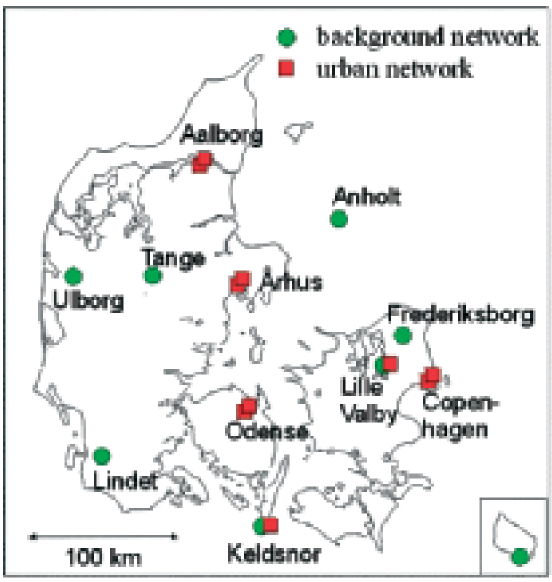


Table 2: Measurements taken at the different stations

Location	NOx	NO_2	O_3	SO_2	SO_2	TSP PM_{10}	Elements	N comp.	CO	Precip.
Averaging time	_ h	24 h	_ h	_ h	24 h	24 h	24 h	24 h	_ h	
Aalborg	x			x		x	x		x	
Aalborg	x		x	x		x	x			
Århus	x					x	x		x	
Århus	x		x			x	x			
Lille Valby	x		x		x	x	x			
Copenhagen	x		x			x	x		x	
Copenhagen	x		x						x	
Odense	x					x	x		x	
Odense			x							
Keldsnor	x		x							
Anholt		x			x		x	x		x
Ulborg	x		x		x		x	x		x
Tange					x		x	x		x
Frederiksborg	x		x		x		x	x		x
Lindet					x		x	x		x
Keldsnor					x		x	x		x
Pedersker										x

Chapter 3 Oceanographic Observations

Contributing to GCOS

For the oceanographic observations GCOS is based upon the open ocean (climate) module of GOOS, which comprises the following programmes: drifting and moored buoy programmes managed by the DBCP (Data Buoy Co-operation Panel), the Ship of Opportunity Programme (SOOP), the Argo array of profiling floats, the Global Sea Level Observing System (GLOSS), the Voluntary Observing Ships Programme (VOS) and the Automated Shipboard Aerological Programme (ASAP).

Denmark participates in the VOS, GLOSS and ASAP programmes as summarised in table 3 below.

Table 3: Participation in the global oceanographic observing systems

	VOS	SOOP	TIDE GAUGES (GLOSS)	SFC DRIFTERS (DBCP)	SUB-SFC FLOATS (Argo)	MOORED BUOYS (DBCP)	ASAP
How many stations are the responsibility of the Party?	47	0	5	0	0	0	2
How many are providing data to international data centres?	47	0	3	0	0	0	2
How many are expected to operating in 2005?	40-50	0	3	0	0	0	2

Voluntary Observing Ships / VOS

VOS is an international scheme, first developed almost 150 years ago, by which ships plying the various oceans and seas of the world are recruited for taking and transmitting meteorological observations. VOS ships make a highly important contribution to the Global Observing System (GOS) of the World Weather Watch (WWW), and increasingly, through the VOS Climate Project (VOS-Clim), to global climate studies. VOS is disseminated on the GTS and are archived by many national meteorological services.

At the end of 2000 the Danish fleet of voluntary observing ships consisted of 47 ships. DMI has the operational and professional responsibility for the observations, which are made every third hour from the ships.

Tide Gauges / GLOSS

GLOSS is an international programme coordinated by the IOC for the establishment of high quality global and regional sea level networks for application to climate, oceanographic, and coastal sea level research. The main component of GLOSS is the Global Core Network (GCN) of 287 sea level stations around the world for long-term climate change and oceanographic sea level monitoring. GLOSS stations are established in Torshavn (Faroe Islands), Nuuk (Greenland) and Ammassalik (Greenland). The former GLOSS stations in Ittoqqortoormiit and Danmarkshavn (both in Greenland) have been abolished. The station in Ammassalik is operated by the Royal Danish Administration for Navigation and Hydrography, whereas the other two stations are operated by DMI. The relevant mean values from the stations are transmitted to the Permanent Service for Mean Sea Level (PSMSL) hosted by the Proudman Oceanographic Laboratory in the UK.

The PSMSL was established in 1933, and is the global data bank for long-term sea level change information from tide gauges. Information on monthly and annual mean sea level is transmitted to PMSLS from 15 stations in Denmark, 5 in Greenland and one on the Faroe Islands.

Automated Shipboard Aerological Programme /ASAP

The ASAP in its present form began in the mid-1980. It involves the generation of upper air profile data from data sparse ocean areas using automated sounding systems carried on board merchant ships plying regular ocean routes. Several National Meteorological Services operate ASAP units and the profile data are made available in real time on the GTS. ASAP data are archived alongside other radiosounding data by many national meteorological services. ASAP is an important contribution to both the WWW and GCOS. Most of the soundings are presently from the North Atlantic and NorthWest Pacific Oceans, but the programme is expanding to other ocean basins, through a new, co-operative World-wide Recurring ASAP Project (WRAP).

Denmark operates two ASAP units, mounted on ships plying routes from Denmark to Greenland.

The European meteorological cooperation EUMETNET started a special E-ASAP programme December 2000. Currently two ASAP units are operated under this programme, one in the Mediterranean and one in the Atlantic. DMI is the responsible member for this programme.

Other National Oceanographic and Marine Observations

Sea Temperature

In Denmark a Network exists for the collection of sea temperatures at 13 coastal stations around Denmark. The stations are operated by DMI, the Royal Danish Administration for Navigation and Hydrograhy and local authorities respectively. Data are available from each of the responsible bodies.

In Greenland a total of 7 stations measure sea temperatures. DMI and the Royal Danish Administration for Navigation and Hydrograhy operates the stations.

National Tide Gauge Network

In Denmark an extensive national network of tide gauges are operated jointly by DMI, the Royal Danish Administration for Navigation and Hydrograhy, local authorities and the Danish Coastal Authority. The network consists of 82 automatic stations.

In Greenland a total of 7 tide gauge stations are operated by DMI and the Royal Danish Administration for Navigation and Hydrograhy.

On the Faroe Islands one station is operated in Torshavn by DMI.

Data are available from the responsible bodies.

Hydrographic and Marine Surveys

The National Environmental Research Institute has the overall responsibility for surveillance of the Danish Waters. Regular Surveys are carried out with the objectives of:

- Determining the actual situation in the open Danish waters;
- Tracing the influence of land based discharges of nutrients;
- Establishing reference data for the local monitoring in coastal areas;
- Securing continued time series for trend monitoring.

Surveys are part of the Danish nationwide monitoring programme NOVA 2003, the HELCOM monitoring programme for the Baltic Sea area (Arkona Sea, Sound, Belt Sea, Kattegat), and the OSPARCOM monitoring programme for the Greater North Sea (Kattegat, Skagerrak, North Sea).

The Danish Institute for Fisheries Research carries out yearly surveys in the Danish Waters, primarily in the North Sea and the Baltic Sea, and in that relevant oceanographic parameters are measured and recorded.

Furthermore, DMI is involved in the following projects:

Biogeochemical cycling of Carbon and Ocean circulation in the northern North Atlantic

The overall aim of the project is to describe the effect of high latitude carbon dynamics on the global ocean-atmosphere carbon system, in general, and on atmospheric pCO_2 in particular. At present, knowledge concerning the seasonal differences in turnover rates of organic material in Polar and sub-polar regions is limited. Thus, in order to achieve the aim of this project it is necessary to obtain biological and chemical rate measurements for the production and destruction of dissolved and particulate organic material at high latitudes and relate these to the convection occurring at different times of the year.

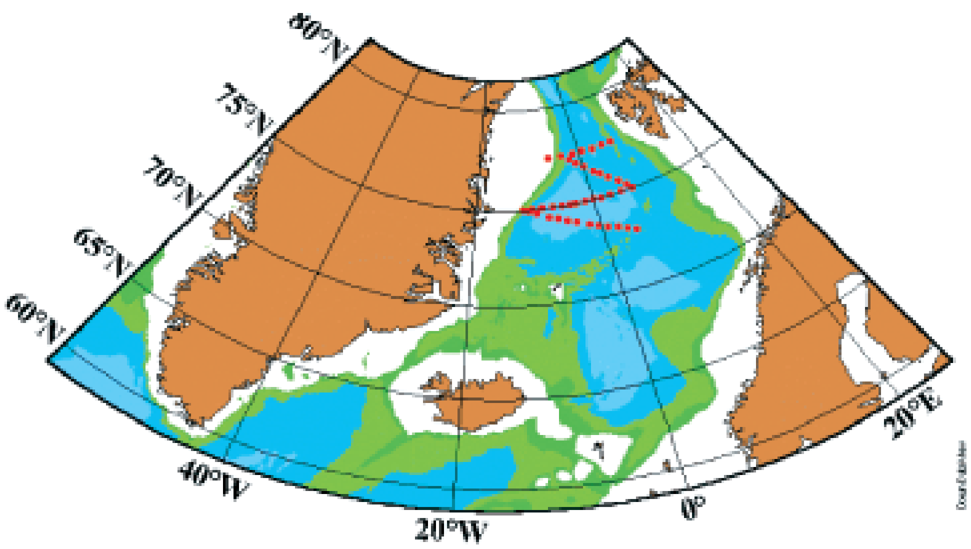
Measurements of water transports across the Greenland-Scotland Ridge

During the Nordic WOCE programme (1993-97) observations of the water transport across the Greenland- Scotland Ridge was initiated and the measurements have been continued after the closing of the Nordic WOCE programme. The goal of the observation campaign was to put reliable numbers on the volume transports of the various current components flowing in and out of the Nordic Seas, and especially to investigate possible seasonal and interannual variability, which might reflect changes in the global thermohaline circulation.

Monitoring of the oceanographic conditions along West Greenland

Denmark/Greenland has in relation to the North Atlantic Fisheries Organisation (NAFO) the responsibility for monitoring the physical oceanographic conditions along the westcoast of Greenland. The formal responsibility for performing these measurements is placed at the Greenland Institute for Natural Resources, Nuuk which since 1998 has allocated the work by contract to the Danish Meteorological Institute.

Figure 7: Biogeochemical cycling of Carbon and Ocean circulation in the northern North Atlantic Programme (the red lines illustrate the observation routes)



The temperature and salinity is measured on standard stations along the Greenland westcoast with the purpose of obtaining knowledge about the marine climate in the area which has a great impact on the recruitment and survival of the fish species living in the area of which some is living close the limit of survival. The data therefore are of great importance to the fisheries' assessment work.

Monitoring of the oceanographic conditions around the Faroe Islands.
The Fisheries Laboratory in Thorshavn monitors the oceanographic conditions around the Faroe Islands on four standard sections four times a year. The purpose of the monitoring is to study the water mass composition and its variability in the area.

Chapter 4 Terrestrial Observations

Except monitoring of snow cover, sea ice and surface radiation Denmark does not carry out further terrestrial observations that can be related to climate change. However, Denmark's climate related research includes monitoring and studying the effect of terrestrial conditions.

Chapter 5 Space-based Observing

Denmark contributes to space based observations through the European agencies ESA (a partnership of 15 European Member Governments, with Canada affiliated), EUMETSAT (a partnership of 17 European Member Governments, with three Cooperating States) and by the utilisation of national small satellites. As such, details of the platforms and sensors are not given in this section, which focuses on Danish specific needs and efforts. The Danish strategy for earth observations (EO) is delivered, largely, through participation in international programmes and to some extent through national programmes such as the Ørsted satellite.

The Danish space activities are not coordinated by one central institution. The Ministry for Science, Technology and Innovation represents Denmark in ESA, whereas the responsibility for the meteorological observation aspects (EUMETSAT) lies with the Ministry of Transport.

The actual activities are carried out by several organisations, such as DMI, the Technical University of Denmark, Danish Space Research Institute and of course private industry.

ESA and EUMETSAT Platforms and Programmes
ESA EO platforms that are either operational now or due for launch before the end of 2005 and the projects where Denmark is participating, include:

- ERS-2. Launched in 1995. Follow on to ERS-1 in examining Earth by radar, microwaves and infrared radiation, carries an additional instrument to observe the ozone hole.
- ENVISAT. Launched planned for January 2002. European environmental satellite to succeed ERS series with advanced versions of in-

struments used in ERS-2 and several important new ones.
- MSG-1 (ESA and EUMETSAT) launch planned for July/August 2002 and MSG-2 about 18 months later. The Meteosat Second Generation geostationary satellites will give far sharper weather information than that from Meteosat, which has operated over the Equator since 1977.
- METOP-1 (ESA and EUMETSAT) launch planned 2005. While Meteosat and MSG observe the weather from above the Equator, METOP will fly over the poles, with advanced instuments for sounding of the atmosphere.

It can further be mentioned that Denmark has been involved in the preparation for new programmes under the ESA-EO: WATS as a core mission and ACE+ as an opportunity mission. The purpose of these missions is to obtain reliable data on the temperature, pressure and humidity of the atmosphere amongst others to secure a better understanding of climate variations.

DMI represents Denmark in EUMETSAT, which has the following current programmes:

- MTP (Meteosat Transition Programme). Operation of Meteosat-7, -6 (standby), -5 (Indian Ocean) in geostationary orbit.
- MSG (Meteosat Second Generation). Future operation of MSG-1, 2, and 3 in geostationary orbit.
- EPS (European Polar System). Future Operation of METOP-1 (launch scheduled for December 2005), 2 and 3 in morning polar orbit.

As part of its distributed application ground segment EUMETSAT has a network of Satellite Application Facilities (SAFs), as specialised development and processing centres (see http://www.eumetsat.de for details). These utilise the specific expertise available in EUMETSAT's Member States, and complement the production of standard meteorological products derived from satellite data at EUMETSAT's Central Facilities in Darmstadt. Seven SAF projects are undergoing development, focusing on the following applications:

- Support to nowcasting and very short range forecasting (Nowcasting SAF)
- Ocean and sea ice SAF
- Ozone monitoring SAF
- Numerical Weather Prediction SAF
- Climate monitoring SAF
- GRAS meteorology SAF
- Land surface analysis SAF

A number of these are relevant to aspects of GCOS monitoring. DMI hosts the GRAS meteorology SAF and also contributes the Ocean and sea ice SAF and the Ozone monitoring SAF.

GPS data from the Ørsted, SAC-C and CHAMP satellites

Measurements of GPS radio occultations are important in use both for numerical weather prediction and to monitoring of climate change processes and their identification. This has been demonstrated first by the American proof-of-concept mission

GPS/MET. The research satellites Ørsted, SAC-C and CHAMP all have the capability of the required high precision reception of GPS signals to perform radio occultation measurements. The GPS data from the Danish Ørsted satellite, launched in 1999, has been used in the EU project CLIMAP (CLImate and environment Monitoring with GPS based Atmospheric Profiling) to study the impact on numerical weather prediction. Further, since the data needs no calibration, they will prove very valuable for climate monitoring purposes by combining several data sets and model forecasts.

The primary objective of the CLIMAP project was to establish end-to-end demonstrations of the operational derivation and usage in Numerical Weather Prediction (NWP) of atmospheric parameters on basis of the reception of GPS signals through the atmosphere. This included data from GPS reception on ground and Radio Occultations from Low Earth Orbiting (LEO) satellite based GPS reception. An "end-to-end" chain for processing of satellite based GPS radio occultation data was developed: From GPS signal reception to assimilation into the NWP models. The chain included operational reception of tracking data from the Ørsted satellite with associated level 0 processing and archiving (operational and prepared by the Danish company TERMA and DMI). This Ørsted processing chain will be further used by DMI on the new GPS occultation data received by the German CHAMP and the Argentinean SAC-C satellite.

Chapter 6 Activities in Developing Countries relating to Observations.

DMI has since 1997 participated in a project at the Meteorological Services Department of Ghana (MSD). The aim of the project is primarily to re-establish the meteorological observing network in the country and ensure the collection of data. Another part of the project is the communication and utilisation of the data. The Project will continue to the end of 2003, and by that time MSD should operate a well-functioning network of approximately 300 stations recording the basic meteorological parameters. The project is funded by the Danish State aid organisation DANIDA.

List of Acronyms

ACE+	Atmosphere Climate Explorer
ASAP	Automated Shipboard Aerological Programme
CHAMP	Challenging Mini-satellite Payload
CLIMAT	Climate message encoded for the WMO network
CLIMAT-TEMP	CLIMAT from upper air soundings
CLIMAP	Climate and environment Monitoring with GPS based Atmospheric Sounding
DIAS	Danish Institute of Agricultural Science
DMI	Danish Meteorological Institute
DBCP	Data Buoy Cooperation Panel
EO	Earth Observations
ERS	European Research Satellite
ESA	European Space Agency
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GAW	Global Atmospheric Watch of WMO
GCN	Global Core Network (of GLOSS)
GCOS	Global Climate Observing System
GLOSS	Global Sea Level Observing System
GNSS	Global Navigation Satellite System
GO3OS	Global Ozone Observing System
GPS	Global Positioning System
GPS/MET	GPS Meteorology
GRAS	GNNS Receiver for Atmospheric sounding
GSN	GCOS Surface Network
GTS	Global Telecommunications System
GOOS	Global Ocean Observing System
GUAN	GCOS Upper Air Network
HELCOM	Helsinki Commission - Baltic Marine Environment Protection Commission
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
LEO	Low Earth Orbiting
MSD	Meteorological Services Department (Ghana)
NERI	National Environmental Research Institute
NOVA2003	Danish Aquatic Environment monitoring and Assessment Programme
OSPARCOM	Oslo and Paris Commissions on the North East Atlantic Sea
SAC-C	Satélite de Aplicaciones Científicas-C
SFC	Surface (Drifters)
SOOP	Ship of Opportunity Programme
SVK	The Water Pollution Committee of the Society of Danish Engineers
UV	Ultraviolet
VOS	Voluntary Observing Ships
WATS	Water Vapour and Temperature in the Troposphere and Stratosphere
WMO	World Meteorological Organization
WRAP	World-wide Recurring ASAP Project
WWW	World Weather Watch (of WMO

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