Denmark's Second National Communication on

Climate Change

Submitted under the United Nations Framework Convention on Climate Change

Ministry of Environment and Energy, Denmark
Danish Environmental Protection Agency

Foreword

Since the first Danish National Communication to the Climate Convention, two major events have taken place. In March 1995 the Conference of the Parties decided to launch negotiations on a protocol to the UNFCCC, with the objective of strengthening the commitment of the industrialised countries regarding emissions of greenhouse gases. Secondly, in December 1995 the UN Intergovernmental Panel on Climate Change, IPCC, approved its Second Assessment Report.

In my view one of the most important new findings of the IPCC is that "The balance of evidence suggests a discernible human influence on global climate". In other words, the panel concludes that it cannot be excluded that the concentrations of greenhouse gases in the atmosphere have reached levels which are likely to destabilise the climate systems of the globe - destabilisation followed by climatic changes and rising sea level.

As stated in this Second National Communication Denmark is not likely to experience great climate changes in the next decade. If we take stock of the situation in due time the incremental costs for the Danish society will be limited. On the other hand we recognise that in other parts of the world, the impacts of climate change and rising sea level could be crucial for the existence or the well-being of other countries and people. It is necessary in the longer term to limit and reduce global emissions of greenhouse gases, in order to prevent the development of "environmental" fugitives and the related economic and political instability.

It is our hope that in negotiations on the protocol to strengthen the commitments of the UNFCCC, the industrialised countries will assume the necessary leadership and agree on substantial reductions of emissions of greenhouse gases. We believe that such commitments are crucial to limit and reduce global emissions on a longer term.

Denmark has taken up the challenge. Already in April 1990, following the debate on the new Energy Action Plan, the Danish Parliament decided to reduce emissions of CO_2 from the energy and transport sectors by 20% in 2005 compared to 1988. The action plans have been revised regularly to secure fulfilment of the target. And in April 1996 - debating an Action Plan for the years 2005-2030 - the Danish Parliament urged the government in negotiations up to Kyoto to strive for a 50% reduction of CO_2 emissions from industrialised countries in 2030 compared to 1990.

The most promising sign in the development of Danish CO_2 emissions is that, looking at emissions for the period 1991 - 1995, there are some indications of a reduction by 3-4%, if the figures are filtered for variations in both electricity exchange and temperature.

One of the more important measures to fulfil the short and long term reductions was the confirmation by Parliament in May 1997 of my decision to prohibit new coal-fired power plants.

As regards the other natural greenhouse gases, CH_4 emissions are expected to stabilise and N_2O emissions are expected to decrease in 2010 if no other measures are imposed. As to the fluorocarbons the use of HFCs in the refrigerating and freezing industry is expected to be phased out before 2006.

It is my hope that this report will demonstrate the willingness of the Danish Government to take the threat of global warming seriously and to implement the measures required.

Svend Auken
Minister for Environment and Energy

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

Exchange rates used:
- in Chapter 3 and 9: USD 1 corresponds to DKK 5.61 (1995),
- in Annex G: the exchange rates shown in the annex,
- in all other chapters and annexes: USD 1 corresponds to DKK 7.00 (september 1997)

1 Executive summary

1.1 National circumstances

National circumstances, Denmark

The population of Denmark amounts to nearly 5.2 million inhabitants and the total area to 43,000 km^2.

Of the total Danish area, 64% is agricultural land, 10% is forest and 10% is natural areas such as moors, marsh, bogs, lakes and streams. The Danish lakes comprise less than 1% of the total area, and the largest lake is 39 km^2. The built-up areas (urban areas, summer residence areas, traffic infrastructure etc.) occupy about 15%.

The Danish climate is mildly temperate with precipitation falling throughout the year. The annual mean temperature is 7.7 °C, and the annual precipitation is in average 712 mm.

The Danish Gross Domestic Product amounted to USD 172,741 million (in 1995 current market prices), corresponding to a per capita income of USD 33,042, giving Denmark one of the highest per capita incomes in the world.
Agriculture, forestry and fishery account for 3.8% of the total GDP, manufacturing 20.1% and services, including Government services, 69.4%.

Energy

Denmark's main indigenous resources of energy, apart from renewables, are the North Sea oil and natural gas fields.

The growth of oil and gas production combined with the decrease in oil demand has made Denmark a net exporter of both oil and gas since 1993.

According to the latest short-term prognosis, oil and gas production will continue to increase in the near-term, but will decline after the turn of the century if new fields are not discovered.

Primary energy consumption increased rapidly in the 1960s, but essentially stabilised at a level of 800 PJ from 1972 to 1995 as a result of the two oil crises and the implementation of rigorous energy policy instruments during the last 20 years.

As a result of the oil crises, oil was substituted by coal at power and heat plants. The decline in the use of oil is also due to energy savings and changes in consumption patterns and the supply system, e.g. the introduction of combined heat and power.

In 1995, source apportionment of the total primary energy consumption of 808 PJ was coal: 30%, natural gas:16%, oil products: 47% and renewables: 7%.

Energy and CO_2 taxes have been implemented on fossil fuels and electricity, especially in the household sector, and the ensuing energy savings in this sector are a strong indication of the efficiency of high energy prices as an instrument to lower energy consumption.

Final energy consumption shows the same pattern of stabilisation since 1972 as primary energy consumption, remaining at a level of approx. 600 PJ per year.

Transport

In Denmark the number of passenger cars increased by 55% from l970 to 1995. At the same time, there has been an increase in individual passenger transport of 84% from 33,400 million person-km to 61,500 million person-km. Transport of goods by road has increased by 40% from 7,800 million tonnes-km in 1970 to 10,900 million tonnes-km in 1995.

1.2 Inventories of anthropogenic greenhouse gases and removals

Emissions and uptake

The basis for the calculation of greenhouse gas emissions from the energy sector is primary energy consumption and emission factors. For the other sectors activity data and estimated national emission factors are used.
The inventory is based on the software and the methodologies developed by the EU and known as the CORINAIR database system. In general, the CORINAIR inventory is transformed in accordance with the 1995-IPCC Guidelines. The Revised 1996-IPCC guidelines have supplementarily been applied to N_2O from agriculture and the pollutants not earlier included (SO_2, HFCs, CFCs and SF_6). In Table 1.1 a short summary is shown.

	1990	1991	1992	1993	1994	1995
CO_2[1]	60,233	61,721	61,358	60,328	59,605	58,917
CO_2[2]	52,277	62,940	57,652	59,356	63,344	59,532
CH_4	421	426	431	445	428	430
N_2O	34	34	34	33	33	33
NO_x	280	320	274	274	272	253
CO	785	800	770	725	704	702
NMVOC	179	176	170	161	166	162
SO_2	180	239	186	152	155	150
HFCs	0.000	0.001	0.006	0.090	0.158	0.197
PFCs	n.a.	n.a.	n.a.	n.a.	n.a.	0.000
SF_6	0.008	0.008	0.008	0.009	0.011	0.009

Table 1.1. *Danish CO_2, CH_4, N_2O, NO_x, CO, NMVOC, SO_2, HFCs, PFCs, and SF_6 emissions 1990 – 1995 in Gg.*

Carbon dioxide, CO_2

The development in total Danish CO_2 emissions 1990 – 95 corrected for both electricity exchange and outside temperature variations indicates a slight negative trend from 1991.

The main sources for CO_2 emissions are power plants and transport, with a share of 53% and 19% respectively in 1995.

The corrected figures reflect CO_2 emissions corresponding to Danish energy consumption under normal meteorological conditions. Thus, when comparing Danish emission figures from year to year to get an impression of the effect of the implemented measures to reduce CO_2 emissions it is necessary to use the corrected figures. These should also be applied when assessing compliance with emission reduction targets under the UNFCCC, etc.

CO_2 sinks

The Danish Parliament has decided that during a period of rotation, e.g. 80 – 100 years, the forest area should be doubled. This decision implies an afforestation rate of about 40 km^2/year, corresponding – at its highest level – to a CO_2 fixation rate of approx. 3,500 Gg CO_2 per year or approx. 5% of present annual anthropogenic emissions in Denmark. The sequestration of CO_2 is not included in the national totals.

Methane, CH_4

Total Danish anthropogenic emissions of CH_4 amounted to 430 Gg in 1995. The dominant sources were animal waste and enteric fermentation in the agricultural sector, which accounted for 327 Gg in 1995 with no clear trend from 1990.

Nitrous oxide, N_2O

[1] Corrected for electricity exchange and inter-annual temperature variations

[2] Not corrected for electricity exchange and inter-annual temperature variations

Anthropogenic emissions of nitrous oxide almost completely derived from the agricultural sector, which accounts for more than 90% of a yearly emission of 33-34 Gg determined by using emission factors from the new IPCC manual.

N_2O - decrease

Due to the impact of the Danish Action Plan for a Sustainable Agricultural Development, the consumption of commercial fertiliser decreased by 25% from 1990 to 1996. This decrease is reflected in the emission figures for the period 1990 – 95.

Secondary substances (NO_x, CO, NMVOC and SO_2)

The trend in the period 1990 - 95 in emissions of secondary substances such as nitrogen oxides (NO_x), carbon monoxide (CO), non methane volatile organic substances (NMVOC) and sulphur dioxide (SO_2) has been negative since 1991. Emissions of NO_x and NMVOC are regulated within the Geneva Convention. Emissions in 1995 are estimated at 254 Gg and 162 Gg respectively. Emissions of CO are estimated at 701 Gg in 1995. Emissions of SO_2 are estimated at 150 Gg in 1995.

HFCs, PFCs and SF_6

The consumption of hydrofluorocarbons (HFCs) increased in line with the replacement of CFCs (0.750 Gg in 1995 with emissions estimated at 0.197 Gg), while the consumption of sulphur hexafluoride (SF_6) remained largely unchanged) (0.017 Gg in 1995 with emission estimated at 0.009 Gg). The consumption of perfluorocarbons (PFCs) in the period 1990 – 95 was negligible.

1.3 Policies and measures to reduce greenhouse gas emissions

National programmes

Danish policies regarding limitation of greenhouse -relevant gases are rooted in many years of active national policies on energy and environment.

The first national energy plan from 1976 together with further development of the policies during the 1980’s resulted in a major restructuring of the energy system in Denmark.

As a result, total primary energy consumption has essentially stabilized despite substantial growth in all economic sectors. In parallel with this the environmental impact of the use of energy has decreased substantially as a direct result of the changes in the energy system, as well as introduction of emission standards, emission quotas and other regulations.

In the late 1980’s, focus gradually shifted from supply security considerations, minimization of energy service costs, and local environmental effects, to wider environmental considerations, notably the goal of achieving long-term sustainable development on a national as well as a global level. In 1988, the Danish Government presented its Action Plan on Environment and Development as a follow-up of the recommendations set forth in the report from the World Commission on Environment and Development, the Brundtland Report.

In 1990, two action plans relating to energy and transport were presented to Parliament. In these plans, reduction of greenhouse gas emissions, notably carbon dioxide, was introduced as explicit targets.

In 1992, the objectives of Danish waste policy were described in the Danish Government's Action Plan for Waste and Recycling 1993 – 97. These included minimization of deposition of organic material in landfills and energy saving through recycling. A consequence of the plan will be a reduction of emissions of methane from landfill sites.

The 1990 Energy Action Plan

In the Energy Action Plan, the Government listed a number of new initiatives aimed at reducing CO_2 emissions for the whole energy sector, excluding transport, by 28% in 2005 as compared to 1988 levels. The Plan received broad political backing from Parliament.

Strategically, the Energy Action Plan emphasized efficiency improvements in end use, especially in the use of electricity, and increased efficiency of the energy supply systems, notably increased use of combined heat and power as well as shifting to cleaner energy sources (natural gas and renewables).

The 1990 Transport Action Plan

The Transport Action Plan, adopted by the Government in May 1990, aimed to stabilize CO_2 emissions from the transport sector by 2005, and to achieve a 25% reduction by 2030 as compared to 1988 levels.

The combined effects of the two action plans were foreseen to be a more than 20% reduction of CO_2 emissions in 2005, as compared to the base year of the two plans (1988). This target was subsequently approved by Parliament.

Apart from this national CO_2 reduction target, Denmark has committed itself to stabilizing emissions of greenhouse gases at the 1990 level by 2000 within the framework of the Climate Convention. Moreover, as a contribution to the overall stabilization of CO_2 emissions from EU countries by the year 2000, Denmark is also committed to achieving a 5 % reduction by 2000 as compared to the 1990 level.

In 1993, a major follow-up of the two action plans was undertaken (*Follow-up on Energy 2000* and *Transport 2005*) in order to secure achievement of the above targets.

In 1995, a discussion paper, Denmark's Energy Futures, containing technical analyses of future scenarios for energy consumption and supply in Denmark, was published. At the same time, the Government presented a general Nature and Environment Policy giving an overview of the Danish efforts for protection of the environment. This was based on the principles of sustainable development and ecological space.

The recent energy action plan, *Energy 21*, approved by the Danish Parliament in April 1996, deals with international market conditions and long-term environmental aspects, as the overall challenges to the energy sector. The major environmental challenge is to achieve convergence of emissions of industrialised countries to a level that would be globally sustainable. Without such a convergence the prospects for expecting the rest of the world to respect the limits of global environmental space will be very meagre.

In connection with the approval of the action plan, the Government decided to work for an international agreement on a 50% reduction of CO_2 emissions from industrialised countries by 2030, compared with 1990 levels. *Energy 21* consequently aims at fulfilling this goal. Such an agreement could be consistent with a global scenario that achieves stabilisation of CO_2 concentration at 450 ppmv.

In 1997, the Government banned new or renovated power capacity based on coal. Power generated by coal will consequently be phased out as coal based plants wear out. This decision confirms the determination to meet reduction targets in the shorter term and the long term aim of achieving a sustainable energy supply.

1.4 Projections and assessment of measures

Energy

As part of the energy action plan, *Energy 21*, future Danish energy consumption and CO_2 emissions related to this consumption have been assessed for the period 1995 – 2030.

The development in energy consumption and CO_2 emissions described in this section is based on *Energy 21* although the projections for 1995 have been replaced by actual figures.

The short term goal of *Energy 21* is to reach the Danish Government's target of reducing CO_2 emissions from the energy-consuming sectors by 20% in 2005 as compared to the 1988 level. A number of initiatives aiming at reaching this goal have therefore been implemented in the Danish energy policy.

The assessment of the development for the period 2005 – 2030 is based on more general considerations, among others conservation of heat and electricity, use of energy efficient appliances and processes and use of renewable energy.

It is assumed that international common efforts during this period will contribute substantially to reducing Danish CO_2 emissions.

On the basis of key variables and assumed future developments, projections have been made of the total primary energy consumption for the period 1996 to 2030.

The expected CO_2 emissions related to the energy consumption are shown in Fig. 1.1 which also shows the expected CO_2 emissions for a "Business-as-Usual" scenario, updated from the *Energy 2000 Plan* drawn up in 1990. This scenario illustrates how CO_2 emissions would have developed from 1990 if no steps had been taken in order to reduce the emissions. Emissions from international transport are not included in Fig. 1.1.

The values for the period 1990 to 1995 are historical data corrected for variations in space heating demand and electricity exchange due to climatic variations. For comparison, uncorrected values for this period are shown as well.

The long-term development in the period to 2030 is expected to result in gradually increasing electricity export from Denmark. This export is not due to climatic variations, but arises from the technical lay-out of the power production system, with increasing shares of cogeneration and wind energy. Since this export is not caused by climatic conditions, the projected CO_2 emissions are not corrected for this export.

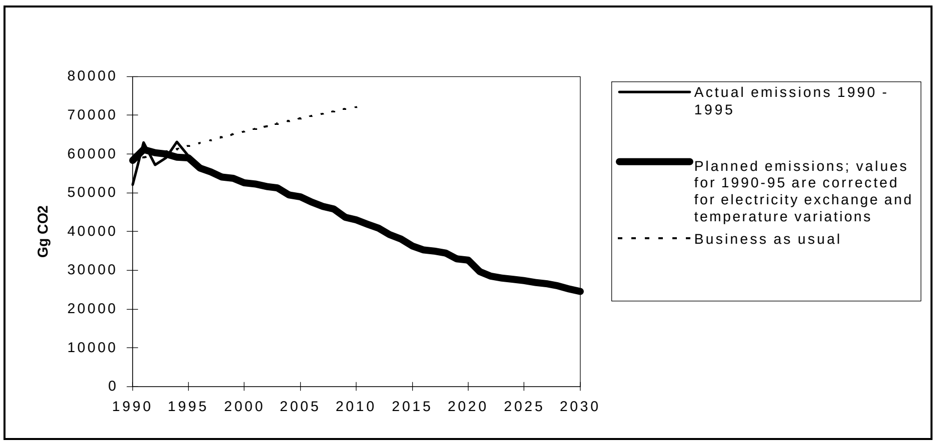


Fig. 1.1. *Planned development of CO_2 emissions from fuel combustion.*

The national target of reducing CO_2 emissions from fuel combustion by 20% from 1988 to 2005 will be fulfilled by implementing the *Energy 21* Action Plan, as the emissions covered by the target are projected to decrease slightly more. The targeted emissions include emissions from international air transport, while flaring is excluded. The target for 2005 as well as the base level of 1988 are defined in terms of emissions corrected for both electricity exchange and outdoor temperature variation.

As a contribution to the overall stabilisation of CO_2 emissions by the year 2000 for the EU countries, Denmark has committed itself to achieve a 5% reduction in 2000 compared with 1990.

The Danish CO_2 emissions are planned to decline from 59,958 Gg in 1990 (corrected for electricity exchange and outside temperature variation) to 54,309 Gg in 2000. This corresponds to a decrease of 9.4%, and the 5% target is therefore expected to be fulfilled. The CO_2 benefit of increasing the forest area has not been taken into account in these figures.

Transport

For the transport sector, the Government has prepared a transport action plan, the objectives of which are to stabilise the sector's CO_2 emissions at the 1988 level by 2005, and to reduce emissions by 25% before 2030. Use of energy efficient cars is one of the major contributors to the emission reduction within the transport sector, and development of such cars, internationally, is therefore of major importance.

The main aim of sustainable transport policy is to promote an efficient transport system to the benefit of the general public and industry, to ensure that the damaging effects of traffic, e.g. pollution and accidents, can be reduced to a minimum in accordance with specified objectives.

The target for CO_2 emissions in the transport sector should be seen in relation to the considerable importance attached to helping to solve local environmental problems, which to some extent entails measures which can actually increase CO_2 emissions, e.g. replacing diesel by petrol.

Waste

The main objectives in the field of waste and recycling are to reduce the quantity of waste arisings, to minimize the environmental impact of waste disposal, and to make use of the resources contained in waste.

Today total waste arisings amount to about 10 million tonnes per annum. The objective is that about 50% of the total amount of wastes generated in the year 2000 should be recycled. The remainder should primarily be incinerated, and landfilling should be minimized. One of the expected effects of the Plan is reducted CH_4 emissions from landfilling.

The aim is to incinerate all combustible wastes which are not to be recycled, and which do not present particular incineration problems. By incineration, the energy content in the waste will be used to replace fossil fuels.

In connection with incineration, the energy content of non-recyclable wastes should be used effectively like other biofuels, since most of the waste is CO_2-neutral and therefore causes lower CO_2 emissions than burning of fossil fuels.

Agriculture

In the projections, the expected reduction in CH_4 emissions gained from cows/cattle is largely offset by the increase in CH_4 emissions from pigs, and as regard N_2O, Danish initiatives to substantially reduce the use of particularly commercial fertiliser before 2000 are expected to reduce N_2O emissions from the agricultural sector.

A summary of the projections for CO_2, CH_4 and N_2O emissions is shown in Table 1.2.

	1990	2000	2005	2010	2020	2030
CO_2	59,958	54,309	50,547	44,660	34,158	26,090
CH_4	424	408	377	362	n.a.	n.a.
N_2O	34	28	28	28	n.a.	n.a.

Table 1.2. *Projections of Danish CO_2, CH_4 and N_2O emissions 2000 – 30 in Gg compared to emissions in 1990.*

1.5 Expected impacts of climate change and vulnerability assessment

Climate change in Denmark

According to the latest findings of the IPCC based on the "business as usual" emission scenario (IS92a) the global mean surface temperature is projected to increase by 2 °C by 2100, and sea level will rise 50 cm. For Denmark the annual mean temperature is projected to increase by almost 2 °C by 2050. Precipitation will increase in winter and decrease in summer. A sea level rise of 9 – 18 cm is projected, with the largest rise in the southern part of the country.

By the end of next century, the annual mean temperature in Denmark is projected to be 2.8 °C warmer than today. In contrast to earlier estimates, the annual mean precipitation is projected to decrease slightly. Sea level is projected to rise 33 – 46 cm.

With respect to agriculture, forestry and coastal protection, however, it can be assumed that the changes will be so modest that they will be manageable through planned adjustment supported by an expected technological development.

A possible exception is the present natural ecosystem, where climate change may be too rapid for some animal and plant species; this may cause temporary instability and in the long run change species composition.

Climate change in Greenland

Climate change in Greenland is predicted to cause an increase in the mean yearly temperature of between 1.8 – 3.6°C by the end of the next century.
The ice cap will respond to warming through increased melt rates at the margins and accumulation rates in the interior. Melt rates will probably dominate. However, precipitation and melt rate predictions are not as reliable as temperature predictions.

Precipitation is predicted to increase by 2 – 24 mm per month, with most of the increase in the summer on the south and west coast but in the winter or all year round on the east coast and at high latitudes. Half the change will occur within the next 40 – 50 years. Other consequences of climate change include: lengthening of the snow-free season by a month or more, a slight increase in the length of the growing season by 1 – 2 weeks, deepening of the soil active layer, and a shorter northward movement of the permafrost boundary.

There is considerable uncertainty regarding predictions for Southern Greenland, which has experienced a cooling of 1 – 1.6°C in the past 60 years. Ocean models predict a cold centre southwest of Greenland. The cooling effect around this centre will counteract and may even neutralise greenhouse warming in Southeast Greenland. This cooling may be related to the 80% reduction in deep water formation observed in the Greenland Sea during the 1980's. Hence, less warm Atlantic water is streaming north. The maximum temperature increase in South Greenland may therefore represent a return to the mean summer temperatures of 60 years ago, and the possibility of a temperature fall must be considered.

Near-future changes (10 – 20 years) in Greenland ecosystems are expected to be modest, particularly in the south, but later a number of different changes may occur.

Climate change in the Faroe Islands

In case of the Faroe Islands it is expected that the temperature increase, if any, will not exceed 1 – 2°C and that the changes in terrestrial ecosystems will be almost undetectable. At sea, temperature may further decrease and cause negative changes in edible fish stocks.

1.6 Adaptation measures

Since it is estimated that the direct effects of climate change in Denmark will be modest and in some cases provide a potential advantage, no adaptative measures have yet been taken. However, different possibilities have been investigated and discussed in national reports. For example a sea level rise of the order of 50 cm, which would augment present coastal retreat, could be be counteracted by coast nourishment. It should be noted that these considerations do not take into account “surprise changes in the global greenhouse”, for example a change in the Gulf Stream.

1.7 Financial assistance and technology transfer

As a consequence of the increasingly global nature of environmental problems, Denmark has intensified action at the international level in recent years in order to meet global challenges.

The climate problem is to be seen in the context of a broader global challenge. The populations’ use of the earth's store of natural resources is still increasing. Curbing these trends will require a coordinated international strategy.

The awareness of this global challenge and the transboundary nature of the environment problems were reflected in the Danish Government's 1988 Plan of Action for Environment and Development in Denmark’s development assistance. As a consequence, a number of environmental sector strategies have been developed covering fisheries, energy, agriculture, forestry, agroforestry, water, health and industry.

The United Nations target of 0.7% of GDP in Overseas Development Aid (ODA) has long been fulfilled by Denmark, and the Danish Government has maintained ODA at 1% of GDP since 1992.

DANIDA and DANCED

Efforts to incorporate environmental objectives into the development assistance administered by DANIDA – the Danish International Development Assistance – were further strengthened during preparation for and follow-up on the 1992 United Nations Conference on Environment and Development in Rio de Janeiro (UNCED). Guidelines have been issued for environmental impact assessment of projects in all sectors. Following a parliamentary resolution in 1992, the Danish Environment and Disaster Relief Facility (EDRF) was established as an additional budgetary allocation to supplement Danish development assistance. This allocation will increase gradually to 0.5% of GDP by 2002. Half of the EDRF is allocated evenly between environmental assistance to Central and Eastern Europe and to developing countries, the assistance to the latter being administered jointly by DANIDA and DANCED – the Danish Cooperation for Environment and Development.

Cooperation with small island developing states

The Danish Government is in the process of strengthening cooperation with small island developing states. Danish NGOs are also involved in this process.

Eastern Europe

The Danish Environmental Support Fund for Eastern Europe (DESF) was established by the Danish Government in April 1991. In 1993, the Fund was incorporated into the new Danish programme for Global Support for the Environment and Disaster Areas, which was initiated after the Rio Conference held in 1992. The DESF is administered by the Danish Environmental Protection Agency. In terms of contribution per habitant, the Danish bilateral environmental support to the Central and East European Countries (CEEC) is significant. The total Danish assistance to Eastern Europe is estimated to have lead to CO_2 emission reductions of more than 1,000 Gg per year.

1.8 Research and systematic observation

Resarch & Development

Denmark contributes actively to international climate research programmes including the World Climate Programme.

A main area at the Danish Meteorological Institute (DMI) is numerical models of the atmosphere. Efforts are directed towards harmonization of the models for weather and climate calculations in order to achieve a uniform model for all problems with a view to enhancing exploitation of new research results.

The work on climate models includes studies on the impact of selected physical processes on the climate and studies on the extra-tropical northern hemisphere climate variability. Another important project is the development of a regional model using a high-resolution model coupled with the global climate model to enable assessment of regional climate changes caused by an increased greenhouse effect.

The Danish EPA together with Risø National Laboratory and the National Environmental Research Institute carried out a project on the socio-economic costs of reducing greenhouse gas emissions in Denmark in 1996.

The project identifies a range of “no-regret” and “low-regret” options to reduce greenhouse gas emissions in different sectors. Implementation of these measures will make it possible to substantially reduce greenhouse gas emissions.

Danish research and development work on reduction technologies for greenhouse gases is mainly related to the energy sector.

The total costs of Danish energy research and development amount to USD 86 – 100 million per year. The greater share of this is used on technologies for increasing efficiency in energy conversion, improving energy efficiency in end use, and developing technologies using fuels which produce less greenhouse gases – particularly technologies using renewable energy. Areas where Denmark has a strong international position include exploitation of wind energy and biomass, energy efficient utilisation of fossil fuels and combined heat and power technologies. Most of the projects are carried out in collaboration between industry and research centres – often with strong international links.

1.9 Education, training and public awareness

Education, training and public awareness

Since the late 1980’s the Danish Ministry of Environment has supported the growing interest among the public in climate change through publications ranging from very detailed descriptions of the climate change issue to more general brochures. Some of the information is also available on electronic media.

The 1992 United Nations Conference on Environment and Development in Rio de Janeiro emphasized the need for the public to be involved in the implementation of sustainable development. Interpreting this as a need for public participation and transparency, the Danish Government has continuously offered NGOs seats in the Danish delegation in the context of inter alia the Framework Convention on Climate Change.

Danish NGOs dealing with environment and development are organised in a network called the 92 Group comprising the 18 major organisations dealing with these issues in Denmark.

2 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. According to the Convention text, the Convention enters into force on the ninetieth day efter the date of deposit of the fiftieth instrument of ratification, which happened on 21 December 1993. Denmark deposited her instrument on the same date. Accordingly, the Convention entered into force on 21 March 1994.

According to decisions taken under article 12 of the Convention each developed country Party shall communicate to the Convention secretariat its second national report presenting inter-alia inventories of emissions by sources and removals by sinks of all greenhouse related gases; a general description of steps taken or envisaged by the Parties to implement the Convention, and other information that the Parties consider relevant to the achievement of the objective of the Convention.

Further, under the Convention the developed countries shall in their communications incorporate detailed descriptions of measures adopted to implement commitments under article 4, paragraph 2(a) and (b), and an estimate of the effects of such measures on anthropogenic emissions.

This report presents the Danish programmes and measures taken to observe the commitments under the Climate Convention. The Danish Government acknowledges the 1995 Guidelines for Communication of Information Under the Framework Convention on Climate Change prepared by the OECD/IEA and approved by the COP 2 in July 1996. Further, the Revised 1996 IPCC guidelines have been applied to N_2O from agriculture and the pollutants not earlier included (SO_2, HFCs, CFCs and SF_6). Background material and data underlying the calculations in the report are available upon request to the Danish Environmental Protection Agency.

In preparing the report, it has been the intention to the extent possible to incorporate in the estimates, e.g. on the impacts of climate changes, relevant material that has been analyzed and assessed in other contexts. As regards material from the North Atlantic parts of the Kingdom of Denmark, i.e. the Faroe Islands and Greenland, only information about population, climate and vulnerability to climate change has been available. It was decided to issue the report without further information on the North Atlantic areas.

Chapter 3 of the report contains a large number of reference data on Denmark, i.a. on geography, population, coasts, climate, and the consumption of primary energy, both for energy and for transport purposes.

Chapter 4 presents an inventory of emissions of greenhouse gases, and describes the scope for restricting emissions and increasing sinks within the forest and agricultural sectors.

Chapter 5 and 6 give an account of the action plans which have been drawn up for the energy, transport and waste sectors, and which will contribute significantly to restricting emissions of greenhouse gases. Chapter 6 contains the projections and assessment of the measures described in Chapter 5. A very comprehensive and thorough description is given of the programmes and plans for the energy sector with additional information presented in Annexes F and I. The twofold purpose is to give a detailed documentation of how Denmark will meet the ambitious target to reduce the emission of CO_2 by 20% by the year 2005 compared to 1988 and to inspire other Parties to the Convention in efforts to control their present as well as their future emissions of the most important greenhouse gases.

Chapter 7 gives an account of the impact of expected climate changes in Denmark, Greenland and Faroe Islands, and the scenarios available for adaptation to the climate changes.

In Chapter 8 is stated that so far no adaptation measures have been taken.

Chapter 9 deals with international cooperation in the field of financial assistance and technology transfer.

Chapter 10 describes the Danish research activities carried out in support of climate research, both at national and at international level, as well as socio-economic assesment of climate change mitigation and technological research and development.

Finally, Chapter 11 deals with aspects of education, training and public awareness.

The following institutions have made contributions to the national report: the Danish Coastal Authority, the Danish Energy Agency, the Danish Meteorological Institute, the Ministry of Food, Agriculture and Fisheries, the Ministry of Foreign Affairs, the Ministry of Transport, the National Environmental Research Institute, the National Forest and Nature Agency, the Statistics Denmark, the Risø National Laboratory, the WWF-Denmark and the Forum for Energy and Development.

3 National circumstances

The Kingdom of Denmark comprises Denmark, Greenland and the Faroe Islands. The Danish government has ratified the UN Framework Convention on Climate Change on behalf of all three parts og the realm. Unless otherwise indicated, the tables, figures, policies and measures etc. presented in this report only relate to Denmark, though.

3.1 National circumstances for Denmark

3.1.1 Population and total area

The population of Denmark amounts to nearly 5.2 million inhabitants and the total area to 43,000 km^2.

Low population increase

In the 1970s and the 1980s the annual population increase was very low, averaging 0.39% and 0.03% respectively.

Year	1970	1975	1980	1985	1990	1993	1995
Population in million.	4.9	5.1	5.1	5.1	5.1	5.2	5.2

Table 3.1. *Population 1970 – 95.*

Projections

The latest projections, based on the population for 1 January 1995, indicate very small annual increases until 2008 and thereafter very small decreases.

Ageing population

Like other developed countries, Denmark has an ageing population. The number of women of 67 years and older is considerably higher than the number of men in the same age group due to the greater life expectancy of Danish women.

Some 85% of the population inhabits urban areas, i.e. towns of 200 or more inhabitants. The population of the Copenhagen metropolitan area amounts to 26% corresponding to 1.3 million.

3.1.2 Geography and land use

Land use

Of the total Danish area, 64% is agricultural land, 10% is forest and 10% is natural areas such as moors, marsh, bogs, lakes and streams. The Danish lakes comprise less than 1% of the total area and the largest lake is 39 km^2. The total length of watercourses is 40,000 km and the longest watercourse stream is 158 km. The built-up areas (urban areas, summer residence areas, traffic infrastructure etc.) occupy about 15%. 4.3% of the total land area is preserved and 10% of the metropolitan region.

The coastline

The Danish coastline stretches for 7,330 km. The coast is mainly made of “soft” materials deposited during the last ice age and are therefore easily formed by waves and currents. The coastline is consequently subject to erosion and at various locations protected by constructions such as groynes and/or revetments.

Approx. 500 km of the coastline is protected by dykes. Some of the dykes protect human settlement areas and some merely flood-endangered green areas such as farmland or areas of recreational value. The dykes along the Wadden Sea coast in southwest Jutland protect the rich farmlands of the marshes and the marshland settlements from the frequently occurring storm floods. In other parts of the country, mainly on the island part of Denmark, dykes protect areas reclaimed by embankment and drainage and which are partly located below sealevel.

Dykes, breakwaters and revetments are designed to withstand the normal range of storm tides. In the most exposed areas, the fortifications are designed for a sea level statistically occurring once in 200 years while in less exposed areas they are designed for a once in 50 years situation. A rise in sea level caused by climate change will therefore diminish the capability of these constructions to withstand the sea during storm tides.

Agriculture

During the last 30 years, the agricultural area has diminished from 72% (30,900 km^2) of the total area in 1960 to 63% (27,300 km^2) in 1992. The crop patterns for the last 25 years are given in Table 3.2.

	1970	1980	1985	1990	1992	1995
Cereals	59	62	56	56	59	53
Pulses and seeds for industrial use	2	4	12	14	11	8
Root crops	10	8	8	8	7	6
Grass and green fodder in rotations	17	14	13	12	13	15
Permanent grassland	10	9	8	8	8	15
Other crops incl. fallow	2	3	3	2	2	3

Table 3.2. *Distribution of agricultural area by crop type, in percent of total cultivated land.*

Declining areas with grass

The proportion of agricultural land with grass and green fodder in rotation as well as with permanent grass has declined considerably since the 1950s.

The consumption of nitrogen has grown considerably during the last 30 years, especially during the first part of the period, and is now 3¼ times greater than in 1960. However, the consumption of nitrogen in commercial fertiliser decreased by 25% from 1990 to 1996. The growth in consumption of nitrogen is due to a change in agricultural practice which has resulted in higher crop production. The consumption of phosphorus has declined since l970, as has the consumption of potassium. During the last three years, the use of fertiliser has fallen, as mentioned in Chapter 4.

Livestock

The number of cattle declined by more than 25% from 1970 to 1995, whereas the number of pigs has grown by 1/3 in the same period. The number of poultry declined until 1985, but has now grown to nearly the same level as in 1970.

Forest areas

As mentioned above, l0% or 4,170 km^2 of Denmark's total area is forest (1990), of which 1/3 consists of broadleaf and 2/3 of conifers. In the eastern part of the country broadleaf is predominant (61% of the wooded area), while in the western part, Jutland, conifers dominate(77%). During the last 70 years the forest area in Denmark has increased by 30%, exclusively with conifers. 350 km^2 is considered to be natural forest by origin.

3.1.3 **Climate**

The Danish climate is mildly temperate with precipitation falling throughout the year.

Temperature

Winters are prevailingly mild and summers cool. The annual mean temperature is 7.7 °C, ranging from 7 °C to 9 °C. January mean temperatures range from -1 °C to +2 °C and July mean temperatures from 15 °C to 17 °C.

The number of heating degree days for the country as a whole is 3175 (base: 17 °C), ranging from 2975 to 3375 over the country.

On the whole, annual average temperature decreased slightly (0.1°C) from the period 1931 – 60 to the period 1961 – 90. In particular, it has become colder in the summer months of July and August, but also in early winter in December. It has become somewhat warmer in the last part of the winter in February and March, and also in October.

Precipitation

The annual precipitation in Denmark is 712 mm, ranging from 500 to 900 mm over the country. November has the largest amount of precipitation with 80 mm, while February is the driest month with less than 40 mm.

For the year as a whole, the precipitation has increased more than 5% from the period 1931 – 60 to the period 1961 – 90. In particular, the increase has taken place in the spring and early winter, while the precipitation has reduced in the summer months proper.

Hours of sunshine

The normal hours of bright sunshine is 1,670 for the whole year. The number of clear days (cloud cover less than 20%) is 31, and the mean cloud cover is 67%.

The number of hours with sunshine has decreased by approx. 5% from the period 1931 – 60 to the period 1961 – 90. In absolute terms as well as in percentage, the decrease is most pronounced in spring and early summer, June – July, and in September. November and December received more than 25% more sunshine than before, however.

Wind

The normal annual mean wind velocity is 6.6 m per sec, and the winds are normally from westerly directions.

The frequency of hurricane force storms (only related to mean wind speed exceeding 25 m per sec) covering more than 40% of the country over a hundred year period is on average one in every four years.

3.1.4 **Gross Domestic Product**

High per capita income

The Danish Gross Domestic Product amounted to USD 172,741 million (in 1995 current market prices), corresponding to a per capita income of USD 33,042, giving Denmark one of the highest per capita incomes in the world (USD 1 corresponds to DKK 5.61 in 1995).

Agriculture, forestry and fishery accounts for 3.8% of the total GDP, manufacturing 20.1% and services, including Government services, 69.4%.

	DKK, million	USD, million	%
Food, beverages, tobacco	31,604	5,634	3.8
Chemical and petroleum industries	23,056	4,110	2.8
Fabricated metal products	60,761	10,831	7.3
Other manufacturing industries	51,404	9,163	6.2
Manufacturing, total	166,825	29,737	20.1
Agriculture, forestry, fishery	34,688	6,183	4.2
Market services	391,792	69,838	47.2
Government services	183,831	32,768	22.2
Other activities	52,458	9,351	6.3
Gross Domestic Product, total	829,594	147,878	100.0

Table 3.3. *Gross Domestic Product at factor cost, apportioned by origin, 1995.*

The development since 1970 has been an increase in total GDP (1980 prices) of 68% whereas agriculture has increased by 111%, manufacturing by 60% and services by 75%.

	1970	1975	1980	1985	1990	1995
Agriculture, forestry, fishery	100	123	138	177	192	211
Manufacturing	100	118	133	152	148	160
Services	100	116	135	153	170	175
Total	100	112	130	147	162	168

Table 3.4. *Gross Domestic Product at factor cost, apportioned by industrial origin. 1980 prices. Index 1970 = 100.*

Employment

In 1994 the total active population was 2,471,000, of which 121,000 were employed in agriculture, forestry and fishery, 477,000 in manufacturing and 1,693,000 in services.

	1970	1975	1980	1985	1990	1994
Agriculture,	260	224	192	175	141	121
Manufacture	570	504	490	524	517	477
Services	1218	1401	1553	1646	1720	1693
Other activities	237	208	206	187	187	180
Total	2284	2337	2442	2532	2564	2471

Table 3.5. *Distribution of employment by industrial origin, unit 1,000 persons.*

3.2 Energy

3.2.1 Available energy resources, kind and level

Oil and natural gas

Denmark's main indigenous resources of energy, apart from renewables, are the North Sea oil and natural gas fields.

The assessment of reserves shown in Fig. 3.1 refers to the amount of oil and gas that can be recovered by means of known technology under the prevailing economic conditions. This assessment only includes reserves in structures where the presence of hydrocarbons has been conclusively established through drilling and testing.

Oil production in 1996 amounted to 12 million m^3 which represents a 10% increase compared to 1995. Gas production increased 21% in 1996 to a level of approx. 6,100 million Nm^3.

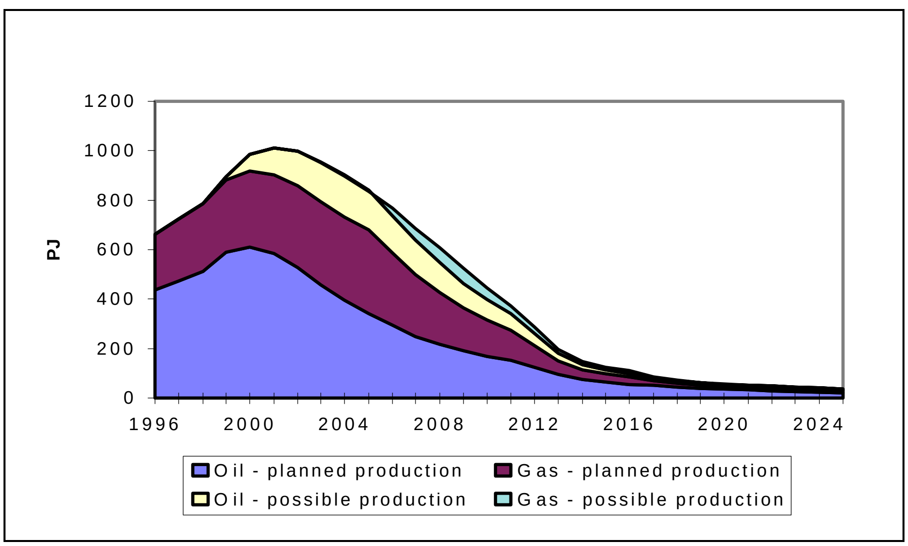


Fig. 3.1. *Prognosis for oil and gas production from the Danish North Sea fields with the actual production in 1996.*

The combined reserves presently corresponds to 15 times the current domestic primary energy demand, 25 times the current domestic oil and gas demand and about 1.3 ‰ of the world's total reserves of oil and gas (not including nonconventional reserves in oil sand, tar sand etc.).

About one third of the gas presently extracted is exported, mainly to Sweden and Germany.

According to the latest short-term prognosis, oil and gas production will continue to increase in the near-term, but will decline after the turn of the century if no new fields are discovered.

The growth of oil and gas production combined with the decrease in oil demand, has made Denmark a net exporter of both oil and gas since 1993.

Renewables

With the present known reserves of oil and natural gas, energy from renewable sources will be Denmark's main energy resource in a 15 – 20 year time span. Estimates indicate a potential of approx. 540 PJ per year (Denmarks Energy Futures, Ministry of Environment and Energy 1996).

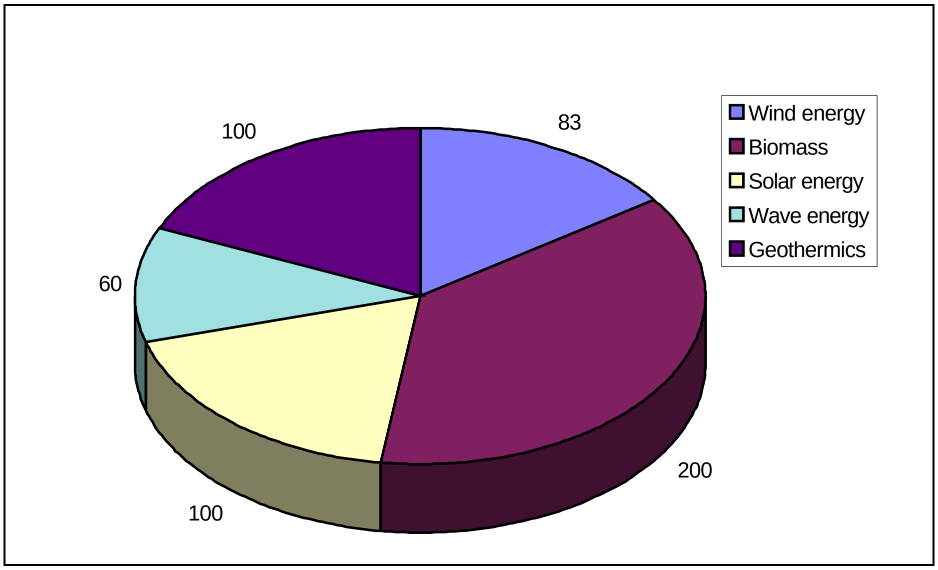


Fig. 3.2. *Potential energy resources from renewables in Denmark.Unit: PJ per year.*

Renewable energy resources are shown apportioned by source in Fig. 3.2. By far the main resource is biomass, including energy crops and residual products of agriculture, forestry, industry and households. Accounting for 57 PJ per year, biomass is also the main renewable resource utilized at present.

The potential for wind energy comprises both terrestrial and off-shore wind turbines. Although present exploitation of the vast potential for offshore wind turbines is still limited, technical obstacles for their exploitation have largely been overcome. The Danish Energy Agency has already received formal applications for approx. 4000 MW wind power capacity sited offshore, which installed would cover more than one third of present electricity consumption.

The three remaining resources – geothermal, solar and wave energy – are presently the least exploited resources. Danish energy policy aims at stimulating the technological and economical preconditions for further exploitation of these resources, however.

3.2.2 **Energy supply and consumption**

The general picture

Primary energy consumption increased rapidly in the 1960s, but essentially stabilised at a level of 800 PJ (values excluding international bunkers corrected for electricity exchange and outside temperature variations) from 1972 to 1995 as a result of the two oil crises and implementation of rigorous energy policy instruments during the last 20 years (Fig. 3.3).

There are several structural changes to note in relation to the past 20 years development.

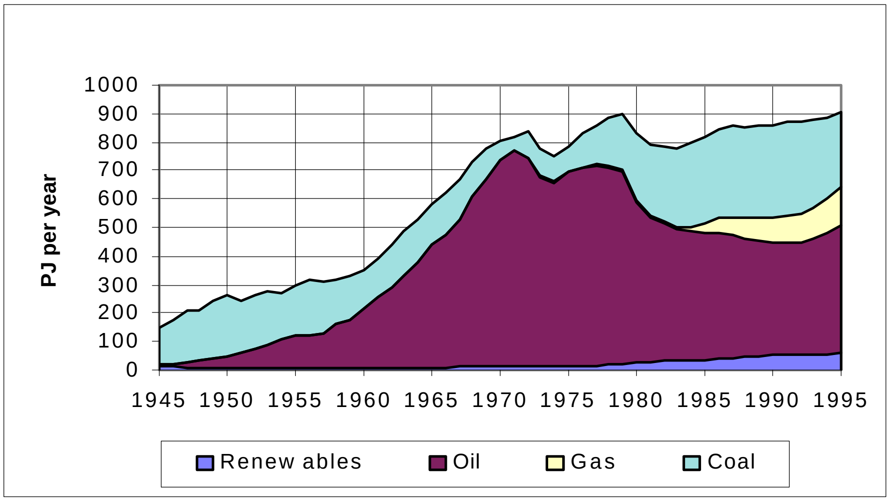


Fig. 3.3. *Total primary energy consumption including international bunkers.*

Note: Not corrected for electricity exchange and inter-annual variations in outside temperature.

Coal substituted for oil

As a result of the oil crises, oil was substituted by coal at the power and heat plants.

All coal used in Denmark is imported, and 94% is used in power plants. The import of roughly 13 million tonnes coal constitutes a relatively large share of internationally traded steam coal, as most coal in the world is used in the producing countries. Due to excellent harbour facilities coal can be imported on very large bulk carriers (150,000 tonnes) directly to the major plant sites. The sources change from year to year, but major sources have been the United States, Columbia and Australia, with other supplies coming from the UK, Poland, the former USSR, Canada and South Africa.

The decline in the use of oil is also due to changes in the supply system and consumption pattern in all sectors.

Natural gas

The introduction of natural gas from domestic sources around the mid 1980s has resulted in a significant increase in the use of natural gas. In 1995, almost 16% of primary energy consumption derived from natural gas.

Natural gas is utilised in individual heating as well as in the heat and power sector.

Renewable energy

Renewable energy sources account for an increasing share of the total primary energy supply and consumption, amounting to about 8% in 1995.

Since the mid 1980s biogas and wind energy have evolved substantially. Municipal waste, forest and wood residuals and surplus straw still account for 85% of the total renewable energy supply, however.

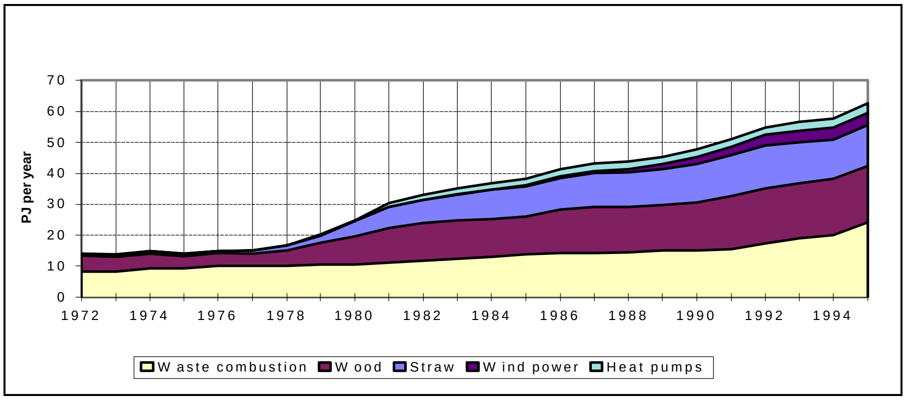


Fig. 3.4. *Contribution of renewable energy sources in primary energy consumption.*

Wind energy accounts for presently about 4% of final domestic electricity consumption (Fig. 3.5).

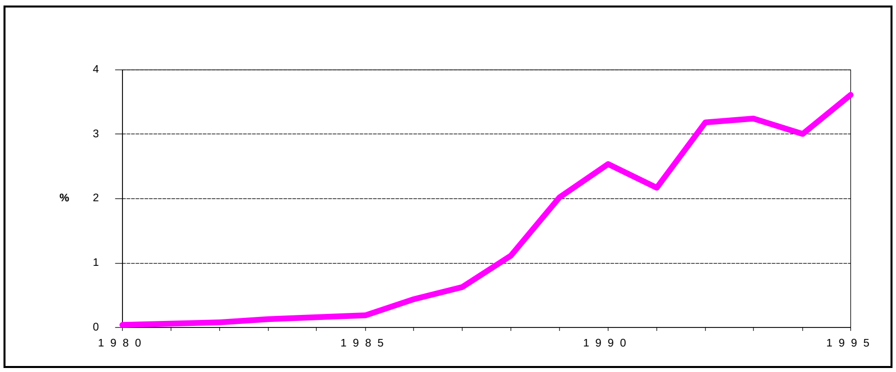


Fig. 3.5. *Contribution of wind energy to net electricity production.*

Electricity and heat sector

District heating has a long tradition in Denmark. Following the oil crises, many district heating plants as well as power plants converted to coal. The flexibility of district heating has subsequently been used to make an almost complete switch away from coal to renewables and especially natural gas, except for the large cities supplied by large co-generated heat and power plants which are still coal fired. Present plans, however, foresee a gradual change to natural gas and renewables also at these plants, in step with replacement of capacity.

Since the mid 1980s focus has increased on the environmental and efficiency gains of co-production of heat and power. The development of the power sector and especially the heat sector is also closely tied to the priority accorded natural gas and renewables in the Danish energy policy.

District heat production currently accounts for close on 50% of energy demand for space heating compared with 30% in 1972. 70% of the district heating production is now based on combined heat and power plants.

When electricity is produced at a typical condensing power plant, only 35 – 40% of the fuel input is utilized, while the remaining energy input is turned into waste heat. By augmenting the fuel input slightly, it is possible to produce district heat instead of waste heat. Typically, more than 2 GJ of district heat can be produced each time the fuel input is augmented by 1 GJ. Thus, the “marginal efficiency” of producing district heat instead of waste heat is more than 200%.

The improvement in the total thermal efficiency of Danish power plants due to the supply of district heating instead of producing waste heat to the environment is illustrated in Fig 3.6.

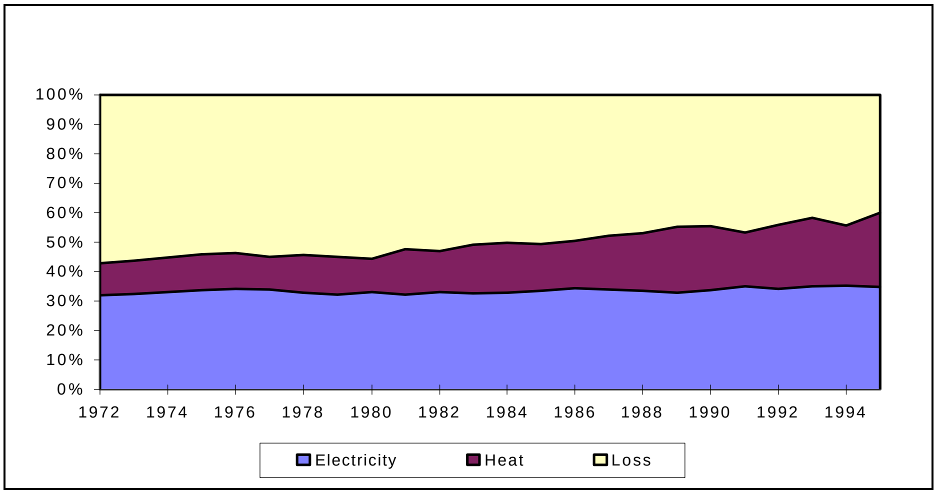


Fig. 3.6. *Efficiency at Central Power Plants as output in percent of fuel used.*

End-use efficiency

Efficiency gains in end-use and conversion systems, have played an important role in stabilising primary energy consumption.

As an example, Fig. 3.7 shows that final energy for heating (energy supplied to the buildings for heating purpose) per square meter of building area has more than halved from 1972 to 1995. Strict standards for new buildings and extensive insulation improvements in the existing stock of buildings as well as the increased use of district heating are the main explanations for this marked improvement.

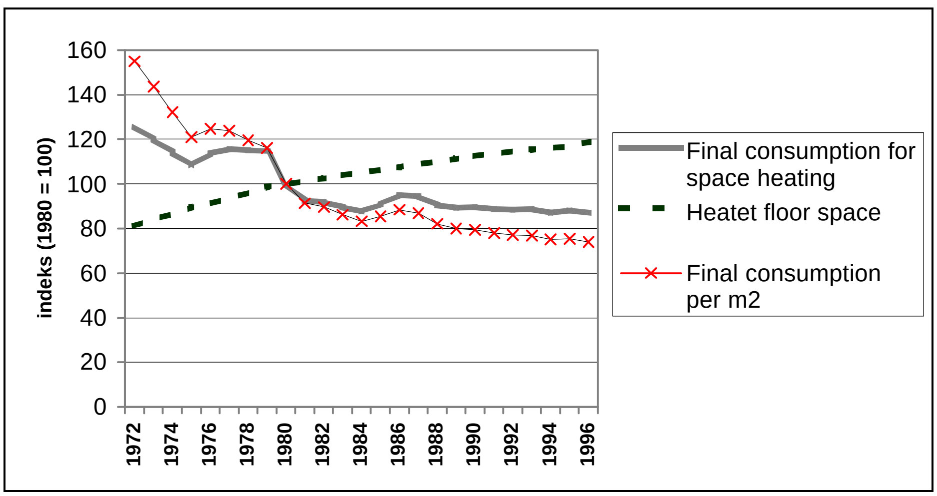


Fig. 3.7. *Final energy consumption for space heating, climate adjusted, 1972 – 95.*

Final energy consumption

Denmark has a relatively mild marine climate, an extensive public service sector and an industrial system dominated by light industries and manufacturing of food products. This combines to give a spectrum of final energy consumption that compared with other industrialised countries is characterized by a relatively large share going to space heating and services, and a relatively small share going to industry.

Final energy consumption shows the same pattern of stabilisation since 1972 as primary energy consumption, remaining at a level of approx. 600 PJ per year.

The development in final energy consumption apportioned by energy type is shown in Fig. 3.8. The shift away from oil in primary energy recurs in final energy consumption. Besides natural gas and renewable energy, final energy consumption has shifted towards the secondary energy types, electricity and district heating. The percentage accounted for by electricity more than doubled to 26% in 1995. In recent years, however, electricity consumption has shown signs of decreasing growth.

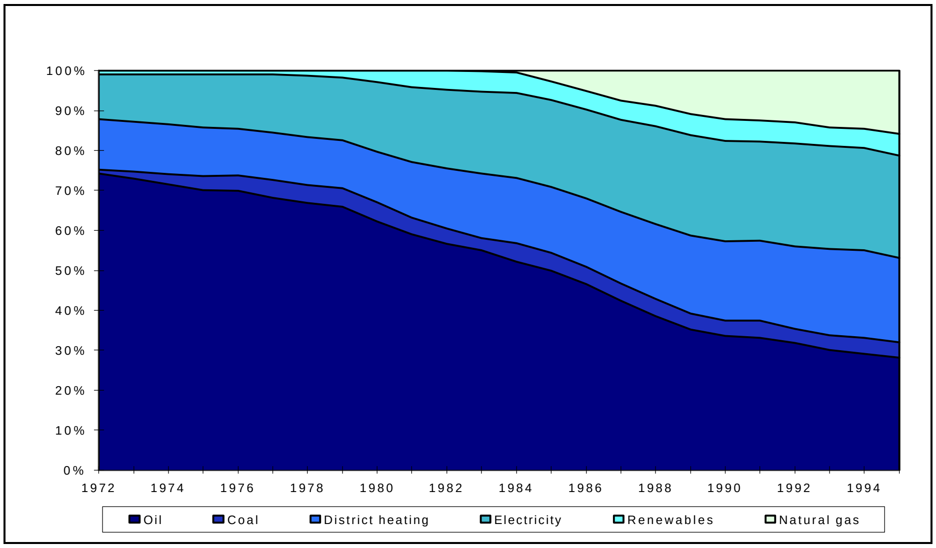


Fig. 3.8. *Final energy consumption apportioned by energy type.*

Note: Oil products related to transportation and non-energy use are not included.

The practically constant final energy consumption conceals interesting shifts in the sectoral composition as illustrated in Fig. 3.9.

Overall, the sectoral composition of final energy consumption shows a decrease in the residential sector and an equivalent increase in the transport sector.

The above mentioned improvements in energy consumption for heating purposes are reflected in Fig. 3.9. Besides the residential sector, heating purposes account for a large share of total energy consumption in the institutional and commercial sectors. However, increased energy consumption of primarily electricity in these two sectors has – in contrast to the residential sector – neutralised the improvements in heating.

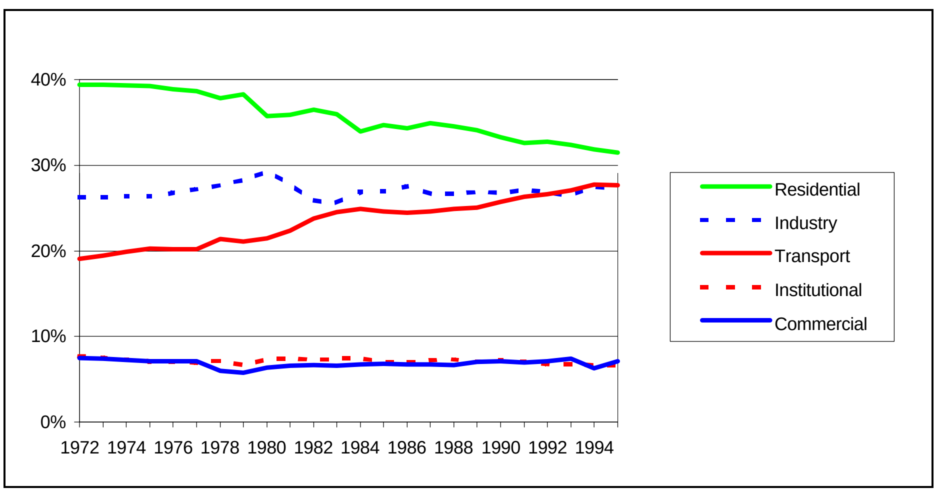


Fig. 3.9. *Final energy consumption apportioned by sector.*

3.2.3 Energy intensity and average CO_2 content

Energy intensity

As shown in Fig. 3.10, primary energy consumption per capita stabilised during the period, and energy intensity (primary energy consumption per GDP) markedly decreased.

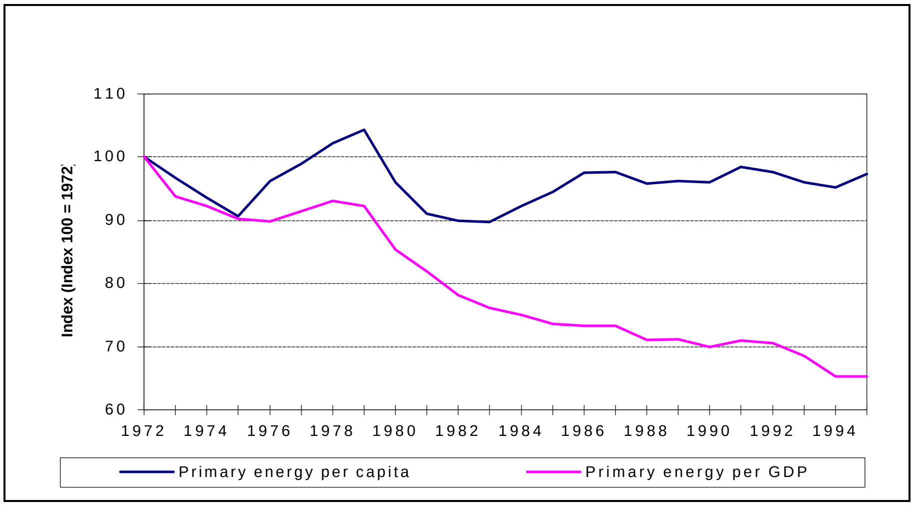


Fig. 3.10. *Primary energy consumption per capita and per unit GDP.*

CO_2 content of the fuel mix

The CO_2 content of the fuel mix increased until the mid 1980s, mainly due to the increasing share of coal (Fig. 3.11).

Thereafter the trend has reversed, actually with an accelerating tendency in recent years.

Increased efficiency in the conversion sector as well as the increased use of natural gas and renewables are primary contributory causes to this decreasing trend.

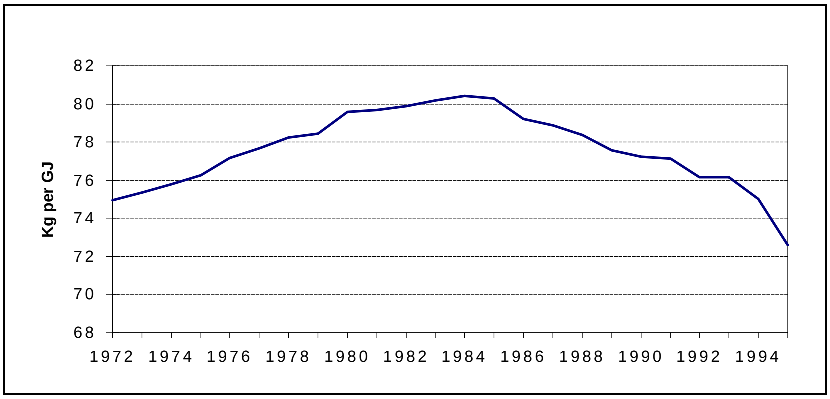


Fig. 3.11. *CO_2 content of the fuel mix.*

Note: Oil products related to transportation and non-energy use are not included.

3.2.4 Transport

CO_2 and energy consumption

In 1995, the energy consumption for national transportation amounted to 163 PJ. In 1980 the figure was 121 PJ. These amounts, however, include a considerable contribution from off-roaders such as agricultural and construction equipment etc., the energy consumption of which cannot in present statistics be distinguished from energy consumed in the transport sector proper.

The 35% increase in energy consumption in the transport sector in the period is above the average consumption growth in other sectors. This means that the transport sector's share of the total energy consumption has grown from approx. 15% to well over 20%.

Also worth noting is that energy consumption for other purposes is based increasingly on natural gas and renewable energy sources, whereas consumption in the transport sector is based almost exclusively on oil. Thus, the transport sector's share of the total oil consumption has increased markedly.

Transport capacity increase

In Denmark the number of passenger cars increased 55% from l970 to 1995. At the same time, there has been an increase in individual passenger transport of 84% from 33,400 million person-km to 61,500 million person-km. Goods transport by road has increased by 40% from 7,800 million tonnes-km in 1970 to 10,900 million tonnes-km in 1995. Vans have changed fuel from petrol to diesel and there has been an increase both in the number of passenger cars and in the number of vans and lorries using diesel.

	1970	1975	1980	1985	1990	1995
Air	0.2	0.3	0.4	0.4	0.5	0.5
Rail	2.8	3.1	4.4	4.8	4.9	4.9
Ship	0.5	0.5	0.5	0.5	0.6	0.6
Passenger cars	33.4	37.8	38.6	43.2	53.6	61.5
Buses	4.6	5.7	7.3	8.8	9.3	10.6
Total	41.5	47.4	51.2	57.7	68.9	78.1
Cycling				4.5	5.4	5.2

Table 3.6. *Passenger transport by mode of transport. Unit: Thousand million person-km.*

	1970	1975	1980	1985	1990	1995
Rail	1.3	1.2	1.2	1.2	1.2	1.3
Ship	1.8	1.7	1.9	1.8	1.9	2.2
Road	7.8	9.5	8.8	9.4	10.7	10.9
Pipeline				0.9	1.9	2.9
Total	10.9	12.4	111.9	12.4	13.8	17.3

Table 3.7. *Goods transport by mode of transport. Unit: Thousand million tonnes-km.*

Note: Goods transportation by air is a minor form of goods transportation.

3.3 National circumstances for Greenland.

Greenland is a geographically separate part of the Danish realm covering an area of 2,175,600 km^2. Of this, the ice cap covers 1,700,000 km^2. The population mainly consists of an indigenous people (1995: 48,600 inhabitants) with language and culture distinct from that of the Danes. The total population is 55,800.

The Danish Constitution applies to all parts of the Danish realm. Since 1953, Greenland has been represented by two permanent members in the Danish Parliament.

The Home Rule Act of 1978 enabled Greenland to take over responsibility in almost all fields of society appertaining exclusively to this community.

Greenland Home Rule is an extensive type of self-government. By the Greenland Home Rule Act, the Danish Parliament has delegated legislative and executive powers to the Home Rule Authority consisting of a popularly elected legislative assembly: The Greenland Home Rule Parliament (Landsting) and the Greenland Home Rule Government (Landsstyre).

The responsibilities of the Home Rule authorities include transport and communication, environmental protection and conservation of nature. Greenland is not a member of the European Union.

3.3.1 The climate of Greenland

Greenland has a polar, arctic climate.

Due to the large geographical spread of the country, from 60° N to almost 85° N, and the large variation in topography, the climate within Greenland differs considerably. During the winter months the mean temperature in January at sea level varies between -35 °C in Peary Land in the north and -3 °C at the south-west coast. In July the mean temperatures ranges from 1 °C to 10 °C with the extremes more often situated between the outer coasts and the interior fjords than between northern and southern parts.

On the Greenland ice-sheet the temperature is much lower, and over the area as a whole the annual mean temperature ranges from 1 °C at the southernmost west coast to about -30 °C in the interior.

The distribution of precipitation ranges from more than 2,000 mm in the Cape Farewell region, the southernmost tip of Greenland, to less than 150 mm at places in north Greenland. In general, the north-western part of Greenland receives its precipitation maximum during the summer months, and the south-eastern part during the autumn and winter months.

The number of heating degree days of the main town Nuuk in south-western Greenland is approx. 6,500 (base: 19 °C).

High wind speeds occur in some fjords as either Foehn or as Katabatic winds, especially coming from the ice cap. In general, storms with hurricane force are most frequent along the coasts of the southern part of Greenland.

3.4 National circumstances for the Faroe Islands

The Faroe Islands are situated in the North Atlantic 430 km southeast of Iceland, 600 km west of Norway and 300 km northwest of Scotland. Of the 18 islands in the Faroes, 17 are inhabited, the total number of inhabitants being 45,300. The total land area is 1,399 km^2 and the largest island is Streymoy with an area of 373.5 km^2.

In 1948 an agreement was made under which the Faroe Islands were granted home rule status within the Kingdom of Denmark. Internal affairs are governed by the 27-member Løgting (Parliament).

The Faroe Islands are not a member of the European Union.

International treaties concluded by the Danish Government bind Greenland and the Faroe Islands to the same extent as they do the Danish Government unless derogations have been specially requested.

3.4.1 The climate of the Faroe Islands

The climate of the Faroe Islands is mildly oceanic with plenty of precipitation.

The annual mean temperature at sea level is close to 6.5 °C. The mean temperature for January is about 3 °C and for July 10 °C.

The number of heating degree days for the Faroes is roughly 3,900 (base, 17 °C).

The annual precipitation ranges from 1,500 mm to 3,000 mm, falling mostly in October (150 to 400 mm). Precipitation is lowest in June (60 to 120 mm).

The frequency of hurricane force storms (only related to mean wind speed exceeding 25 m per sec) is generally high, more than two per year.

4 Inventories of anthropogenic greenhouse gases and removals

In 1996, the Danish Environmental Protection Agency together with the National Environmental Research Institute decided to use the software and the methodologies developed by the EU and known as the CORINAIR – database system as the foundation for the Danish national database system for air pollutants. This ensured the highest degree of compatibility with other database systems for air pollutants and at the same time facilitated updating and maintenance. The inventory presented below is based on the CORINAIR system.

In general, the CORINAIR-inventory is transformed in accordance with the 1995-Guidelines for Communication of Information Under the Framework Convention on Climate Change (IPCC) into the IPCC-inventory. The Revised 1996-IPCC guidelines have supplementary been applied to N_2O from agriculture and the pollutants not earlier included (SO_2, HFCs, CFCs and SF_6).

4.1 Inventory of anthropogenic emissions by source

4.1.1 Introduction

Pollutants

This section presents the results of the Danish inventory of emissions for the years 1990 – 1995 apportioned by source according to the IPCC guidelines as descibed above. In Annex A the inventory is shown in full IPCC reporting format. The pollutants reported here are the primary greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as the secondary substances nitrogen oxides (NO_x), carbon monoxide(CO), non methane volatile organic substances (NMVOC) and sulphur dioxide (SO_2). Emission data for hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are presented in an condensed format. The figures for 1995 are preliminary data.

The secondary substances are important for different reasons. Thus CO can react with hydroxide (OH^-) in the atmosphere, thereby preventing the oxidation of CH_4, while NO_x and NMVOC are precursors to the greenhouse gas ozone (O_3).

Statistics and emission factors

The basis for the Danish emission inventory is activity data for the categories described in detail in Fenhann et al., 1997, energy statistics from the Danish Energy Agency shown in Table 4.1 and Annex B, agricultural livestock statistics from Statistics Denmark shown in Annex C, and the emission factors for each source and each fuel or livestock shown in Annex D. Other statistics and activity data used can be obtained at the National Environmental Research Institute.

Energy	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Primary energy consumption in PJ	**685**	**809**	**753**	**777**	**829**	**808**
A Fuel Combustion	681	801	744	770	821	802
1 Energy Industries	317	414	362	380	437	408
2 Manufacturing Industries and Construction	83	88	89	92	86	89
3 Domestic transport	143	151	151	156	162	164
4a Commercial/Institutional	22	24	22	22	20	23
4b Residential	85	91	89	91	89	88
4c Agriculture/Forestry/Fishery	31	33	32	29	28	30
B Fugitive Emissions from Fuels	4	9	9	8	8	6
Corrected primary energy consumption[1] in PJ	**779**	**798**	**795**	**787**	**791**	**801**
Correction for electricity exchange[2]	67	-18	35	11	-41	-6
Correction for the impact of outside temperature variation[3]	27	7	7	-1	3	0
International bunkers[4]	**66**	**60**	**63**	**80**	**90**	**94**
A Aviation Bunkers	27	25	25	24	27	27
B Marine Bunkers	40	36	37	56	63	67

General note: Numbers in colums may not add up to the total due to rounding and data for especially 1993 and 1994 may be subject to future revisions due to changes in the statistical system.
Note 1: Primary energy consumption with the corrections shown in the table.
Note 2: A positive correction indicates net import; negative net export.
Note 3: A positive correction indicates a warmer climate than average; negative colder than average.
Note 4: International bunkers are not included in the national totals.

Table 4.1. *Primary energy consumption, corrections used in national planning/statistics and international bunkers, 1990 – 95.*

The emissions from the transport sector are calculated on the basis of fuel sales in Denmark. Emissions from international transports (aviation bunkers and marine bunkers), based on fuel sales in Denmark is calculated in the inventory for each pollutants. These emissions are shown in Tables 4.2 – 4.8 and Annex A, but are not included in the national totals. The emission factors for road transport are based on calculations with the COPERT - model for the transport sector, this being a background model for the CORINAIR work.

The emission factors for CO_2 are based on the assumption that all the carbon content of the fuel is oxidised (complete combustion), albeit that this is seldom the case. Some carbon will be released as other compounds, e.g., CH_4, CO or hydrocarbons (NMVOCs), and will eventually be transformed to CO_2 in the atmosphere. The emission factors for CO_2 is calculated from the low heat values and the carbon content of the fuels, as shown in Andersen et al., 1995.

Factors for CH_4 emission from livestock are from the 1995-IPCC guidelines.

Dominant sources

The dominant source of Danish CO_2, CO and NO_x emissions is combustion of fossil fuel. Apart from combustion, the main source of N_2O and CH_4 emissions is agriculture while that of NMVOC emissions is solvent use.

Uncertainty

The uncertainty in the Danish emission inventories arises from two sources: Uncertainty in the statistics and uncertainty in the emission factors used. As mentioned above, the statistics are the official Danish statistics. The emission factors are based on either calculations, as is the case with CO_2 (heat values and carbon content), or on measurements. The measurements originate from either existing Danish plants or from comparable European installations. Another uncertainty is whether all (major) sources of emissions are included in the inventory. It is assumed that the uncertainty is greatest for the inventories of NMVOC, CH_4 and N_2O, perhaps with an uncertainty factor of 2. With the CO and NO_x inventories, the uncertainty is assumed to be less than 30 – 40%. With the CO_2, the uncertainty may be as low as 1 – 2%.

Electricity exchange and temperature variations

In some years Denmark imports considerable electricity while in other years electricity is exported. The variation is due to changes in precipitation in Norway and Sweden leading to fluctuations in the availability of hydropower.

Climate variation imply not only a variation in electricity exchange but also inter-annual fluctuations in domestic energy consumption due to variation in outside temperature. Consequently, correction for the impact of outside temperature variation has been applied as well.

In Table 4.1 and in the energy balances in Annex B these corrections are shown.

Both corrections are only significant for CO_2 and are given separately together with the corrected values in Table 4.2. These values should be used in assessing the inter-annual variation in CO_2 emissions corresponding to the energy consumption. The corrected values should also be used in connection with evaluation of compliance with emission reduction commitments.

The calculation method is futher described in Annex E.

4.1.2 CO_2

CO_2

As mentioned above the emission factors used for the CO_2 emission inventory are based on the assumption that all the carbon in the fuel is oxidised during combustion. This is in accordance with the recommendations in the IPCC-guidelines.

Emissions from biomass fuels are not included in the inventory. Biomass fuels here include wood, straw, biogas and refuse. It should be noted that not all of the refuse used as fuel is renewable and hence a biomass fuel, but it has not yet been possible to divide the refuse burned in Denmark into different fractions.

Danish emissions of CO_2 amounted to 59,500 Gg in 1995 (Table 4.2 and Annex A[3]). The main part – 58,000 Gg – derived from the combustion sector. The remaining 1,500 Gg derived from industrial processes, with cement production being the main source.

The development in total Danish CO_2 emissions corrected for electricity exchange and outside temperature variation is shown in Table 4.2, and as it can be seen from Figure 4.1, this development indicates a slight negative trend from 1991.

CO_2	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Total National Emission in Gg	**52277**	**62940**	**57652**	**59356**	**63344**	**59532**
1A Fuel Combustion	50898	61136	55711	57472	61117	57748
1 Energy and Transformation Industries	25865	34864	29540	31028	35213	31482
2 Industry (ISIC)	5776	6114	6218	6168	6481	6039
3 Transport	10474	10946	11072	11301	11345	11370
4 Comm./Institutional, Residential, Agri./Forestry/Fishing	8664	8925	8740	8738	8020	8718
5 Other Combustion Activities	119	287	141	237	58	139
1B Fugitive Emissions from Fuels	240	495	511	445	782	348
2 Industrial Processes	1006	1178	1300	1311	1318	1311
3 Solvent and Other Product Use	133	131	130	128	127	125
5 Land Use Change & Forestry	0	0	0	0	0	0
Corrected[1] Total National Emission in Gg	**60233**	**61721**	**61358**	**60328**	**59605**	**58917**
Correction for electricity exchange[2]	6253	-1721	3273	988	-3932	-615
Correction for the impact of outside temperature variation[3]	1703	502	433	-16	193	0
International bunkers[4] in Gg	**4986**	**4507**	**4677**	**6041**	**6736**	**7080**
Total National Removal[4] in Gg	**-924**	**-932**	**-940**	**-948**	**-956**	**-964**
CO_2 fixation in existing forests	-916	-916	-916	-916	-916	-916
CO_2 fixation in new forests	-8	-16	-24	-32	-40	-48

General note: Numbers in colums may not add up to the total due to rounding.
Note 1: Only corrections shown in the table are applied.
Note 2: A positive correction indicates net import; negative net export.
Note 3: A positive correction indicates a warmer climate than average; negative colder than average.
Note 4: Not included in the national totals.

[3] The CO_2 emissions given in Annex A differ slightly from the ones shown in Annex B. This is due to the use of different calculation methods. Efforts towards harmonization of the calculation methods are on-going.

Table 4.2. *CO_2 emissions to air by sources and removals by sinks and correction for electricity exchange and outside temperature variation in Gg 1990 – 95.*

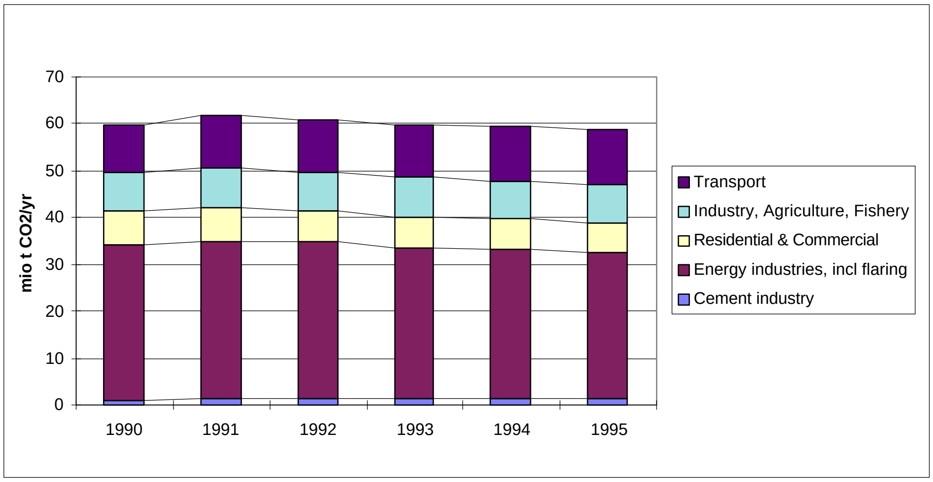


Figure 4.1. *Development in CO_2 emissions by sources corrected for electricity exchange and outside temperature variations 1990 – 95.*

The corrected figures reflect CO_2 emissions corresponding to Danish energy consumption under normal meteorological conditions. Thus, when comparing Danish emission figures from year to year to get an impression of the effect of the implemented measures to reduce CO_2 emissions it is necessary to use the corrected figures. These should also be applied when assessing the compliance with emission reduction targets under the UNFCCC, etc.

CO_2 uptake by sequestration in existing and new forests is given separately in Table 4.2 and Annex A.

4.1.3 **CH_4**

CH_4

Total Danish anthropogenic emissions of CH_4 amounted to 430 Gg in 1995 (Table 4.3 and Annex A). The dominant sources were animal waste and enteric fermentation in the agricultural sector, which accounted for 327 Gg in 1995. A new calculation has been used applying the emission factors recommended in the 1995-IPCC guidelines.

CH_4	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Total National Emission in Gg	**421**	**426**	**431**	**445**	**428**	**430**
1A Fuel Combustion	10	11	11	10	10	11
1B Fugitive Emissions from Fuels	12	14	14	14	17	17
2 Industrial Processes					1	1
4 Agriculture	329	330	335	348	326	327
6 Waste	71	71	72	72	74	74
International bunkers[1] in Gg	**0**	**0**	**0**	**0**	**0**	**0**

General note: Numbers in colums may not add up to the total due to rounding.

Note 1: Not included in the national totals.

Table 4.3. *CH_4 emissions to air by sources in Gg 1990 – 95.*

The second most important source was waste, with CH_4 emissions from landfills being dominant (74 Gg in 1995). Only a minor part (28 Gg in 1995) derived from fuel combustion and fugitive sources. The inventory takes into account animal waste treatment in biogas plants.

From January 1997 the disposal of any kind of combustible waste at landfills is prohibited. CH_4 gas emissions from landfills are consequently expected to drop in the future.

At present there are no rules in Denmark for gas collection at landfills. In the EU Commission's proposal for a Council Directive on landfilling of waste it is proposed that landfill gas should be collected from all landfills receiving biodegradable waste and thereafter treated and used, or alternatively flared. Thirteen Danish landfills currently generate electricity by extracting methane gas with an aggregated heating value of 550 TJ per year.

CH_4 emissions in the period 1990 – 95 ranged from 421 to 445 Gg per year with no clear trend.

4.1.4 N_2O

N_2O

Total estimated emissions to air of N_2O from Danish sources amounted to 33 – 34 Gg in the period 1990 – 95 (Table 4.4 and Annex A).

N_2O	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Total National Emission in Gg	**34**	**34**	**34**	**33**	**33**	**33**
1A Fuel Combustion	2	2	2	2	3	3
4D Agricultural Soils	33	32	32	31	30	30
5D Other Land Use Change Activities					1	1
International bunkers[1] in Gg	**0**	**0**	**0**	**0**	**0**	**0**

General note: Numbers in colums may not add up to the total due to rounding.
Note 1: Not included in the national totals.

Table 4.4. *N_2O emissions to air by sources in Gg 1990 – 95.*

Using the Revised 1996-IPCC guidelines, five major sources have been identified: Direct emissions from fertiliser and nitrogen fixation, emissions from nitrogen deposition, emissions from nitrogen leaching, emissions from livestock and emissions from histosols. IPCC emission factors have been applied for each source.

In Denmark's first national communication only the first source category was taken into account. This implied an underestimation of total N_2O emissions from the agricultural sector by a factor of 3 – 4.

Due to the impact of the Danish Action Plan for a Sustainable Agricultural Development, the consumption of commercial fertiliser decreased by 25% from 1990 to 1996. This decrease is reflected in the emission figures for the period 1990 – 95.

4.1.5 NO_x

NO_x

Total emissions to air of NO_x from Danish sources amounted to 253 Gg in 1995 (Table 4.5 and Annex A). Fuel combustion was practically the only source of Danish NO_x emissions.

NO_x	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Total National Emission in Gg	**280**	**320**	**274**	**274**	**272**	**254**
1A Fuel Combustion	278	317	272	271	269	251
1 Energy and Transformation Industries	96	135	93	97	106	92
2 Industry (ISIC)	19	20	20	20	24	23
3 Transport	125	121	119	117	103	100
4 Comm./Institutional, Residential, Agri./Forestry/Fishing	37	38	38	35	35	35
5 Other Combustion Activities	1	2	1	2	1	2
1B Fugitive Emissions from Fuels	1	3	3	2	3	2
2 Industrial Processes	1				1	0
International bunkers[1] in Gg	**85**	**74**	**74**	**112**	**124**	**130**

General note: Numbers in colums may not add up to the total due to rounding.
Note 1: Not included in the national totals.

Table 4.5. *NO_x emissions to air by sources in Gg 1990 – 95.*

The NO_x emissions tended to decrease over the period, from 280 Gg in 1990 to 253 Gg in 1995.

4.1.6 **CO**

CO

Total anthropogenic emissions of CO from Danish sources amounted to 702 - 726 Gg in 1995 (Table 4.6 and Annex A).

The main source was combustion processes, accounting for 656 Gg in 1995. The second most important source was fugitive emissions from coal stores, accounting for 45 Gg in 1995. This is calculated using an emission factor of 0.0000034 Gg CO per tonne of stored coal.

CO	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Total National Emission in Gg	**785**	**800**	**770**	**725**	**704**	**701**
1A Fuel Combustion	751	756	728	688	662	656
1 Energy and Transformation Industries	38	40	43	47	48	49
2 Industry (ISIC)	9	9	9	8	12	10
3 Transport	552	542	509	470	422	389
4 Comm./Institutional, Residential, Agri./Forestry/Fishing	153	164	166	162	180	206
5 Other Combustion Activities	0	2	1	1	1	2
1B Fugitive Emissions from Fuels	34	44	43	37	41	45
International bunkers[1] in Gg	**9**	**8**	**9**	**12**	**12**	**13**

General note: Numbers in colums may not add up to the total due to rounding.
Note 1: Not included in the national totals.

Table 4.6. *CO emissions to air by sources in Gg 1990 – 95.*

The CO emissions tended to decrease over the period, from 785 Gg in 1990 to 702 Gg in 1995.

4.1.7 **NMVOC**

NMVOC

Total Danish anthropogenic NMVOC emissions amounted to 162 Gg in 1995 (Table 4.7 and Annex A). The main part – 93 Gg – came from combustion processes. 40 Gg came from solvent use, where paint application were the most important sub-category.

NMVOC emissions also tended to decrease over the period, from 179 Gg in 1990 to 162 Gg in 1995.

NMVOC	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Total National Emission in Gg	**179**	**176**	**170**	**161**	**166**	**162**
1A Fuel Combustion	116	114	109	101	97	93
1 Energy and Transformation Industries	1	1	1	1	1	2
2 Industry (ISIC)	2	2	2	2	3	3
3 Transport	101	97	93	85	77	71
4 Comm./Institutional, Residential, Agri./Forestry/Fishing	12	13	13	12	15	17
5 Other Combustion Activities	0	0	0	0	0	0
1B Fugitive Emissions from Fuels	8	8	7	7	16	17
2 Industrial Processes					1	1
3 Solvent and Other Product use	43	42	42	41	41	40
4 Agriculture	2	2	2	2	2	2
5D Other Land Use Change Activities	9	9	9	9	9	9
International bunkers[1] in Gg	**3**	**3**	**3**	**4**	**4**	**4**

General note: Numbers in colums may not add up to the total due to rounding.
Note 1: Not included in the national totals.

Table 4.7. *NMVOC emissions to air by sources in Gg 1990 – 95.*

4.1.8 **SO_2**

SO_2

Danish SO_2 emissions were computed using the emission factors in Annex D and the corresponding consumption of sulphur-containing fuel. Since most Danish power plants are equipped with desulphurisation units, emissions from this source are based on direct measurements. Total Danish anthropogenic SO_2 emissions amounted to 150 Gg in 1995 (Table 4.8 and Annex A). The main part – 106 Gg – came from the source category public power, CHP and district heating.

SO_2	1990	1991	1992	1993	1994	1995
Total National Emission in Gg	**180**	**239**	**186**	**152**	**155**	**150**
1A Fuel Combustion	180	239	186	152	150	147
1 Energy and Transformation Industries	132	188	143	112	111	106
2 Industry (ISIC)	21	23	22	20	22	19
3 Transport	15	16	11	9	10	10
4 Comm./Institutional, Residential, Agri./Forestry/Fishing	11	12	11	11	7	12
5 Other Combustion Activities						
2 Industrial Processes					4	3
6C Waste Incineration					1	0
International bunkers[1] in Gg	**55**	**46**	**38**	**66**	**70**	**78**

General note: Numbers in colums may not add up to the total due to rounding.
Note 1: Not included in the national totals.

Table 4.8. *SO_2 emissions to air by sources in Gg 1990 – 95.*

4.1.9 HFCs, PFCs and SF_6

HFCs, PFCs and SF_6

The consumption of HFCs in the period 1990 – 95 increased in line with the replacement of CFCs, while the consumption of SF_6 remained largely unchanged (Table 4.9 and Annex A). The consumption of PFCs in the period was negligible.

Consumption of HFCs, PFCs and SF_6	1990	1991	1992	1993	1994	1995
HFCs in Gg	0.000	0.003	0.024	0.343	0.600	0.750
PFCs in Gg	n.a.	n.a.	n.a.	n.a.	n.a.	0.002
SF_6 in Gg	0.015	0.015	0.015	0.017	0.021	0.017

Table 4.9. *Consumption of HFCs, PFCs and SF_6 in Gg, 1990 – 95.*

The Danish consumption figures, estimated actual emission figures and GWP-weighted emissions from industrial non-energy processes in 1995 are shown for HFCs, PFCs and SF_6 in Table 4.10.

GWP of HFCs, PFCs and SF_6	1995		
	Consumption (Gg)	*Estimated actual emission (Gg)*	*GWP-weighted actual emission (Gg CO_2 eqv.)*
Total GWP	-	-	**419**
HFCs	0.750	0.197	216
- 134a	0.565	0.147	191
- 152a	0.050	0.044	6.2
- 404a	0.120	0.005	19
other HFCs	0.015	0.001	unknown
PFCs	0.0015	<0.00015	<1
SF_6	0.017	0.0085	203

Table 4.10. *HFCs, PFCs and SF_6 , consumption, emissions to air and the related GWP in Gg, 1995.*

The estimated actual emissions are computed from the consumption figures by applying the method recommended in the Revised 1996-IPCC guidelines.

Total GWP-weighted emissions of HFCs, PFCs and SF_6 was 419 Gg CO_2 equivalents in 1995, of which was accounted for by HFCs (52%) and SF_6 (48%).

HFCs

HFCs are mainly emitted during the blowing of sealing foams (63%). A further 15 % is emitted in the manufacture of refrigerator/freezer insolation foam and 12% during the blowing of miscellaneous foams, e.g. open cell foam.

PFCs

Consumption and emissions of PFCs are insignificant, only perfluoropropane being used in Denmark. PFCs are not produced in Denmark.

SF_6

70% of the SF_6 is emitted during the production of soundproof windows and 18% from magnesium foundries (used as cover gas). The rest is emitted from electrical equipment (insulation medium) in power plants, research institutions (e.g. air trace gas) and miscellaneous applications, e.g. low-noise proof car tyres.

4.2 Sinks

CO_2-sequestration in existing forests.

The forest area is defined as closed canopy high forest. This means that open woodland and open areas within the forest are not included.

The assumption is that the Government's strategy of doubling the forest area within the next 80 – 100 years will be followed. Afforestation will gradually reach 40 km^2 per year as the interest in private afforestation and appropriations for national afforestation increases. The peak afforestation rate will be around the year 2020.

The 1990 inventory on forests gives a total standing stock volume of 55,154,000 m^3.

The standing stock volume is in average 13,200 m^3 per km^2 in 1990. Using the IPCC recommended conversion factors the amount of carbon stored in existing forests in 1990 was 23,600 Gg corresponding to 86,526 Gg CO_2 as shown in Table 4.11.

***CO_2* reservoirs and sinks**	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
CO_2 reservoir in forests[1] in Gg	**86526**					
Total CO_2 uptake in Gg	**924**	**932**	**940**	**948**	**956**	**964**
CO_2 uptake due to net increment in existing forests[1] in Gg	916	916	916	916	916	916
CO_2 uptake due to afforestation since 1st. Jan. 1990 in Gg	8	16	24	32	40	48
Note 1: Forests existing by 1st. Jan. 1990						

Table 4.11. *CO_2 reservoir and uptake in forests in Gg, 1990 – 95.*

Annual CO_2 fixation in existing forests.

The annual net-increment (increment minus thinning removals) in the period 1990 – 2000 is estimated to be 600,000 m^3 per year. Using the IPCC conversion factors this equals around 250 Gg carbon per year or 916 Gg CO_2 per year. Annual felling / removal based on 1990 figures was 480 m^3 per km^2 per year or 0.110 Gg carbon per km^2 per year.

Increasing carbon fixation through afforestation.

The total annual afforestation rate during the period 1990 – 95 is estimated to have been around 19 km^2 per year. This includes both areas covered with trees and open areas in the forest. In connection with carbon fixation it is the tree-covered area that is the interesting factor. The annual afforestation rate is therefore estimated to be between 10 and 15 km^2 per year. It is expected that the rate will increase gradually, as new afforestation incentives (adopted in 1996) takes effect, and peak with 40 km^2 per year around the year 2020.

Assuming that the forest area doubles within the next 80 – 100 years, the following CO_2 binding pattern can be expected. Over the next 30 years, CO_2 binding will be small. 70 – 120 years after the forest is planted, CO_2 binding will peak at approx. 3,500 Gg CO_2 per year or approx. 5% of present annual anthropogenic emissions in Denmark.

Within the next 10 – 20 years, the quantity of wood for energy purposes is expected to rise while the quantity of wood for pulp and paper production will fall.

1990 – 95

The average afforestation rate over the period 1990 – 95 was 19.38 km^2 per year. Danish CO_2 uptake and growth models show an average CO_2 binding rate of 0.41 Gg CO_2 per km^2 per year on average basis through the whole afforestation period of 150 years. This means that the 19.38 km^2 per year equals 8 Gg CO_2 per year. The total annual uptake over the period 1990 – 95 is shown in Table 4.11 and Annex A.

4.3 Agricultural sector

Agricultural Land use

In 1992 the total arable area was 27,600 km^2, which is about 65% of the total area of Denmark. The distribution of agricultural area by crop type is shown in Table 4.12.

Since the 1930s the arable area has decreased by about 10%. Part of this land has been used for infrastructure and municipal development. More recently the area of agricultural land has also decreased due to afforestation and environmental measures.

Permanent grassland has also decreased by about 10% during this period, whereas annual crops have increased.

Due to the EU Agricultural Policy reform, 2,000 km^2 of arable land has been set aside every year in order to reduce food production. This land may be used for non-food production, however.

According to the Action Plan for Sustainable Agricultural Development, the arable area is expected to decrease by a further 2,500 to 4,500 km^2 over the next 15 years. Land is needed for municipal development and infrastructure, and marginal land will be set aside or taken out for other environmental reasons. It is not expected that the use of the arable land will change considerably.

Biomass in agricultural ecosystems

During the last 30 years, there has been a considerable increase in the biomass production of in the agricultural ecosystem due to a change in agricultural practice. In concert with this there has been an increase in the use of fertiliser, especially nitrogen.

It is difficult to give an exact measure of production in the agricultural ecosystem as this is closely related to climate conditions. Average crop production over the four-year period 1989 – 92 is shown in Table 4.12.

Total annual dry matter crop production in Denmark is about 17,100 Gg.

Assuming that approx. 1/3 of crop biomass is accounted for by roots, straw etc. (left in field), total biomass production in the Danish agricultural ecosystem can be estimated at 23,000 Gg per year or 0.833 Gg/km2.

Crop production in average 1989-92	Freshweight (Gg)	Dry matter (Gg)
Total Crop Production	**41,704**	**17,106**
Cereals	8,647	7,350
Rape	645	587
Pulses	437	371
Straw	3,535	3,005
Roots	10,854	2,388
Tops	2,258	339
Grass and green fodder	15,328	3,066

Table 4.12. *Average annual crop production in Gg for the last four-year period 1989 –1992.*

4.3.1 Possibilities in the agricultural sector for CO_2 sequestration and the reduction of other greenhouse gas emissions

CO_2

In cultivated soils humus masses comprises 2 – 5% of the top soil, depending on the type of soil and crop.

It might be possible to increase the humus content slightly in some fields, though an increase will be very slow, and only be within the limits of the natural capacity of the soil. The most important factor for an increase is a constant high input of organic matter.

It is unlikely that a change in soil humus content can be of a sufficient magnitude to sequester significant amounts of CO_2.

N_2O

The emission rate of N_2O from cultivated soil depends on a complex array of factors including soil structure, pH, climate, crop, soil carbon content, water status, and amount and kind of nitrogen fertilizer. The possible impact on N_2O emissions of changing these factors is not well known.

Possibly the most effective way to influence emissions is to reduce nitrogen input to the soil and improve the use and handling of fertilizer, especially animal fertilizer.

In Denmark, several measures have been taken to improve the handling and utilisation of animal fertilizer and to decrease the total nitrogen input to the soil. The measures include compulsory crop rotation and fertilization planning at each farm, limits on the amount of animal fertilizer applied per hectare and improved utilisation of its nitrogen content. Nitrogen requirement norms for the different crops have been defined and the total application of nitrogen is not allowed to exceed the calculated requirement based on these norms. The consumption of nitrogen in commercial fertilizer has decreased by 25% from 1990 to 1996.

Methane, CH_4

In the agricultural sector methane is produced by enteric fermentation in the digestive tract of ruminants. The methane production is dependent on the amount and quality of the ingested diet and the weight of the animal. Methane emission from cattle can be reduced by increasing digestibility of the diet, although the diet of a Danish dairy cow usually has a high digestibility.

Methane emission can also be reduced by reducing the number of cattle. During the last 10 years the number of cattle has been reduced by 24% and a further reduction is expected.

In Denmark, sheep are of no importance in relation to the methane emission due to their small number.

Manure

Manure from livestock also contributes to methane emissions, especially when kept under anaerobic conditions, e.q. liquid manure tanks. About 75% of the manure from Danish farms is stored in this way. *Energy 21* foresees a gradual increase in the number of community biogas plants based on manure and other organic residues, which will contribute to the future reduction of CH_4-emissions (compare table 6.3).

4.3.2 **Biofuel production**

Agriculturally produced raw material for liquid biofuel production is expected to have an important potential for the future. However, further investigation, research and development is needed before this potential can be determined and exploited fully.

The full utilisation of the potential is closely related to existing agricultural and energy policies. It is not presently attractive for farmers to engage in biofuel production due to existing price levels on products for other purposes and taxation on energy produced from biofuels. Recently, however, the production of biofuels has been made more attractive to farmers under the EU set-aside scheme.

The technological and economic issues are presently being reviewed by a joint task force from the Ministry of Environment and Energy and the Ministry of Food, Agriculture and Fisheries.

Energy 21 foresees a gradually increasing contribution from biofuels in the transport sector in the later half of the period until 2030.

4.3.3 **Energy Crops**

Surplus straw is already used for power and district heating production to a considerable degree. Existing agreements with power producers will expand this utilisation further in the near term.

In the longer term, solid biofuels from various energy crops from the agricultural sector is foreseen in *Energy 21* to reach a level of about 50 PJ.

5 Policies and measures to reduce greenhouse gas emissions

5.1 Carbon dioxide, CO_2

The Danish Government's target is to reduce carbon dioxide emissions from the energy consuming sectors by 20% by the year 2005 as compared to 1988. Besides, the Government is working towards an international agreement on a 50% reduction of CO_2 emissions by 2030, compared with 1990.

The new Danish energy action plan *Energy 21* launched in April 1996 confirms and maintains Denmark's national objectives as mentioned above and contains a number of new or revised measures. By following the plan, it is possible to reach the 2005 reduction target. In Chapter 6, a detailed presentation of the plan is given.

In addition to the plan, the Government has decided to work for an annual increase in the use of renewable energy by 1%, averagely, until 2030. This implies that renewable energy will constitute approx. 35% of the gross energy consumption in 2030.

Lately, the Government has announced a *coal stop*, implying that new capacity in the power sector based on coal will not be permitted.

5.1.1 Energy policy measures of relevance to the limitation of greenhouse gas emissions

Danish energy policy 1976 – 88

Danish policies regarding limitation of the environmental impact of the use of energy are rooted in many years of active national policies on energy and the environment.

Energy plans

The first national plan from 1976 together with further development of the policies during the 1980s resulted in major restructuring of the energy system in Denmark. The implemented policies included:

- Conversion of power plants from oil to coal.
- Development of oil and natural gas fields in the North Sea.
- Construction of a national gas distribution network.
- Massive change of heat supply from individual oil furnaces to district heating and natural gas.
- Elimination of oil used for district heating in favour of local resources (straw, wood, waste) and natural gas.
- Expansion of combined heat and power systems in order to increase total system efficiency.
- Development and implementation of renewable energy sources such as wind, biomass and solar energy, as well as waste incineration and biogas based on recycling of organic waste.
- Comprehensive energy savings programmes in the industrial and residential sectors.
- Strengthening of standards for new buildings
- Increased research and development on energy technologies.

As a result, total primary energy consumption was stable, despite substantial growth in all economic sectors. In parallel, the environmental impact of energy use was reduced substantially as a direct result of the changes in the energy system, as well as by implementation of emission standards, emission quotas and other regulations.

Nuclear power

In 1985, it was decided not to use nuclear power in Denmark. This decision was reflected in the energy action plans as well.

Danish energy policy since 1988

In the late 1980s, focus gradually shifted from considerations in security of supply, minimisation of energy service costs and local environmental effects to broader environmental considerations, notably the goal of achieving long-term sustainable development, on a national as well as global level.

Plan of Action on Environment and Development

In 1988, the Danish Government presented its Plan of Action on Environment and Development, as a follow-up of the recommendations set out in the report from the World Commission on Environment and Development, the Brundtland Report, and in the United Nations' Environmental Perspective to the year 2000. This action plan set out the targets to be reached and the initiatives to be implemented in all sectors in order to obtain sustainable development.

Energy 2000

The Energy Action Plan, *Energy 2000*, followed in 1990 based on a political agreement of 20 March 1990. It introduced the goal of sustainable development in the energy sector and formulated the national objective of a 20 % reduction in CO_2 emissions by 2005 compared to 1988. *Energy 2000* focused on savings in energy consumption, increased efficiency of the supply system, conversion to cleaner sources of energy and on research and development.

Energy 2000 – follow-up

These plans have been followed up through political agreements and legislation. The *Energy 2000 – follow-up* from 1993 contained a review of trends and policies together with a number of further initiatives.

The most important initiatives during the period 1990 – 95 are summarized in Box 5.1.

Discussion paper

Prior to the new energy action plan, *Energy 21*, a discussion paper, *Denmark's Energy Futures*, was published in December 1995. This paper contained technical analyses of future scenarios for energy consumption and supply in Denmark.

At the same time, the Government presented a general Nature and Environment Policy giving an overview of the Danish efforts for protection of the environment. This futher framed the principles of sustainable development and ecological space.

Small-scale CHP. Extension of small-scale CHP (combined heat and power production), increased connection of consumers to collective supply systems and the use of natural gas in central power stations, as well as a further expansion of 100 MW wind power under the auspices of the electric utilities.

CO_2 tax and subsidies: The "CO_2 package" of May 1992 comprised four Acts which among other things made it possible to grant State subsidies in connection with conversion to or exploitation of CHP.

The biomass action plan: A political agreement of 14 June 1993 focused on increased use of biomass in energy supply.

Efficiency standards for appliances etc.: Legislation dated March 1994 made it possible to establish general requirements for the energy efficiency of appliances and equipment.

Integrated resource planning: Legislation dated February 1994 ordered the utilities to carry out plans for electricity savings as part of the power production forecasts.

Building code: The Building code of 1995, which entered into force on 1 January 1996, entailed a reduction of 20-25% of the net heat demand for new buildings.

Energy labelling: With effect from 1 January 1995, energy labelling of refrigerators and freezers was introduced, and in addition it was decided to energy label other appliances in accordance with a new EU directive.

Green taxes: As part of the tax reform 1994 – 98, legislation of June 1993 imposed a number of increased new green taxes on households. Legislation coming into force January 1 1996 imposes increased CO_2 taxes on heavy and light processes in industry as well as new taxes on space heating in industry which will be increased to the levels applied to households. In addition the legislation made it possible to employ agreements on energy efficiency measures between authorities and enterprises. A new sulphur tax was also introduced.

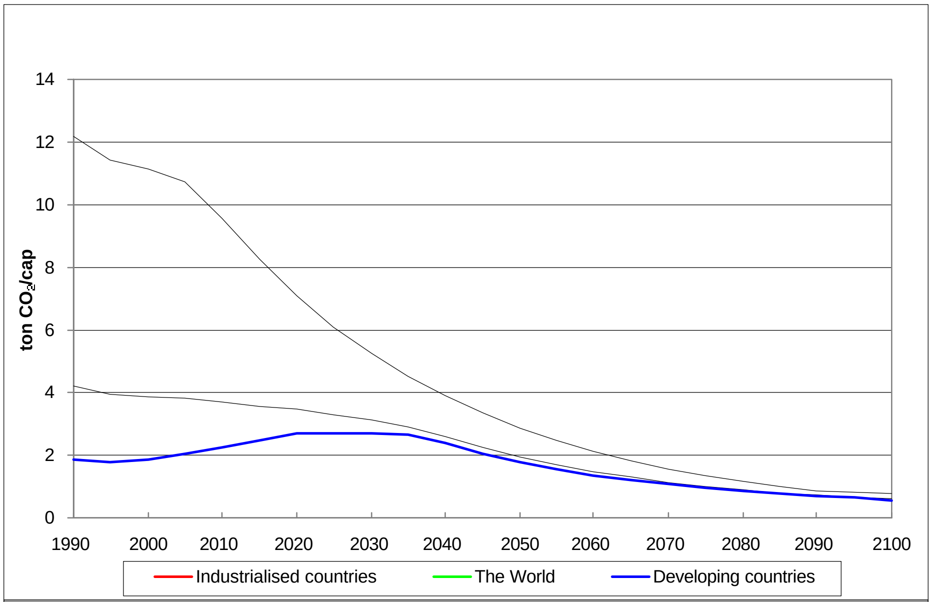
Renewable energy: In November 1995, the Minister for Environment and Energy presented *Renewable Energy – New Initiatives* aiming at an extension of the use of wind power, biomass and solar heat.

Box 5.1. *The most important initiatives contained in the Energy 2000 – follow-up from 1993.*

Energy 21

The new energy action plan, *Energy 21*, deals with international market conditions and long-term environmental aspects, as the overall challenges to the energy sector. The major environmental challenge is to achieve a convergence of emissions of industrialised countries to a level that would be globally sustainable. Without such a convergence the prospects for expecting the rest of the world to respect the limits of global environmental space will be very meagre.

In connection with the approval of the action plan, the Parliament decided to work for an international agreement on a 50% reduction of CO_2 emissions from industrialised countries by 2030, compared with 1990 levels. *Energy 21* consequently aims at fulfilling this goal. Such an agreement could be consistent with a global scenario that achieves stabilisation of CO_2 concentration at 450 ppmv, see figure 5.1.



Note : Required of the development of per capita emissions to stabilise the atmospheric content of CO2 at 450 ppmv, inter alia presupposing that technologies introduced in the industrialised countries will be able to be utilised in the developing countries with a delay of 20 years.

Figure 5.1. *Global CO_2 emission scenario of the Danish Energy Agency that achieves stabilisation at 450 ppmv.*

The plan sets out the framework for a number of initiatives focusing especially on reducing the requirements for resources and the impact on the environment from the energy sector. National "yardsticks" regarding improvement of energy intensity and enhanced use of renewables are formulated.

Besides, the Parliament decided to work for an annual increase in the share of renewable energy by 1% until 2030. This implies that renewable energy will constitute approx. 35% of the gross energy consumption in 2030.

In March 1997, the Government announced a *coal stop*, implying that new capacity in the power sector based on coal will not be permitted.

Energy 21 introduces a number of new measures in the energy sector. A description of these energy related legislation and measures is provided in Annex F together with a full list of earlier measures.

CO_2 reduction targets

In May 1990 the Government adopted the Transport Action Plan, which aims at stabilising CO_2 emissions by 2005 and a 25% reduction by 2030, compared to 1988 level for this sector.

The combined effects of *Energy 2000* and the *Transport Action Plan* were expected to be more than a 20% reduction in emissions from energy use in 2005. This target was subsequently approved by Parliament.

The target was defined in terms of emission values from energy use in 1988 corrected for variations in electricity exchange and outside temperature, including international air traffic, but excluding bunkers and flaring, and entailed a reduction of 12,200 Gg CO_2 out of a total of 61,200 Gg.

Internationally, Denmark has committed itself to stabilise emissions at the 1990 level by 2000 within the framework of the Climate Convention, and as a contribution to the overall stabilisation by the year 2000 for the countries of the EU to achieve a 5% reduction in 2000 compared with 1990.

As previously mentioned, the Government is working towards an international agreement on a 50% reduction of CO_2 emissions by 2030 compared with 1990 levels.

5.1.2 **Transport**

Targets for CO_2 emissions

The Danish transport sector contributes approx. 20% of the total Danish CO_2 emissions from the energy consuming sectors.

The reduction in CO_2 emissions must as far as possible be based on the most cost effective initiatives.

In 1990, the Danish Government presented a Transport Action Plan, which laid down the present CO_2 emission target for the transport sector. The target is to stabilise CO_2 emissions at the 1988 level by the year 2005, and reduce it by 25% up to 2030.

The Transport Action Plan was followed up in December 1993 by *Transport 2005* which reviewed the implementation of the energy and environmental targets. It was emphasised that fulfilment of the target for CO_2 emissions while continuing to provide an efficient and flexible transport system to the public and commercial sector is the greatest challenge of national transport policy in the years to come.

In immediate continuation of *Transport 2005*, the Danish Ministry of Transport therefore initiated further clarifying work aiming to at identifying effective policies and measures for reducing CO_2 emissions in the transport sector.

The Danish Parliament has confirmed the CO_2 emission targets for the transport sector on several occasions, most recently in February 1996.

It is Danish policy that the present CO_2 emission targets in the transport sector must be met. In future, further follow-up will be carried out at regular intervals in order to ensure among other things a reasonable balance between the efforts in the transport sector and those in other energy consuming sectors. At the same time, the targets for the period up to 2030 must be seen as interim, as these must be determined in the context of future assessments of the latitude allowed by ecological considerations.

Future environmental impact of the transport sector

It has not been possible to slow down the increase in CO_2 emissions from the transport sector and as a consequence of rapid growth in traffic volume in the first half of the 1990s CO_2 emissions in 1995 were well above the level in 1988.

As shown in Fig. 5.2, CO_2 emissions will have to be reduced by between 7 and 20% by the year 2005 if the target of stabilising CO_2 emissions at the 1988 level is to be met. Correspondingly, CO_2 emissions in 2030 will have to be reduced by 30 to 40% by the year 2030 if a reduction of 25% compared to the 1988 level is to be achieved.

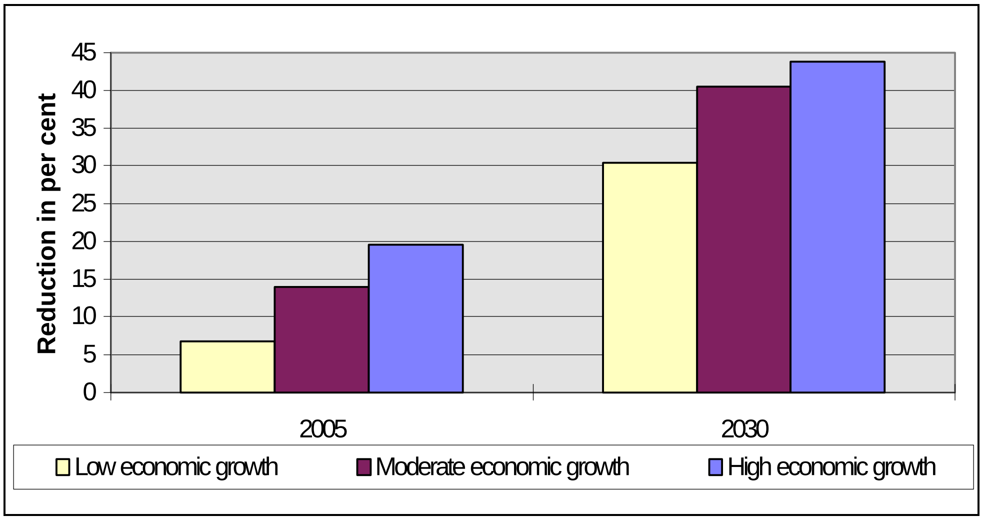


Fig. 5.2. *Reductions in CO2 emissions required by 2005 and 2030 to meet reduction targets given various economic scenarios.*

The basic premise of the projections should be the moderate growth scenario. If the growth turns out to be higher, further reductions may be achieved, primarily through greater use of economic instruments.

A premise of Danish transport policy is the continued provision of an efficient and flexible transport system to the public and commercial sector. Passenger vehicle traffic will therefore continue to account for most of the passenger and goods transport. The Transport Action Plan contributes towards making cars more environmentally sound, and towards limiting the growth of the overall volume of road traffic.

Transport costs

It is the Danish Government's opinion that the total social costs, including the environmental costs of transport, should be integrated in the pricing of transport. To the extent that costs are not reflected in the price of the transport mode in question, they may – as a matter of principle – be incorporated in the form of taxes.

It is estimated that it is possible to meet the target of stabilising the level of carbon dioxide emissions at the 1988 level by 2005 if the price of petrol rises roughly in tandem with the improvements in energy efficiency of new cars.

Assuming continued gains in the energy efficiency of new cars, the price of petrol must rise if the principle of unchanged fuel costs per kilometre for new cars is to be followed. At the same time, it is assumed that the price of diesel will follow the rise in petrol prices.

To the extent that increases are not realised through increases in producers prices, other means to influence the variable transport costs will be considered. The rate of possible tax increases will be adjusted to the level of the prices of petrol and diesel in our neighbouring countries, so as to avoid undesirable cross-border trade. In this connection, Denmark will work on raising the minimum rates for fuel taxes in accordance with the EU Mineral Oil Directive. Furthermore, the Danish Government will work actively to create a coordinated policy in the area together with our neighbouring countries.

Improved energy efficiency

Even without any specific action taken, there will be gains in energy efficiency due to ongoing R&D in carproduction. It is thus assumed that new petrol powered cars drive an average of 14 kilometres per litre in 1995 and 15 kilometres per litre by 2005. Some uncertainty is involved in calculating the energy efficiency of new cars, however.

The Danish Government proposes to enter into specific agreements at the EU level with car manufacturers on limiting the CO_2 emissions per car. It is assumed that this will result in a reduction of at least 25% compared to the 1990 level by 2005. Consequent to upon the assumption that the price of petrol will follow the average gain in energy efficiency, it is futher assumed that the rise in energy efficiency at the EU level will be reflected fully in the average energy efficiency of new cars in Denmark at a level of 18 kilometres per litre by the year 2005.

An average energy efficiency of new cars of 20 kilometres per litre is to be achieved by further specific decisions on the use of financial incentives and information campaigns on the fuel efficiency of cars. From July 1997, the base for annual road tax for all new cars has shifted from weight to energy efficiency. However an analysis based on international comparisons indicates that it is relatively difficult to change buying habits in connection with car purchases by differentiating the consumer prices on the basis of energy efficiency. The goal – 20 kilometres per litre – may therefore turn out to be ambitious.

An energy efficiency of 20 kilometres per litre for new cars entails an increase in energy efficiency by 2005 of approx. 30% (20 km per l vs. 15 km per l). Only part of this improved energy efficiency will be effective for the car fleet as a whole by 2005. Considering the expectations of a relatively high level of car sales, together with the fact that new cars are driven more than older cars, it is assumed that 30 to 35 % of the increase in energy efficiency for new cars by 2005 effect a rise in average energy efficiency of 11% for the car fleet as a whole.

As a consequence of higher fuel efficiency and the correspondingly lower costs of owning and driving a car, the population will drive more. On the basis of various surveys it is assumed that every time the energy costs drop by 1% the car travel activity rises by 0.4%. The expected 11% rise in energy efficiency for the car fleet as a whole thus entails a 4% rise in car travel activity. When this rise in car travel activity is combined with the 11% gain in average fuel efficiency, the total energy savings on passenger car transport will be approx. 6 to 7%. As passenger cars are responsible for approx. 55% of emissions, the total reduction in CO_2 emissions from the transport sector will be 3 to 4%. The total long-term effect is estimated to be approx. 9%, and the rest of the increase (from 3 – 4% to 9%) is expected to become effective mainly during the period 2005 to 2010.

Danish fuel prices up to 2005

The Energy Agency assumes that producers' prices for diesel and petrol will in relation to 1996 lead to an increase in consumer prices of approx. 25% by 2005 compared with 1996 prices. Besides this increase, the use of financial incentives to lower increase in car travel activity is assumed to entail a futher increase in the fuel prices of about DKK 0.50 (USD 0.07).

On the basis of various surveys it is assumed that when the energy price rises by 1%, the fuel consumption for passenger cars falls by 0.4 %, and for vans and lorries by 0.2%.

The expected increase in fuel prices thus entails a fall in fuel consumption of approx. 11% for passenger cars and 6 to 7% for van and lorry transport. As passenger cars are responsible for approx. 55% of the emissions, and vans and lorries are responsible for approx. 35%, this means a reduction in total emissions of approx. 8%.

Other areas for special efforts up to 2005

The other policy areas singled out for special efforts include:

- Physical planning
- Research and development
- Promotion of energy efficient behaviour, including energy efficient driving
- Promotion of a reduction of the transport need of households and companies
- Promotion of bicycle transport
- Promotion of energy efficient public transport
- Promotion of coastal sea transport
- Promotion of optimisation of environmentally sound goods transport

It is estimated that these areas combined can yield CO_2 emission reductions of up to 4%.

Total effect

The estimated total effect of the above mentioned policies and influences a reduction in CO_2 emissions of about 15% in comparison to the expected emission level by 2005, the net effect being stabilisation at the 1988 level.

5.1.3 **Agriculture**

The main areas of agriculture affecting CO_2 emissions are field burning of straw and the production of non-food crops. Field burning of straw has been prohibited in Denmark for several years. As a consequence, straw is increasingly ploughed into the ground or used as a fuel. This increases carbon accumulation in the soil and reduces the emissions of CO_2 and N_2O, while using the straw as a fuel reduces emissions from fossil fuel combustion.

The growth of non-food crops on about 40,000 ha together with the use of part of these non-food crops for energy purposes (biofuels) replaces fossil fuels and reduces CO_2 emissions.

5.1.4 **Land use change and forestry**

Forestry.

The majority of forests in Denmark are reserved for multiple use forestry and are protected against deforestation by the Forest Act (revised May 1996). The forest area has been increasing steadily during this century and the Danish Parliament recently decided to double the forest area over the next of 80 – 100 years.

Achievement of this objective necessitates an afforestation rate of 40 km^2 per year through public and private initiatives. According to the latest revision of the Forest Act in 1996, new and improved incentive structures will be put in place to promote private afforestation on agricultural lands. It is estimated that these new incentives will ensure a sufficient rate of afforestation.

Regarding forestry, it could be mentioned that an increasing amount of wood chips is expected to be used in the energy production**.**

5.2 Methane, CH_4

Agriculture

Existing policies have secured the construction of 20 large community size biogas plants that produce electricity and heat for villages or towns, thereby simultaneously reducing CH_4 emissions and emissions from fossil fuel. The *Energy 21* foresees a further expansion in the number of such plants., leading to a significant reduction in CH_4 emissions from the storage of manure.

Waste management

The main objectives in the field of waste and recycling are to reduce the quantity of waste production, to minimise the environmental impact of waste disposal, and to make use of the resources contained in waste.

The general order of priorities is as follows:

1. Cleaner technologies
2. Recycling
3. Incineration with energy use
4. Landfilling

The objectives and the initiatives required are described in the Danish Government's Action Plan for Waste and Recycling 1993 – 1997.

The plan introduces a series of initiatives reflecting the above priorities, based on the overall principle that all wastes should be managed in a manner which is safe from the point of view of occupational health.

In 1995 the total waste production was about 11.2 million tonnes. The objective is that about 50% of the total amount of wastes generated in the year 2000 should be recycled. The remainder should primarily be incinerated and landfilling should be minimised.

The aim is to incinerate all combustible wastes which is not recycled, and which does not present particular incineration problems, with use being made of the energy produced.

In connection with incineration, the energy content of non-recyclable wastes should be used effectively like other biofuels, since most of the waste is CO_2-neutral and therefore causes lower CO_2 emissions than burning of fossil fuels.

Landfilling of combustible waste has been prohibited from January 1997 in order to reduce landfill gas emissions (CH_4).

The emission factors have partly been calculated on the basis of the carbon content of the different types of waste and partly on the assumption that 50% of the carbon is converted to CH_4 and that 10% of the Danish CH_4 is converted to CO_2 by bacteria.

Environmental Impacts

Recycling implies a number of significant elements of raw materials and energy saving.

<u>Organic waste</u>: In the case of biogas and nutrient effluent production or composting of organic wastes, the following environmental aspects of CO_2 emissions should be taken into consideration in connection with incineration or landfilling:

- Compost/nutrient effluent may replace imported fertilisers, the production of which is energy-intensive
- Energy in connection with biogas production and incineration can be utilised, whereas by composting energy is consumed
- CO_2 emissions extend over longer periods and will be slightly lower with biogas production and composting than with incineration, since part of the slowly degradable

carbon remains in the compost. Addition of compost to cultivated soils slowly increases the humus content of the soil.

- Avoiding landfilling of organic waste results in lower emissions of CH_4.

In 1995, 575,000 tonnes of organic waste was treated in composting or biogas plants. Of this 66% was garden and park waste.

Paper/cardboard: By recycling paper it is possible to reduce the energy consumption for paper production to between one third and one half. Such energy savings by far outweigh the energy used for CO_2-neutral incineration of waste paper. Recycling of paper/cardboard therefore reduces CO_2 emissions. In 1995, the quantity of paper recycled amounted to about 557,000 tonnes, corresponding to 45% of the potential amounts.

Glass: Recycling of glass contributes to reducing the consumption of energy. Reductions compared to production of new glass containers/non-returnable containers are larger by reuse (i.e. refilling) than by recovery (i.e. use of cullet in the production process). In addition to beer and mineral water containers in return and deposit schemes, a total of about 104,000 tonnes is recovered, corresponding to approx. 63% of the potential.

Plastic: Recycling plastic reduces the consumption of energy, since the energy consumed in processing of plastic waste is about one third of the energy consumed in the production of completely new plastic raw materials. In addition to the energy content of raw materials, recycling also results in savings of process energy. Plastic recycling amounts to approx. 29,000 tonnes.

Iron and metal: Iron and metal mining is based on the considerable amounts of energy that may be saved by recycling. Recycling of iron and metal scrap amounts to approx. 983,000 tonnes.

The objectives laid down in the Action Plan result in increased recycling, amounting to almost 2 million tonnes per year. The corresponding CO_2-limiting effects have not been quantified. The quantities of waste for incineration are not significantly changed. The need for landfilling will be reduced by 50%, which means that about 1.8 million tonnes of waste per year is not landfilled but recycled or incinerated. Of this total, combustible waste removed from landfills amounts to approx. 0.8 million tonnes per year.

Status

The objective of about 50% recycling was already reached in 1994. As a result of the Action Plan for Waste and Recycling, recycling now increased to 61%. Incineration reached 20% in 1995, with the goal for the year 2000 being 25%. Landfilling fell to 18% in 1995, the goal being to reduce the landfilling further. In 1995, 1% of the waste was treated as hazardous waste.

Recycling of some waste fractions has already reached the objective for the year 2000. These fractions are demolition waste, garden and park waste, residual products from power generation, and sewage sludge.

In 1995, the amount of waste reached 11.2 million tonnes. According to the Action Plan for Waste and Recycling, the amount in the year 2000 is expected to be approx. 9.8 million tonnes.

Recycling of organic household waste is far from reaching the objective for the year 2000. Landfilling of waste from institutions, industries, trade and commerce will have to be reduced significantly to reach the target for the year 2000.

The waste objectives will be achieved using a series of instruments, including:

- Agreements with industry, supplemented with legislation on take-back obligations, and producer liability for a number of products, based on recycling objectives stipulated by the Minister for Environment and Energy
- Increase and differentiation of waste charges, with a view to increasing landfill charges compared to incineration charges

- Legislation providing for separation of non-recyclable waste in combustible and non-combustible fractions, and prohibiting landfilling of combustible waste
- Agreement with local authorities, or legislation on dual collection of organic waste and remaining waste from private households, with subsequent introduction of collection systems for paper/cardboard and glass
- New guidelines on the design and operation of landfill sites

Land fill gas

Thirteen Danish landfills currently generate electricity by extracting methane gas. The energy of the gas is about 550 TJ per year.

5.3 Nitrous oxide, N_2O

Agriculture

The Danish Action Plan for Sustainable Development in the Agricultural sector was approved by the Parliament in 1991. The plan aims at obtaining an agricultural sector which functions and develops in harmony with the ecological cycles in nature and at the same time is economical viable.

The plan emphasis that sustainable development must be based on:

- Production of healthy products of good quality
- Production in an ethical responsible way and without undesirable effects on the environment and on nature
- Important contributions to GDP, employment and the balance of trade

The Action Plan pays special attention to the main environmental problems in the Danish agricultural sector notably nitrogen emissions and the use of pesticides. A goal has been set to achieve a 47% reduction in nitrogen emissions by the end of the century and a 50% reduction in the use of pesticides by 1997. Policy measures and instruments are reviewed and strengthened, as appropriate, on a regular basis.

Less intensive farming and nature restoration, in particular on marginal soils, set-aside schemes combined with environmental obligations have also resulted in a reduction of the external effects of agricultural production.

Data on fertiliser sales indicate a substantial decrease and the utilisation of nutrients in livestock manure have improved. This development means less emission of N_2O.

5.4 Other greenhouse gases and precursors

5.4.1 HFCs.

With the aim of phasing out the use of CFCs as fast as possible, HFCs have been used to replace CFCs in some areas. Consumption thus increased from zero in 1990 to around 750 tonnes in 1995. During the last couple of years the Danish EPA has supported a number of research activities to develop products and production processes which do not use HFCs or other strong greenhouse gases, e.g. replacement of HFCs by natural cooling agents.

It is the aim of the Danish Government to phase out the use of HFCs within the refrigerating industries before 2006

Since 1977, it has been prohibited to use HFCs as a fire fighting agent and HFC-134a as a propellant/solvent in aerosol sprays.

5.4.2 **Precursors**

VOC

Denmark is a Party to the 1979 ECE Convention on Long-range Transboundary Air Pollution.

One of the Protocols agreed under this Convention is the Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes. Denmark signed the Protocol in November 1991 and ratified the Protocol in April 1996.

According to the Protocol, Denmark is now obliged to reduce VOC-emissions by 30% before the end of 1999 compared to the 1985 level.

Denmark will meet this obligation through legislation concerning:

- Catalytic converters for cars
- Limitation of emissions from refuelling at petrol stations
- Limitation of emissions from petrol storage and petrol distribution
- Voluntary agreements with Danish industry on the reduction of VOC-emissions from industrial processes by about 40% before 2000 compared to the 1988 level.

NO_x

The Convention on Long-range transboundary Air Pollution also includes a Protocol Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes. This entered into force in February 1991 and contains an obligation to stabilise NO_x emissions before 31 December 1994. Denmark has met this commitment.

Twelve Parties to the Protocol, including Denmark, have further agreed on a 30 % reduction in NO_x emissions by 1998. Denmark will meet this obligation through the existing Energy and Transport Plans.

6 Projections and assessment of measures

6.1 Carbon Dioxide, CO_2

6.1.1 The Energy Sector

Introduction

Assessment of measures

As part of the energy action plan, *Energy 21*, future Danish energy consumption and CO_2- emissions related to this consumption have been assessed for the period 1995 – 2030.

The development in energy consumption and CO_2 emissions described in this section is based on *Energy 21* although the projections for 1995 have been replaced by actual figures.

The short term goal of *Energy 21* is to reach the Danish Government's target of reducing CO_2 emissions from the energy-consuming sectors by 20% in 2005 as compared to the 1988 level. A number of initiatives aiming at reaching this goal have therefore been implemented in the Danish energy policy, as described in Chapter 5 and Annex F.

The assessment of the development for the period 2005 – 2030 is based on more general considerations, among others

- Conservation of heat and electricity
- Use of energy efficient appliances and processes
- Use of renewable energy.

It is assumed that international common efforts during this period will contribute substantially to reducing Danish CO_2 emissions.

For the transport sector, the Government has prepared a transport action plan, the objectives of which are to stabilise the sector's CO_2 emissions at the 1988 level by 2005, and to reduce emissions by 25% before 2030. Use of energy efficient cars is one of the major contributors to the emission reduction within the transport sector, and development of such cars, internationally, is therefore of major importance.

Calculation Method

The calculation method used for the projections is described in the report *Energy 21 – Preconditions and Results*, (Danish Energy Agency, 1997). In the following, a brief description of the calculation method is given.

Computer models

The projections are based on calculations carried out by a number of separate models, as illustrated in Fig. 6.1. The calculations are carried out specifically for the three years 2005, 2020 and 2030, with actual energy consumption in 1994 being used as the basis for the projections. For all other years within the period 1994 – 2030 the calculations are carried out by interpolation.

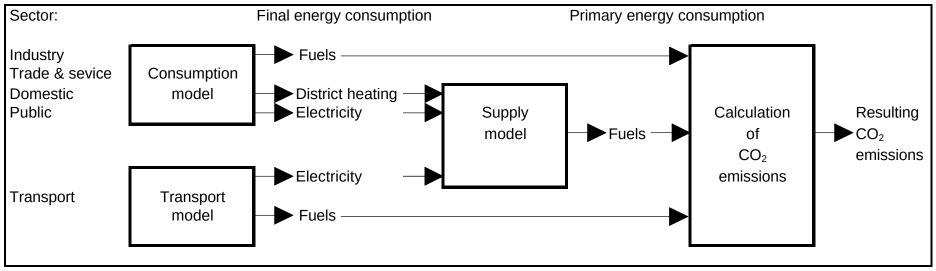


Fig. 6.1. *Overview of models used for the calculation of primary energy consumption and CO_2 emissions.*

Consumption model

Projections of the final energy consumption for all sectors except the transport sector are calculated in two steps using the consumption model:

First, a future energy consumption based solely on external factors is calculated. The actual 1994-consumption is used as starting point, and the development is based on assumed developments of external factors such as GDP, population, etc. Thus in this projection, no saving measures or fuel conversions are included.

Second, the changes in energy consumption due to improved efficiencies, altered consumer behaviour and conversions to other fuels and/or production methods are calculated. The calculations result in a specification of the total final energy demand, subdivided as electricity, district heating and different types of fuel.

Transport model

Projections of the final energy consumption within the transport sector are calculated in a separate transport model. The calculation principle is similar to the one used for the other sectors, i.e. the development in the need for transportation and the related energy consumption is first calculated, and the effect of improved efficiencies etc. is then added. The calculations result in a specification of the total final energy demand, subdivided as electricity and different types of fuel.

Supply model

The calculated demands for electricity and district heat are used as input to the supply model, which calculates the amounts of different types of fuels necessary for the production of heat and electricity. The calculation is based on detailed information for a large number of existing and planned power, heat and CHP plants.

Totals

The total CO_2 emission from fuel combustion in Denmark is then calculated from the total consumption of different types of fuels projected by the consumption model, the transport model and the supply model.

Key Variables and Assumptions in the Projections Analysis

Detailed assumptions used for the projections are described in *Energy 21 – Preconditions and Results*, (Danish Energy Agency, 1997). Some key assumptions are summarized in Table 6.1.

	1994	1995	2000	2005	2010	2020	2030
Fuel prices: [1)] Coal (USD per tonne) Crude oil (USD per bbl)	 - -	 41 18	 47 23	 50 28	 50 28	 50 28	 50 28
Exchange rate used for fuel price forecast (DKK/USD)	-	5.6	6.5	6.5	6.5	6.5	6.5
Population (millions)	5.20	5.22	5.30	5.39	5.42	5.47	5.51
Heated building areas: Dwellings (million m^2) Public sector (million m^2)	 255.3 44.8	 257.5 45.1	 268.7 46.6	 279.9 48.1	 283.4 49.6	 290.5 52.6	 293.0 54.8
Annual growth in GDP	-	2.2%	2.2%	2.2%	1.5%	1.5%	1.5%
Development of GDI for industry, DKK thousand million (1980)[2)]	119	122	138	154	168	197	227
Development of GDI for trade and service, DKK thousand million (1980)	119	122	139	156	180	228	278

Note1: Assumed Danish import prices, based on “World Energy Outlook 1995”, IEA, 1995.

Note 2: Comprising the sectors: Agriculture, fishing, forestry etc.; food, beverages and tobacco; construction; construction materials; iron and non-iron; chemical manufacturing; and other manufacturing. In “Energy 21 - Preconditions and Results”, Danish Energy Agency, 1997 developments of GDI are stated separately for each of the sectors.

Table 6.1. *Summary of key variables and assumptions employed in the projections analysis. The figures for 1994 are actual values. All other figures are forecasts.*

The economic fuel prices used for the *Energy 21* calculations are listed in Annex G. A description of the Danish energy tax system is given in Annex H.

Future Development

The energy initiatives will lead to:

- Increasing efficiencies of electric appliances and other energy equipment
- Reductions in energy consumption due to improved consumer habits
- Conversions to other fuels and/or energy supply systems at consumer level
- Increased use of combined heat and power production
- Increased use of natural gas and renewables for heat and power production.

A description of all Danish energy-related Acts and measures is given in Annex F. How these acts and measures contribute to the above described development is described below. The figures in square brackets refer to the numbers in the annex.

Increased efficiencies

Increased efficiency of electric appliances and other energy equipment will, depending on the specific appliance, lead to reductions in energy consumption of 15 – 78% by the year 2030 as compared to the average 1995-consumption.

The improvements during the period 1996 - 2005 are assumed to result from:

Green taxes, subsidies and voluntary agreements [10] - [13]

EU labelling schemes for refrigerators and freezers [24]

Efficiency standards for electric appliances and other equipment [25]

Act on promotion of energy and water conservation in buildings [1]

Improved windows initiative [33]

Revised building code [21]

Product-oriented initiatives: Labelling, economic incentives, buying clubs and voluntary agreements [29] - [30], [33]

Initiatives directed at local authorities [4], [5]

Mandatory energy management in State-owned buildings [2]

Information campaigns [6], [22], [28]

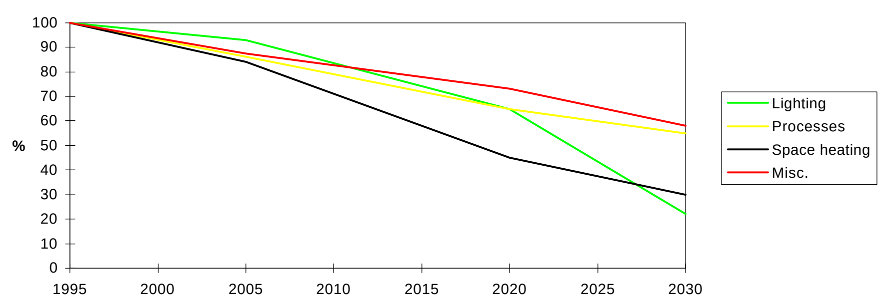
Subsidies for energy savings in pensioners' dwellings [7]

Autonomous technological development

Box 6.1. *Improvements due to increased efficiency. Figures in [ ] refer to Annex F.*

Improvements after 2005 are assumed to result from continuation of the above mentioned measures, intensified measures where necessary plus increased influence from international measures.

The increases in efficiency have been assessed separately for the trade and industry sector, the residential sector and the institutional sector. The detailed assessment is presented in *Energy 21 – Preconditions and Results* (Danish Energy Agency, 1997). As an example, Fig. 6.2 shows the development in specific energy consumption for equipment used in trade and industry.



Note: The development for space heat and miscellaneous are approximate values.
Note: Development only due to more efficient equipment, consumer behaviour is not included.

Fig. 6.2. *Planned development in specific energy consumption in trade and industry.*

Improved consumer habits

Apart from general response of energy taxation, reductions in energy consumption due to improved consumer habits are assumed to be rather small.

The reductions due to improved consumer habits are assumed result from:

"Act on promotion of energy and water conservation in buildings" [1]

Individual metering [26]

Informative electricity bills [27].

Box 6.2. *Improved consumer habits. Figures in [ ] refer to Annex F.*

Fuel conversions

Consumer-level conversion to other fuels and/or energy supply systems comprises conversion from the use of oil, coal and electricity (for space heating) to the use of natural gas, district heating, heat pumps (based on electricity and natural gas), solar heat, straw, wood and other kinds of biomass. After 2005 conversion from natural gas to district heating is also assumed to take place due to expansion of the district heating networks.

Fuel conversions during the period 1996 - 2005 are assumed to result from:

Taxes, subsidies and voluntary agreements [10] - [13]

Subsidies for connection of older buildings to district heating [9]

Subsidies for renewable energy, including demonstration projects [19]

Subsidies for district heating projects in areas not supplied by natural gas, large existing combined heat and power plants or heat from waste incineration[15]

Subsidies for conversion of electrically heated buildings [32]

Ban on conversion to electric heating [31]

Autonomous development

Box 6.3. *Fuel conversions. Figures in [ ] refer to Annex F.*

Improvements after 2005 are assumed to result from continuation of the above mentioned measures plus intensified measures where necessary.

To illustrate the effect of fuel conversions, the assumed conversions for industry are shown in Fig. 6.3. The use of heat from local CHP plants instead of oil and coal constitutes a major part of the conversions. The detailed assessment of fuel conversions is presented in *Energy 21 – Preconditions and Results* (Danish Energy Agency, 1997), for the industrial, commercial, institutional and residential sectors, respectively.

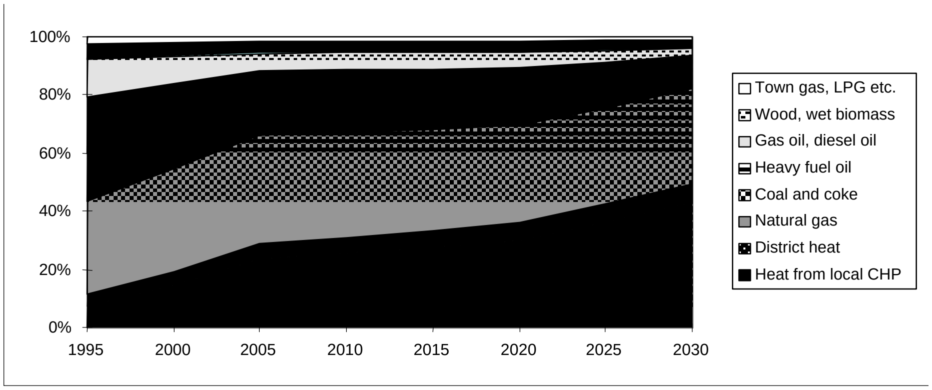


Fig. 6.3. *Conversion to other fuels and energy sources for process energy and space heating in industry.*

Combined heat and power production

The increased use of combined heat and power production contributes substantially to the improvement of overall energy efficiency.

Increased use of combined heat and power production will result from:

Individual consumers converting to district heating (as described above), in areas where the heat is produced in combination with power

Increased industrial co-generation, promoted by green taxes, industrial subsidies and voluntary agreements [10] - [13], and by subsidies for electricity production [14]

Small scale co-generation in the residential and institutional sector, promoted by autonomous development and by subsidies for electricity production [14]

Conversion of heat-only boilers using straw and wood (at district heating plants) to combined heat and power plants using straw, wood and biogas, cf. the Heat Supply Act, promoted by subsidies for electricity production [14]

Box 6.4. *Combined heat and power production. Figures in [ ] refer to Annex F.*

The development in electricity production is shown apportioned by source in Fig. 6.4.

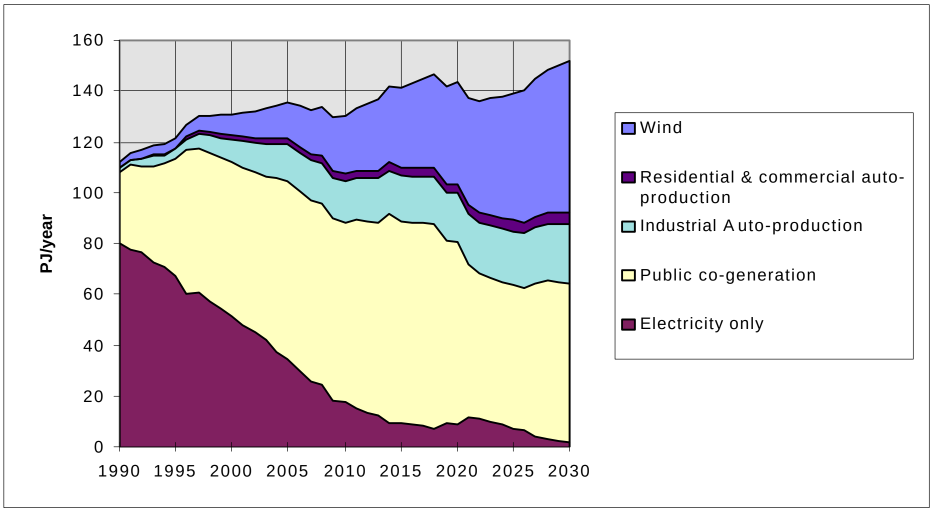


Fig. 6.4. *Electricity production by source.*

Use of natural gas and renewables

The increased use of natural gas and renewables for heat and power production will result in a gradual phasing out of coal and oil by 2030. Today, coal is mainly used at the large power plants, while only a minor amount of oil is used in electricity production. In *Energy 21* it is assumed that all new plants to be built until 2030 will use natural gas and/or renewables. The use of coal and oil will then be reduced as the existing plants are being scrapped. Additionally, a large increase in use of wind turbines plus a certain use of photovoltaic energy, geothermal heat and wave energy is assumed in the last part of the period. After 2005, energy crops will contribute to the supply with renewable fuels.

Development in the consumption of different fuel types for electricity and district heating is shown in Fig. 6.5.

The development in use of natural gas and renewables until 2005 is based on the following Acts and measures:

The Electricity Supply Act and the Heat Supply Act, due to which the use of specific fuels can be stated

CO_2 taxes [8], [10]

Subsidies to new CHP plants using waste or biomass [15]

Wind energy planning [17]

Subsidies for renewable energy, including demonstration projects [19]

Formation of a council for sustainable development and renewable energy [23]

Expansion of district heating will also contribute indirectly to the increase in use of natural gas and renewables.

Box 6.5. *Use of natural gas and renewable energy. Figures in [ ] refer to Annex F.*

Development in the consumption of different fuel types for electricity and district heating is shown in Fig. 6.5.

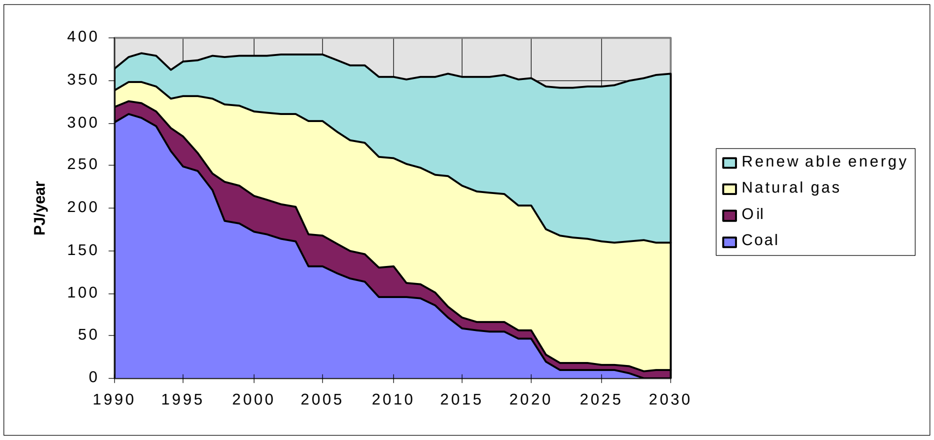


Fig. 6.5. *Fuel consumption for electricity and district heating.*

Transport sector

Within the transport sector, a large number of measures are assumed to be implemented in order to obtain the CO_2 emission reduction goal for this sector.

The initiatives within the transport sector include:
Use of more energy-efficient vehicles
Use of differentiated car taxes
Initiatives aiming at replacing vehicle transport by other means of transport, e.g. bicycle transport.

Box 6.6. *The transport sector.*

Main Results of the Projections Analysis

Primary energy consumption

On the basis of key variables and assumed future developments, projections have been made of total primary energy consumption for the period 1996 to 2030. This is shown apportioned by fuel type in Fig. 6.6.

Renewable energy

The use of renewable energy is projected to grow rapidly during the period. The expected use of renewable energy is shown apportioned by source in Fig. 6.7.

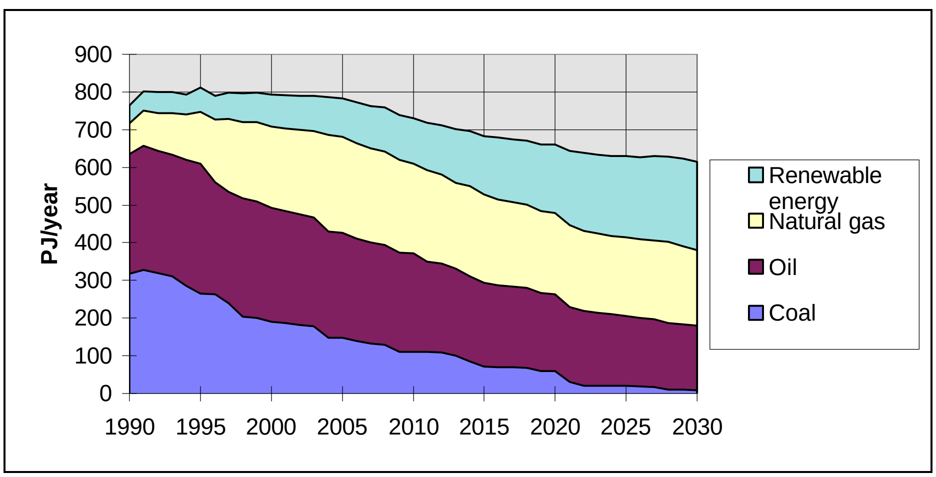


Fig. 6.6. *Expected primary energy consumption apportioned by fuel type.*

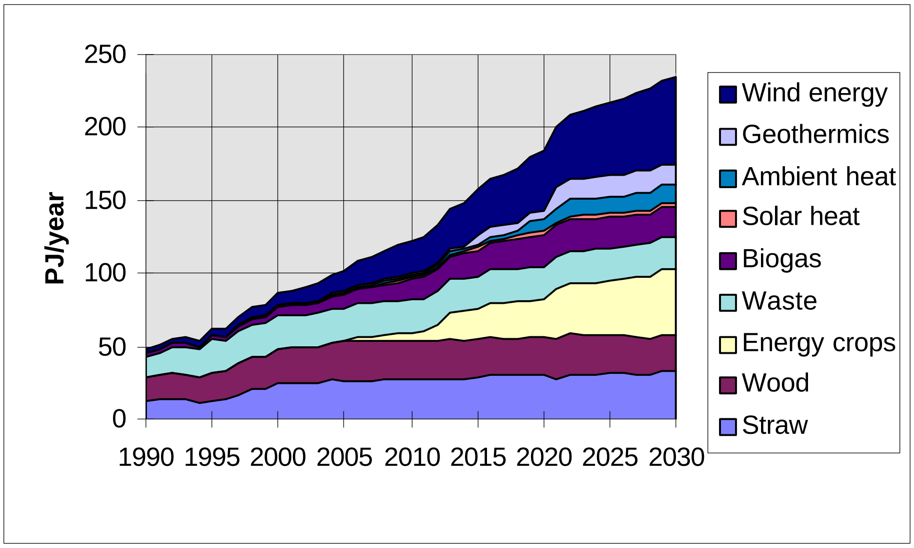


Fig. 6.7. *Use of renewable energy shown apportioned by source.*

CO_2 emissions

The expected CO_2 emission related to the energy consumption is shown in Fig. 6.8 which also shows the expected CO_2 emission for a "Business-as-Usual" scenario, updated from the *Energy 2000 Plan* drawn up in 1990. This scenario illustrates how CO_2 emissions would have developed from 1990 if no steps had been taken in order to reduce the emissions. Emissions from international transport are not included in Fig. 6.8.

The values for the period 1990 to 1995 are historical data corrected for variations in space heating demand and electricity exchange due to climatic variations. For comparison, uncorrected values for this period are shown as well.

The long-term development in the period to 2030 is expected to result in gradually increasing electricity export from Denmark. This export is not due to climatic variations, but arises from the technical lay-out of the power production system, with increasing shares of cogeneration and wind energy. Since the this export is not caused by climatic conditions, the projected CO_2 emissions are not corrected for this export.

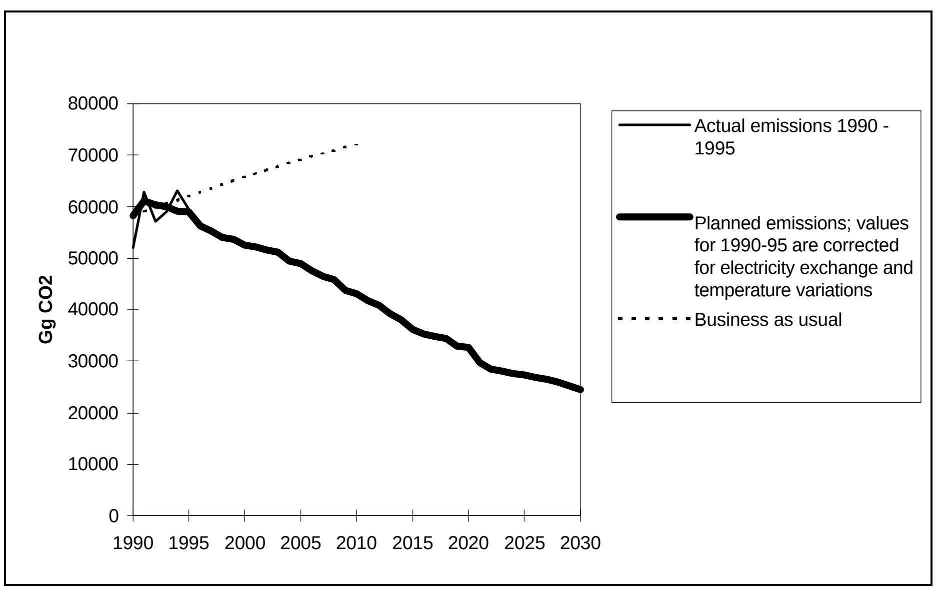


Fig. 6.8. *Planned development in CO_2 emissions from fuel combustion.*

The national target of reducing CO_2 emissions from fuel combustion by 20% from 1988 to 2005 will be fulfilled by implementing the *Energy 21* Action Plan, as the emissions covered by the target are projected to decrease slightly more. The targeted emissions include emissions from international air transport, while flaring is excluded. The target for 2005 as well as the base level of 1988 are defined in terms of emissions corrected for both electricity exchange and outdoor temperature variation.

CO_2 content of fuel mix

The average CO_2 content of the fuels consumed will decline markedly during the period. In 1995, the CO_2 content of the fuel mix was approx. 72 kg/GJ, which is close to the CO_2 content in fuel oil. In 2030, the CO_2 content will be approx. 35 kg per GJ, due to a large contribution from renewable energy. The expected development in CO_2 content of the fuel mix is shown in Fig. 6.9.

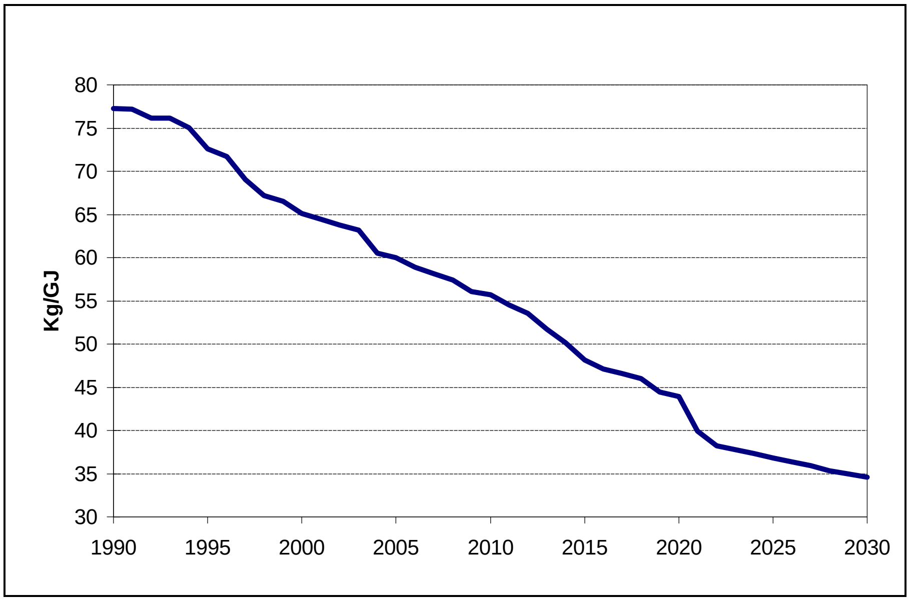


Fig. 6.9. *Development in CO_2 content of the fuel mix.*

6.1.2 **Land use change and forestry**

<u>CO_2 uptake due to afforestation and in existing forests</u>

When establishing new forests through afforestation, the CO_2 uptake per ha is not linear over time, but follows a non-linear pattern over a 70 – 150 year period with low starting and ending values, but with high net uptake in the middle period around 30 years after planting. While the average uptake over a 150 year period is around 0.004 Gg CO_2 per ha, much higher values are reached in the peak period. As a rough approximation projections have been made using the average value of 0.0041 Gg CO_2 per ha per year until 2009, and a higher average, influenced by peak uptake, of 0.016 Gg per ha per year from 2010 to 2030.

6.1.3 **Total Carbon Dioxide Emissions**

The expected development in CO_2 emissions is shown apportioned by purposes in Table 6.2. A more detailed breakdown of the emissions from the fuel combustion is given in Annex B, which contains sectoral energy balances and resulting CO_2 emissions for the years 1990, 2000, 2005, 2010, 2020 and 2030.

CO_2	1990	2000	2005	2010	2020	2030
Total National Emission[1] in Gg	**59958**	**54309**	**50547**	**44660**	**34158**	**26090**
1 All Energy (Fuel Combustion + Fugitive)	50997	52997	49235	43348	32847	24778
A Fuel Combustion	50757	52178	48417	42529	32732	24778
1 Energy Industries	32904	26365	22971	18694	12158	6832
2 Manufacturing Industries and Construction	5845	6508	6988	6672	6046	5823
3 Transport (Domestic)	10490	11021	10282	9863	8928	7735
4 Commercial/Institutional, Residential, Agri./Forestry/Fishing	9473	8284	8175	7300	5600	4388
5 Other						
B Fugitive Emissions from Fuels	240	819	819	819	115	0
1 Solid Fuels						
2 Oil and Natural Gas	240	819	819	819	115	0
2 Industrial Processes	1005	1312	1312	1312	1312	1312
A Mineral Products	1005	1312	1312	1312	1312	1312
International bunkers[2] in Gg	**4975**	**8327**	**9645**	**11094**	**12530**	**13942**
A Aviation Bunkers	1915	2379	2750	3100	3700	4188
B Marine Bunkers	3059	5948	6895	7993	8830	9753
Total National Removal[2] in Gg	**-924**	**-1046**	**-1128**	**-2063**	**-2703**	**-3342**

General note: Numbers in colums may not add up to the total due to rounding and may diverge from table 4.2 due to the use of different calculation methods.

Note 1: The 1990 emissions are corrected for electricity exchange and outside temperature variation.

Note 2: Not included in the national totals.

Table 6.2. *Projected CO_2 emissions from Denmark for the period 2000 – 30 compared to the emissions in 1990.*

As a contribution to the overall stabilisation of CO_2 emissions by the year 2000 for the EU countries, Denmark has committed itself to achieve a 5% reduction in 2000 compared with 1990.

As can be seen from the table, the Danish CO_2 emission will decline from 59,958 Gg in 1990 (corrected for electricity exchange and outside temperature variation) to 54,309 Gg in 2000. This corresponds to a decrease of 9.4%, and the 5% target is therefore expected to be fulfilled. The CO_2 benefit of increasing the forest area has not been taken into account in these figures.

6.2 Methane, CH_4

6.2.1 Agriculture.

Due to the EU ceiling on the national milk production and the increased milk production pr. milking cow both the number of milking cows and the cattle stock are expected to decrease in 2010. As the same emission factors are used for 1990 – as in Chapter 4 – and 2010, methane emissions are reduced accordingly compared to the 1990 – level.

On the other hand, however, the production of pigs is expected to grow substantially from 1990 to 2010, and the reduction in methane emissions gained from cows/cattle is largely offset by the increase in the methane emissions from pigs.

CH_4	*1990*	*2000*	*2005*	*2010*
Total National Emission in Gg	**424**	**408**	**377**	**362**
1 All Energy (Fuel Combustion + Fugitive)	23	42	53	52
A Fuel Combustion	11	27	39	39
1 Energy Industries	1	2	2	2
2 Manufacturing Industries and Construction	1	12	22	23
3 Transport (Domestic)	2	2	2	1
4 Commercial/Institutional, Residential, Agri./Forestry/Fishing	7	11	13	13
5 Other				
B Fugitive Emissions from Fuels	12	15	14	13
1 Solid Fuels	3	4	3	2
2 Oil and Natural Gas	9	11	11	11
4 Agriculture	329	299	267	260
A Enteric Fermentation	167	143	128	139
B Manure Management	161	156	138	121
6 Waste	72	66	57	50
A Solid Waste Disposal	71	65	55	48
B Wastewater Handling	2	2	2	2
International bunkers[1] in Gg	**0**	**0**	**0**	**0**
A Aviation Bunkers	0	0	0	0
B Marine Bunkers	0	0	0	0

General note: Numbers in colums may not add up to the total due to rounding and may diverge from table 4.3 due to the use of different calculation methods.
Note 1: Not included in the national totals.

Table 6.3. *Projected methane emissions from Denmark over the period 2000 –10 compared to the emissions in 1990.*

6.2.2 Waste.

The effect of the Action Plan for Recycling and Waste is expected to be a substantial reduction in landfilling of waste from the domestic sector, gardens and the commercial sector before 2000. After 2000, the landfilling from these sectors is expected to cease completely and the most important sources would then be bulky waste, industrial waste, waste from building and construction, sewage treatment and ash & slag.

Using a half-life of 10 years, the total integrated CH_4-emissions from open landfills are estimated to be as shown in Table 6.3.

Total Danish methane emissions in 2000, 2005 and 2010 are therefore predicted to be 408, 377 and 362, respectively.

6.3 Nitrous oxides, N_2O

Danish initiatives to substantially reduce the use of in particular commercial fertiliser before 2000 are expected to significantly reduce N_2O emissions from the agricultural sector from an estimated 30 Gg in 1995 to around 26 Gg per year from 2000 onwards.

N_2O	1990	2000	2005	2010
Total National Emission in Gg	**34**	**28**	**28**	**28**
1 All Energy (Fuel Combustion + Fugitive)	2	3	3	3
A Fuel Combustion	2	3	3	3
1 Energy Industries	1	1	1	1
2 Manufacturing Industries and Construction	0	0	0	0
3 Transport (Domestic)	0	1	1	1
4 Commercial/Institutional, Residential, Agri./Forestry/Fishing	0	0	0	0
5 Other				
B Fugitive Emissions from Fuels	0	0	0	0
1 Solid Fuels				
2 Oil and Natural Gas	0	0	0	0
4 Agriculture	32	26	26	26
D Agricultural Soils	32	26	26	26
International bunkers[1] in Gg	**0**	**0**	**1**	**1**
A Aviation Bunkers	0	0	0	0
B Marine Bunkers	0	0	0	1

General note: Numbers in colums may not add up to the total due to rounding and may diverge from table 4.4 due to the use of different calculation methods.

Note 1: Not included in the national totals.

Table 6.4. *Projected N_2O emissions from Danmark over the period 2000 – 10 compared to the emissions in 1990.*

Total Danish N_2O emissions 2000 – 10 are predicted to be 28 Gg.

6.4 **Other emissions**

The projections also includes NO_x, CO, NMVOC and SO_2 - emissions.
In Table 6.5 the national totals of these projections are shown.
The projections are based on the Danish action plans and include the fullfilment of the Danish commitments under the Convention on Long-Range Transboundary Air Pollution.

	1990	2000	2005	2010	2020	2030
NO_x	276	234	229	216	194	157
CO	763	617	528	445	398	350
NMVOC	176	143	127	115	109	105
SO_2	181	89	87	86	61	24

Table 6.5. *Projections of Danish NO_x, CO, NMVOC and SO_2 - emissions 2000 – 30 in Gg compared to the emissions in 1990.*
Note: Numbers in colums may diverge from table 4.5, 4.6, 4.7 and 4.8 due to the use of different calculation methods.

7 Expected impacts of climate change and vulnerability assessment.

7.1 Climate change in Denmark

Climate models and climate scenarios

The future climate is projected using climate models. Global climate models are mathematical equations based on physical laws and empirical relationships describing the climate system. State-of-the-art climate models are very complex, and running the models requires considerable computer resources.

Confidence in climate models has increased in recent years. The best models are now able to simulate the most important features of the present climate, including seasonal and large-scale geographical variations. Model resolution is limited by the available computer resources, however, and it is presently not possible with global models to describe regional details with sufficient accuracy. Methods to "interpret" global model results regionally have therefore been developed and used to establish climate scenarios for Denmark based on recent global model experiments.

The "business as usual" scenario

According to the latest findings of the IPCC, the global mean surface temperature is projected to increase by 2 °C by 2100, and sea level will rise 50 cm using the "business as usual" emission scenario (IS92a). For Denmark the annual mean temperature is projected to increase by almost 2 °C by 2050. Precipitation will increase in winter and decrease in summer. A sea level rise of 9 – 18 cm is projected, with the largest rise in the southern part of the country.

By the end of next century the annual mean temperature in Denmark is projected to be 2.8 °C warmer than today. In contrast to earlier estimates, the annual mean precipitation is projected to decrease slightly. Sea level is projected to rise 33 – 46 cm.

Unpleasant surprises such as weakening of the Gulf Stream have not been taken into account.

7.1.1 Impacts and possibilities of adaptation in Denmark

Denmark and the World

Different areas of the World will be differently affected by possible climate changes. Evaluation of the global impact must therefore necessarily be based on individual investigations. Parallel to, and to some extent as a basis for international activities, individual countries therefore carry out national investigations.

Such an investigation has recently been carried out in Denmark based on the above mentioned climate change scenarios.

Denmark only accounts for about 1/1000 of the World population and covers even less of the global land surface. Climatic impacts in Denmark are therefore insignificant in economic evaluations of the seriousness of the total global impact, and in discussions of which degree of intervention is justified. On the other hand, it is imperative to know as much as possible about impacts in Denmark when planning a policy for adaptation to unavoidable impacts. Such information can also be useful in evaluations for other countries.

Human health and well-being

The predicted climate changes will by and large mean that the climate of Denmark will become like the present climate of southern England. In itself this is unlikely to pose any health problems. A certain risk of diseases transferable by insects (malaria) cannot be excluded, and there may be infections as a consequence of increased tourism and immigration. The generally high degree of hygiene in Denmark combined with an expected development of vaccines will probably render this problem insignificant.

The "technical" sectors

In the energy, industry and transport sectors it will be possible to adjust to changing climate as part of normal maintenance and renewal. Moreover, in Denmark these sectors will mainly benefit from a milder climate.

Water resources

Temperature changes per se are not usually decisive, but must be considered in connection with changes in precipitation – not only the total amount – but also the time pattern. Here soil properties and the possibilities of runoff play a significant role. Since the new scenarios for Denmark – in contrast to the previous scenarios – imply a slight reduction in precipitation, problems cannot be excluded.

In a case study, an increase in evaporation of 7% up to year 2100 has been calculated. With a simultaneous reduction in precipitation this results in a reduction in runoff of 40%. The largest effect appears during the summer and will presumably result in a much bigger need for irrigation. During winter and spring, when the temperature and precipitation increase, the soil water deposits will be saturated; this will result in increased evaporation and surface run-off; thereby reducing total formation of groundwater. Runoff from more sandy soils will be dominated by surface runoff and variation in the water flow will increase.

Agriculture

The expected climate changes may lead to a rise in potential yield in Danish agriculture.This will be largest in vegetative crops and unchanged or slightly reduced for most cerial and seed crops. In combination with the fertilisation effect of the increasing carbon dioxide levels, this may lead to an increase in potential yield of 5 – 20% by the middle of the next century. Simultaneously, however, there may be increasing problems with attempts to reduce nitrogen leaching and the use of pesticides.

Forestry

Contrary to agriculture, forestry is characterised by very long production times with a rotation age for our trees of between 50 and 180 years. The trees currently being planted in Denmark, thus need to be suited for the climate at the end of next century. Moreover, there is a risk of increased attack from pests, which will thrive in a milder climate. With the uncertainties inherent in the climate scenarios, the best strategy is to increase the general adaptability of the forests – both by choice of tree species and by treatment of the stand. Norway spruce, which is the most common tree in Denmark, already appears to be threatened by mild winters. It is therefore important to convert the large Norway spruce plantations in Jutland to more stable mixtures with a large fraction of deciduous trees including oak and beach.

Terrestrial ecosystems

Denmark is mostly a cultivated landscape, with extensive management of the terrestrial vegetation. This means that in Denmark, changes in vegetation in the agricultural part of the landscape as a consequence of human impact on climate will presumably be minimal. Cultivated forests, however, may suffer from short-term anthropogenic climate changes. Natural ecosystems such as coastal heaths, bogs, mires and natural forests may be strongly affected by climate change. Consequently, Denmark has to a large extent both the knowledge and the technology required to meet negative impacts. It should, however, be taken into account that large constructions such as motor ways and urban areas can hamper natural adjustment.

Larger uncertainty lies in the future climatic development. Often it is not the average temperature or precipitation that determine the distribution of a species, but rather extremes such as unusually humid or mild winters, or very dry summers. Since the extremes can change in both directions for the different climatic factors, they may affect species with completely different demands. There is therefore a risk of reduction in the variability of our flora and fauna, but which species will suffer cannot be predicted.

Freshwater ecosystems

The expected climatic changes can result in strongly impaired living conditions for small animals and fish in watercourses. Because of the lower flow in the watercourses, they will generally be more vulnerable to impacts from releases of sewage effluent and land reclamation in the catchment area. The deterioration of water quality will be most pronounced in small watercourses, where frequent summer desiccation will dominate, especially on the island part of Denmark.

Watercourse velocity and reaeration will be reduced and as a consequence, the macroinvertebrates will become impoverished with fewer and more specialised species. The living conditions for salmon and trout will generally be impaired due to reduced spawning and growth conditions, reduced physical space and reduced foodstuf availability. An expected general reduction in diffuse nutrient loss to freshwater will counteract the negative effects of the temperature rise on the environment in lakes. Important countermeasures in freshwater ecosystems are: Reduction of loading by nutrients, organic compounds and other xenobiotic compounds; more efficient water resource housekeeping; and restoration of watercourses, river valleys and lakes.

Natural emissions of greenhouse gases

While changes in the atmospheric concentrations of greenhouse gases can give climatic changes, climate changes can in turn influence natural sources of greenhouse gases and thus create a positive or negative feedback.. It has not hitherto been possible to determine the magnitude or even the direction of such effects in Denmark. It is known, though, that the formation of nitrous oxide is directly related to the use of fertiliser in agriculture.

Coasts and coastal areas

Since the end of the last ice age about 10,000 years ago, the Danish coastline has changed markedly as a consequence of relative land settlements and elevations as well as the constant erosion by the sea. A global sea level rise will increase the problems along the Danish coasts.

An assumed sea level rise of 50 cm by the year 2100 (i.e. in the upper end of what can be expected) will result in coastal retreat over and about that already taking place. However, it will be possible to counteract this by coast nourishment, where sand is recovered from deep areas of the the sea floor and dredged onto the shore. The process must be repeated at regular intervals, however, and will therefore constitute an economic load. The safety level for the existing dyke and storm flood protection will be reduced, but the sea level rise will be so slow that there will be ample time to adjust the constructions to the changed conditions. Moreover, there has been a tendency to abandon old dykes protecting marginal areas. In coastal cities the effectiveness of drainage systems will be reduced. Necessary extensive renovation of worn-out parts of the sewage system must take into account the sea level rise.

7.2 **Climate change in Greenland**

An exception to the general trend in arctic climate change

The overall assumption of the most recent IPCC climate change report (Houghton *et al*. 1996) is that the on-going increase in atmospheric CO_2 leads to atmospheric warming, most drastic at high latitudes. Arctic and sub-Arctic regions are predicted to experience greater warming than the global average, although Greenland may be an exception as a result of changes in thermohaline circulation in the North Atlantic sea and its generally more maritime climate than other High Arctic regions. Statements in the present Chapter are further discussed in Heide-Jøregnsen & Johnsen (1997).

Climate scenario

Climate change in Greenland is predicted to cause an increase in the mean yearly temperature of between 1.8 – 3.6°C by the end of the next century. The greatest increase is expected at mid- and high latitudes in West Greenland. The increase will primarily be an increase in winter temperatures. A slight diminution of the north-south temperature gradient is expected. The predicted maximum increase in July temperature is about +2°C for Ilulissat (Jakobshavn). The frequency of extreme low temperatures is expected to decrease. Warm extremes may occur more frequently both winter and summer.

The ice cap will respond to warming through increased melt rates at the margins and accumulation rates in the interior. Melt rates will probably dominate. However, precipitation and melt rate predictions are not as reliable as temperature predictions.

Precipitation is predicted to increase by 2 – 24 mm per month, with most of the increase in the summer on the south and west coast but in the winter or all year round on the east coast and at high latitudes. Half the change will occur within the next 40 – 50 years. Other consequences of climate change include: lengthening of the snow-free season by a month or more, a slight increase in the length of the growing season by 1 – 2 weeks, a deepening of the soil active layer, and a shorter northward movement of the permafrost boundary.

Uncertainty for Southern Greenland

There is considerable uncertainty regarding predictions for Southern Greenland, which has experienced a cooling of 1 – 1.6°C in the past 60 years. Ocean models predict a cold centre SW of Greenland. The cooling effect around this centre will counteract and may even neutralise greenhouse warming in SEGreenland. This cooling may be related to the 80% reduction in deep water formation observed in the Greenland Sea during the 1980s. Hence, less warm Atlantic water is streaming north. The maximum temperature increase in South Greenland may therefore represent a return to the mean summer temperatures of 60 years ago, and the possibility of a temperature fall must be considered.

Ozone and UV-B

Depletion of the stratospheric ozone layer will continue in the first half of the next century, causing increased UV-B radiation, particularly towards the north, where the effect is increased by snow and ice albedo.

Sea surface temperature

At sea, a decrease in the north-south gradient of sea surface temperatures is expected. Changes in sea level are still unclear, but in Greenland a world-wide increase in sea level will most likely be counterbalanced by a land raise. Reductions in sea ice thickness, surface area and duration are also expected.

7.2.1 **Ecological implications**

Long-term predictions of Arctic plant performance require a knowledge of the natural variation and dynamics in Greenland ecosystems, as well as a not yet available understanding of feedback mechanisms on element cycling, microclimate, etc. Near-future changes (10 – 20 years) are expected to be modest, particularly in the south, but later the following changes may occur leading to warming:

7.2.2 **Changes in patterns of terrestrial ecosystems**

New dominant ecosystems

Initial changes at the population level in existing communities and ecosystems are expected to be followed by major changes in community structure, resulting in new types of dominant ecosystems. Disintegration of plant communities in the Arctic will also result in drastic changes for animal population.

Lichens and mosses may become less frequent in heath and wetland ecosystems, and dwarf shrub and shrub vegetation may be favoured at the expense of grasses and herbs. Consequently, graminoid-dominated wetland may become restricted, causing a decline in plant species diversity and the abundance of grazing animals and their predators. Certain dwarf shrubs possess chemical defence against herbivores.

Evergreen perennial plants may respond slowly or not at all with increased biomass and suffer a competitive disadvantage in communities with aggressive deciduous species, such as dwarf birch.

As the summer-winter temperature difference tends to decrease, coastal heath types, dominated by crowberry may expand in coastal regions.

Longer growing season, colonisation and migration

Increased length of the growing season will cause present distribution boundaries for a number of plant species and vegetation types to move northward and to higher altitudes. A direct result of such a migration could be competitive exclusion of northern species by southern species. Animals will experience extended feeding areas and season in more productive high latitudes.

As seed plants play a minor role in the High Arctic, lichens and mosses are expected to be the first to benefit from higher temperatures due to the existence of a dormant propagule bank. More dramatic changes are expected where colonizable bare ground exists, unless water supply is a limiting factor.

Arctic deserts, semi-deserts, and fellfields may be colonised by invading plants and animals, improving living conditions for man. Fast invasion of both barren and occupied areas may occur from existing, milder microhabitats. Species from outside such protected habitats are expected to immigrate much more slowly.

Due to strong physical barriers, it is unlikely that Arctic plants can migrate fast enough to keep up with the speed of climate change. Eventually, however, immigration may lead to increased species diversity (decades, centuries).

Small scale forestry and farming

If south Greenland becomes warmer there may be a potential for small scale forestry and farming with highland cattle as the tree-line moves north and the risk of frost damage decreases. The northward migration of forest may be very slow, slower than in most other Arctic areas, because only a few copses exist in the southernmost, sub-Arctic Greenland. Migration rates for alder and birch are about 130 – 1000 m per year.

Loss of diversity

A loss of species and biodiversity is predicted for the first many decades. Extreme changes in soil moisture and species competition may be direct causes, the latter influenced by nutrient availability, temperature, CO_2, and UV-B.

Endangered plants

Only a few High Arctic plants are in danger of being exterminated as a direct consequence of temperature increase. *Ranunculus sabinei*, which is currently limited to the narrow outer coastal zone of north Greenland, has nowhere to mitigate to avoid a warmer and drier climate. For individual species, plant or animal, temperature responses will be greatest closest to their climatic distributional limit.

Fossil evidence of the survival of arctic eco- systems

Fossil evidence from the relatively warm Pleistocene shows, first, that High Arctic lowland fens can be restored from openings in boreal forest. Second, the occurrence of arctic species in Pleistocene remains indicates that although the treeline and foresttundra will move northward as warming proceeds, High Arctic ecosystems will not disappear from high latitudes with short growing seasons. In undisturbed fens, establishment of new plants is extremely slow.

UV-B sensitive lichens and plants

Lichens and some arctic mosses and higher plants are sensitive to UV-B radiation. The long-term changes, given an increasing UV-B irradiance trend in the Arctic, may be a reduction in cover and frequency. Interactions between increased CO_2 and UV-B radiation may reduce the nutritional value of plants to herbivores. Data are lacking on UV-B as a threat to skin, vision and immune systems.

Herbivores, birds and insects

Arctic animals depend on stable winter climate with unbroken frost. Increasing snow depth and changed species composition of plant communities in the north may result in mass mortality of musk-ox and caribou. Rising winter temperatures could also be harmful to large herbivores, Arctic hares, and small rodents, such as lemmings, living beneath the snow cover. Repeated freezing and thawing results in ice-crust formation, making it difficult to reach vegetation in winter. Herbivores may therefore experience periods of severe starvation. A decrease in herbivore populations will affect predators (fox and wolf) as well.

Increased snow cover, ice-crust formation and a prolonged thawing period will have a great impact on migratory birds, depending on the availability of insects or plants when they arrive in spring. If these food sources are not available in time, the birds will starve.

The size of insect populations are controlled by temperature. The expected rise in winter temperature, therefore, may increase egg survival. Aphid populations, for example, may increase strongly considerably.

Four of Greenland's five butterfly species are confined to the High Arctic or become more rare towards the south. They are expected to move north when warming occurs. Beetles depend on higher temperatures and may benefit from a warming and extend their range. Since insects are very sensitive to temperature changes, they could be useful as indicators of such changes.

7.2.3 **Change in processes of terrestrial ecosystems**

Permafrost melt, drainage and soil drying

A marked impact on vegetation is expected from permafrost melt, resulting in waterlogging or drought, depending on precipitation. As permafrost melts, there will be land subsidence (thermokarst erosion). This in turn leads to the formation of ponds and lakes. The changes in landscape, sea ice distribution, lake and river ice may not only have significant biological impacts, such as changes in caribou and polar bear migration routes, but would affect indigenous peoples.

Improved drainage may result due to thickening of the unfrozen zone between the seasonal frost and permafrost layers. General drying-out of the soils will greatly affect wetland areas.

In areas subject to soil drying, herbivore productivity will be reduced. The absence of herbivores favours mosses, which act as an insulating layer over the soil, preserving water and slowing decomposition and nutrient cycling.

Where soils become wetter, lichens and mosses will play a more important role in ecosystem carbon fixation and control of water loss from the soil to the atmosphere. The largest effect may be seen where drying accompanies warming, since replacement of mosses by deciduous species will result in increased rates of carbon and nutrient cycling.

Increased N_2-fixation

N_2- fixation rates (primarily by cyanobacteria) are predicted to increase by a factor of 1.5 – 2 as a result of temperature, moisture, and CO_2 changes. This will lead to a 25 – 50% increase in nitrogen input to arctic ecosystems, thus affecting the abundant N-deficient ecosystems in Greenland.

Increased nutrient availability, combined with higher temperatures, may result in a shift towards an ecosystem composition and structure having higher annual nutrient requirements, litter quality and tissue turnover rates.

CO_2 and CH_4 release

As the area of Greenland wetland soils is small relative to the area of global tundra soils, it is believed that enhanced release of CO_2 and CH_4 from increasing peat decomposition will have a relatively modest impact on global climate. It is unclear whether enhanced net primary production will offset increased decomposition rates, and thus whether the Arctic will continue to serve as a carbon sink.

Mineralization and nutrient availability

Decomposition and soil mineralization rates are expected to increase due to higher fluxes of oxygen to the soil organic matter, higher soil temperatures and higher nitrogen fixation rates. This will improve conditions for plant growth and soil nutrient mineralization.

High Arctic ecosystems are presently more limited by temperature than by nutrient availability, while the opposite characterises Low Arctic ecosystems. Low Arctic plants show a greater response to nutritional increases than High Arctic plants, whereas plant response to temperature elevation is greatest in the High Arctic, stimulating development, reproduction and seed germination.

Arctic vegetation is generally nutrient-limited, and almost all the nitrogen and phosphorous in the soil-vegetation system is bound in plants and soil microorganisms. Nutrients released by increased decomposition and mineralization would not necessarily be available to plants, since they are rather efficiently immobilised by soil microorganisms. It is uncertain, whether shrubs having mycorrhiza may circumvent microbial nutrient immobilisation.

Plant productivity in polar deserts

In polar deserts, herb barrens, and heaths in northern Greenland, plant productivity and long-term differentiation of vegetation types are strongly correlated with increases in precipitation. In such areas, reduced moisture may lead to greater mortality, decreased seed germination and seedling survival.

Food quality of plants

If CO_2-fixation increases without a matching increase in nutrient uptake, the quality of plant tissue as a food resource is likely to decrease, due to a greater C/N ratio. This may reduce the growth and abundance of invertebrates and retard decomposition rates in soil microorganisms, both of which are involved in litter breakdown. It may also affect herbivory, as herbivores would have to increase consumption in order to compensate for poor food quality and avoid malnutrition.

7.2.4 **Marine ecosystems**

Changes due to fresh water input and to UV-B

The influx of freshwater from melting ice and river runoff may cause a shift in the structure of biological communities in the upper ocean layers (e.g. coccolithophorids to diatoms).

Increased UV-B radiation may induce a change in species composition of both zooplankton and phytoplankton towards dominance of toxic species and species of low food value. This could cause major changes in food chains. Increased nitrogen demand may reduce productivity. Inhibition of photosynthesis might occur in some species, while bacteria may be stimulated because of an increase in substance availability.

Sea surface temperature and productivity

A rise in sea surface temperatures at high latitudes will result in a longer growing season and higher productivity. It may also result in the extinction of some species while others might proliferate. In southern waters, temperature may not rise and the return of the cod may fail.

Polynyas

Reduced supply of relatively warm Atlantic water to upwelling sites will cause decreased ice-edge primary production, a general nutrient loss, and a decrease in bioproductivity. A potential risk is that the polynyas of north Greenland may freeze, resulting in drastic changes for marine life including sea mammals and birds overwintering there.

Polar bears and ringed seals

Reduced sea ice will improve access by ships to harbours all over Greenland, but will cause problems for polar bears and seals. The polar bear migrates all over Greenland, but resident populations occur primarily in NW and NE Greenland. The breeding areas have stable winter climates, permanent snow cover, ice-covered inlets and drift ice, with abundant ringed seals which depend on sea ice for breeding, resting, and as diving platforms.

It is expected that the southern limit for resident polar bear populations will move northward since a decrease or periodic disappearance of sea ice will reduce the abundance of the ringed seal. During a prolonged ice-free period, polar bears would have less time to build up fat reserves. This may result in declining body condition, thereby lowering survival rate through the ice-free period, reducing reproductive rates and reducing cub survival.

More rain in late winter and early spring is another threat to both polar bears and ringed seals. The rain may cause seal birth lairs and maternity dens of polar bears to collapse. The dens are situated so deep in the snow that the weight of the snow above may crush females and cubs. Collapse of seal birth lairs in the upper snow layers can cause increased exposure of pups to predation by polar bears and Arctic foxes. Thaw and melt events in a milder winter may also damage the dens and birth lairs.

Other marine mammals

Other mammals which are more dependent on open water and less well adapted to the extreme arctic climate than the ringed seal may benefit from a prolonged ice-free period as long as their food chains are intact. Such animals are the walrus, harbour seal, harp seal and bearded seal. However, some of the seals may be forced to seek areas for breeding and shedding hairs further north. Fewer incidents of ice entrapment of whales are expected.

The danger of seal plagues and other diseases may increase. High temperatures combined with large densities of seals may be responsible for the seal plagues caused by viruses earlier this century.

7.3 Climate change in the Faroe Islands

Climate scenario

The North Atlantic region, including south Greenland and the Faroe Islands, is expected to warm less or at a slower rate than elsewhere in the northern hemisphere. All atmospheric circulation models seem to agree that the North Atlantic region, including the Faroe Islands, will experience the slowest rate of temperature increase. Adding the cooling effect of the reduced North Atlantic Current, it is unlikely that the annual mean air temperature increase will exceed 1 – 2°C within the next century. The rise in winter temperature may be twice the rise in summer temperature. The risk of frost in the high mountains may be reduced. An increase in yearly precipitation is expected to be less than 4%. Gale frequencies are expected to increase.

The sea

Sea surface temperature may drop due to reduced thermohaline circulation. The sea level may rise at a similar rate of 5 cm per decade as predicted for the British Isles and is not expected to be compensated for by a land rise. Estimates of sea level rise vary from two to five times the rate of 10 – 25 cm observed over the past century.

7.3.1 Ecological implications

Reduced species diversity

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.

Unpredictable changes in marine ecosystems

The greatest changes are expected at sea, although the uncertainty is also the 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 will 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 will have a high risk of UV-B induced damages.

Effects on marine mammals and seabirds are expected mainly to concern spatial shifts in areas of food production and primary productivity (changes in upwelling sights), nesting and rearing sites, and increases in diseases and oceanic biotoxin production (both from temperature increase and current changes).

The reappearance of the cod seems highly dependent on what happens to sea currents. That there have been 3 – 4 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 will worsen the present lack of the fry's favourite food.

8 Adaptation measures

Even the most optimistic emission scenarios imply some future human impact on the global climate. As its apparent from Chapter 7, however, the direct effects of climate change in Denmark will be modest and in some cases will provide a potential advantage. No adaptative measures have yet been taken, but the possibilities have been investigated and have been discussed in national reports (Fenger & Torp 1992; Fenger et al. 1996 and references therein).

In the agricultural sector a change in crops including a switch to more winter wheat may be advantageous. This can be accomplished at relatively short notice. In forestry, the most common tree, the Norway spruce, is already threatened by mild winters and should be substituted with more stable mixtures including oak and beech.

A temperature rise in combination with a small reduction in precipitation will require more efficient water resource housekeeping and restoration of freshwater systems.

A sea level rise of the order of 50 cm will augment present coastal retreat, but can be counteracted by coast nourishment. Problems with regard to dykes can be solved in the course of general maintenance. Necessary renovation of the sewerage system must take a possible sea level rise into account.

Note that these consideration do not take into account “surprises changes in the global greenhouse”, for example a change in the Gulf Stream.

9 Financial assistance and technology transfer

9.1 Financial resources and transfer of technology and know-how

As a consequence of the increasingly global nature of environmental problems, Denmark has intensified action at the international level in recent years in order to meet global challenges.

At the regional level, the EU is the most important forum addressing global environmental issues. One of the overall objectives of the Maastricht Treaty is to promote sustainable and non-inflationary growth while according due consideration to the environment. To complement cooperation in the environmental field within the EU an international dimension has been added to facilitate active involvement by the Union in addressing and solving the environmental problems.

At the Nordic level, cooperation has been long standing based on shared objectives and visions. The Nordic countries are actively involved in solving regional and global environmental problems.

The climate problem is to be seen in the context of a broader global challenge. The populations use of the earth's store of natural resources is still increasing. Curbing these trends will require a coordinated international strategy.

The awareness of this global challenge and the transboundary nature of the environment problems were reflected in the Danish Government's 1988 Plan of Action for Environment and Development in Denmarks development assistance. As a consequence, a number of environmental sector strategies have been developed covering fisheries, energy, agriculture, forestry, agroforestry, water, health and industry.

The United Nations target of 0.7% of GNP in Overseas Development Aid (ODA) has long been fulfilled by Denmark and the Danish Government has maintained ODA at 1% of GNP since 1992.

Efforts to incorporate environmental objectives into the development assistance administered by DANIDA – the Danish International Development Assistance – were further strengthened during preparation for and follow-up on the 1992 United Nations Conference on Environment and Development in Rio de Janeiro (UNCED). Guidelines have been issued for environmental impact assessment of projects in all sectors. Following a parliamentary resolution in 1992, the Danish Environment and Disaster Relief Facility (EDRF) was established as an additional budgetary allocation to supplement Danish development assistance. This allocation will increase gradually to 0.5% of GNP by 2002. Half of the EDRF is allocated evenly between environmental assistance to Central and to Eastern Europe and developing countries, the assistance to the latter being administered jointly by DANIDA and DANCED – the Danish Cooperation for Environment and Development.

Development assistance (DANIDA)

Denmark's environment-related assistance efforts are expressed primarily by the incorporation of environmental concerns as one of the crosscutting themes of Danish bilateral assistance on par with Women in Development and Human Rights and Democratisation. In addition, a DKK 135 million (USD 24.1 million) multilateral budgetary allocation is devoted to global environmental activities. UNEP and GEF are major recipients. Other recipients include a considerable number of innovative and catalytic pilot activities, a large number of which focus on implementing measures dealing with the Climate Change Convention, the Convention on Biodiversity and the recent UN Convention to Combat Desertification.

Apart from those programmes and projects in bilateral development assistance in which the prime objective is the environment, it is difficult to quantify the resources devoted to environmental protection and environmentally sustainable development. A broad assessment indicates that 15 – 20% of total bilateral development assistance aims at important environmental objectives in the areas of 1) sustainable management of natural resources, 2) containment of water, air and soil pollution, and 3) sustainable energy use. Environmental strategies have been prepared for six thematic sectors and five main recipient countries.

Total bilateral development aid in the years 1994, 1995 and 1996 is summarized in Table 9.1.

	Contributions (million USD)		
	1994	1995	1996
Bilateral development aid	802.6	894.6	1,061

Table 9.1. *Total danish bilateral development Aid.*

Environment-related development activities in developing countries supported by Denmark include sustainable utilisation of land and natural resources and the protection of water catchment areas. Other measures cover the development of environmental expertise and administrative capacity, reducing air and water pollution, forest management, renewable energy, and making energy production and waste treatment more efficient. In conjunction with aid to the private sector, support has been offered for the transfer of relevant environmental technology to small companies.

Denmarks total contributions to multilateral institutions in the years 1994, 1995 and 1996 are summarized in the Table 9.2. The amounts quoted include “new and additional” financial contributions as it is not possible to separate these contributions.

	Contributions (million USD)		
	1994	1995	1996
Global Environment Facility	9.1	9.1	9.1
World Bank	83.7	91.2	99.5
International Finance Corporation	2.9	2.5	2.2
European Bank for Reconstruction and Development	45.0	39.8	23.2
African Development Bank, Asian Development Bank, Inter-American Development Bank	31.1	19.8	26.6
United Nations Development Programme	95.8	95.8	104.2
United Nations Environment Programme	1.9	2.2	2.2

Table 9.2. *Financial contributions to the operating entity or entities of the financial mechanism, regional and other multilateral institutions and programmes.*

In addition to the contributions shown in Table 9.2 DANIDA has provided financial support for issues related to Climate Change as shown in Table 9.3.

As with Table 9.2, it is not possible to single out "new and additional financial contributions" and these are therefore included in the amounts shown.

EDRF
Environmental assistance (DANCED and DANIDA)

DANCED was established under the Ministry of Environment and Energy in 1994 to provide Danish environmental assistance to middle income developing countries funded under the EDRF. This assistance is provided in cooperation with DANIDA's EDRF-funded environmental assistance to least developed countries, and is directed towards two regions: Southeast Asia and Southern Africa. The overall objective of Danish environmental assistance is to contribute to restoring the global environment in accordance with the recommendations of the 1992 UNCED conference in Rio de Janeiro. Initiatives are directed towards:

- Promotion of environmentally sustainable utilisation of natural resources
- Prevention and limitation of air, water and soil pollution
- Promotion of sustainable energy.

DANCED initiated activities in Thailand and Malaysia in 1994. In 1995, activities were extended to the Republic of South Africa and Namibia, and in 1996 to Botswana, Swaziland and Lesotho.

	Contributions (million USD)		
	1994	1995	1996
Climate Change Secretariat, Voluntary Fund for Participation	0.08	0.12	0.05
Climate Change Secretariat, Country Activities, Information Exchange System	0.20		
Climate Change Secretariat, Communication and Review Project	0.66		
UNEP, Country Case Study	0.97		
IPCC	0.20	0.25	
UNEP Collaborating Centre on Energy and Environment, (UCCEE)		0.77	1.60
UCCEE, Greenhouse Gas Mitigation for Peru		0.31	0.34
UCCEE Regional Gas Mitigation in SADC	0.12		0.48
UNEP Regional Office for Latin America and the Caribbean: Open Forum on New Partnerships to Reduce the Building of GHGs			0.04
World Bank, Study of the Renewable Energy Component of the Vietnam Rural Electrification Master Plan			0.35
Contribution to various NGOs (climate change)	0.17	0.18	0.50

Table 9.3. *Danish financial contributions to the Framework Convention on Climate Change Process.*

DANIDA started its EDRF-activities in the above mentioned two regions in 1996.

In relation to the issue of climate change, EDRF projects include two important activities:

- Carbon sequestration through reforestation of depleted lands
- Reduction of CO_2 emissions through promotion of energy conservation and renewable energy

Protection and rehabilitation of forests has been a priority issue for DANCED since the start of the programme. In Malaysia, support is provided on sustainable management of peat swamp forests and mangroves, and in Thailand, a number of projects address the issue of social forestry and the interaction between people and forests. In Namibia, DANCED is providing support to rehabilitate the wood land in Owampoland. Special efforts are directed towards public participation and awareness raising.

Sustainable energy was only included as a separate issue in the EDRF policy in 1996. Accordingly, many activities are still under preparation. Energy conservation projects have been implemented in Thailand as a follow-up of the new Energy Conservation Act. Energy conservation is also integrated into several cleaner technology projects in both Thailand and Malaysia. Activities related to energy conservation in the housing sector are under preparation in South Africa. Renewable energy projects are under preparation in Thailand, South Africa, Lesotho and Swaziland. Support has also been provided to strengthen energy administrations and to awareness raising through NGOs addressing energy issues.

	Mitigation	
Recipient country	Energy	Forest
1. Thailand	2.303	1.818
2. Thailand	1.212	2.727
3. Thailand	2.894	1.121
4. Thailand	1.894	2.894
5. Malaysia	2.015	2.015
6. Malaysia	0.879	1.258
7. Malaysia		1.091
8. South Africa	0.939	1.591
9. South Africa	0.758	1.530
10. South Africa		1.636

Table 9.4. *Bilateral EDRF contributions in 1997 related to implementation of the Rio-Convention, USD(million).*

Capacity building and training.

In addition to the DANCED programmes, the Danish Environmental Protection Agency has supplied expert assistance and training to foreign environmental authorities and organisations since 1980s. The basic strategy has hitherto been to build up or extend a central environmental administration or similar central state organisation to control environmental conditions right from the start of specific development projects.

As such the programmes are not specifically directed towards Climate Change issues. However, as sustainable development is one of the guiding principles, in the long term the outcome of the programmes will also have an impact on issues related to Climate Change.

Through these programmes Danish environmental administration, monitoring systems and consultancy have been transferred and adjusted to the culture, traditions and special environmental problems of individual countries. This form of know-how transfer is a relatively long-term process and the direct Danish effort is therefore supplemented by local training and education by national experts.

The Danish EPA's export of know-how and expertise has included support for the reorganisation of national environmental protection agencies (e.g. the People's Republic of China) and support for environmental administrations (e.g. Gaza/Jericho and Egypt). These activities take place on a commercial basis, i.e. on a contract basis with an international financing institution (IFI) or as sub-contractor to one or several private consultancy companies.

Cooperation with small island developing states

In continuation of the 1992 Rio Conference, the 1994 Barbados Conference and the ongoing climate negotiations, the Danish Government is in the process of strengthening cooperation with small island developing states. Danish NGOs are also involved in this process.

The cooperation aims at strengthening the capacity of relevant regions with regard to renewable energy, climate change issues and information dissemination.

9.2 **Cooperation with Central and Eastern Europe**

The Danish Environmental Support Fund

The Danish Environmental Support Fund for Eastern Europe (DESF) was established by the Danish Government in April 1991. In 1993, the Fund was incorporated into the new Danish programme for Global Support for the Environment and Disaster Areas, which was initiated after the Rio Conference held in 1992. The DESF is administered by the Danish Environmental Protection Agency. In terms of contribution per habitant, the Danish bilateral environmental support to the CEEC is significant.

The objectives of the DESF are:

- to contribute as much as possible to the protection of nature and the environment in the CEEC and to limit regional as well as global pollution, including cross-border pollution affecting Denmark;
- to contribute towards political and economic development in an environmentally friendly manner, specifically to support democratic and market-based economic development in such a way that the environment is protected as much as possible; and
- to promote the transfer of knowledge about the environment and environmental protection technology from Denmark to the CEEC to the benefit of both the CEEC and Denmark.

The Danish environmental assistance and environmentally related assistance are primarily targeted at the eastern European countries which are situated close to Denmark, including Poland, the Baltic States and the Baltic areas of Russia. The point of departure of the environmental efforts is Denmark's leading role in the fields of environment and energy. The efforts are primarily related to the fields of environment and energy but are also related closely to most of the major sectors, for instance agriculture, industry etc.

Results in CEEC

Up to and including 1996, the DESF has allocated USD 0.21 billion of which USD 0.18 billion has been allocated to direct environmental investments or the preparation hereof. Danish investments are connected to other investments of approx. USD 0.71 billion. Thus total investments in this field are approx. USD 0.89 billion. The major part of these funds originate from the recipient countries themselves but international banks have also contributed to the funds.

A number of positive environmental effects which have already been achieved or will be achieved when investments are made should be mentioned even though these effects only indirectly and to an uncertain extent affect the climate:

SO_2

With a future 135 Gg per year reduction in SO_2 emissions, a significant reduction in the cross-border air pollution from desulphurization projects at Polish power plants can be achieved. This reduction corresponds to 90 per cent of the total Danish yearly SO_2 emissions. Other examples of important investment fields related to reduction in air pollution are reduction in airborne particles, nitrogen oxides, organic solvents etc. The efforts are closely linked to the countries' compliance with the Convention on long-range air pollution (LRTAP 1979) and its protocols.

Substances with the potentiel of harming the ozone layer

As regards protecting the ozone layer, considerable efforts have primarily been targeted at Russia. Russia contributes approx. 20 per cent to world consumption and production. A limited effort of USD 1.8 million has succeeded in preparing for the allocation of a USD 125 million grant from the Global Environmental Facility (GEF). In this field the best known effect has been Danish export of new district heating pipes which do not harm the ozone layer. These efforts are closely linked to the efforts related to energy.

A considerable number of other investments have been made in waste treatment plants and substitution of nuclear sources. Institutional strengthening has been given priority, too. An example is the bilateral cooperation related to approximation to EU environmental legislation by the countries.

Danish efforts through the environmentally related sectoral programmes in the energy field cover overall assistance to energy planning, establishment of organisations, planning of district heating, investments in wood-fired burners, energy efficiency and conservation schemes. These efforts have established the basis for an environmentally sustainable energy sector in the Baltic countries.

CO_2

Apart from implementing the national Danish strategy for CO_2 reduction, Denmark is implementing a similar strategy in Eastern Europe by granting assistance to projects targeted at reducing CO_2 emissions.

Already implemented projects targeted at reducing CO_2 emissions are shown in Table 9.5.

Project	Emission reduction in Gg CO_2 per year
Geothermal plants in Pyrzyce, Poland	68.724
The combined heat and power plant in Decin, Czech Republic	26.650
Utilisation of gas from landfills in Poland	3.290
Management of coal incineration in Poland	10.710
Low NO_X burners for the Dolna Odra plant in Poland	62.730
Windmills in the Czech Republic	9.900
Total	182.004

Table 9.5. *Implemented projects targeted at reducing CO_2 emissions.*

Projects under implementation are shown in Table 9.6.

Project	Emission reduction in Gg CO_2 per year
Wood-fired plants in Latvia	8.640
Geothermal plants in Podhale, Poland	350.000
Geothermal plants in Klaipeda, Lithuania	50.000
Biological gas plant in Poprad, Slovakia	7.000
Air particulate filters, wood industry, Czech Republic and Slovakia	7.000
Flue gas cleaning projects in Ukraine	17.700
Straw-fired burners in Hungary	3.776
Combined heat and power plant in Decin, Czech Republic	26.000
Total	470.116

Table 9.6 *Projects under implementation targeted at reducing CO_2 emissions.*

Furthermore, a considerable number of projects with a smaller reduction have been implemented. The accumulated reduction as a result of the projects is estimated at more than 800 Gg CO_2 per year. Add to this, considerable energy conservation originating from projects whose effects have not yet been calculated. The total Danish assistance is estimated to have lead to a reduction in CO_2 emissions of more than 1,000 Gg per year.

Presently none of the Danish bilateral projects participate in the pilot phase for Activities Implemented Jointly of the Climate Change Convention.

10 Research and systematic observation.

10.1 National activities and contributions to international climate research and development programmes

The Danish Meteorological Institute (DMI) contributes actively to international climate research programmes, including the World Climate Research Programme.

Harmonisation of models

A main area within climate research is the numerical models of the atmosphere, i.e. weather and climate models. Efforts are directed towards harmonisation of the models for weather and climate calculations in order to achieve a uniform model for all problems with a view to enhancing the exploitation of new resarch results.

HIRLAM

DMI is engaged in a further development of its detailed regional weather forecast model HIRLAM (**HI**gh **R**esolution **L**imited **A**rea **M**odel) for weather forecasts for Denmark and Greenland, as well as coupled meteorological-oceanographic models for storm surges (natural disaster reduction) etc. One of the major current research activities within the HIRLAM project is the development of a variational technique for data assimilation.

Global models and climate simulations

Global climate modelling at DMI is currently focused on the preparation of seasonal forecasts and evaluation of future climate variability and climate change. The work on global climate models includes studying the impact of selected physical processes and climate variability. Another aspect of global modelling is related to the role of ozone as a climate gas.

An important climate modelling task has become the development and usage of a regional atmospheric climate model based on HIRLAM. This model is used for various regional climate modelling projects. The main focus is on regional aspects of anthropogenic climate change over Scandinavia, where a version with 18 km horizontal grid spacing is applied as a dynamic down-scaling tool to the most recent global coupled model simulations from the Max Planck Institute for Meteorology.

Nordic Climate Centre

DMI has been selected as a focal point for a major Nordic climate modelling research effort, which is partly funded by the Nordic Council of Ministers. The scope of this project is to increase the knowledge on the interaction between clouds and radiation.

Series of climate data

DMI's elaboration of climate data series (temperature, precipitation, sea level, and others) includes homogenisation of data series. The objectives are climate monitoring and the detection of climate change etc. Further time series are needed in order to increase the understanding of the climate system and to enable an evaluation of the results of climate models. The work includes coordination of the “European North Atlantic Climatological Data Set (NACD)” project.

Solar activity

Another major area of concern is the transfer of energy from the sun to terrestrial environments, and in particular the processes which can be expected to influence weather and climate. The transfer of energy to terrestrial environments occurs via a series of processes that cause changes in the composition, state and dynamics of the Earth's atmosphere, from the upper stratosphere to the troposphere. Recent DMI investigations confirm evidence of a correlation between the temperature of the northern hemisphere and variations in solar activity. The results are important, among other things in connection with the greenhouse effect, since they may help increase the understanding of natural climate variation and hence the possibilities for identifying possible anthropogenic changes.

10.1.1 **Climate relevant gases in the atmosphere**

Ozone

Ozone is a greenhouse gas, and its relative contribution to the greenhouse effect is about (10%). The total column of ozone is measured daily in Copenhagen as well as in Kangerlussuaq and Pituffik, Greenland. The height distribution of ozone is measured once a week in Ittoqqortoormiit, Greenland. The total column ozone trend is about -0.6% per year in Copenhagen and Kangerlussuaq, -0.8% per year in Ittoqqoormiit, and -1.0% per year in Pituffik. Ozone trends and ozone's greenhouse effect variy with height, however, and it is presently difficult to estimate the effects of ozone changes on climate.

DMI's activities in the troposphere and stratosphere include ozone monitoring and research. DMI monitors the ozone layer and measures ultraviolet radiation in Greenland and Denmark in collaboration with research institutes in other European countries and the USA. DMI also participates in a series of international projects studying the ozone balance and ozone-depleting processes and in a Nordic climate research project called "Ozone as a climate gas". The aim of the latter project is to investigate how longterm changes in atmospheric ozone may affect the climate of the Earth. The project consists of a) ozone soundings and analysis of the height profiles in the upper troposphere and lower stratosphere, b) analysis of the large scale ozone distribution using satellite observations, c) modelling of ozone distributions and changes, d) calculations of change in radiative forcing in the troposphere due to changes in ozone distribution, and e) Global Climate Model studies of the impact on climate of tropospheric ozone changes.

DMI also collaborates with eleven other West European national meteorological institutes in the European Climate Support Network (ECSN) in promoting more effective collaboration in the field of climate monitoring, research and prediction.

10.1.2 **National activities and contributions to international measuring and monitoring systems**

DMI contributes to climate monitoring within the WMO-coordinated observation programmes (World Weather Watch and the World Climate Data Programme). The institute has also been involved in the planning of a global Network for Detection of Stratospheric Change (NDSC), and one of the observatories in Greenland will be part of the NDSC.

10.1.3 **Data centres and data banks**

Meteorological data are filed in the DMI climate data base. Observations from several Danish stations are available on electronic media back to 1872, while sea level observations are available back to 1890, and sea surface temperatures back to 1931. About 20,000 observations are added daily. At the end of 1996 the database held about 80 million observations.

Besides the meteorological parameters, measurements are also made of solar radiation, sea level at 14 stations in Denmark, and ozone soundings and ground based spectroscopic equipment in Greenland.

The North Atlantic Climatological Data set (NACD) was a coproject between nine Northwest European meteorological institutes wherein DMI has co-ordinated the work of collecting monthly climatic data from 9 northwest European countries. The data set was published in 1996, and will soon be followed by another data set, the WASA data set, which consists of pressure observations from a large number of stations having homogenous records back to the end of the previous century. This project is also coordinated by DMI, and is funded by the European Commission.

Regarding the Greenland Ice Core Project, GRIP, reference is made to the first national communication.

10.2 **The socio-economic costs of reducing greenhouse gas emissions in Denmark**

While the cost of reducing CO_2 emissions in the energy sector in Denmark has been investigated in detail for a number of years the costs of reducing the other greenhouse gases (CH_4 and N_2O) and the possibilities for reducing greenhouse gases in the other sectors (i.e. agriculture, transport, industry, domestic waste and forestry) have only recently been initiated.

The Danish EPA together with Risø National Laboratory and the National Environmental Research Institute carried out a project on these issues in 1996.

The purpose of the project was

- To calculate the national economic costs related to a number of options for reducing Danish greenhouse gas emissions (CO_2, CH_4 and N_2O) by using the same methodology for all the important sectors in the economy, i.e. energy, agriculture, transport, industry, domestic waste and forestry.

- To compare the cost-efficiency of these options not only within the individual sectors but also across the sectoral boundaries to achieve an overall view of the reduction possibilities in society and the associated costs.

The main issues addressed were:

- Fine tuning of the baseline

- Development of a reduction cost curve for energy. Using the latest Danish energy action plan *Energy 21* as a basis the reduction cost curve for the energy sector was established by decomposing the plan into a number of mutual exclusive option categories. The cost curve was subsequently used as a reference for intersectoral comparisons.

- Identification of a number of options (technologies or policies and measures) that significantly reduce greenhouse gas emissions. The options selected within the sectors; energy, agriculture, transport and domestic waste. The industrial sector and forestry was treated in a more superficial way. The selected options were evaluated with regard to reduction potential and associated costs.

- Development of a partial cost curve across the individual sectors. This was done using the cost curve for the energy sector as a starting point and taking into account the interdependencies among the sectors, thereby obtaining a cross-sectoral view of reduction possibilities and associated costs.

The study identifies a range of “no-regret” and “low-regret” options to reduce greenhouse gas emissions in different sectors. Implementation of these measures will make it possible to substantially reduce greenhouse gas emissions.

10.3 **Technology research and development**

Danish research and development work on reduction technologies for greenhouse gases is mainly related to the energy sector.

The total cost of Danish energy research and development amounts to USD 86 – 100 million per year. The greater share of this is used on technologies for increasing efficiency in energy conversion, improving energy efficiency in end use, and developing technologies using fuels which produce less greenhouse gases – particularly technologies using renewable energy. Areas where Denmark has a strong international position include exploitation of wind energy and biomass, energy efficient utilisation of fossil fuels and combined heat and power technologies.

Examples of subjects covered by Danish research projects are:

- Improvement of the design basis for windmills.
- Integration of windmills in the electricity system.
- Technologies for combustion of biomass with high efficiency and low environmental impact. Special emphasis is placed on combined heat and power plants with high electricity efficiency.
- Technologies for energy production based on gasification of organic waste from farming, industry and households.
- Technologies for decreasing methane release from natural gas-fired lean burn motors.
- Solid oxide fuel cells with high efficiencies.
- High efficiency converters for photovoltaic plants.
- Superconductors and super conducting cables.
- CFC-free pipes for district heating systems.
- Low energy windows.
- Solar walls.
- Energy efficient pumps.
- Technology for energy-efficient cooling in industry.

Most of the projects are carried out in collaboration between industry and research centres – often with strong international links.

11 Education, training and public awareness

Since the late 1980s the Danish Ministry of Environment has supported the growing interest among the public in climate change through publications ranging from very detailed description of the climate change issue to more general brochures. Some of the information are also available on electronic media.

The interest among the public, journalists, employees of the central and local administration, and decision makers has increased steadily and the green NGOs and industrial NGOs have shown great interest in Climate Change.

The general impression is that the Danish public is highly interested in the subject and is well oriented due to the generally high level of education.

Many Danish municipalities have implemented their own action plan in accordance with Agenda 21 and the Confederation of Danish Industries and the Danish Electric Utilities are very active in producing TV spots and other material encouraging the public to behave sustainably.

The Danish 92 Group

The 1992 United Nations Conference on Environment and Development in Rio de Janeiro emphasized the need for the public to be involved in the implementation of sustainable development. Interpreting this as a need for public participation and transparency, the Danish government has continuously offered NGOs seats in the Danish delegation in the context of inter alia the Framework Convention on Climate Change.

Danish NGOs dealing with environment and development are organised in a network called the 92 Group comprising the 18 major organisations dealing with these issues in Denmark. Originally established in 1991, the 92 Group is currently the major framework for discussions among organisations and the most important link between the organisations and the government on issues related to global environment and development.

The organisations in the 92 Group meet once every month to coordinate their efforts in relation to environment and development, particularly to prepare for and evaluate international events and Danish input to these.

Since 1993, a representative of the Danish 92 Group has been a member of the Danish delegation at meetings in the FCCC context, particularly at INC, COP and AGBM.

Annex A: Emissions inventories 1990 – 95

Notes to the tables:

General note:
Numbers in columns may not add up to the total due to rounding.

Note P: Potential emissions based on Tier 1 Approach.
A: Actual emissions based on Tier 2 Approach.

Note 1: Sectorial Report For Energy, Industrial Processes, Solvent And Other Product Use, Agriculture, Land-use Change And Forestry, Waste And Other can be obtained at The National Environmental Research Institute (NERI)
2: Sectorial Approach acc. to IPCC or Reference Approach
3: Transformation Industries included here
4: Industries according to ISIC
5: Comm./Institutional, Residential, Agri./Forestry/Fishing
6: Military
7: Forest is the only ecosystem type included
8: Only corrections shown in the table are applied.
9: A positive correction indicates net import; negative net export.
10: A positive correction indicates a warmer climate than average; negative colder than average.
11: Not included in national totals.

IPCC TABLE 7A - SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
Estimation from CORINAIR National Annual Data, allocated to IPCC Source and Sink Categories

DENMARK

		1990													
		ESTIMATES OF EMISSIONS BY SOURCES AND REMOVALS BY SINKS in Gg													
		CO_2	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Emissions	Removals												
	NOTE		11							P	A	P	A	P	A
NATIONAL TOTALS		**52277**	**924**	**421**	**34**	**280**	**785**	**179**	**180**	**0.000**				**0.015**	
1 Energy	1	**51138**		**22**	**2**	**279**	**785**	**124**	**180**						
A Fuel Combustion	2	50898		10	2	278	751	116	180						
1 Energy Industries	3	25865		1	1	96	38	1	132						
2 Manufacturing Industries and Construction	4	5776		1	0	19	9	2	21						
3 Transport		10474		2	0	125	552	101	15						
4 Other Sectors	5	8664		6	0	37	153	12	11						
5 Other (Specified if any)	6	119		0	0	1	0	0							
B Fugitive Emissions from Fuels		240		12	0	1	34	8							
1 Solid Fuels				3			33								
2 Oil and Natural Gas Fuels		240		9	0	1	1	8							
2 Industrial Processes	1	**1006**				**1**			**0**						
A Mineral Products															
B Chemical Industry															
C Metal Production															
D Other Production															
E Production of Halocarbons and Sulphur Hexafloride															
F Consumption of Halocarbons and Sulphur Hexafloride										0.000	NE	NE	NE	0.015	NE
G Other (Specified if any)															
3 Solvent and Other Product Use	1	**133**						**43**							
4 Agriculture	1			**329**	**33**			**2**							
A Enteric Fermentation				167											
B Manure Management				161											
C Rice Cultivation															
D Agricultural Soils					33			2							
E Prescribed Burning of Savannas															
F Field Burning of Agricultural Residues															
G Other (Specified if any)															
5 Land Use Change & Forestry	1		**924**					**9**							
A Changes in Forest and Other Woody Biomass Stock	7		924												
B Forest and Grassland Conversion															
C Abandonment of Managed Lands															
D CO_2 Emissions and Removals from soil								9							
E Other (Specified if any)															
6 Waste	1			**71**											
A Solid Waste Disposal on Land				71											
B Wastewater Treatment															
C Waste Incineration															
D Other (Specified if any)															
7 Other (Specified if any)	1														
Corrections:															
CORRECTED NATIONAL TOTALS	8	**60233**													
a Correction for electricity exchange	9	6253													
c Correction for the impact of climate variation	10	1703													
Memo Items:															
International Aviation and Marine Bunkers	11	4986		0	0	85	9	3							
a International Aviation															
b International Marine															
CO2 Emissions from Biomass															

IPCC TABLE 7A - SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
Estimation from CORINAIR National Annual Data, allocated to IPCC Source and Sink Categories

DENMARK

		1991													
		ESTIMATES OF EMISSIONS BY SOURCES AND REMOVALS BY SINKS in Gg													
		CO_2	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Emissions	Removals												
	NOTE		11							P	A	P	A	P	A
NATIONAL TOTALS		**62940**	**932**	**426**	**34**	**320**	**800**	**176**	**239**	**0.003**				**0.015**	
1 Energy	1	**61631**		**24**	**2**	**320**	**800**	**122**	**239**						
A Fuel Combustion	2	61136		11	2	317	756	114	239						
1 Energy Industries	3	34864		1	1	135	40	1	188						
2 Manufacturing Industries and Construction	4	6114		1	0	20	9	2	23						
3 Transport		10946		2	0	121	542	97	16						
4 Other Sectors	5	8925		7	0	38	164	13	12						
5 Other (Specified if any)	6	287		0	0	2	2	0							
B Fugitive Emissions from Fuels		495		14	0	3	44	8							
1 Solid Fuels				4			42								
2 Oil and Natural Gas Fuels		495		10	0	3	2	8							
2 Industrial Processes	1	**1178**													
A Mineral Products															
B Chemical Industry															
C Metal Production															
D Other Production															
E Production of Halocarbons and Sulphur Hexafloride															
F Consumption of Halocarbons and Sulphur Hexafloride										0.003	NE	NE	NE	0.015	NE
G Other (Specified if any)															
3 Solvent and Other Product Use	1	**131**						**42**							
4 Agriculture	1			**330**	**32**			**2**							
A Enteric Fermentation				167											
B Manure Management				163											
C Rice Cultivation															
D Agricultural Soils					32			2							
E Prescribed Burning of Savannas															
F Field Burning of Agricultural Residues															
G Other (Specified if any)															
5 Land Use Change & Forestry	1		**932**					**9**							
A Changes in Forest and Other Woody Biomass Stock	7		932												
B Forest and Grassland Conversion															
C Abandonment of Managed Lands															
D CO_2 Emissions and Removals from soil								9							
E Other (Specified if any)															
6 Waste	1			**71**											
A Solid Waste Disposal on Land				71											
B Wastewater Treatment															
C Waste Incineration															
D Other (Specified if any)															
7 Other (Specified if any)	1														
Corrections:															
CORRECTED NATIONAL TOTALS	8	**61721**													
a Correction for electricity exchange	9	-1721													
c Correction for the impact of climate variation	10	502													
Memo Items:															
International Aviation and Marine Bunkers	11	4507	0	0	74	8	3	46							
a International Aviation															
b International Marine															
CO2 Emissions from Biomass															

IPCC TABLE 7A - SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
Estimation from CORINAIR National Annual Data, allocated to IPCC Source and Sink Categories

DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	NOTE	1992 ESTIMATES OF EMISSIONS BY SOURCES AND REMOVALS BY SINKS in Gg CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
	NOTE		11							P	A	P	A	P	A
NATIONAL TOTALS		**57652**	**940**	**431**	**34**	**274**	**770**	**170**	**186**	**0.024**				**0.015**	
1 Energy	1	**56222**		**24**	**2**	**274**	**770**	**116**	**186**						
A Fuel Combustion	2	55711		11	2	272	728	109	186						
1 Energy Industries	3	29540		1	1	93	43	1	143						
2 Manufacturing Industries and Construction	4	6218		1	0	20	9	2	22						
3 Transport		11072		2	1	119	509	93	11						
4 Other Sectors	5	8740		7	0	38	166	13	11						
5 Other (Specified if any)	6	141		0	0	1	1	0							
B Fugitive Emissions from Fuels		511		14	0	3	43	7							
1 Solid Fuels				4			41								
2 Oil and Natural Gas Fuels		511		10	0	3	2	7							
2 Industrial Processes	1	**1300**													
A Mineral Products															
B Chemical Industry															
C Metal Production															
D Other Production															
E Production of Halocarbons and Sulphur Hexafloride															
F Consumption of Halocarbons and Sulphur Hexafloride										0.024	NE	NE	NE	0.015	NE
G Other (Specified if any)															
3 Solvent and Other Product Use	1	**130**						**42**							
4 Agriculture	1			**335**	**32**			**2**							
A Enteric Fermentation				166											
B Manure Management				169											
C Rice Cultivation															
D Agricultural Soils					32			2							
E Prescribed Burning of Savannas															
F Field Burning of Agricultural Residues															
G Other (Specified if any)															
5 Land Use Change & Forestry	1		**940**					**9**							
A Changes in Forest and Other Woody Biomass Stock	7		940												
B Forest and Grassland Conversion															
C Abandonment of Managed Lands															
D CO_2 Emissions and Removals from soil								9							
E Other (Specified if any)															
6 Waste	1			**72**											
A Solid Waste Disposal on Land				72											
B Wastewater Treatment															
C Waste Incineration															
D Other (Specified if any)															
7 Other (Specified if any)	1														

Corrections:	NOTE	CO_2 Emissions
CORRECTED NATIONAL TOTALS	8	**61358**
a Correction for electricity exchange	9	3273
c Correction for the impact of climate variation	10	433

Memo Items:	NOTE	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
International Aviation and Marine Bunkers	11	4677		0	0	74	9	3	38
a International Aviation									
b International Marine									
CO2 Emissions from Biomass									

IPCC TABLE 7A - SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
Estimation from CORINAIR National Annual Data, allocated to IPCC Source and Sink Categories

DENMARK

		1993													
		ESTIMATES OF EMISSIONS BY SOURCES AND REMOVALS BY SINKS in Gg													
		CO_2	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Emissions	Removals												
	NOTE		11							P	A	P	A	P	A
NATIONAL TOTALS		**59356**	**924**	**445**	**33**	**274**	**725**	**161**	**152**	**0.343**				**0.017**	
1 Energy	1	**57917**		**25**	**2**	**274**	**725**	**108**	**152**						
A Fuel Combustion	2	57472		10	2	271	688	101	152						
1 Energy Industries	3	31028		1	1	97	47	1	112						
2 Manufacturing Industries and Construction	4	6168		1	0	20	8	2	20						
3 Transport		11301		2	1	117	470	85	9						
4 Other Sectors	5	8738		7	0	35	162	12	11						
5 Other (Specified if any)	6	237		0	0	2	1	0							
B Fugitive Emissions from Fuels		445		14	0	2	37	7							
1 Solid Fuels				5			35								
2 Oil and Natural Gas Fuels		445		10	0	2	2	7							
2 Industrial Processes	1	**1311**													
A Mineral Products															
B Chemical Industry															
C Metal Production															
D Other Production															
E Production of Halocarbons and Sulphur Hexafloride															
F Consumption of Halocarbons and Sulphur Hexafloride										0.343	NE	NE	NE	0.017	NE
G Other (Specified if any)															
3 Solvent and Other Product Use	1	**128**						**41**							
4 Agriculture	1			**348**	**31**			**2**							
A Enteric Fermentation				168											
B Manure Management				180											
C Rice Cultivation															
D Agricultural Soils					31			2							
E Prescribed Burning of Savannas															
F Field Burning of Agricultural Residues															
G Other (Specified if any)															
5 Land Use Change & Forestry	1		**948**					**9**							
A Changes in Forest and Other Woody Biomass Stock	7		948												
B Forest and Grassland Conversion															
C Abandonment of Managed Lands															
D CO_2 Emissions and Removals from soil								9							
E Other (Specified if any)															
6 Waste	1			**72**											
A Solid Waste Disposal on Land				72											
B Wastewater Treatment															
C Waste Incineration															
D Other (Specified if any)															
7 Other (Specified if any)	1														

		CO_2 Emissions
Corrections:		
CORRECTED NATIONAL TOTALS	8	**60328**
a Correction for electricity exchange	9	988
c Correction for the impact of climate variation	10	-16

		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Memo Items:									
International Aviation and Marine Bunkers	11	6041		0	0	112	12	4	66
a International Aviation									
b International Marine									
CO2 Emissions from Biomass									

IPCC TABLE 7A - SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
Estimation from CORINAIR National Annual Data, allocated to IPCC Source and Sink Categories

DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	NOTE	1994 ESTIMATES OF EMISSIONS BY SOURCES AND REMOVALS BY SINKS in Gg: CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs P	HFCs A	PFCs P	PFCs A	SF_6 P	SF_6 A
			11												
NATIONAL TOTALS		**63344**	**956**	**428**	**33**	**272**	**704**	**166**	**155**	**0.600**				**0.021**	
1 Energy	1	**61899**		**27**	**3**	**271**	**704**	**113**	**150**						
A Fuel Combustion	2	61117		10	3	269	662	97	150						
1 Energy Industries	3	35213		1	1	106	48	1	111						
2 Manufacturing Industries and Construction	4	6481		1	0	24	12	3	22						
3 Transport		11345		2	1	103	422	77	10						
4 Other Sectors	5	8020		6	0	35	180	15	7						
5 Other (Specified if any)	6	58		0	0	1	1	0							
B Fugitive Emissions from Fuels		782		17	0	3	41	16							
1 Solid Fuels		0		6		0	40	0							
2 Oil and Natural Gas Fuels		782		11	0	3	2	16							
2 Industrial Processes	1	**1318**		**1**		**1**	**0**	**1**	**4**						
A Mineral Products															
B Chemical Industry															
C Metal Production															
D Other Production															
E Production of Halocarbons and Sulphur Hexafloride															
F Consumption of Halocarbons and Sulphur Hexafloride										0.600	NE	NE	NE	0.021	NE
G Other (Specified if any)															
3 Solvent and Other Product Use	1	**127**						**41**							
4 Agriculture	1			**326**	**30**			**2**							
A Enteric Fermentation				155											
B Manure Management				171											
C Rice Cultivation															
D Agricultural Soils					30			2							
E Prescribed Burning of Savannas															
F Field Burning of Agricultural Residues															
G Other (Specified if any)															
5 Land Use Change & Forestry	1		**956**		**1**			**9**							
A Changes in Forest and Other Woody Biomass Stock	7		956												
B Forest and Grassland Conversion															
C Abandonment of Managed Lands															
D CO_2 Emissions and Removals from soil					1			9							
E Other (Specified if any)															
6 Waste	1			**74**					**1**						
A Solid Waste Disposal on Land				72											
B Wastewater Treatment				2											
C Waste Incineration									1						
D Other (Specified if any)															
7 Other (Specified if any)	1														

Corrections:	NOTE	CO_2 Emissions
CORRECTED NATIONAL TOTALS	8	**59605**
a Correction for electricity exchange	9	-3932
c Correction for the impact of climate variation	10	193

Memo Items:	NOTE	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
International Aviation and Marine Bunkers	11	6736		0	0	124	12	4	70
a International Aviation									
b International Marine									
CO2 Emissions from Biomass									

IPCC TABLE 7A - SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
Estimation from CORINAIR National Annual Data, allocated to IPCC Source and Sink Categories

DENMARK

		1995													
		ESTIMATES OF EMISSIONS BY SOURCES AND REMOVALS BY SINKS in Gg													
		CO_2	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Emissions	Removals												
	NOTE		11							P	A	P	A	P	A
NATIONAL TOTALS		**59532**	**924**	**430**	**33**	**253**	**702**	**162**	**150**	**0.750**		**0.002**		**0.017**	
1 Energy	1	**58096**		**29**	**3**	**252**	**702**	**109**	**147**						
A Fuel Combustion	2	57748		11	3	250	656	93	147						
1 Energy Industries	3	31482		1	1	91	49	2	106						
2 Manufacturing Industries and Construction	4	6039		1	0	23	10	3	19						
3 Transport		11370		2	1	100	389	71	10						
4 Other Sectors	5	8718		7	0	35	206	17	12						
5 Other (Specified if any)	6	139		0	0	2	2	0							
B Fugitive Emissions from Fuels		348		17	0	2	45	17							
1 Solid Fuels				6		0	44	0							
2 Oil and Natural Gas Fuels		348		11	0	2	1	17							
2 Industrial Processes	1	**1311**		**1**		**1**	**0**	**1**	**3**						
A Mineral Products															
B Chemical Industry															
C Metal Production															
D Other Production															
E Production of Halocarbons and Sulphur Hexafloride															
F Consumption of Halocarbons and Sulphur Hexafloride										0.750	NE	0.002	NE	0.017	NE
G Other (Specified if any)															
3 Solvent and Other Product Use	1	**125**						**40**							
4 Agriculture	1			**327**	**30**			**2**							
A Enteric Fermentation				155											
B Manure Management				172											
C Rice Cultivation															
D Agricultural Soils					30			2							
E Prescribed Burning of Savannas															
F Field Burning of Agricultural Residues								**0**							
G Other (Specified if any)								**0**							
5 Land Use Change & Forestry	1		**964**		1			**9**							
A Changes in Forest and Other Woody Biomass Stock	7		964												
B Forest and Grassland Conversion															
C Abandonment of Managed Lands															
D CO_2 Emissions and Removals from soil					1			9							
E Other (Specified if any)															
6 Waste	1			**74**											
A Solid Waste Disposal on Land				72											
B Wastewater Treatment				2											
C Waste Incineration															
D Other (Specified if any)															
7 Other (Specified if any)	1														

Corrections:									
CORRECTED NATIONAL TOTALS	8	**58917**							
a Correction for electricity exchange	9	-615							
c Correction for the impact of climate variation	10	0							

Memo Items:									
International Aviation and Marine Bunkers	11	7080		0	0	130	13	4	78
a International Aviation									
b International Marine									
CO2 Emissions from Biomass									

Annex B: Energy balances

Energy balances 1990, 2000, 2005, 2010, 2020 and 2030

The energy balances provided by the Danish Energy Agency are shown for the years 1990, 2000, 2005, 2010, 2020 and 2030.

Statistical data cover the period 1972 to 1995 and the action plan, *Energy 21*, is the source for projected figures. The period 1996 to 2005 is based on expected development from all measures implemented or decided. The remaining period 2005 to 2030 is based on expected development from contemplated new measures for the post 2005 period.

Autoproducers are here listed among other conversion technologies. In the inventory and projections tables in IPCC format, their fuel consumption and emission are included under the sector where they are located.

Notes to individual columns:	1) sum of (2)+(3)+(11)+(17) 5) including waste oil, lubrificatives and bitumen 10) town gas and refinery gas 11) sum of (4) through (10) 16) primary energy equivalent. Including hydro and solar heating. 17) sum of (12) through (16) 18) direct CO_2 emissions in mio t/year from primary energy combustion 22) sum of primary energy (1) plus secondary energy (19) through (21)
Notes to individual rows:	23) Nonenergy use, mostly bitumen and lubrificatives. CO_2 emissions at full oxidisation of about 1 mio t/year are not included in total domestic consumption to avoid double counting (material is either recycled or included when burned - see note to row (5))

Energy Balance for Denmark 1990 PJ per Year Scenario: actual 1990 data corrected for outsite temperatures + electricity exchange

actual 1990 data corrected for outsite temperatures + electricity exchange

	0 All Fuels (1)	Primary Energy: Coal & Coke (2)	Natural Gas (3)	crude Oil (4)	Residual oil (5)	Heating oil (6)	Gaso-line (7)	JP1 & JP4 (8)	LPG (9)	Derived Gas (10)	Total Oilproducts (11)	Straw (12)	Refuse (13)	Wood (14)	Weet Biomass (15)	Wind & Solar (16)	Total Renewable (17)	CO2 mio t CO2 (18)	0 Elec-tricity (19)	District Heat (20)	Cogen Heat (21)	All Final Energy (22)
Net Imports	433.95	324.91	-28.92	80.14	-9.87	49.91	1.62	17.99	-2.03	0.19	137.96	0.00	0.00	0.00	0.00	0.00	0.00	39.99	0.01	-0.32	0.00	433.64
Domestic Sources	424.32	0.00	115.97	255.96	0.00	0.00	0.00	0.00	0.00	0.00	255.96	13.87	16.92	16.90	1.83	2.87	52.39	25.46	0.00	0.00	0.00	424.32
Total Supply of Fuels	**858.26**	**324.91**	**87.05**	**336.10**	**-9.87**	**49.91**	**1.62**	**17.99**	**-2.03**	**0.19**	**393.92**	**13.87**	**16.92**	**16.90**	**1.83**	**2.87**	**52.39**	**65.45**	**0.01**	**-0.32**	**0.00**	**857.95**
International air and marine bunkers	**66.40**	**0.00**	**0.00**	**0.00**	**28.54**	**11.26**	**0.01**	**26.59**	**0.00**	**0.00**	**66.40**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**4.97**	**0.00**	**0.00**	**0.00**	**66.40**
Nonenergy Uses (23)	**12.74**	**0.00**	**0.00**	**0.00**	**8.61**	**3.11**	**1.02**	**0.00**	**0.00**	**0.00**	**12.74**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.98**	**0.00**	**0.00**	**0.00**	**12.74**
Total Domestic Consumption	**779.12**	**324.91**	**87.05**	**336.10**	**-47.02**	**35.54**	**0.59**	**-8.60**	**-2.03**	**0.19**	**314.78**	**13.87**	**16.92**	**16.90**	**1.83**	**2.87**	**52.39**	**59.50**	**0.01**	**-0.32**	**0.00**	**778.81**
Electricity Import correction	**67.00**	**63.02**	**1.58**	**0.00**	**2.19**	**0.08**	**0.00**	**0.00**	**0.00**	**0.00**	**2.26**	**0.13**	**0.00**	**0.00**	**0.00**	**0.00**	**0.13**	**6.25**	**-25.37**	**0.00**	**0.00**	**41.63**
Refineries, throughput	**1.00**	**0.00**	**0.00**	**336.10**	**-90.79**	**-143.80**	**-68.91**	**-10.85**	**-6.58**	**-14.17**	**1.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.00**
Total Conversion and Distribution sector	**338.76**	**245.35**	**34.61**	**0.00**	**14.18**	**2.48**	**0.00**	**0.00**	**0.18**	**12.49**	**29.34**	**4.46**	**16.92**	**4.62**	**1.15**	**2.30**	**29.46**	**27.29**	**-79.64**	**-82.87**	**0.00**	**176.25**
Oil and Gas Sector (refineries, Offshore, gasworks)	28.34	0.00	14.42	0.00	1.31	0.01	0.00	0.00	0.17	12.43	13.92	0.00	0.00	0.00	0.00	0.00	0.00	1.64	0.00	0.00	0.00	28.34
Refineries, own consumption	15.34	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	14.03	15.34	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	15.34
Offshore fuel consumption including flaring	12.86	0.00	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	12.86
Town gas plants, throughput and own consumption	0.14	0.00	1.56	0.00	0.00	0.01	0.00	0.00	0.17	-1.60	-1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.14
Electricity and District Heat Production	309.89	245.35	19.72	0.00	12.87	2.47	0.00	0.00	0.01	0.00	15.36	4.46	16.92	4.62	1.15	2.30	29.46	25.62	-87.74	-103.63	0.00	118.51
(of which used for electric rail)	2.10	1.98	0.05	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.20	-0.80	0.00	0.00	1.31
Electricity production by Wind and Water Power	2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	2.30	0.00	-2.30	0.00	0.00	0.00
Thermal electric Power Plants, Condensing Plants	149.58	140.69	3.54	0.00	4.89	0.17	0.00	0.00	0.00	0.00	5.06	0.29	0.00	0.00	0.00	0.00	0.29	13.96	-55.72	0.00	0.00	93.86
Thermal Electric Power Plants, Back Pressure Plants	101.88	95.83	2.41	0.00	3.33	0.12	0.00	0.00	0.00	0.00	3.44	0.20	0.00	0.00	0.00	0.00	0.20	9.51	-28.16	-59.88	0.00	13.84
Autoproducers of heat and electricity (cogeneration)	6.14	1.95	0.49	0.00	2.39	0.00	0.00	0.00	0.00	0.00	2.39	0.00	0.00	0.99	0.32	0.00	1.31	0.40	-1.56	-2.20	0.00	2.38
District Heating Plants (including Peaking Boilers at Central Heat and Power Plants)	49.98	6.88	13.28	0.00	2.27	2.19	0.00	0.00	0.01	0.00	4.46	3.97	16.92	3.63	0.83	0.00	25.36	1.75	0.00	-41.55	0.00	8.43
Loss and own consumption in distribution and transmission of electricity, heat and gas	0.53	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	8.11	20.77	0.00	29.40
Final Energy Consumption	**372.37**	**16.54**	**50.86**	**0.00**	**27.40**	**176.78**	**69.50**	**2.25**	**4.37**	**1.87**	**282.17**	**9.27**	**0.00**	**12.28**	**0.67**	**0.57**	**22.79**	**25.95**	**105.02**	**82.55**	**0.00**	**559.93**
Total Transport Energy	142.62	0.00	0.00	0.00	3.58	67.32	69.00	2.25	0.46	0.00	142.62	0.00	0.00	0.00	0.00	0.00	0.00	10.49	0.74	0.00	0.00	143.36
Road Transport in Denmark, final Energy	131.18	0.00	0.00	0.00	0.02	58.60	72.11	0.00	0.46	0.00	131.18	0.00	0.00	0.00	0.00	0.00	0.00	9.63	0.00	0.00	0.00	131.18
Rail Transport in Denmark, final Energy	4.03	0.00	0.00	0.00	0.00	4.01	0.02	0.00	0.00	0.00	4.03	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.74	0.00	0.00	4.77
Air and Sea Transport in Denmark, final Energy	7.26	0.00	0.00	0.00	3.56	2.78	0.16	0.76	0.00	0.00	7.26	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	7.26
Local border Trade (net export)	-1.50	0.00	0.00	0.00	0.00	1.79	-3.29	0.00	0.00	0.00	-1.50	0.00	0.00	0.00	0.00	0.00	0.00	-0.11	0.00	0.00	0.00	-1.50
Military Consumption	1.65	0.00	0.00	0.00	0.00	0.15	0.01	1.50	0.00	0.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	1.65
Total Process Energy	109.40	15.61	24.15	0.00	21.47	37.58	0.50	0.00	3.06	0.31	62.92	2.12	0.00	3.94	0.66	0.00	6.72	8.19	37.65	4.09	0.00	151.15
Industry	72.75	13.09	21.81	0.00	18.12	12.64	0.18	0.00	2.03	0.31	33.28	0.00	0.00	3.91	0.66	0.00	4.57	5.60	31.17	1.99	0.00	105.91
Construction	5.20	0.00	0.12	0.00	1.00	3.55	0.03	0.00	0.50	0.00	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.38	1.05	0.00	0.00	6.25
Agriculture and Forestry	20.66	2.52	2.22	0.00	2.06	10.94	0.28	0.00	0.49	0.00	13.77	2.12	0.00	0.03	0.00	0.00	2.15	1.41	5.43	2.10	0.00	28.19
Fishery	10.79	0.00	0.00	0.00	0.29	10.45	0.01	0.00	0.04	0.00	10.79	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	10.79
Total Consumption of Residential Commercial Sectors	120.35	0.93	26.71	0.00	2.35	71.88	0.00	0.00	0.84	1.56	76.64	7.15	0.00	8.34	0.01	0.57	16.07	7.28	66.63	78.45	0.00	265.43
Final Energy Demand for heating:	120.01	0.93	26.71	0.00	2.35	71.88	0.00	0.00	0.84	1.22	76.30	7.15	0.00	8.34	0.01	0.57	16.07	7.26	10.07	78.45	0.00	208.53
Electricity and gas use for Appliances and cooking (excl heating)	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.02	56.56	0.00	0.00	56.90

Danish Energy Agency file: cc_pak

Statistical data 1972 to 1995.
Energy 21 (april 1996) 1996 to 2005: Expected development from all measures implemented or decided.
Energy 21 (april 1996) 2005 to 2030: Expected development from contemplated new measures for the post 2005 period

Energy Balance for Denmark **2000** **PJ per Year Scenario: Energy 21, Plan**

Energy 21, Plan	0 All Fuels (1)	Primary Energy: Coal & Coke (2)	Natural Gas (3)	crude Oil (4)	Residual oil (5)	Heating oil (6)	Gaso- line (7)	JP1 & JP4 (8)	LPG (9)	Derived Gas (10)	Total Oilproducts (11)	Straw (12)	Refuse (13)	Wood (14)	Weet Biomass (15)	Wind & Solar (16)	Total Renewables (17)	CO2 mio t CO2 (18)	0 Elec- tricity (19)	District Heat (20)	Cogen Heat (21)	All Final Energy (22)
Net Imports	74.15	190.75	-111.42	0.00	18.66	-15.77	-28.95	27.93	-5.37	-1.68	-5.18	0.00	0.00	0.00	0.00	0.00	0.00	-1.12	-10.06	0.00	0.00	64.09
Domestic Sources	849.27	0.00	325.84	437.00	0.00	0.00	0.00	0.00	0.00	0.00	437.00	24.76	22.72	23.87	5.20	9.87	86.42	63.34	0.00	0.00	0.00	849.27
Total Supply of Fuels	**923.42**	**190.75**	**214.43**	**437.00**	**18.66**	**-15.77**	**-28.95**	**27.93**	**-5.37**	**-1.68**	**431.82**	**24.76**	**22.72**	**23.87**	**5.20**	**9.87**	**86.42**	**62.22**	**-10.06**	**0.00**	**0.00**	**913.36**
International air and marine bunkers	**110.95**	**0.00**	**0.00**	**0.00**	**45.80**	**32.10**	**0.00**	**33.05**	**0.00**	**0.00**	**110.95**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**8.33**	**0.00**	**0.00**	**0.00**	**110.95**
Nonenergy Uses (23)	**12.66**	**0.00**	**0.00**	**0.00**	**11.64**	**1.02**	**0.00**	**0.00**	**0.00**	**0.00**	**12.66**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.98**	**0.00**	**0.00**	**0.00**	**12.66**
Total Domestic Consumption	**799.81**	**190.75**	**214.43**	**437.00**	**-38.78**	**-48.89**	**-28.95**	**-5.12**	**-5.37**	**-1.68**	**308.21**	**24.76**	**22.72**	**23.87**	**5.20**	**9.87**	**86.42**	**52.91**	**-10.06**	**0.00**	**0.00**	**789.75**
Electricity Import correction																						
Refineries, throughput	**0.80**	**0.00**	**0.00**	**437.00**	**-95.00**	**-197.00**	**-106.30**	**-8.40**	**-9.40**	**-20.10**	**0.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.80**
Total Conversion and Distribution sector	**446.04**	**172.67**	**145.84**	**0.00**	**42.62**	**1.19**	**0.00**	**0.00**	**0.00**	**18.30**	**62.10**	**19.84**	**22.72**	**9.24**	**4.87**	**8.76**	**65.43**	**29.20**	**-122.99**	**-94.63**	**-14.42**	**214.00**
Oil and Gas Sector (refineries, Offshore, gasworks)	64.49	0.00	46.80	0.00	3.15	0.00	0.00	0.00	0.00	14.55	17.70	0.00	0.00	0.00	0.00	0.00	0.00	3.74	0.00	0.00	0.00	64.49
Refineries, own consumption	19.01	0.00	0.00	0.00	3.15	0.00	0.00	0.00	0.00	15.86	19.01	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	19.01
Offshore fuel consumption including flaring	45.48	0.00	45.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.59	0.00	0.00	0.00	45.48
Town gas plants, throughput and own consumption	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	-1.32	-1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and District Heat Production	380.78	172.67	98.28	0.00	39.47	1.19	0.00	0.00	0.00	3.75	44.40	19.84	22.72	9.24	4.87	8.76	65.43	25.42	-131.49	-118.42	-14.42	116.45
(of which used for electric rail)	2.69	2.11	0.20	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.31	0.07	0.00	0.01	0.00	0.00	0.08	0.24	-1.02	0.00	0.00	1.67
Electricity production by Wind and Water Power	8.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.58	8.58	0.00	-8.58	0.00	0.00	0.00
Thermal electric Power Plants, Condensing Plants	126.43	76.98	20.80	0.00	14.47	0.00	0.00	0.00	0.00	0.00	14.47	6.27	6.81	1.01	0.11	0.00	14.19	9.64	-51.12	0.00	0.00	75.31
Thermal Electric Power Plants, Back Pressure Plants	165.51	92.91	31.72	0.00	20.64	0.00	0.00	0.00	0.00	0.00	20.64	8.17	10.38	1.54	0.16	0.00	20.24	12.27	-51.90	-84.25	0.00	29.37
Autoproducers of heat and electricity (cogeneration)	35.27	1.76	25.62	0.00	2.21	0.12	0.00	0.00	0.00	3.75	6.07	0.16	0.00	1.30	0.36	0.00	1.82	2.02	-11.07	-4.35	-14.42	5.42
District Heating Plants (including Peaking Boilers at Central Heat and Power Plants)	44.98	1.03	20.13	0.00	2.16	1.07	0.00	0.00	0.00	0.00	3.23	5.24	5.54	5.40	4.24	0.18	20.60	1.49	-8.82	-29.82	0.00	6.34
Loss and own consumption in distribution and transmission of electricity, heat and gas	0.77	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	8.50	23.79	0.00	33.06
Final Energy Consumption	**352.97**	**18.08**	**68.59**	**0.00**	**13.60**	**146.92**	**77.35**	**3.28**	**4.03**	**0.13**	**245.31**	**4.92**	**0.00**	**14.63**	**0.34**	**1.11**	**20.99**	**23.71**	**112.93**	**94.63**	**14.42**	**574.95**
Total Transport Energy	150.00	0.00	0.00	0.00	1.20	68.55	76.97	3.28	0.00	0.00	150.00	0.00	0.00	0.00	0.00	0.00	0.00	11.02	0.95	0.00	0.00	150.95
Road Transport in Denmark, final Energy	136.22	0.00	0.00	0.00	0.00	62.00	74.22	0.00	0.00	0.00	136.22	0.00	0.00	0.00	0.00	0.00	0.00	10.01	0.00	0.00	0.00	136.22
Rail Transport in Denmark, final Energy	2.54	0.00	0.00	0.00	0.00	2.54	0.00	0.00	0.00	0.00	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.95	0.00	0.00	3.48
Air and Sea Transport in Denmark, final Energy	4.34	0.00	0.00	0.00	1.20	2.21	0.00	0.92	0.00	0.00	4.34	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	4.34
Local border Trade (net export)	3.63	0.00	0.00	0.00	0.00	0.90	2.74	0.00	0.00	0.00	3.63	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	3.63
Military Consumption	3.27	0.00	0.00	0.00	0.00	0.90	0.01	2.36	0.00	0.00	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	3.27
Total Process Energy	98.64	16.77	30.57	0.00	11.54	31.89	0.35	0.00	2.45	0.10	46.33	1.34	0.00	3.60	0.02	0.00	4.97	6.78	44.26	5.88	12.32	161.10
Industry	64.17	13.97	28.17	0.00	9.53	7.25	0.10	0.00	1.46	0.10	18.43	0.00	0.00	3.58	0.02	0.00	3.60	4.32	36.31	3.96	11.40	115.84
Construction	6.09	0.00	0.24	0.00	0.24	4.87	0.03	0.00	0.71	0.00	5.84	0.00	0.00	0.00	0.00	0.00	0.00	0.44	1.30	0.00	0.00	7.38
Agriculture and Forestry	28.38	2.80	2.16	0.00	1.76	19.78	0.23	0.00	0.29	0.00	22.05	1.34	0.00	0.03	0.00	0.00	1.37	2.02	6.65	1.92	0.92	37.88
Fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption of Residential Commercial Sectors	104.33	1.31	38.02	0.00	0.86	46.48	0.03	0.00	1.57	0.03	48.98	3.57	0.00	11.03	0.31	1.11	16.02	5.90	67.72	88.76	2.10	262.91
Final Energy Demand for heating:	104.10	1.31	38.01	0.00	0.86	46.39	0.03	0.00	1.45	0.03	48.76	3.57	0.00	11.03	0.31	1.11	16.02	5.89	7.80	88.76	2.10	202.76
Electricity and gas use for Appliances and cooking (excl heating)	0.23	0.00	0.01	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.02	59.92	0.00	0.00	60.15

Danish Energy Agency file: cc_pak

Statistical data 1972 to 1995.
Energy 21 (april 1996) 1996 to 2005: Expected development from all measures implemented or decided.
Energy 21 (april 1996) 2005 to 2030: Expected development from contemplated new measures for the post 2005 period

Energy Balance for Denmark 2005 PJ per Year Scenario: Energy 21, Plan

Energy 21, Plan	0 All Fuels (1)	Primary Energy: Coal & Coke (2)	Natural Gas (3)	crude Oil (4)	Residual oil (5)	Heating oil (6)	Gaso-line (7)	JP1 & JP4 (8)	LPG (9)	Derived Gas (10)	Total Oilproducts (11)	Straw (12)	Refuse (13)	Wood (14)	Weet Biomass (15)	Wind & Solar (16)	Total Renewable (17)	CO2 mio t CO2 (18)	0 Elec-tricity (19)	District Heat (20)	Cogen Heat (21)	All Final Energy (22)
Net Imports	62.80	148.00	-72.25	0.00	15.16	-21.91	-36.02	33.09	-5.47	2.22	-12.95	0.00	0.00	0.00	0.00	0.00	0.00	12.38	-14.85	0.00	0.00	47.94
Domestic Sources	866.48	0.00	327.89	437.00	0.00	0.00	0.00	0.00	0.00	0.00	437.00	26.65	22.56	26.54	8.95	16.89	101.60	47.46	0.00	0.00	0.00	866.48
Total Supply of Fuels	929.28	148.00	255.63	437.00	15.16	-21.91	-36.02	33.09	-5.47	2.22	424.05	26.65	22.56	26.54	8.95	16.89	101.60	59.83	-14.85	0.00	0.00	914.43
International air and marine bunkers	128.50	0.00	0.00	0.00	53.10	37.21	0.00	38.19	0.00	0.00	128.50	0.00	0.00	0.00	0.00	0.00	0.00	9.65	0.00	0.00	0.00	128.50
Nonenergy Uses (23)	12.66	0.00	0.00	0.00	11.64	1.02	0.00	0.00	0.00	0.00	12.66	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	12.66
Total Domestic Consumption	788.12	148.00	255.63	437.00	-49.57	-60.15	-36.02	-5.11	-5.47	2.22	282.89	26.65	22.56	26.54	8.95	16.89	101.60	49.20	-14.85	0.00	0.00	773.27
Electricity Import correction																						
Refineries, throughput	0.80	0.00	0.00	437.00	-95.00	-197.00	-106.30	-8.40	-9.40	-20.10	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
Total Conversion and Distribution sector	453.35	131.31	183.42	0.00	36.31	0.70	0.00	0.00	0.00	22.21	59.21	22.00	22.56	10.83	8.69	15.33	79.41	27.09	-128.01	-99.79	-23.89	201.65
Oil and Gas Sector (refineries, Offshore, gasworks)	66.90	0.00	48.84	0.00	2.23	0.00	0.00	0.00	0.00	15.84	18.06	0.00	0.00	0.00	0.00	0.00	0.00	3.85	0.00	0.00	0.00	66.90
Refineries, own consumption	19.38	0.00	0.00	0.00	2.23	0.00	0.00	0.00	0.00	17.15	19.38	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	19.38
Offshore fuel consumption including flaring	47.52	0.00	47.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	0.00	0.00	0.00	47.52
Town gas plants, throughput and own consumption	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	-1.32	-1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and District Heat Production	385.68	131.31	133.81	0.00	34.08	0.70	0.00	0.00	0.00	6.38	41.15	22.00	22.56	10.83	8.69	15.33	79.41	23.20	-136.53	-124.85	-23.89	100.40
(of which used for electric rail)	3.40	2.15	0.67	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.46	0.11	0.00	0.01	0.00	0.00	0.12	0.28	-1.31	0.00	0.00	2.09
Electricity production by Wind and Water Power	13.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.83	13.83	0.00	-13.83	0.00	0.00	0.00
Thermal electric Power Plants, Condensing Plants	84.94	44.95	19.87	0.00	8.80	0.00	0.00	0.00	0.00	0.00	8.80	5.31	5.17	0.75	0.08	0.00	11.31	6.10	-34.38	0.00	0.00	50.56
Thermal Electric Power Plants, Back Pressure Plants	172.91	83.56	46.45	0.00	18.36	0.00	0.00	0.00	0.00	0.00	18.36	10.45	12.13	1.77	0.19	0.00	24.54	12.04	-57.96	-84.95	0.00	30.00
Autoproducers of heat and electricity (cogeneration)	58.47	1.79	45.43	0.00	2.27	0.13	0.00	0.00	0.00	6.38	8.77	0.30	0.00	1.54	0.65	0.00	2.49	3.30	-18.40	-4.48	-23.89	11.70
District Heating Plants (including Peaking Boilers at Central Heat and Power Plants)	55.53	1.00	22.06	0.00	4.66	0.57	0.00	0.00	0.00	0.00	5.23	5.94	5.27	6.77	7.77	1.50	27.25	1.76	-11.97	-35.42	0.00	8.14
Loss and own consumption in distribution and transmission of electricity, heat and gas	0.77	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	8.52	25.06	0.00	34.35
Final Energy Consumption	333.97	16.69	72.21	0.00	9.12	136.16	70.28	3.29	3.93	0.11	222.88	4.65	0.00	15.72	0.26	1.56	22.19	22.11	113.16	99.79	23.89	570.81
Total Transport Energy	139.92	0.00	0.00	0.00	1.10	65.65	69.88	3.29	0.00	0.00	139.92	0.00	0.00	0.00	0.00	0.00	0.00	10.28	1.22	0.00	0.00	141.14
Road Transport in Denmark, final Energy	130.63	0.00	0.00	0.00	0.00	60.76	69.87	0.00	0.00	0.00	130.63	0.00	0.00	0.00	0.00	0.00	0.00	9.60	0.00	0.00	0.00	130.63
Rail Transport in Denmark, final Energy	1.74	0.00	0.00	0.00	0.00	1.74	0.00	0.00	0.00	0.00	1.74	0.00	0.00	0.00	0.00	0.00	0.00	0.13	1.22	0.00	0.00	2.96
Air and Sea Transport in Denmark, final Energy	4.29	0.00	0.00	0.00	1.10	2.25	0.00	0.93	0.00	0.00	4.29	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	4.29
Local border Trade (net export)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Military Consumption	3.27	0.00	0.00	0.00	0.00	0.90	0.01	2.36	0.00	0.00	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	3.27
Total Process Energy	93.10	15.41	32.02	0.00	7.21	31.16	0.37	0.00	2.31	0.07	41.12	1.34	0.00	3.19	0.02	0.00	4.55	6.34	46.51	6.33	20.64	166.58
Industry	56.84	12.55	29.81	0.00	5.29	4.73	0.07	0.00	1.13	0.07	11.30	0.00	0.00	3.16	0.02	0.00	3.18	3.73	38.46	4.32	18.95	118.57
Construction	6.77	0.00	0.29	0.00	0.26	5.34	0.03	0.00	0.85	0.00	6.48	0.00	0.00	0.00	0.00	0.00	0.00	0.49	1.41	0.00	0.00	8.18
Agriculture and Forestry	29.49	2.86	1.93	0.00	1.66	21.09	0.26	0.00	0.33	0.00	23.34	1.34	0.00	0.03	0.00	0.00	1.37	2.11	6.64	2.01	1.69	39.83
Fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption of Residential Commercial Sectors	100.95	1.29	40.19	0.00	0.81	39.35	0.03	0.00	1.61	0.03	41.83	3.31	0.00	12.53	0.24	1.56	17.64	5.49	65.43	93.46	3.25	263.09
Final Energy Demand for heating:	100.68	1.29	40.17	0.00	0.81	39.24	0.03	0.00	1.47	0.03	41.58	3.31	0.00	12.53	0.24	1.56	17.64	5.47	6.56	93.46	3.25	203.95
Electricity and gas use for Appliances and cooking (excl heating)	0.27	0.00	0.02	0.00	0.00	0.11	0.00	0.00	0.14	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.02	58.87	0.00	0.00	59.13

Danish Energy Agency file: cc_pak

Statistical data 1972 to 1995.
Energy 21 (april 1996) 1996 to 2005: Expected development from all measures implemented or decided.
Energy 21 (april 1996) 2005 to 2030: Expected development from contemplated new measures for the post 2005 period

Energy Balance for Denmark 2010 PJ per Year Scenario: Energy 21, Plan

Energy 21, Plan	0 All Fuels (1)	Primary Energy: Coal & Coke (2)	Natural Gas (3)	crude Oil (4)	Residual oil (5)	Heating oil (6)	Gaso-line (7)	JP1 & JP4 (8)	LPG (9)	Derived Gas (10)	Total Oilproducts (11)	Straw (12)	Refuse (13)	Wood (14)	Weet Biomass (15)	Wind & Solar (16)	Total Renewable (17)	CO2 mio t CO2 (18)	0 Elec-tricity (19)	District Heat (20)	Cogen Heat (21)	All Final Energy (22)
Net Imports	153.06	110.59	52.67	0.00	21.86	-27.34	-39.33	38.00	-5.60	2.21	-10.19	0.00	0.00	0.00	0.00	0.00	0.00	28.42	-9.18	0.00	0.00	143.88
Domestic Sources	743.47	0.00	184.08	437.00	0.00	0.00	0.00	0.00	0.00	0.00	437.00	27.46	22.63	32.21	13.25	26.84	122.39	27.01	0.00	0.00	0.00	743.47
Total Supply of Fuels	**896.53**	**110.59**	**236.74**	**437.00**	**21.86**	**-27.34**	**-39.33**	**38.00**	**-5.60**	**2.21**	**426.81**	**27.46**	**22.63**	**32.21**	**13.25**	**26.84**	**122.39**	**55.43**	**-9.18**	**0.00**	**0.00**	**887.34**
International air and marine bunkers	**147.75**	**0.00**	**0.00**	**0.00**	**61.55**	**43.14**	**0.00**	**43.06**	**0.00**	**0.00**	**147.75**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**11.09**	**0.00**	**0.00**	**0.00**	**147.75**
Nonenergy Uses (23)	**12.66**	**0.00**	**0.00**	**0.00**	**11.64**	**1.02**	**0.00**	**0.00**	**0.00**	**0.00**	**12.66**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.98**	**0.00**	**0.00**	**0.00**	**12.66**
Total Domestic Consumption	**736.12**	**110.59**	**236.74**	**437.00**	**-51.33**	**-71.50**	**-39.33**	**-5.05**	**-5.60**	**2.21**	**266.40**	**27.46**	**22.63**	**32.21**	**13.25**	**26.84**	**122.39**	**43.35**	**-9.18**	**0.00**	**0.00**	**726.93**
Electricity Import correction																						
Refineries, throughput	**0.80**	**0.00**	**0.00**	**437.00**	**-95.00**	**-197.00**	**-106.30**	**-8.40**	**-9.40**	**-20.10**	**0.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.80**
Total Conversion and Distribution sector	**420.70**	**95.21**	**170.02**	**0.00**	**35.36**	**0.56**	**0.00**	**0.00**	**0.00**	**22.21**	**58.13**	**23.46**	**22.63**	**13.89**	**13.00**	**24.38**	**97.35**	**22.82**	**-122.81**	**-100.44**	**-25.43**	**172.02**
Oil and Gas Sector (refineries, Offshore, gasworks)	60.64	0.00	42.58	0.00	2.23	0.00	0.00	0.00	0.00	15.84	18.06	0.00	0.00	0.00	0.00	0.00	0.00	3.50	0.00	0.00	0.00	60.64
Refineries, own consumption	19.38	0.00	0.00	0.00	2.23	0.00	0.00	0.00	0.00	17.15	19.38	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	19.38
Offshore fuel consumption including flaring	41.26	0.00	41.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.35	0.00	0.00	0.00	41.26
Town gas plants, throughput and own consumption	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	-1.32	-1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and District Heat Production	359.29	95.21	126.67	0.00	33.13	0.56	0.00	0.00	0.00	6.38	40.07	23.46	22.63	13.89	13.00	24.38	97.35	19.27	-131.37	-125.64	-25.43	76.85
(of which used for electric rail)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity production by Wind and Water Power	22.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.71	22.71	0.00	-22.71	0.00	0.00	0.00
Thermal electric Power Plants, Condensing Plants	43.02	18.84	11.39	0.00	5.36	0.00	0.00	0.00	0.00	0.00	5.36	3.00	3.33	1.05	0.05	0.00	7.44	2.86	-17.63	0.00	0.00	25.40
Thermal Electric Power Plants, Back Pressure Plants	170.53	74.26	46.53	0.00	18.52	0.00	0.00	0.00	0.00	0.00	18.52	12.61	13.99	4.41	0.22	0.00	31.23	11.17	-57.75	-82.99	0.00	29.80
Autoproducers of heat and electricity (cogeneration)	62.69	1.28	46.61	0.00	2.01	0.12	0.00	0.00	0.00	6.38	8.50	1.76	0.00	1.96	2.58	0.00	6.30	3.30	-20.22	-4.51	-25.43	12.53
District Heating Plants (including Peaking Boilers at Central Heat and Power Plants)	60.33	0.83	22.13	0.00	7.24	0.45	0.00	0.00	0.00	0.00	7.69	6.09	5.31	6.47	10.14	1.66	29.68	1.94	-13.06	-38.15	0.00	9.13
Loss and own consumption in distribution and transmission of electricity, heat and gas	0.77	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	8.55	25.20	0.00	34.52
Final Energy Consumption	**314.61**	**15.38**	**66.73**	**0.00**	**8.31**	**124.94**	**66.97**	**3.35**	**3.80**	**0.10**	**207.46**	**4.00**	**0.00**	**18.32**	**0.25**	**2.47**	**25.04**	**20.53**	**113.63**	**100.44**	**25.43**	**554.11**
Total Transport Energy	137.41	0.00	0.80	0.00	1.02	62.66	66.59	3.35	0.00	0.00	133.61	0.00	0.00	3.00	0.00	0.00	3.00	9.86	1.50	0.00	0.00	138.90
Road Transport in Denmark, final Energy	128.94	0.00	0.80	0.00	0.00	58.56	66.58	0.00	0.00	0.00	125.14	0.00	0.00	3.00	0.00	0.00	3.00	9.24	0.14	0.00	0.00	129.08
Rail Transport in Denmark, final Energy	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	1.36	0.00	0.00	2.36
Air and Sea Transport in Denmark, final Energy	4.19	0.00	0.00	0.00	1.02	2.19	0.00	0.99	0.00	0.00	4.19	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	4.19
Local border Trade (net export)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Military Consumption	3.27	0.00	0.00	0.00	0.00	0.90	0.01	2.36	0.00	0.00	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	3.27
Total Process Energy	86.32	14.18	29.25	0.00	6.52	29.55	0.35	0.00	2.28	0.07	38.77	1.14	0.00	2.98	0.02	0.00	4.13	5.88	47.18	6.25	21.41	161.16
Industry	51.71	11.46	27.10	0.00	4.68	4.34	0.07	0.00	1.06	0.07	10.22	0.00	0.00	2.90	0.02	0.00	2.92	3.40	39.25	4.26	19.11	114.32
Construction	7.13	0.00	0.31	0.00	0.27	5.63	0.03	0.00	0.89	0.00	6.82	0.00	0.00	0.00	0.00	0.00	0.00	0.52	1.46	0.00	0.00	8.59
Agriculture and Forestry	27.48	2.71	1.84	0.00	1.57	19.58	0.25	0.00	0.32	0.00	21.72	1.14	0.00	0.07	0.00	0.00	1.21	1.97	6.48	2.00	2.30	38.25
Fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption of Residential Commercial Sectors	90.89	1.20	36.68	0.00	0.78	32.73	0.03	0.00	1.52	0.03	35.09	2.86	0.00	12.35	0.24	2.47	17.91	4.79	64.96	94.19	4.02	254.05
Final Energy Demand for heating:	90.61	1.20	36.66	0.00	0.78	32.62	0.03	0.00	1.38	0.03	34.84	2.86	0.00	12.35	0.24	2.47	17.91	4.77	6.15	94.19	4.02	194.97
Electricity and gas use for Appliances and cooking (excl heating)	0.28	0.00	0.02	0.00	0.00	0.11	0.00	0.00	0.15	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.02	58.80	0.00	0.00	59.08

Danish Energy Agency file: cc_pak

Statistical data 1972 to 1995.
Energy 21 (april 1996) 1996 to 2005: Expected development from all measures implemented or decided.
Energy 21 (april 1996) 2005 to 2030: Expected development from contemplated new measures for the post 2005 period

Energy Balance for Denmark 2020 PJ per Year Scenario: Energy 21, Plan

Energy 21, Plan	All Fuels (1)	Coal & Coke (2)	Natural Gas (3)	crude Oil (4)	Residual oil (5)	Heating oil (6)	Gaso-line (7)	JP1 & JP4 (8)	LPG (9)	Derived Gas (10)	Total Oilproducts (11)	Straw (12)	Refuse (13)	Wood (14)	Weet Biomass (15)	Wind & Solar (16)	Total Renewable (17)	CO2 mio t CO2 (18)	Elec-tricity (19)	District Heat (20)	Cogen Heat (21)	All Final Energy (22)
	0	Primary Energy:																	0			
Net Imports	196.50	59.80	185.23	0.00	1.49	-44.91	-47.84	46.38	-5.85	2.20	-48.53	0.00	0.00	0.00	0.00	0.00	0.00	41.25	-21.65	0.00	0.00	174.85
Domestic Sources	649.87	0.00	29.12	437.00	0.00	0.00	0.00	0.00	0.00	0.00	437.00	29.98	22.75	51.89	22.05	57.09	183.75	5.12	0.00	0.00	0.00	649.87
Total Supply of Fuels	**846.37**	**59.80**	**214.35**	**437.00**	**1.49**	**-44.91**	**-47.84**	**46.38**	**-5.85**	**2.20**	**388.47**	**29.98**	**22.75**	**51.89**	**22.05**	**57.09**	**183.75**	**46.37**	**-21.65**	**0.00**	**0.00**	**824.72**
International air and marine bunkers	**167.04**	**0.00**	**0.00**	**0.00**	**67.99**	**47.65**	**0.00**	**51.40**	**0.00**	**0.00**	**167.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**12.53**	**0.00**	**0.00**	**0.00**	**167.04**
Nonenergy Uses (23)	**12.66**	**0.00**	**0.00**	**0.00**	**11.64**	**1.02**	**0.00**	**0.00**	**0.00**	**0.00**	**12.66**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.98**	**0.00**	**0.00**	**0.00**	**12.66**
Total Domestic Consumption	**666.67**	**59.80**	**214.35**	**437.00**	**-78.14**	**-93.58**	**-47.84**	**-5.02**	**-5.86**	**2.20**	**208.77**	**29.98**	**22.75**	**51.89**	**22.05**	**57.09**	**183.75**	**32.86**	**-21.65**	**0.00**	**0.00**	**645.02**
Electricity Import correction																						
Refineries, throughput	**0.80**	**0.00**	**0.00**	**437.00**	**-95.00**	**-197.00**	**-106.30**	**-8.40**	**-9.40**	**-20.10**	**0.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.80**
Total Conversion and Distribution sector	**391.31**	**47.05**	**158.60**	**0.00**	**10.16**	**0.30**	**0.00**	**0.00**	**0.00**	**22.21**	**32.67**	**27.27**	**22.75**	**28.35**	**21.81**	**52.81**	**152.99**	**15.57**	**-136.04**	**-101.73**	**-28.51**	**125.03**
Oil and Gas Sector (refineries, Offshore, gasworks)	29.91	0.00	11.85	0.00	2.23	0.00	0.00	0.00	0.00	15.84	18.06	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.00	0.00	0.00	29.91
Refineries, own consumption	19.38	0.00	0.00	0.00	2.23	0.00	0.00	0.00	0.00	17.15	19.38	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	19.38
Offshore fuel consumption including flaring	10.53	0.00	10.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	10.53
Town gas plants, throughput and own consumption	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	-1.32	-1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and District Heat Production	360.63	47.05	145.98	0.00	7.94	0.30	0.00	0.00	0.00	6.38	14.61	27.27	22.75	28.35	21.81	52.81	152.99	13.78	-144.65	-127.21	-28.51	60.26
(of which used for electric rail)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity production by Wind and Water Power	40.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.25	40.25	0.00	-40.25	0.00	0.00	0.00
Thermal electric Power Plants, Condensing Plants	16.37	4.24	6.92	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.24	1.50	1.62	1.82	0.03	0.00	4.97	0.82	-8.65	0.00	0.00	7.72
Thermal Electric Power Plants, Back Pressure Plants	160.95	41.73	68.06	0.00	2.32	0.00	0.00	0.00	0.00	0.00	2.32	14.72	15.93	17.88	0.31	0.00	48.84	8.02	-59.88	-74.52	0.00	26.55
Autoproducers of heat and electricity (cogeneration)	71.13	0.27	48.98	0.00	1.49	0.10	0.00	0.00	0.00	6.38	7.97	4.68	0.00	2.80	6.44	0.00	13.92	3.30	-23.86	-2.66	-28.51	16.10
District Heating Plants (including Peaking Boilers at Central Heat and Power Plants)	71.93	0.81	22.01	0.00	3.89	0.20	0.00	0.00	0.00	0.00	4.08	6.38	5.19	5.86	15.03	12.56	45.02	1.65	-12.02	-50.03	0.00	9.88
Loss and own consumption in distribution and transmission of electricity, heat and gas	0.77	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	8.61	25.48	0.00	34.86
Final Energy Consumption	**274.56**	**12.75**	**55.75**	**0.00**	**6.70**	**103.12**	**58.46**	**3.38**	**3.54**	**0.09**	**175.30**	**2.70**	**0.00**	**23.53**	**0.25**	**4.28**	**30.76**	**17.28**	**114.39**	**101.74**	**28.51**	**519.19**
Total Transport Energy	131.03	0.00	2.40	0.00	0.85	57.30	58.10	3.38	0.00	0.00	119.63	0.00	0.00	9.00	0.00	0.00	9.00	8.93	1.87	0.00	0.00	132.90
Road Transport in Denmark, final Energy	123.46	0.00	2.40	0.00	0.00	53.96	58.09	0.00	0.00	0.00	112.06	0.00	0.00	9.00	0.00	0.00	9.00	8.37	0.35	0.00	0.00	123.80
Rail Transport in Denmark, final Energy	0.42	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.03	1.53	0.00	0.00	1.94
Air and Sea Transport in Denmark, final Energy	3.89	0.00	0.00	0.00	0.85	2.02	0.00	1.02	0.00	0.00	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	3.89
Local border Trade (net export)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Military Consumption	3.27	0.00	0.00	0.00	0.00	0.90	0.01	2.36	0.00	0.00	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	3.27
Total Process Energy	72.76	11.72	23.69	0.00	5.13	26.33	0.33	0.00	2.20	0.06	34.05	0.74	0.00	2.54	0.02	0.00	3.30	4.98	48.51	6.09	22.95	150.32
Industry	41.43	9.29	21.69	0.00	3.46	3.56	0.06	0.00	0.92	0.06	8.06	0.00	0.00	2.38	0.02	0.00	2.40	2.72	40.82	4.12	19.44	105.81
Construction	7.86	0.00	0.35	0.00	0.30	6.19	0.04	0.00	0.99	0.00	7.51	0.00	0.00	0.00	0.00	0.00	0.00	0.57	1.54	0.00	0.00	9.40
Agriculture and Forestry	23.47	2.43	1.65	0.00	1.38	16.58	0.23	0.00	0.29	0.00	18.49	0.74	0.00	0.16	0.00	0.00	0.90	1.70	6.15	1.97	3.52	35.11
Fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption of Residential Commercial Sectors	70.77	1.03	29.66	0.00	0.72	19.49	0.03	0.00	1.34	0.03	21.62	1.97	0.00	11.99	0.23	4.28	18.46	3.37	64.00	95.64	5.56	235.97
Final Energy Demand for heating:	70.47	1.03	29.63	0.00	0.72	19.38	0.03	0.00	1.20	0.03	21.36	1.97	0.00	11.99	0.23	4.28	18.46	3.36	5.33	95.64	5.56	177.00
Electricity and gas use for Appliances and cooking (excl heating)	0.29	0.00	0.03	0.00	0.00	0.11	0.00	0.00	0.15	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.02	58.68	0.00	0.00	58.97

Danish Energy Agency file: cc_pak

Statistical data 1972 to 1995.
Energy 21 (april 1996) 1996 to 2005: Expected development from all measures implemented or decided.
Energy 21 (april 1996) 2005 to 2030: Expected development from contemplated new measures for the post 2005 period

Energy Balance for Denmark 2030 PJ per Year Scenario: Energy 21, Plan

Energy 21, Plan	0 All Fuels (1)	Primary Energy: Coal & Coke (2)	Natural Gas (3)	crude Oil (4)	Residual oil (5)	Heating oil (6)	Gaso-line (7)	JP1 & JP4 (8)	LPG (9)	Derived Gas (10)	Total Oilproducts (11)	Straw (12)	Refuse (13)	Wood (14)	Weet Biomass (15)	Wind & Solar (16)	Total Renewable (17)	CO2 mio t CO2 (18)	0 Elec-tricity (19)	District Heat (20)	Cogen Heat (21)	All Final Energy (22)
Net Imports	135.44	8.99	188.12	0.00	5.44	-57.61	-58.23	53.10	-6.54	2.16	-61.68	0.00	0.00	0.00	0.00	0.00	0.00	39.10	-40.54	0.00	0.00	94.89
Domestic Sources	682.07	0.00	10.41	437.00	0.00	0.00	0.00	0.00	0.00	0.00	437.00	33.57	22.10	69.95	19.95	89.09	234.66	0.59	0.00	0.00	0.00	682.07
Total Supply of Fuels	**817.51**	**8.99**	**198.54**	**437.00**	**5.44**	**-57.61**	**-58.23**	**53.10**	**-6.54**	**2.16**	**375.32**	**33.57**	**22.10**	**69.95**	**19.95**	**89.09**	**234.66**	**39.69**	**-40.54**	**0.00**	**0.00**	**776.97**
International air and marine bunkers	**185.92**	**0.00**	**0.00**	**0.00**	**75.11**	**52.64**	**0.00**	**58.17**	**0.00**	**0.00**	**185.92**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**13.94**	**0.00**	**0.00**	**0.00**	**185.92**
Nonenergy Uses (23)	**12.66**	**0.00**	**0.00**	**0.00**	**11.64**	**1.02**	**0.00**	**0.00**	**0.00**	**0.00**	**12.66**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.98**	**0.00**	**0.00**	**0.00**	**12.66**
Total Domestic Consumption	**618.93**	**8.99**	**198.54**	**437.00**	**-81.31**	**-111.27**	**-58.23**	**-5.07**	**-6.54**	**2.16**	**176.74**	**33.57**	**22.10**	**69.95**	**19.95**	**89.09**	**234.66**	**24.76**	**-40.54**	**0.00**	**0.00**	**578.39**
Electricity Import correction																						
Refineries, throughput	**0.80**	**0.00**	**0.00**	**437.00**	**-95.00**	**-197.00**	**-106.30**	**-8.40**	**-9.40**	**-20.10**	**0.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.80**
Total Conversion and Distribution sector	**382.25**	**0.48**	**152.02**	**0.00**	**9.03**	**0.08**	**0.00**	**0.00**	**0.00**	**22.21**	**31.32**	**31.98**	**22.10**	**42.15**	**19.73**	**82.48**	**198.44**	**10.67**	**-145.03**	**-98.57**	**-35.20**	**103.45**
Oil and Gas Sector (refineries, Offshore, gasworks)	19.38	0.00	1.32	0.00	2.23	0.00	0.00	0.00	0.00	15.84	18.06	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	19.38
Refineries, own consumption	19.38	0.00	0.00	0.00	2.23	0.00	0.00	0.00	0.00	17.15	19.38	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	19.38
Offshore fuel consumption including flaring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Town gas plants, throughput and own consumption	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	-1.32	-1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and District Heat Production	362.10	0.48	149.93	0.00	6.80	0.08	0.00	0.00	0.00	6.38	13.25	31.98	22.10	42.15	19.73	82.48	198.44	9.48	-152.90	-123.22	-35.20	50.79
(of which used for electric rail)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity production by Wind and Water Power	59.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.83	59.83	0.00	-59.83	0.00	0.00	0.00
Thermal electric Power Plants, Condensing Plants	3.22	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.42	0.76	0.01	0.00	1.61	0.09	-1.62	0.00	0.00	1.60
Thermal Electric Power Plants, Back Pressure Plants	131.82	0.00	65.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.52	17.11	31.03	0.33	0.00	66.00	3.75	-52.75	-57.83	0.00	21.24
Autoproducers of heat and electricity (cogeneration)	84.99	0.00	59.43	0.00	1.10	0.08	0.00	0.00	0.00	6.38	7.55	7.76	0.00	4.37	5.88	0.00	18.01	3.84	-29.03	-2.63	-35.20	18.13
District Heating Plants (including Peaking Boilers at Central Heat and Power Plants)	82.24	0.48	23.08	0.00	5.70	0.00	0.00	0.00	0.00	0.00	5.70	6.27	4.58	5.99	13.50	22.65	52.99	1.80	-9.67	-62.76	0.00	9.81
Loss and own consumption in distribution and transmission of electricity, heat and gas	0.77	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	7.86	24.64	0.00	33.28
Final Energy Consumption	**235.88**	**8.52**	**46.52**	**0.00**	**4.67**	**85.65**	**48.07**	**3.33**	**2.86**	**0.05**	**144.63**	**1.58**	**0.00**	**27.80**	**0.23**	**6.61**	**36.22**	**14.10**	**104.49**	**98.58**	**35.20**	**474.14**
Total Transport Energy	121.15	0.00	4.00	0.00	0.70	50.36	47.77	3.33	0.00	0.00	102.15	0.00	0.00	15.00	0.00	0.00	15.00	7.74	2.10	0.00	0.00	123.25
Road Transport in Denmark, final Energy	114.43	0.00	4.00	0.00	0.00	47.67	47.76	0.00	0.00	0.00	95.43	0.00	0.00	15.00	0.00	0.00	15.00	7.24	0.44	0.00	0.00	114.87
Rail Transport in Denmark, final Energy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	0.00	0.00	1.66
Air and Sea Transport in Denmark, final Energy	3.45	0.00	0.00	0.00	0.70	1.79	0.00	0.97	0.00	0.00	3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	3.45
Local border Trade (net export)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Military Consumption	3.27	0.00	0.00	0.00	0.00	0.90	0.01	2.36	0.00	0.00	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	3.27
Total Process Energy	59.37	7.67	21.05	0.00	3.30	23.04	0.27	0.00	1.71	0.03	28.35	0.34	0.00	1.94	0.01	0.00	2.30	4.02	41.32	5.38	28.05	134.11
Industry	29.06	5.11	18.89	0.00	1.47	1.34	0.03	0.00	0.39	0.03	3.25	0.00	0.00	1.79	0.01	0.00	1.80	1.80	33.52	3.50	24.79	90.86
Construction	8.80	0.00	0.39	0.00	0.33	6.97	0.04	0.00	1.06	0.00	8.41	0.00	0.00	0.00	0.00	0.00	0.00	0.64	1.68	0.00	0.00	10.48
Agriculture and Forestry	21.51	2.56	1.78	0.00	1.49	14.72	0.20	0.00	0.26	0.00	16.68	0.34	0.00	0.16	0.00	0.00	0.49	1.58	6.12	1.88	3.26	32.77
Fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption of Residential Commercial Sectors	55.36	0.85	21.46	0.00	0.67	12.25	0.03	0.00	1.15	0.03	14.13	1.25	0.00	10.86	0.21	6.61	18.93	2.34	61.07	93.20	7.15	216.78
Final Energy Demand for heating:	55.06	0.85	21.41	0.00	0.67	12.14	0.03	0.00	1.00	0.03	13.87	1.25	0.00	10.86	0.21	6.61	18.93	2.32	5.01	93.20	7.15	160.42
Electricity and gas use for Appliances and cooking (excl heating)	0.30	0.00	0.05	0.00	0.00	0.11	0.00	0.00	0.15	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.02	56.05	0.00	0.00	56.36

Danish Energy Agency file: cc_pak

Statistical data 1972 to 1995.
Energy 21 (april 1996) 1996 to 2005: Expected development from all measures implemented or decided.
Energy 21 (april 1996) 2005 to 2030: Expected development from contemplated new measures for the post 2005 period

Annex C: Danish livestock statistics

	1970	1980	1985	1990	1995
Cattle	2,840	2,961	2,620	2,240	2,090
Pigs	8,360	9,957	9,090	9,500	11,084
Poultry	19,770	15,509	15,220	16,250	19,620

Table C.1. *Development in livestock (thousand head), 1970 – 1995.*

Year	Hor-ses	Cattle other than cows	Cows	Pigs other than sows	Sows	Sheep	Fowls other than chickens for slaughtering	Chickens for slaugh-tering
1990	38	1,399	840	8,593	904	159	5,696	9,802
1991	32	1,379	843	8,855	928	188	5,067	10,019
1992	28	1,366	824	9,454	1,001	182	5,639	12,620
1993	20	1,357	838	10,527	1,041	157	5,517	13,399
1994	18	1,288	817	9,931	992	145	6,931	12,023
1995	18	1,265	825	10,069	1,015	145	6,088	12,585

Table C.2. *Danish livestock for the years 1990 – 94 (thousand head).*

Annex D: Emission factors

Source category	Fuel	Valid in period	Sulphur %	SO_2 kg/GJ	NO_x kg/GJ	CO_2 kg/GJ	N_2O kg/GJ	CH_4 kg/GJ	NMVOC kg/GJ	CO kg/GJ
Public Power	Coal	1972-82	1,00	0,714	0,400	95,0	0,003	0,0015	0,0015	0,010
		1983-95	se note	see note	see note					
	Orimulsion	1995-	2,00	0,990	0,240	80,0	0,002	0,0030	0,0030	0,015
	Refuse	1972-95		0,090	0,150	117,0	0,004	0,0060	0,0090	2,188
		1996-		0,025						
	Straw	1972-95		0,025	0,130	102,0	0,004	0,0320	0,0480	0,160
	Wood	1972-95		0,025	0,130	102,0	0,004	0,0320	0,0480	0,160
	Residual	1972-77	2,50	1,238	0,240	78,0	0,002	0,0030	0,0030	0,015
		1978-88	2,30	1,139						
		1989-95	0,92	0,455						
	Diesel oil	1972-85	0,50	0,234	0,300	74,0	0,002	0,0015	0,0015	0,012
		1986-88	0,30	0,141						
		1989-95	0,20	0,094						
	Natural gas	1972-95		0,0003	0,240	56,9	0,001	0,0025	0,0025	0,020
District heating plants	Coal	1972-88	1,00	0,649	0,200	95,0	0,003	0,0150	0,0150	0,097
		1989-95	0,90	0,584						
	Refuse	1972-95		0,090	0,150	117,0	0,004	0,0060	0,0090	2,188
		1996-		0,025						
	Straw	1972-95		0,025	0,130	102,0	0,004	0,0320	0,0480	0,160
	Wood	1972-95		0,025	0,130	102,0	0,004	0,0320	0,0480	0,097
	Fish oil	1972-95	0,10	0,047	0,100	74,0	0,002	0,0015	0,0015	0,012
	Residual	1972-85	2,35	1,163	0,150	78,0	0,002	0,0030	0,0030	0,015
		1986-88	1,45	0,718						
		1989-95	1,00	0,495						
	Gas oil	1972-85	0,50	0,234	0,100	74,0	0,002	0,0015	0,0015	0,012
		1986-88	0,30	0,141						
		1989-95	0,20	0,094						
		1996-	0,05	0,023						
	Natural gas	1972-95		0,0003	0,150	56,9	0,001	0,0040	0,0040	0,013
Autoproducer Industrial combustion	Natural gas	1972-95		0,0003	0,250	56,9	0,001	0,5983	0,0040	0,013
	Coal	1972-88	1,00	0,649	0,200	95,0	0,003	0,0150	0,0150	0,097
		1989-95	0,90	0,584						
	Straw	1972-95		0,025	0,130	102,0	0,004	0,0320	0,0480	0,160
	Wood	1972-95		0,025	0,130	102,0	0,004	0,0320	0,0480	0,160
	Petroleum	1972-95		0,680	0,200	102,0	0,003	0,0015	0,0015	0,097
	Residual	1972-85	2,35	1,163	0,150	78,0	0,002	0,0030	0,0030	0,015
		1986-88	1,45	0,718						
		1989-95	1,00	0,495						
	Gas oil	1972-85	0,50	0,234	0,100	74,0	0,002	0,0015	0,0015	0,012
		1986-88	0,30	0,141						
		1989-95	0,20	0,094						
		1996-	0,05	0,023						
	LPG	1972-95	0,00	0,000	0,100	65,0	0,001	0,0009	0,0021	0,013
	Natural gas	1972-95		0,0003	0,100	56,9	0,001	0,0040	0,0040	0,013
Residential & Service burners	Straw	1972-95		0,025	0,050	102,0	0,003	0,4000	0,6000	10,000
	Wood	1972-95		0,025	0,050	102,0	0,003	0,4000	0,6000	10,000
	Petroleum	1972-95		0,680	0,050	102,0	0,003	0,0015	0,0015	1,000
	Gas oil	1972-85	0,50	0,234	0,050	74,0	0,002	0,0070	0,0030	0,020
		1986-88	0,30	0,141						
		1989-95	0,20	0,094						
		1996-	0,05	0,023						
	Kerosine	1972-95	0,01	0,005	0,050	72,0	0,002	0,0070	0,0030	0,020
	LPG	1972-95	0,00	0,000	0,100	65,0	0,001	0,0009	0,0021	0,025
	Natural gas	1972-95		0,0003	0,050	56,9	0,001	0,0050	0,0050	0,025
Road transport	Diesel oil (Passenger	1972-85	0,50	0,234	0,251	74,0	0,004	0,0022	0,0681	0,286
		1986-88	0,30	0,141						
		1989-90	0,20	0,094						
		1991	0,20	0,092	0,238					
		1992	0,13	0,059	0,243					
		1993	0,05	0,023	0,253					
		1994			0,246					
		1995			0,246					
	Diesel oil (light duty	1972-85	0,50	0,234	0,375	74,0	0,004	0,0013	0,1129	0,418
		1986-88	0,30	0,141						
		1989-90	0,20	0,094						
		1991	0,20	0,092	0,356					
		1992	0,13	0,059	0,362					
		1993	0,05	0,023	0,377					
		1994			0,366					
		1995			0,368					
	Diesel oil (heavy duty	1972-85	0,50	0,234	0,984	74,0	0,003	0,0063	0,1983	1,006
		1986-88	0,30	0,141						

continue next page

Emissions factors (continued)

		1989-90	0,20	0,094						
		1991	0,20	0,092	0,356					
		1992	0,13	0,059	0,362					
		1993	0,05	0,023	0,377					
		1994			0,366					
		1995			0,368					
	Diesel oil (heavy duty vehicle)	1972-85	0,50	0,234	0,984	74,0	0,003	0,0063	0,1983	1,006
		1986-88	0,30	0,141						
		1989-90	0,20	0,094						
		1991	0,20	0,092	0,924					
		1992	0,13	0,059	0,940					
		1993	0,05	0,023	0,980					
		1994			0,960					
		1995			0,961					
	Gasoline (road)	1972-90	0,01	0,005	0,859	73,0	0,0023	0,0219	1,2426	6,972
		1991			0,813		0,0030	0,0210	1,1798	6,751
		1992			0,780		0,0043	0,0204	1,0972	6,207
		1993			0,724		0,0063	0,0194	0,9951	5,715
		1994			0,634		0,0084	0,0177	0,8861	4,957
		1995			0,522		0,0096	0,0163	0,7724	4,439
		2010			0,175		0,0190	0,0044	0,2485	1,394
		2030			0,088		0,0380	0,0022	0,1243	0,697
	Biofuel	1972-95		0	0,898		0,0020	0,0192	0,3585	1,610
	Natural gas (road)	1972-95		0,0003	0,898	56,9	0,0020	0,0192	0,3585	1,610
	LPG (road)	1972-95	0,00	0,000	0,898	65,0	0,0020	0,0192	0,3585	1,610
Other mobile sources	Residual oil (sea)	1972-91	3,00	1,485	1,411	78,0	0,005	0,0018	0,0576	0,183
		1992	1,80	0,891						
		1993	2,42	1,197						
		1994	2,60	1,287						
		1995	2,79	1,381						
	Diesel oil (off-road)	1972-85	0,50	0,234	1,439	74,0	0,003	0,0048	0,2038	0,680
		1986-88	0,30	0,141						
		1989-95	0,20	0,094						
		1996-	0,05	0,023						
	Diesel oil (fishery)	1972-88	1,00	0,468	1,335	74,0	0,005	0,0017	0,0545	0,173
		1989-95	0,20	0,094						
		1996-	0,10	0,047						
	Diesel oil (railway)	1972-85	0,50	0,234	1,073	74,0	0,002	0,0056	0,1817	0,333
		1986-88	0,30	0,141						
		1989-92	0,20	0,094						
		1993-95	0,05	0,023						
	Diesel oil (sea)	1972-95	1,00	0,468	1,335	74,0	0,005	0,0017	0,0545	0,173
	LPG off-road	1972-95	0,00	0,000	1,249	65,0	0,002	0,0203	0,3849	0,443
	Gasoline off-road	1972-95	0,01	0,005	0,204	73,0	0,002	0,3469	4,0457	25,461
	Gasoline (air)	1972-95	0,01	0,005	0,859	73,0	0,002	0,0219	1,2426	6,972
	J.P.1 (air-LTO)	1972-94	0,01	0,005	0,291	72,0	0,002	0,0044	0,0416	0,205
		1995			0,292			0,0045	0,0419	0,206
Refineries	Refinery gas	1972-95	0,00	0,000	0,100	56,9	0,001	0,0040	0,0040	0,013
	Natural gas,turbine	1972-95		0,000	0,290	56,9	0,001	0,0185	0,0100	0,027
	Natural gas,flared	1972-95	0,00	0,000	0,308	56,9	0,001	0,1615	0,0872	0,200
	Residual oil	1972-79		2,081	0,150	78,0	0,002	0,0030	0,0030	0,015
International transport	Residual oil (sea)	1972-91	3,50	1,733	2,153	78,0	0,005	0,0018	0,0576	0,183
		1992	2,88	1,426						
		1993	3,12	1,544						
		1994	3,04	1,504						
		1995	3,30	1,635						
	Diesel oil (sea)	1972-95	1,00	0,468	1,335	74,0	0,005	0,0017	0,0545	0,173
	J.P.1 (air-cruise)	1972-95	0,01	0,005	0,297	72,0	0,002	0,0028	0,0260	0,020

Note: SO_2 and NO_x emissions from power plants for 1983-95 are measured and not calculated with emission factors.
All commas in figures are decimal points.
If no emission factor is shown it means equal to the number above.

Annex E: Electricity exchange and temperature corrections

Danish CO_2 inventory adjusted for electricity exchange and temperature variations

Electricity exchange

In some years Denmark imports considerable electricity while in other years electricity is exported. The variation is due to changes in precipitation in Norway and Sweden leading to fluctuations in the availability of hydropower.

The CO_2 emission inventory include a correction for this exchange of electricity. The correction is done from the assumption that the electricity is produced using the average fuels used at Danish power plants. The corrected emission is calculated as follows:

$$Emi_{Corr} = Emi \times \left(1 - \frac{H}{Eff_h \times En}\right) \times \frac{I}{P}$$

where:

Emi - is the calculated total emission from central power plants in tonnes.
H - is the heat production at the power plants, used for district heating in PJ.
En - is the total fuel consumption at the central power plants in PJ.
I - is the imported or exported electricity in kWh.
P - is the produced electricity at the central power plants in kWh.
Eff_h - is the marginal efficiency of heat production, estimated to be 2.0.

The correction for electricity exchange is intended to absorbe fluctuations due to varying availability of hydropower in Norway and Sweden caused by varying precipitation. The correction method assumes that all the actual variation in net exchange has this origin. However, the pattern seen in the latest years might include a more systematic change in the electricity exchange. In order to seperate such systematic changes from the fluctuations due to precipitation, work has been initiated on developing a revised correction methodology, which will guaranty that the ajustments, seen over several years, will be without systematic bias.

Temperature variations

Climate variation imply not only a variation in electricity exchange but also inter-annual fluctuations in domestic energy consumption due to variation in outside temperature. Consequently, correction for the impact of outside temperature variation has been applied as well.

The energy consumption for space heating in the service sector and in households is corrected for variations in outdoor temperature. Also consumption of district heat and 20% of the consumption of oil and natural gas used in industry is corrected.

Corrections for temperature variation is made by applying a correction factor to all space heating demands and the corresponding implied fuel consumption in the space heating, power and district heating sectors. The correction factor is based on the number of degree-days for the specific years, compared to the average number of degree days for a long period of years. The information source is the Danish Technological Institute.

The number of degree days for each year during the period 1990 to 1995 is shown in Table E.1. From the number of degree days, a correction index is calculated, assuming that 50% of the heat consumption depends on the outdoor temperature, while the other 50% is independent of the temperature (heat used for e.g. hot tap water).

Year:	Normal year	1990	1991	1992	1993	1994	1995
Degree days	2691	2093	2515	2530	2697	2617	2692
Corr. factor	1	1.1249	1.0338	1.0309	0.9989	1.0139	0.9997

Table E.1. *Number of degree days and the corresponding correction factor for each year 1990 - 95.*

The corrections for electricity exchange and for outside temperature variation are only significant for the CO_2 emissions and have therefore only been applied to these emissions.

Annex F: Description of energy-related Acts and measures

F.1 **The Electricity Supply Act**

The Act defines the rules for accounting and tariff-setting (essentially defining - electricity supply as a non-profit business) and sets the regulatory framework for the sector. The Act – originally from 1976 – also enables the Minister of Energy to order electricity supply companies to use specific fuels and specific modes of generation. The "modes of generation" can be used to ensure that new capacity is in the form of combined heat and power plants, wind turbines, etc.

In 1985, it was decided not to use nuclear power in Denmark.

The same year, the Minister of Energy and the power companies signed an agreement securing the construction of 100 MW of wind power capacity before 1991.

In 1986, following an agreement between the government and the major opposition party, the power companies agreed to build 450 MW of small-scale combined heat and power plants fuelled by natural gas and (other) indigenous fuels (wood chips, straw, municipal solid waste and bio gas).

In 1990, after a similar agreement, the power companies agreed to establish another 100 MW of wind capacity before 1994.

In March 1992, Parliament passed a resolution, to be implemented by the Minister of Energy, according to which:

Electricity utilities shall be urged to set up targets for energy conservation and assess the fulfilment of the targets, and electricity utilities shall undertake fuel substitutions – from coal to natural gas and bio-mass – which are necessary to achieve the target of a reduction of 20% in CO_2 emissions by 2005.

Furthermore, in an agreement of June 1993 between the government and three opposition parties, it was decided that by the year 2000, power companies must utilise 1.2 million tonnes of straw and 0.2 million tonnes of forest residues per year (totalling about 19 PJ per year), primarily in large coal-fired power plants. As an element of the new energy action plan *Energy 21* more flexibility will be provided for the utilities regarding the concrete use of biomass in the central power plants.

A new planning method for the utilities, Integrated Resource Planning (IRP), was introduced in 1994 by an amendment to the Electricity Supply Act. IRP is a least-cost planning method that takes account of all options for meeting a projected increase in electricity demand, including energy efficiency programmes. In December 1995, the utilities reported the results of the first round of IRP to the Energy Authorities. Although the method is still to be improved, the initial results show that expectations to IRP as an instrument to promote enhanced energy efficiency and energy conservation have been fulfilled.

Late November 1995, the Parliament passed a bill concerning the accounting price which the utilities must offer independent producers delivering power to the network. This initiative ensures that accounting practice in the utilities is based on long-term avoided costs such that the utilities – having the network monopoly – cannot set barriers for the establishment of small-scale CHP as an instrument to reduce CO_2-emissions.

In February 1996, the Minister for Environment and Energy announced a new agreement with the main electricity utilities to establish an additional 200 MW wind capacity during the next four years.

In March 1997, the Government announced a *coal stop*, implying that new capacity in the power sector based on coal will not be permitted.

Parallel to the new energy action plan *Energy 21* the Government has started a reform of the legal and economic framework of the Danish electricity and CHP sector. As a first step, Parliament passed an amendment to the Electricity Supply Act in May 1996. In the new system, private companies and distribution companies with an annual electricity consumption of more than 100 GWh will have third party access to the grid. The proposal corresponds in principle to a 90% opening of the Danish electricity market. However, the companies are required to pay for public service obligations in line with the EU directive. Thus the environmental tasks related to the fulfilment of *Energy 21* are ensured by refunding the electricity producer a proportional part of the expenditure arising from environmental tasks. The funds for refusion are recovered from all consumers in Denmark through an obligation for all consumers to purchase a fair share of "green" electricity or alternatively pay a fair share of the costs. This contribution is collected when the network is used to transmit the power.

The new system will come into force following a final approval by the EU Commission.

F.2 **The Heat Supply act**

The Heat Supply Act requires municipal councils to draw up heating plans to determine the future supply of energy for heating based on socio-economic criteria, available supply options and government guidelines.

The options to be chosen through the planning process include individual heating or collective heating, i.e. piped natural gas or district heating systems.

For district heating, the method and the fuel for the heat production have also to be defined. In addition local energy resources such as straw, forest residues, industrial waste heat, waste incineration and biogas have to be examined.

To ensure proper coordination of large-scale distribution of gas and district heating from power plants, the regional authorities must be involved in the planning process together with the public, the energy supply companies and other relevant parties, such as local fuel producers. Construction projects envisaged in the plan must subsequently be carried out in accordance with a time schedule specified in the plan. Local authorities may make consumer connection to a collective system and integration of existing heating plants into the system mandatory. Moreover they may prohibit the installation of certain forms of heating (i.e. electric heating) in areas with collective supply systems (district heating or gas). In 1988, this prohibition was made mandatory.

The Minister of Energy can define the framework for the planning (which fuels and methods to consider, planning methods and deadlines). During the 1980s plans were drawn up for all 275 municipalities and the necessary distribution systems for gas and district heating built or extended. This resulted in a big increase in the market share of collective heating and a corresponding decrease in individual heating (mainly heating oil). In addition, the use of oil at district heating plants was almost eliminated through substitution by local biomass fuels, waste heat and natural gas.

In 1985, the Minister of Energy decreed that no new coal-fired district heating plants were to be built. In 1990, it was decided that approx. 300 district heating plants outside the large combined heat and power areas of the big cities should be converted to

CHP plants based on natural gas, biomass or waste incineration during the 1990s, with the expected result of adding about 1,200 MW generating capacity by the end of 1998. By early 1994, about 800 MW of this capacity was running, the figure increasing to approx. 1000 MW by late 1995.

F.3 **Energy-related measures, by sector**

F.3.1 **Residential, including public sector**

1. Act on promotion of energy and water conservation in buildings

As part of *Energy 21*, a new legislation was introduced aiming at promoting energy and water savings in buildings. This requires that all buildings from 1997 onwards should be energy labelled and that owners draw up an energy plan. Modernised consultancy services regarding building energy plans and energy conservation will support these efforts. Based on an evaluation of the existing consultancy schemes for buildings, new schemes are implemented from 1997 modernising the following schemes:

Heating inspections and energy certificates
Since 1981, a scheme for auditing of existing buildings has been in force involving identification of measures with less than 8 to 10 years simple pay back time (in consumer prices). The audits are offered by special state-authorised energy consultants. Following implementation of all the measures identified, an energy certificate is issued. In the period 1981 – 84 heating inspection was combined with a grant scheme. In the first year of the scheme, a heating inspection was a precondition for a government subsidy for heat savings measures. Hereafter, heating inspection was a subsidised option, and in the last period of the grant scheme, heating inspections received 80 – 100% subsidies. Since 1985, the provision of a heating inspection report or an energy certificate has been mandatory when a building changes hands (although no sanctions were implied).

For small buildings under 1,500 m^2 energy labelling will be mandatory from 1997, when the building is sold. The label will make it easier for potential byers to compare buildings and to evaluate their energy consumption.

Annual inspection of small oil burners (OR-scheme)
Since 1979, annual inspection of the then 900,000 small oil burners (up to 120 kW) used in central heating systems, has been mandatory. The inspection was carried out by authorised firms – chimney sweepers or oil burner maintenance firms – by persons who have attended a special course. This inspection scheme will be extended to included all oil burners by 1 January 1997.

Consultancy scheme for large buildings
In 1981, an annual inspection scheme was implemented for oil burners exceeding 120 kW. This was later extended to large gas burners as well as district heating installations in buildings with more than 1,00 m^2 heated area. The scheme involves cooperation between authorised consultants and the local manager of the heating installation. The local manager regularly compiles data which are checked by the consultant for inefficient performance. Once a year, the consultant inspects the installation and instructs the local manager in energy-efficient operation of the installation.

This scheme will be extended and replaced by a consultancy scheme for large buildings.

For large buildings (large installations) the existing scheme will be integrated with initiatives ensuring wider use of local energy management in buildings. The inspection scheme will be further extended to include use of cold water and electricity, i.e. all usage of energy and water in all buildings covering more than

1,500 m^2. It will be mandatory to have an energy label and an energy plan that has to be updated once a year. The initiative will be supported by an information campaign.

2. Mandatory energy management in State-owned buildings

Since 1992, energy management and annual reporting on energy consumption have been mandatory in every building used by the State (central administration and state institutions, defence, and state-owned entities like the railways, etc.). Local energy managers must be appointed in every institution. A special consultancy service for energy audits and assistance, computer programmes etc. are offered to the managers. Coordinated purchase of office equipment of high energy standard is encouraged.

3. Improved funding of energy management in government buildings

The possibilities for financing investments in energy-saving measures in central government buildings are being improved by through a special grant scheme totalling USD 1.4 million per year. Besides the energy tax, the governmental institutions have to pay a special tax of 5% of their energy expenses.

4. Energy conscious buying in the public sector

This initiative is aimed at getting central and local government authorities to pursue a more energy-conscious buying policy, especially with respect to electrical equipment and appliances. The Danish Energy Agency co-operates with the Danish EPA to ensure that due consideration is accorded to environmental and energy aspects when products are bought by government authorities. Information material on energy consumption of the best products on the market is distributed to the public purchasers.

5. Energy management in local government buildings

The government will improve the incentives to implement energy conservation in public buildings. Among other things, this can be achieved by ensuring that a proportion of the money saved on the energy bill can be used for other purposes. Local commitment should be ensured at the county and municipal level. They shall promote energy-saving efforts at the local level, including the introduction of "green accounts". In addition, it is intended to promote the use of third-party financing of the implementation of energy-saving measures in the public sector.

6. Luxury holiday homes

An information campaign targeted at owners, lessees and users of luxury holiday homes in the tourist sector is being launched to ensure that consideration is paid to energy consumption in connection with the installation and use of installations with a high energy consumption (jacuzzis, swimming pools, solaria, etc.).

7. State subsidies for energy savings in pensioner's dwellings

From 1993 State subsidies have been granted to energy-saving measures in dwellings inhabited by pensioners with low incomes and relative high bills for heating. Subsidies of up to 50% of investment costs can be obtained up to a maximum of USD 3,600 per dwelling. Approx. 5,000 houses are granted subsidies each year at a total cost of approx. USD 7.1 million per year.

8. CO_2 tax (tax and subsidies – the CO_2 laws)

Following the former energy plan from 1990, *Energy 2000*, a packet of new laws was approved, introducing a CO_2-tax and a number of subsidy schemes recycling some of the revenue for various energy-saving measures:

"Act on a Carbon Dioxide Tax on certain Energy Products" and "Act on Change of Tax on certain Oil Products", "Act on tax on Coal, Lignite and Coke etc", "Act on Tax on Electricity" and "Act on Tax on Gas", of 21 December 1991

The Act implemented a CO_2-tax on oil, coal and gas of approx. USD 14,300 per Gg of CO_2. The tax is fully paid by households and the public sector, while industry and the commercial sector were originally entitled to a 50% or more refund. The Act has entered into force on 15 May 1992 for households and the public sector, and 1 January 1993 for industry and the commercial sector. (Taxes for industry and the commercial sector have been changed from 1996 – see No. 11, below). For electricity, the Act institutes a CO_2-tax of USD 0.014 per kWh, roughly corresponding to USD 14,300 per Gg of CO_2 emitted in the production of the electricity.

9. "Act on State Subsidies for Conversion of Older Dwellings to CHP", of 3 January 1992

As a subsidy scheme connected to the CO_2 Acts (No. 8), this Act grants subsidies for installation of water-borne central heating in dwellings erected before 1950, motivated by connection to CHP-supplied district heating networks (mainly in the centres of the large cities), totalling up to USD 214 million over 10 years. The estimated impact is the connection of around 65,000 dwellings. Apart from the CO_2 and energy savings obtained by changing to CHP-derived heat, conversion also contributes to lower SO_2 and NO_x emission levels in the cities.

10. Green taxes in the 1994 – 98 general tax reform

The general tax reform phased in during the period 1994 – 98 has the aim of introducing a gradual shift of the weight of the tax system away from taxing earned income towards taxing the consumption of scarce resources and pressure on the environment. The tax reform involves a gradual increase of green taxes, primarily in the household sector. The main increase in energy taxes applies for coal and electricity, and in the average tax on household heating will increase to approx. USD 86,000 per Gg CO_2. The tax reform's increases in green taxes do not apply to energy use by enterprises. A series of new initiatives has therefore been introduced to come into force from the beginning of 1996 and to be phased in during the subsequent years. (see No. 11, below)

F.3.2 **Industry and Trade**

11. Green taxes and agreements for improvements in energy efficiency in industry

The Danish energy tax on industry has been revised so as to improve energy efficiency in industry. The new legislation which entered into force in January 1996, introduced different carbon tax rates in the industry for room heating, heavy processes and light processes. The tax rates are to be gradually increased from 1996 to 2000. All of the revenue raised by the tax will be recycled to the industry through extended possibilities for investment grants and through a reduction of the social security contribution paid by the employers. A number of energy-intensive companies will receive a reimbursement, provided they agree to implement energy efficiency measures under agreements negotiated between the individual companies and the Danish Energy Agency. If the companies do not fulfil the agreements, reimbursements already paid will have to be returned and the tax will be imposed in full. Together, the energy and the carbon tax on room heating will gradually be increased to the same level as for households, an average of approx. USD 86,000 per Gg CO_2. The rates for light and heavy processes are somewhat lower. A sulphur tax corresponding to USD 1.4 per kg SO_2 was also introduced. The revised energy and carbon tax system related to the industry is estimated to reduce total CO_2 emissions in Denmark by about 5%. The new system will be reviewed in 1998.

12. "Act on State Subsidies for covering Expenditure in certain Companies with a large Energy Consumption", of 3 January 1992

As an element of the CO_2 Acts (No. 8), this Act defined the conditions for partial refunding of CO_2-taxes, which is linked to the implementation of energy audits and energy management. The scope of the Act is to deal with the special problems of energy-intensive industries caused by the non-implementation of CO_2-taxes in other countries. This subsidy scheme was changed from 1 January 1996 in accordance with the new CO_2-taxes and agreements on energy audits for industry (see No. 11, above)

13. "Act on State Subsidies for Energy Savings in Trade and Industry", of 3 January 1992

As an element of the CO_2 Acts (No. 8), this Act implements a general subsidy scheme in the industrial and commercial sectors. Grants for large projects are limited to 30% and are based on an individual evaluation. Smaller projects can receive 26% if the measures are standard measures defined for specific industrial or commercial branches. Energy audits may receive 50% support and information campaigns 100%. With the new taxes on energy consumption in industry and the commercial sector, the general subsidy scheme is increased from USD 28.6 million in 1995 to approx. USD 100 million per year until the year 2000.

F.3.3 **Energy transformation sector**

14. "Act on State Subsidies for Electricity Production", of 27 Dec. 1991

As an element of the CO_2 Acys (No. 8), a subsidy of USD 0.014 per kWh electricity is granted for CHP-plants based on natural gas or renewable energy. The subsidy is to compensate for the CO_2-tax levied on the consumer's electricity price, rather than on the main fuel (coal) used for electricity production. An additional subsidy of USD 0.024 per kWh can be obtained for electricity produced by wind turbines or from biomass. For CHP plants based on natural gas the rate of USD 0.014 per kWh will be reduced to USD 0.01 in 1997 in combination with special compensating subsidies to economically vulnerable projects.

15. "Act on State Subsidies for the Promotion of CHP Plants and Exploitation of Biomass Fuels", of 3 January 1992

As an element of the CO_2 Acts (No. 8), this Act encourages the conversion of coal-fired district heating plants to combined heat and power plants based on natural gas, waste or biomass, and the use of biomass in areas not supplied by natural gas, large existing combined heat and power plants or heat from waste incineration. Subsidies of up to 50% of investments can be obtained, but typical grants are in the range of 15% to 25% of investments. Subsidies amount to up to approx. USD 7.1 million annually.

This subsidy scheme also enables subsidies to be granted for service pipes, both in existing biomass-based CHP districts and district heating networks planning to convert to biomass-based CHP and in connection with completely new biomass-based CHP supply networks (bare-field projects).

16. "Law on State Subsidies for the Completion of Distribution Networks for District Heating", of 3 January 1992

As an element of the CO_2 Acts (No. 8), this Act implements a subsidy scheme for extending and renovating district heating networks supplied from large central power stations. Grants up to 50% are given for renovation of existing networks, and grants up to 100% for new networks. The subsidies total USD 0.2 million over 6 years. In the case of subsidies for new networks it is a condition that the local municipality makes connection to the network compulsory. These subsidies will cease by the end of 1997.

17. Wind energy planning

To ensure that an adequate number of new sites for wind turbines can be found to reach the target of 1,500 MW installed by the year 2005, the government has demanded that municipalities integrate plans for future wind turbine siting, into local zoning plans. Plans were finalised in many municipalities by 1 July 1995. The planning procedures will continue to ensure that all municipalities comply.

18. Catalogue of ideas for increasing connection to district heating

A study has been made of the steps taken in the various municipalities to increase connection to district heating. The results are summarised and communicated to the municipalities in the form of a catalogue of ideas.

19. Subsidies for renewable energy and demonstration projects

Since 1981 government subsidies have been granted for renewable energy at an almost constant level of about USD 21.4 million per year. About 40% of the subsidies have been given as general subsidies covering up to 30% of investment cost for the purchase of equipment that has been approved by one of the test-stations for renewable energy (test stations for wind, solar energy, biomass and heat pumps). Subsidies have been eliminated completely or partially (examples: biomass burners for district heating and wind energy, for which subsidies have been reduced from 30% to 0%) following successful achievement of market penetration. Another 40% of the funds has been granted to pilot- or demonstration projects, and has been used to bring several technologies to market maturity, starting with wind farms, continuing with large district heating stations for wood and straw, and large biogas plants. The focus is now on biomass-based co-generation and gasification. From experience, repetition of projects in numbers of 6 to 10, geographical dispersion, and location in realistic organisational and economical environments, are very effective means of accelerating the necessary technological development and the subsequent market take-up. The final 20% of the funds are used for basic activities e.g. test stations and information.

As part of the State Budget for 1997, some of the subsidies are earmarked for the development of new technologies in renewable energy, among others wave energy and offshore wind turbines.

F.3.4 **Cross-sectoral**

20. Energy Research and development

Starting in 1976, the national energy research programme expanded rapidly. From 1981 to the present time, government funding has been of the magnitude of USD 17 – 21 million per year. Energy conservation and renewable energy have had a large share of the programmes. In the present programme, increased emphasis is given to electricity conservation, biomass combustion, wind energy and super conductors.

The energy research and development programme supplements funding from other government sources (approx. USD 21 million per year), from the EU (approx. USD 5 million per year) and from industry and utilities (approx. USD 43 million per year).

21. Building codes

The code for new buildings has been tightened in several steps. The Building Regulation of 1977 introduced stricter insulation requirements from 1979. In 1985, the Regulation for small buildings was modified to allow flexible solutions within a total limit for heating and ventilation (in terms of maximum net heating requirement per m^2), among other things the intention being to encourage increased use of passive solar concepts.

As decided in the previous energy action plan *Energy 2000* a new code has been introduced, which will cut an additional 25% of net heating demand, reducing it to about 70 kWh per m^2 per year. The code also sets limits on electricity consumption for ventilation and will enforce low temperature heating systems in order to increase the efficiency of various heat supply systems, such as district heating systems, condensing boilers, solar energy and heat pumps. The new code entered into force in May 1995.

A planned further reduction to half of the present level, i.e. to 45 kWh per m^2 is scheduled to enter into force around the year 2005. Development work by building companies and research institutions to this end is being pursued. Buildings respecting this limit through combined exploitation of passive solar techniques, insulation and coated glazing are already being built.

22. Energy efficiency activities of the electric utilities

The Danish power distribution companies, which are either consumer-owned or publicly owned, have established extensive information and consultancy schemes recognised as a natural activity by the regulatory authorities. Most companies are involved in local information activities directed towards consumers and educational institutions and offer a certain basic package of consultancy on electricity savings free of charge. Other initiatives include arrangements with stores and electricians to supply low-energy light bulbs to consumers funded via the electricity bill, schemes for distributing low-energy bulbs to all their customers free of charge, or for buying back old, inefficient appliances when new efficient ones are sold.

A large project for determining methods to be used for implementing integrated resource planning (least-cost planning) has been carried out by the sector, in the framework of the EU's SAVE Programme.

23. Council for Sustainable Development and Renewable Energy

A new Council was established in spring 1996 to act as an advisory body to the Government and the Parliament and to provoke debate and create new ideas. The Council is independent, and include experts from important sectors and organisations. It is a merger of two previous councils pertaining to electricity savings and renewables.

24. Energy labelling

An extensive scheme for energy labelling of appliances was notified to the EU by the Danish Government in April 1990. In August 1991, the EU Commission presented a Directive for energy labelling to the Council of Ministers. An EU Directive for labelling of the first category of appliances (freezers and refrigerators) entered into force in January 1995. EU Directives for washing machines and dryers were implemented in October 1996. Directives for other major household appliances and light sources will follow.

A Danish system for informing consumers of the electricity consumption of various appliances, and for facilitating easy comparisons between different competing products (so-called energy arrows) has been devised by the utilities with support from the government. These complete market lists of various consumer appliances work with and supplement the labelling scheme.

25. Efficiency standards

The Danish Parliament has approved an Act empowering the Minister of Energy to set efficiency standards for electrical appliances and other equipment. The schedule and efficiency improvements envisaged are as follows:

For household appliances, standards are foreseen for refrigerators/freezers, washing machines, dishwashers, tumble dryers, electric stoves, lighting, equipment with a stand-by facility such as TVs, and water beds. Efficiency standards for refrigerators/-freezers were adopted in 1996 as EU-wide standards and will become effective from late 1999, bringing efficiency improvements of 15% compared to the 1992 market. The Directive does not include a second phase. For washing machines and dishwashers, phase 1 was expected to enter into effect in 1996 and will imply exclusion of 50% of the models that were on the market in 1993. Phase 2 will go into effect in 1999 and will be designed to minimise total discounted cost (see below). For other domestic appliances, phase 1 was scheduled to go into effect in 1999, and phase 2 in 2002.

For manufacturing companies and the public and private service sectors, it is foreseen that standards will be introduced for refrigerators/freezers, washing machines and dishwashers, office equipment, lighting, electric motors, process ventilation, pumps, boilers and technical insulation. Phase 1 was expected to start in 1996, and to be in effect for all the appliances mentioned before 1998.

The first two draft executive orders under the Act regarding washing machines and dishwashers were notified to the EU in August 1994. The political reaction from the Commission and several Member States was quite negative. An analysis under the revised technical basis will be made as soon as possible and a decision will subsequently be established on the further process depending on the political situation in Europe.

Hitherto experiences and difficulties in the actual implementation of standards implies that the above schedule and the levels of efficiency improvement expected will have to be revised.

26. Individual metering

The Ministry of Housing is in a process of issuing new regulations concerning metering and accounting of the use of electricity, district heating, gas and water. Individual metering of the use of resources in buildings has become mandatory in new buildings from 1996 and in existing buildings from 1997.

27. Informative electricity bills

This initiative comprises in introducing informative electricity bills for households and for customers in the public and private service sectors. The initiative will include more frequent meter readings, regular billing of actual consumption and graphic presentation of the customers' electricity consumption. The Danish Association of Power Companies has appointed a working group to prepare the practical implementation of informative electricity bills. The group reported in February 1994. The informative electricity bills are currently being implemented by the utilities.

28. Campaigns for replacement of appliances

This initiative means that the campaigns run by some power companies for replacement of electrical appliances (particularly refrigerators and freezers and low-energy lighting) will be expanded into longer or permanent schemes/campaigns covering consumers throughout the country. The schemes can also be expanded to cover other types of appliances. Danish power companies have carried out a successful country-wide replacement campaign for freezers. Possibly more country-wide campaigns will be carried out in the future for other types of appliances.

29. Buying clubs and buyer policies

This initiative consists in organising buying clubs, each composed of users of a specific product – for example, housing associations, large companies, and retail chains. The buying clubs draw up strict requirements concerning the product's energy efficiency, price, materials, etc. The manufacturer that best meets these requirements is rewarded with guaranteed sales of the product in question. This initiative works in two ways – it influences the buying process and promotes the development of more energy-efficient equipment. In 1997, initiatives will be taken to organise buyer policies within housing associations. Emphasis will be on demand of the most efficient appliances on the market. Later the initiatives will be extended to include demands for better products than those already on the market.

30. Supplementary training in energy labelling

A pilot project for supplementary training of store personnel to motivate them to use the EU's energy labelling of kitchen hardware as an active selling tool was carried out in 1994. The experience from the project was used as the basis for a proper, country-wide supplementary training scheme when the first EU energy label was brought into effect in early 1995 and disseminated to all EU countries.

31. Ban on conversion to electric heating in exiting buildings

In 1994, the Government passed an amendment to the Heat Supply Act that enables the scope of the ban on electric heating to be extended to include a ban on the conversion to electric heating of existing buildings situated within a district heating or natural gas supply network.

32. Conversion of electrically heated buildings

This initiative comprises in getting existing buildings with electric heating converted to district heating or natural-gas heating. This conversion will promote electricity savings and better utilisation of the district heating and natural gas networks. Conversion is advantageous both from a general socio-economic point of view and environmentally.

Conversion from electric heating to district heating or natural gas heating requires substantial investments in the buildings in question for installation of a central heating system. To overcome this barrier to conversion, a state subsidy system has been established.

Electrically heated buildings for use in industry and trade can receive subsidies for conversion to central heating by means of the general subsidy scheme for energy savings in industry (Nos.11 – 13).

In 1995, the Act on State Subsidies for Conversion of Electrically Heated Buildings was passed. This Act, which came in force on January 1 1996, enables subsidies to be given for the installation of central heating in electrically heated dwellings and public buildings in areas not presently supplied with district heating or natural gas. The immediate substitute will be oil-heating, but additional subsidies may be given to convert to biomass heating etc. This grant scheme for supporting conversion from electrical heating to central heating (especially in combination with renewable energy) amounts to USD 8.6 million annually.

A new subsidy scheme has been established for the installation of district heating or natural gas heating in electrically heated dwellings and public buildings. These subsidies will be used in areas presently supplied with district heating or natural gas.

This initiative is expected to come into force in 1997. The proposed subsidy will be managed by a committee composed of representatives of consumers, interest groups, utility companies and the Government. The committee will be named Electricity Savings Fund, and members are to be appointed by the Minister for Environment and Energy. The fund will also be charged with granting subsidies to promote energy efficiency in electrical appliances in dwellings and public institutions. USD 7.1 million will be set aside for the scheme in 1997. From 1998, the scheme will be financed by a fixed amount of USD 0.0086 per sold kWh.

The potential for conversion of electrically heated buildings is estimated to be approx. 50,000 buildings in areas supplied with district heating or natural gas and approx. 25,000 buildings in areas not supplied by these sources.

33. Subsidy scheme for product-oriented saving efforts

As proposed in *Energy 21*, a new subsidy scheme will be established in 1997. The aim is to grant subsidies for the development and implementation of energy-efficient appliances and products, especially in dwellings and the public sector. Subsidies will amount to USD 6.4 million per year and will also be granted for marketing and procurement of energy- efficient products.

Annex G: Economic fuel prices

C.I.F. - prices. (imported fuels). Fixed 1995 prices.									
	Crude oil	Crude oil	Natural gas	Coal	Fuel oil	Gas oil	Petrol		DKK/US$
	US$/bbl	US$/GJ	US$/GJ	US$/GJ	US$/GJ	US$/GJ	US$/GJ		
1995	18	3,10	2,48	1,61	2,33	4,08	4,32		5,6
1996	19	3,27	2,65	1,66	2,48	4,28	4,52		5,9
1997	20	3,44	2,82	1,71	2,63	4,48	4,71		6,2
1998	21	3,61	3,00	1,76	2,78	4,68	4,91		6,5
1999	22	3,79	3,18	1,82	2,94	4,88	5,10		6,5
2000	23	3,96	3,36	1,87	3,09	5,09	5,30		6,5
2001	24	4,13	3,55	1,89	3,25	5,30	5,51		6,5
2002	25	4,30	3,74	1,92	3,40	5,50	5,71		6,5
2003	26	4,48	3,94	1,94	3,56	5,71	5,91		6,5
2004	27	4,65	4,14	1,96	3,75	5,89	6,09		6,5
2005	28	4,82	4,34	1,99	3,94	6,07	6,26		6,5
2006	28	4,82	4,34	1,99	3,94	6,07	6,26		6,5
2007	28	4,82	4,34	1,99	3,94	6,07	6,26		6,5
2008	28	4,82	4,34	1,99	3,94	6,07	6,26		6,5
2009	28	4,82	4,34	1,99	3,94	6,07	6,26		6,5
2010	28	4,82	4,34	1,99	3,94	6,07	6,26		6,5

Economic fuel prices (including transportation costs), US$/GJ at place of consumption

Fixed 1995 prices.

	Natural gas	Coal*	Fuel oil	Woodchips and pellets	Waste combustion	Straw	Woodchips and pellets	Energy crops	Gas oil	Petrol	JP1 & 4
	Ex. network	At power station	At plant	At plant	At plant	At plant	At consumer	At plant	At consumer	At consumer	At consumer
1995	2,90	1,81	2,97	2,40	-3,57	2,96	3,67	4,47	5,98	6,22	5,98
1996	3,05	1,85	3,08	2,26	-3,39	2,81	3,46	4,23	6,08	6,32	6,08
1997	3,20	1,90	3,20	2,13	-3,23	2,67	3,27	4,01	6,20	6,43	6,20
1998	3,36	1,94	3,33	2,02	-3,08	2,55	3,10	3,82	6,32	7,00	6,32
1999	3,54	1,99	3,48	2,00	-3,08	2,55	3,09	3,81	6,52	6,74	6,52
2000	3,73	2,05	3,64	1,98	-3,08	2,55	3,07	3,80	6,73	6,94	6,73
2001	3,92	2,07	3,79	1,96	-3,08	2,55	3,05	3,79	6,93	7,14	6,93
2002	4,11	2,09	3,95	1,94	-3,08	2,55	3,03	3,78	7,14	7,34	7,14
2003	4,30	2,12	4,10	1,93	-3,08	2,55	3,02	3,78	7,34	7,54	7,34
2004	4,50	2,14	4,30	1,91	-3,08	2,55	3,00	3,77	7,53	7,72	7,53
2005	4,70	2,16	4,48	1,90	-3,08	2,55	2,98	3,76	7,70	7,89	7,70
2006	4,70	2,16	4,48	1,90	-3,08	2,55	2,98	3,76	7,70	7,89	7,70
2007	4,70	2,16	4,48	1,90	-3,08	2,55	2,98	3,76	7,70	7,89	7,70
2008	4,70	2,16	4,48	1,90	-3,08	2,55	2,98	3,76	7,70	7,89	7,70
2009	4,70	2,16	4,48	1,90	-3,08	2,55	2,98	3,76	7,70	7,89	7,70
2010	4,70	2,16	4,48	1,90	-3,08	2,55	2,98	3,76	7,70	7,89	7,70

* Orimulsion is assumed to comply with the coal price added a 4.75% supplement

1) Fixed prices are assumed from 2005 to 2030.

2) The price of energy crops is assumed to be 10 DKK/GJ highter than the average of straw and wood prices.

3) The price of JP1 & JP4 is assumed to be equal to the price of gas oil.

Annex H: Description of the Danish energy-, fuel- and vehicles tax system

Energy price levels have a significant impact on the efficiency improvements and the substitution possibilities between fuels that the economic agents of the economy will enter into voluntarily, or may be stimulated to enter into, by various government policies.

Energy taxes

In Denmark, especially in the residential sector, energy taxes have been implemented on fossil fuels through fuel taxes and on electricity through taxes levied on consumption. The ensuing energy savings in the residential sector, relative to other sectors, is a strong indication of the efficiency of high energy prices as an instrument for reducing energy consumption.

Consumer prices

When international fuel prices fell in the middle of the 1980s, consumer prices for private consumers were kept high in Denmark by fuel tax increases in order to sustain the long-term energy policy. Despite this, most consumer prices have in fact been declining in real terms, since the beginning of the 1980s.

Until the beginning of the 1990s, industry and the commercial sector have largely been exempted from energy taxes, mainly for reasons of international competitiveness.

Energy and CO_2 taxes

After the energy taxation reform in 1993, a rather elaborate system of taxes was replaced by a combined energy and CO_2 tax. The level for private households is USD 14,000 per Gg CO_2, or approx. USD 5.7 per GJ. Industry and the commercial sector only paid the CO_2-tax, and received a 50% tax reduction. Due to special reimbursement for energy-intensive enterprises, the average tax burden on industry was effectively USD 5,000 per Gg CO_2. This tax reform was replaced by two subsequent reforms – a Green tax reform and Green taxes in Industry.

Green tax reform

The general tax reform, which is being phased in over the period 1994 – 98, will gradually shift the balance in the tax system away from income taxation towards environmental taxation. As a result, the energy taxes related to coal, electricity, diesel and petrol are increasing during the period.

All in all, the reform will increase the average tax for heating and power in the residential sector from a level corresponding to approx. USD 64,000 per Gg CO_2 to approx. USD 86,000. Industry and the commercial sector are not affected by the increased energy taxes.

Since the energy and CO_2 taxes are subject to VAT (25%) , a 1% increase in energy or CO_2 taxes will consequently increase the price by more than 1%.

The rather high level of Danish taxes is as the equivalent CO_2 tax illustrated in Fig. H.1 for some central energy types. Note the relatively high weight of the energy taxes as compared to the CO_2 taxes.

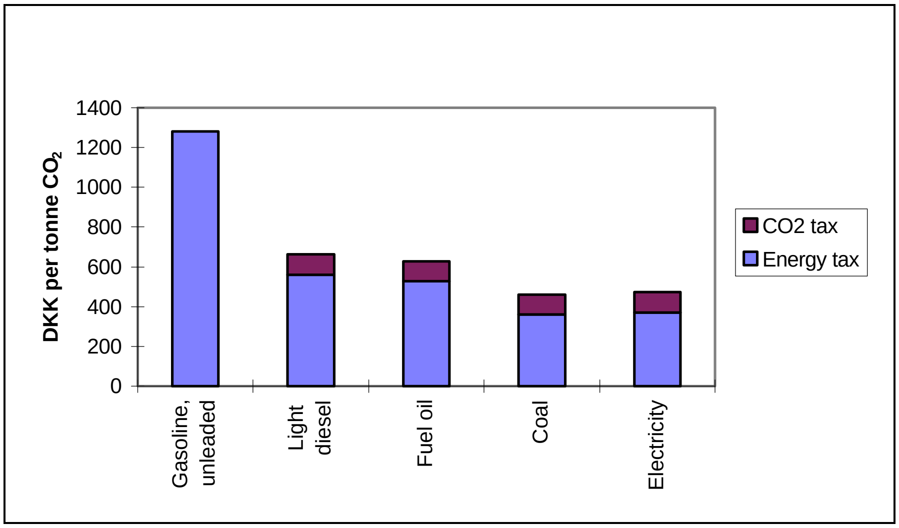


Fig. H.1. *Some central Danish energy and CO_2 taxes in 1996 expressed as the equivalent CO_2 tax.*

Green taxes on commerce and industry

In 1995, the energy tax on commerce and industry was revised. In the new legislation, green taxes on energy consumption by commerce and industry will be phased in during the period 1996 – 2000. In addition a SO_2 tax amounting to USD 2.9 per kg SO_2 was introduced on all sectors.
A tranche of CO_2 and SO_2 taxes is combined with recycling of revenue through investment subsidies aimed at promoting energy efficiency and a reduction in other company taxes. Overall, the package is intended to be revenue neutral.

In 1998, the tax on space heating will reach a level corresponding to USD 86,000 per Gg CO_2, i.e. the same level as in the residential sector.
For reasons of competitiveness, taxes on energy used in production are lower and differentiated depending on the type of process. Light processes, mainly prevalent in the commercial sector, reach a level of USD 13,000 per Gg CO_2 in the year 2000. Heavy processes, i.e. energy-intensive processes mainly in industry, are taxed at USD 3,600 per Gg CO_2. Approx. 700 companies with the most energy-intensive processes have the option to enter an agreement with the authorities concerning energy-saving measures. In return, lower tax rates are levied on these companies, i.e. USD 9,700 and USD 430 per Gg CO_2 in year 2000 for light and heavy processes, respectively.

The green taxes in the industrial and commercial sectors will contribute to a narrowing of the tax gap between residential and commercial energy consumption. All in all, the energy and CO_2 taxes have occupied an increasing influence in the Danish energy policy. The development in some energy and CO_2 central taxes is shown in Fig. H.2.

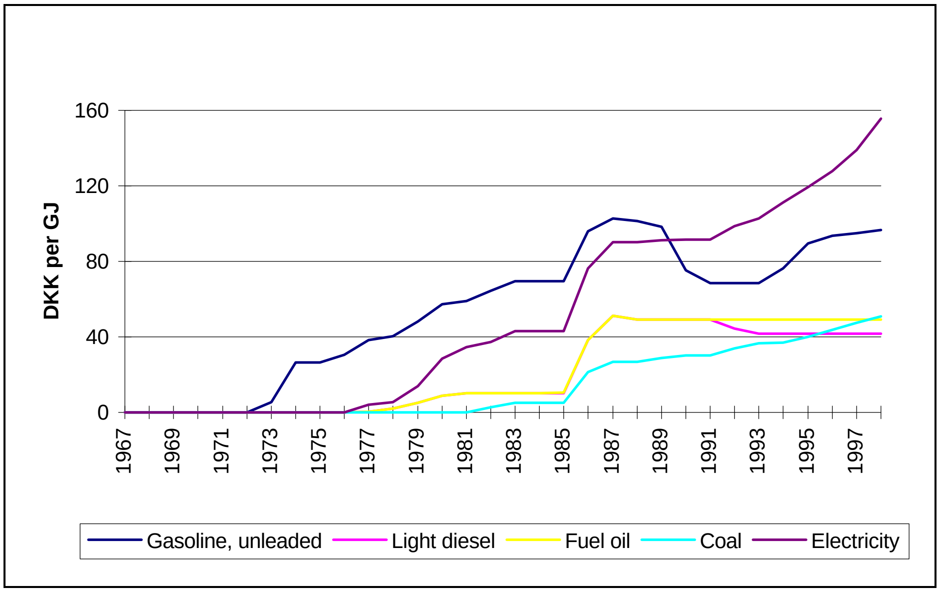


Fig. H.2. *Development in some central Danish energy and CO_2 taxes (current prices).*

Recent development in taxation of vehicles and fuels in Denmark

In May 1997 the Danish Parliament passed a package of changes in the existing taxation system for motor vehicles and fuels. Three of these changes are directed towards improvement of energy consumption and air pollution.

Passenger cars

In the existing system the car owners have to pay a yearly tax based on the weight of the car. 7 different classes are defined. A typical vehicle in Denmark belongs to the group 801 – 1,100 kg with a yearly rate of USD 323 for petrol cars and USD 496 for diesel cars. From 1st July 1997 the yearly tax will be based on energy consumption measured according to directive 93/116 in stead of weight. 24 classes are defined for both petrol and diesel cars. Examples of selected classes (basis 1997) are given below (the figures will be increased with inflation plus 1.5% every year):

	Class	Km pr. litre	Yearly tax (USD)
Petrol	1	above 20.0	29
	11	10.0 – 10.5	314
	24	below 4.5	1,057
Diesel	1	above 22.5	113
	12	10.2 – 11.3	556
	24	below 5.1	1,447

It is estimated that the new system will give approximately the same income as the earlier one.

Petrol

To day the taxation of unleaded petrol is fixed to USD 0.47 pr litre (excluding 25% VAT). For leaded petrol the figure is USD 0.57 pr litre. As a result leaded petrol has been removed from the market since March 1994. Since 1995 incentives (USD 0.004 pr litre) have been given to petrol delivered from stations equipped with vapour recovery systems. From 1st of January 1998 (or after approval from the Commission) differentiation will be introduced according to the content of benzene. The following figures have been decided:

Benzene (%)	Differentiation (USD/l)
below 1	-0.006
1 – 2	-0.003
2 – 3	0.000
3 – 4	+0.003
4 – 5	+0.006

Light commercial vehicles

In the new system incentives will be given to light commercial vehicles for which it can be demonstrated that they meet the proposed future EURO 3 (2000) or EURO 4 (2005) standards. The reference is the figures given in the Commission proposal COM(97) 61, dated 20th of February 1997.

The Danish system operates with 4 classes based on gross vehicle weight. Examples on the reduction in the yearly taxes for class 1 and 4 are given below:

Class		EURO 3 (USD)	EURO 4 (USD)
1 (below 1,000 kg)	1998–2000	50	64
	2001	0	14
	2002–2005	0	14
4 (2,500–3,500 kg)	1998–2000	164	229
	2001	164	229
	2002–2005	0	64

The system will enter into force 1st of January 1998 (or after approval from the Commission). It is the intention to introduce the same system for passenger cars at a later date.

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