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Inventory of Climate Change Indicators for the Nordic Countries

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Inventory of Climate Change Indicators for the Nordic Countries

Abstract:
This report gives a broad inventory of potential climate change indicators. It represents a good basis – for example – for the selection of a narrower set of indicators for use in special environmental indicator reports. Readily available data have been used and structured according to the driving force-pressure-state-response framework. In order to present indicators as far as possible policy relevant, the main focus is on driving force, pressure and response indicators. The report also presents a background description of the Nordic countries that explains why it is of interest to regard the Nordic countries as one unit when discussing the climate change issue. Both the data quality and availability of the selected indicators have been evaluated. The original report was initiated and issued by the cooperation group between the energy sector and the environmental sector of the Nordic Council of Ministers, and prepared jointly by Statistics Norway and Statistics Sweden.

Keywords: Climate change, environment, environmental indicators, inventory.

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Foreword

This report is a reprint of the publication *Inventory of Climate Change Indicators for the Nordic Countries* (TemaNord 1999:505) issued by the Nordic Council of Ministers.

The report gives a broad inventory of potential climate change indicators. It represents a good basis – for example – for the selection of a narrower set of indicators for use in special environmental indicator reports. Readily available data have been used and structured according to the driving force-pressure-state-response framework. Both the data quality and availability of the selected indicators have been evaluated.

The report was initiated and issued by the cooperation group between the energy sector and the environmental sector of the Nordic Council of Ministers, and prepared jointly by Statistics Norway and Statistics Sweden.

This reprint has been produced with the kind permission of the Nordic Council of Ministers.

Oslo, September 1999

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Preface

The Nordic Council of Ministers has established a co-operation group between the energy sector and the environmental sector. The members of the co-operation group are:

Olle Björk, chairman, Ministry of Industry and Trade, Sweden
Nina Persson, secretary, Ministry of Industry and Trade, Sweden
Tom Hedlund, Swedish Environmental Protection Agency, Sweden
Jørgen Abildgaard, Danish Energy Agency, Denmark
Michael Rask, Danish EPA, Denmark
Jon D. Engebretsen, Ministry of Petroleum and Energy, Norway
Inger-Johanne Wiese, Ministry of Environment, Norway
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Magnus Cederlöf, Ministry of the Environment, Finland
Jon Ingimarsson, Ministry of Industry and Trade, Iceland
Halldor Thorgeirsson, Ministry of the Environment, Iceland
Catharina Peters, Nordic Council of Ministers
Peter Molander, Nordic Council of Ministers

This group has initiated projects in the area of energy and environment. One of these projects is *Climate Change Indicators*. The project was assigned to Statistics Norway and Statistics Sweden who have jointly prepared the present document.

Environmental indicators have received increasing attention as an aid in quantifying changes in the state of the environment, and as a means of identifying and giving priority to important environmental issues. Another important aspect of environmental indicators is their usefulness for evaluating the state of the environment, and pressures on the environment, in relation to national goals and international requirements. Finally, indicators that are internationally agreed upon may provide an opportunity for comparisons of environmental performance between countries. It should be underlined that much additional work is needed on the methodological aspects on the accurate development and proper use of indicators. It is the opinion of the co-operation group that the report is a suitable basis for further discussions e.g. on distributional and equity aspects of commitments.

This report gives a rather broad first inventory of potential climate change indicators. The authors would, however, like to emphasise that much more work is needed on the presentation side concerning texts, tables and graphics, when developing such indicator reports for different target groups. All the proposed indicators in this report have been evaluated according to data availability and data quality. Beyond this conclusion the co-operation group has not taken any views on the content of the report.

The project was concluded in Stockholm, December 1998.

Olle Björk
Chairman

1. Introduction and summary

Background

The greenhouse effect of the atmosphere is an important prerequisite for life on Earth as we know it. Without this effect, the mean temperature on Earth would have been -18 °C – this is the average temperature on the Moon – and not +15 °C as now.

How much of the long-wave radiation from the surface of the Earth that is released through the atmosphere is determined by its chemical composition. Gases such as water vapour, carbon dioxide, methane, nitrous oxide, tropospheric ozone and fluorinated gases absorb the radiation from the Earth and contribute to a rise in temperature. Next to water vapour, carbon dioxide is the most important in this respect.

The carbon dioxide concentration is now about 30 per cent higher than in pre-industrial times. With an increasing concentration of greenhouse gases in the atmosphere, a larger proportion of the heat radiated from the earth will be retained. This is expected to result in a warmer climate, changes in precipitation patterns and wind systems, a displacement of climate zones and a rise in sea level. There is still much uncertainty about the actual effects – especially on the more local or regional level – of a rise in temperature, but the impacts on the world's agricultural production and ecosystems, for example, and flooding due to a rise in sea level, could be considerable.

Carbon dioxide (CO_2) is the most important of the so-called greenhouse gases. Many of the other greenhouse gases absorb the heat radiated from the earth much more effectively than CO_2 does, but the emissions of these gases are much smaller than for CO_2, and the concentration in the atmosphere is lower. In the natural carbon cycle, about 200 billion tonnes of carbon are exchanged every year between the atmosphere and vegetation, soil, and oceans through the processes of respiration, photosynthesis and chemical diffusion. The total anthropogenic emissions from combustion of fossil fuels, which were estimated to about 6 billion tonnes of carbon in 1990, are relatively small compared with this natural exchange, but can nevertheless influence the climate.

The other greenhouse gases considered in the Kyoto Protocol are methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and hydro-fluorocarbons (HFCs). The first two gases may be emitted to the atmosphere by natural reasons as well as the anthropogenic, while the latter gases are mainly synthetic. While emissions of CO_2 mostly originate from use of fossil fuels, the emissions of these other gases originate from other activities like agriculture, industrial processes and landfills.

Why Nordic climate change indicators?

The climate change issue is considered to be one of the major environmental problems today. Many of the aspects of climate change require a great deal of specialised scientific knowledge. The indicators make it possible to follow the development in areas of importance for the climate issue even for those not specialised in every area considered. There is also an important connection between the indicators and possibilities to change or influence the development, i.e. the indicators should as far as possible be policy relevant.

The Nordic countries are very interdependent. This is especially evident when it comes to electricity trade. When countries like Norway and Sweden are short of hydropower, they have to import Danish thermal power. Also, due to the short distances between the countries, measures like taxes on commodities, e.g. gasoline, in one country may have trade implications like increased border trade.

Many aspects of the climate issue are related to geographical and economic conditions together with the structure of industries. The Nordic countries are rather similar in many of these aspects. The climate is cold, natural resources are plenty and the population density is low. It is of great interest to follow the development over time in closely related countries to see what impact different habits, policies and new technologies might have on the emissions.

All the Nordic countries are economically well developed and have relatively equalised incomes in the population. This is very important for the consumer patterns in the countries with, for example, many families being able to have one or two private cars. The level of education is high, and the interest and knowledge about the environmental questions and problems are widespread.

The above-mentioned factors imply that for many aspects of the climate change issue, the Nordic countries should be considered as a unit.

This report is basically structured according to the *pressure-state-response* (PSR) framework developed by OECD, which is a widely used basic structure for environmental indicators. We have added another category, *driving forces,* including general background information and important issues, as for example energy use, that are influencing the direct pressures (see also page 31 for further explanation of terms).

As is shown in chapter 3, there are several ways of structuring and presenting indicators, and it is not always evident under which category every indicator belongs. The PSR model is mainly used as a help of cataloguing the indicators in this report. Ranking of the chosen indicators has not been undertaken. When describing and discussing the results of this work it seems more appropriate to discuss one sector or problem area at the time.

Carbon dioxide emissions are determined by different factors such as:

- The fuel mix, which determines how much CO_2 is generated per energy unit.
- The energy use in industry, where basic industries are more energy intensive than others.
- The energy use in households, which is mainly linked to residential heating coupled to the size of households, the insulating properties of houses, and the use and energy effectiveness of electric appliances and hot water.
- The energy use for travel and transport of goods.

Before discussing the different sectors or areas that generate emissions, it is of great importance to look at the fuel mix and the other background conditions in the Nordic countries. This information tells a lot about what can be expected in terms of energy use and emissions of greenhouse gases.

The energy sector has increased substantially the last ten years, especially from oil and gas production in Norway, and the increase explains much of the increase of CO_2 emissions in Norway. Especially in Norway and Iceland, but in Sweden and Finland as well, hydropower is very important for the production of electricity. This production contributes to maintaining the emissions on a lower level than they otherwise would have been. The development of nuclear power in Sweden and Finland also contributes to lower CO_2 emissions. Denmark has the highest production of electricity from fossil fuels. On the other hand, Denmark has the largest production of electricity from windmills, landfill gas and solar panels.

Many of the conditions of importance for the climate change issue are rather similar in the Nordic countries. Nevertheless many of the chosen indicators are more relevant in some countries and of less importance in others. This is mainly due to differences in energy mix, natural resources and basic industries.

Sweden, Finland and Norway have large forest areas that are carbon sinks and producers of wood. Iceland has no net forest sink and in Denmark the sink is small, but the average in the Nordic countries is nearly 40 per cent of total anthropogenic emissions. The forests have contributed to the development of the basic industries, which are large consumers of energy. The industrial structure – measured as the different industries' contribution to GDP – is fairly similar in the Nordic countries. The oil industry in Norway and the importance of fisheries in Iceland are exceptions that are of importance for the climate change issue.

Transportation is an important sector in all the Nordic countries, and the sector – along with its emission problems – continues to grow. The population density is low, and indicates long distances for people and goods to travel. Large amounts of raw materials and goods from the basic industries, combined with long distances to the markets require a lot of transportation. The «just in time delivery» in manufacturing has contributed to an increasing use of trucks rather than railways.

Manufacturing industry is the largest energy consumer (and therefore cause large CO_2 emissions) in Norway, Sweden and Finland. However, the emissions from this sector have decreased measured as kg C per US$ of value added during the period 1970–1991 (Schipper et al. 1997). The change of fuel mix has been important for this decrease, so has the structural change of the manufacturing industry in these countries. There is a change going on from basic industries towards knowledge based industries like technological and pharmaceutical companies, etc. This might indicate less emissions from manufacturing industries in the long run.

In Denmark, the residential sector is the largest energy consumer, but the CO_2 emissions have decreased due to a large extension of district heating. In 1995, about 1/3 of the residential heating in Denmark came from district heating. This is more than in any other Nordic country.

The purchasing power has increased in all the Nordic countries during the 1990s. This often means increased energy use in the residential, travel and freight sectors. The energy production and use have increased in all the Nordic countries during the 1990s.

Data and statistics in the Nordic countries

In principle, the air emission inventories, energy balances and national accounts give the possibility to find comparable data for many relevant indicators. However, the methods for estimating emissions, and the differences in treatment of international activities such as air traffic and shipping often make the trends for national data more reliable for comparison, than comparisons between countries. In this report the emission figures have been taken from the national reporting to the climate change convention (UNFCCC). The data reported there are assumed to be comparable, and international shipping and air traffic should, according to the reporting guidelines, not be included.

Data for the driving force indicators are mostly collected from statistical yearbooks, Nordic statistics on CD-ROM and other indicator publications. The availability of statistics is high in the Nordic countries, but sometimes it is difficult to compare data because of different classifications and methods. Limited resources have forced us – in this report – to use readily available data.

What is left to study; examples of other indicators of interest for the climate issue

The list of climate change indicators presented in this report is extensive, but not complete. The response indicators should be developed due to what policies will be taken in the different countries. It would be of interest to develop indicators that cover consumer patterns in the Nordic countries. The private consumption habits are to some degree described by the indicators we present, but they do not fully cover the area. Another issue that probably will be described and analysed in other fields of study is the growth of the «IT-society» and the possibilities to work, shop and do business by the computer. This might have a substantial impact on travelling, which is an important source of CO_2 emissions in the Nordic countries.

An important aspect of environmental indicators is their usefulness for evaluating the state of the environment, and pressures on the environment, in relation to national goals and international requirements. Indicators that are internationally agreed upon will provide an opportunity for comparisons of environmental performance between countries. A further development of this project on climate change indicators would therefore be to make a selection of indicators from this inventory, and to collect data for all the Nordic countries. Methodologies and criteria for evaluation and presentation of the climate change situation in the different Nordic countries based on the selected indicators could be developed. An example of such an approach is the «core set» of climate change indicators presented in the report *«Indicators of the State of the Environment in the Nordic Countries»* (Nordic Council of Ministers 1997a).

Summary table of indicators

Driving force indicators	**-Climate and natural conditions in the Nordic countries**	-Land use in the Nordic countries -Annual growth of forest
	-Population	-Population size and development -Population density -Population density in major city regions -Part of population in major city regions
	-Natural resources	-Reserves of non-renewable energy sources -Renewable energy sources -Annual production capacity for hydropower
	-Transport, roads and infrastructure	-Road lengths -Road transport of goods -Domestic passenger transport by air -Personal journeys by mode of transport -Transport of oil and gas by pipelines -Transport by tankers
	-Economic conditions and production	-GDP per capita -Consumption expenditures: Housing and heating, and transport -Consumer price index: Total, housing and heating, and transport -Private consumption -Examples of «industry profiles» -Value added per unit emission -Industrial structure and exports of goods
	-Housing and building structure	-Part of population in big blocks of flats -District heating as part of total residential heating -Energy sources for heating in different types of buildings -Residential area
	-Energy production and trade with energy	-Primary energy production -Secondary gross energy production -Electricity production -Trade with energy -Net imports of electricity
	-Production, use and trade of wood products	-Production of wood products -Annual removal of forests -Use of fuelwood -Foreign trade
	-Energy use	-End use of energy, index -End use of energy, commodities -End use of energy, consumer groups -End use of energy, per capita
	-Other driving force indicators	-Use of nitrogen fertilisers -Number of domestic animals -Deposition of waste
Pressure indicators	**-Actual emissions**	-Emission of all greenhouse gases. -Index (GWP) -Per capita -Emissions of carbon dioxide -Total emissions, time series -Per emission source -Emissions of methane per emission source -Emissions of nitrous oxide per emission source -Emissions of other greenhouse gases

	-Adjusted emissions	-Energy consumption adjusted for temperature variations -Emissions of CO_2 equivalents per unit GDP
	-Sinks of CO_2	-Forest sinks
State indicators	**-Global temperature**	
	-Atmospheric concentration of carbon dioxide	
	-Atmospheric concentration of other greenhouse gases	-Methane -CFC-11
	-Radiative forcing	
	-Other state indicators	
Response indicators	**-Goals and agreements**	-Greenhouse gas emissions compared to reduction requirements of the Kyoto Protocol
	-Response indicators for CO_2	-Environmental taxes and prices of selected fuels - Gasoline prices and taxes - Indices of energy prices, industry - Indices of energy prices, households -Taxes on electricity -Public transport -Prices on public transport -Energy production from new renewable energy sources -Non-fossil energy use -Energy efficiency and energy intensity -Energy efficiency in power plants -Industrial energy use per unit production -Industry oil consumption per unit production -Residential energy intensity -Transport -Specific gasoline consumption, passenger cars -Number of electric cars -Measures to increase forest growth
	-Response indicators for CH_4	-Taxes on waste deposition -Collection of methane from landfills -Methane from animals
	-Response indicators for N_2O	-Agriculture -Output per unit fertiliser applied -Industry
	-Response indicators for other greenhouse gases	

2. Methodologies. Overview of energy accounts, energy data and air emission inventories in the Nordic countries

2.1. Energy accounts and energy balances

All the Nordic countries make *energy accounts* that are connected to the national accounts. Finland, Denmark, Norway and Iceland produce annual accounts, Sweden every second year. The structure of the energy accounts is based upon the structure of the national accounts, and the industrial classifications ISIC (International Standard Industrial Classification of all Economic Activities) and NACE (Nomenclature générale des Activités economiques dans les Communautés Europées). This means that the division in branches of industry varies depending on how they are divided in the national accounts. In all of the Nordic countries, energy statistics are also calculated and presented as *energy balances*. The energy balances often serve as a basis for national air emission calculations. In some countries they also form a basis for the energy accounts.

Most of the energy sources included are the same, with a few exceptions that vary with the local conditions, such as Iceland's hot springs, and the nuclear power and peat burning in Sweden and Finland, for example. The thermal heating values for the energy sources differ somewhat between the countries (See Nordic Council of Ministers 1997b).

Energy balances include all activities within the national territory, from extraction or import to final consumption. For the energy balances, guidelines are developed that enable international comparison of the data. Therefore, in this report most of the information is gathered from the energy balances. Energy accounts include those activities performed by national companies within or outside the country. In some parts of the accounts – for example how to deal with international shipping and air traffic – the methods differ between the countries.

2.2. Emissions to air

All the Nordic countries publish annual data about greenhouse gas emissions, although all such gases are seldom reported (see 4.3.1). Data are available in time series from the 1980s. As the calculation models improve, efforts are made to recalculate older figures in order to make data comparable over time. All the Nordic countries report emission data to EEA (Corinair) and to the UN Framework Convention on Climate Change (UNFCCC) according to IPCC guidelines. In this report the UNFCCC reporting is the most interesting, since it covers more of the climate gases than Corinair do.

The models for environmental accounts and emission inventories largely follow the same framework in the Nordic countries. Emissions from combustion are estimated from energy statistics and different emission coefficients. The Nordic countries show only small differences in emission factors of CO_2. Iceland use only estimated figures in their model, the other countries also use measured data from larger selected point-sources. The calculation method for emissions from industrial processes also differs between the countries. Definitions and classifications show only minor diversities between the countries.

Only Denmark makes adjustments for both export and import of electricity, i.e. Denmark includes CO_2 from imported electricity in their national statistics of emissions to air. Finland, Norway and Sweden do not adjust for imported or exported electricity. Different principles of bookkeeping may lead to omissions or double counting, in comparisons between countries. Denmark is the only country to publish data of CO_2 emissions corrected for annual variations in temperature.

2.3. Environmental accounts

Sweden and Norway have now established integrated accounts of economy and environment, SWEEA and NOREEA, respectively. Similar work is under development in Denmark and Finland. The work is supported by the EU through Eurostat's NAMEA project (National Accounting Matrix including Environmental Accounts). These accounts integrate national accounts data on production and other economic data in monetary terms with energy use and emissions of pollutants expressed in physical terms in order to show each industry's contribution to society with respect to value added and pollution (see example on page 46).

3. International work on environmental indicators

In the following paragraphs selected examples of international and national environmental indicator reports are reviewed and the indicators with special relevance to the climate change issue are presented.

3.1. OECD

The report *«Environmental indicators OECD Core Set»* (OECD 1994) presents proposals for pressure, state and response indicators for 12 issues, and in addition a set of general indicators that are not attributable to specific issues. Only a selection of the proposed indicators is included in the report. The indicators are classified or specified according to availability; short (S, see table below), medium (M) and long term (L). The short term indicators are basic data that are available for a majority of OECD countries, while the long term indicators are not available for a majority of countries, and they furthermore are in need of sustained data collection and conceptual efforts. The OECD indicators in the report that are most relevant in the context of climate change are presented in the table below (some of the general indicators are also included):

Issues	**PRESSURE** **Indicators of environmental pressures**	**STATE** **Indicators of environmental conditions**	**RESPONSE** **Indicators of societal responses**
Climate change	• Index of greenhouse gas emissions (M) • CO_2 emissions (S)	• Atmospheric concentration of greenhouse gases (S) • Global mean temperature (S)	• Energy efficiency (M/L) • Energy intensity (S) • Economic and fiscal instruments (M)
General indicators	• Population growth & density (S) • Growth of GDP (S) • Private final consumption expenditure (S) • Industrial production (S) • Structure of energy supply (S) • Road traffic volumes (S) • Stock of road vehicles (S) • Agricultural production (S)	Not applicable	• Environmental expenditures (M/L) • Pollution control and abatement expenditures (S/M) • Public opinion (S)

The next edition of the OECD publication on environmental indicators will be published in 1998.

OECD is, in addition to the indicators for the measurement of *environmental performance* presented above, also developing indicators for the integration of environmental concerns into *sectoral policies,* i.e. energy, transport, agriculture (OECD 1993a and b), and indicators for the integration of environmental concerns into economic policies more generally, mainly through *environmental accounting.*

3.2. Eurostat

In the Communication on «Environmental Indicators and Green National Accounting» of December 1994 (COM(94) 670, final), the European Commission proposed the creation of an integrated economic-environmental information system covering the main policy areas. This was to be achieved by developing two complementary approaches:

1) «satellite accounts» alongside the national accounts and closely linked to them in physical or in monetary terms;
2) calculation of «physical indicators and indices» related to the pressure of human and economic activities on the environment.

3.2.1. The «Environmental Pressure Indices Project» (EPIP)

Eurostat is currently developing the second approach (see above) of the integrated economic-environmental information system. The primary goal of the project is to create the methodological infrastructure necessary for a comprehensive and accurate description of the pressures on the environment resulting from human activities (according to the framework of the Pressure-State-Response model).

The project is composed of 30 Sub-Projects structured in a chain process as follows:

- *Module 1*: 10 Pressure Indices Pilot Projects (PIPs), aiming at identifying the «demand» for indicators and related statistics from the standpoint of the users;
- *Module 2*: 12 Sectoral Infrastructure Projects (SIPs), aiming at identifying the «demand» and the «supply» of indicators with a sectoral breakdown;
- *Module 3*: 8 «Environmental Pressure Information System» Projects, EPIS, aiming at «supplying» indicators through a database that integrates physical and socio-economic data.

Pressure Indices Pilot Projects (PIPs)

This group of projects aims to produce a set of indicators describing pressures on the environment resulting from human activities in a highly aggregated format for the ten problem areas or policy fields defined in the Fifth Environmental Action Programme (5th EAP):

1. Climate Change
2. Ozone Layer Depletion
3. Loss of Biodiversity
4. Resource Depletion
5. Waste
6. Air Pollution
7. Dispersion of Toxics
8. Water Pollution & Water Resources
9. Marine Environment & Coastal Zones
10. Urban Problems, Noise & Odours

The selection of indicators was carried out by surveys among experts as follows:

- selection of a panel of around 200 EU experts (the so-called *Scientific Advisory Group, SAG*) by policy field, realised by 10 Specialised Institutes (each SI was responsible for one policy field);

- Involvement of «societal actors» (associations, ministries, environmentalist groups, etc.) for nominating experts in order to ensure a broad democratic legitimacy for the process, the neutrality of the chosen indicators and the final support for environmental policy decision;
- identification of the most relevant indicators describing the pressure by policy field through a written questionnaire sent to the expert panels (Survey 1). This survey started in December 1994, and more than 2000 different indicators were proposed;
- reduction of the proposed indicators to a manageable number of 25–30 per field;
- a second survey among the experts (via a written questionnaire) to let them judge the usefulness of these indicators, to reach a consensus on the indicators to be used in the project and to obtain a final set of «core indicators» by policy field. This survey started in October 1996 and the results are now available.

Climate change is the first of the 10 policy fields described in the 5th EAP. Below are the final results of the second survey among the experts:

Policy field	**Pressure indicators** ***Core indicators***
Climate change	• Total CO_2 emissions per year -CO_2 emissions per capita -CO_2 emissions per GDP -CO_2 emissions per GJ energy consumption -CO_2 emissions per year per sector -CO_2 emissions from energy per capita -CO_2 emissions from energy per GDP • CH_4 emissions per year -CH_4 emissions per year per sector • N_2O emissions per year -N_2O emissions per year per sector • CFC emissions per year • NOx emissions per year -NOx emissions per year per sector • Particle emissions • SOx emissions per year • CO_2 removals per year • NMVOC emissions per year -NMVOC emissions per year per sector • Fluorocarbon emissions • CO emission per year -CO emissions per year per sector

3.2.2. Evaluation of CSD indicators

Eurostat has recently performed a pilot study (Eurostat 1997) following the methodology of the United Nations Commission on Sustainable Development (see below). The study presents more than forty indicators in the format of the *«Blue book»,* and is an important contribution to further development of sustainable development indicators.

3.3. Nordic Council of Ministers

The Nordic environmental indicator report from May 1997 (Nordic Council of Ministers 1997a) is structured according to the *pressure–state–response* framework developed by OECD. The issues addressed and the selection of indicators are also to a considerable degree based on the core set of indicators described in the OECD indicator report from 1994 (OECD 1994). The climate change indicators in the Nordic report are:

Issue	Pressure	State	Response
1. Climate change	• Emissions of carbon dioxide.	• Atmospheric concentration of carbon dioxide. • Global mean temperature.	• Use of non-fossil energy as percentage of total energy use. • International agreements and national goals and measures.

3.4. United Nations Commission on Sustainable Development

In their report *«Indicators of Sustainable Development. Framework and Methodologies»* (UN 1996, also called the *«Blue Book»*), the United Nations Commission on Sustainable Development presents a list of indicators organised in the Driving Force–State–Response framework (*DSR*). The list includes about 130 indicators. The *driving force indicators* represent human activities, processes and patterns that impact on sustainable development, *state indicators* indicate the «state» of sustainable development, and *response indicators* indicate policy options and other responses to changes in the state of sustainable development. The DSR framework can be considered as a variant of the *PSR* framework, where the «broader» term *driving force* is used to include indicators of sustainable development that cannot be described as direct *pressures* on the environment as in a more limited environmental indicator set.

The indicators are grouped into four main parts according to different aspects of sustainable development: *social, economic, environmental* and *institutional,* and the different indicators are also referred to the relevant chapter of Agenda 21. The «Blue book» contains so-called methodology sheets presenting the definitions, methodological descriptions and significance of each of the indicators selected. Further improvements of the indicators and methodology sheets will be implemented as feedback and results from testing of the proposed indicators are received (see for example Eurostat, above).

The indicators in the report that are most relevant in the context of climate change are:

Chapters of Agenda 21	Driving force indicators	State indicators	Response indicators
Category: Social			
Chapter 5: Demographic dynamics and sustainability	-Population growth rate	-Population density	
Chapter 7: Promoting sustainable human settlement development	-Per capita consumption of fossil fuel by motor vehicle transport		
Category: Economic			
Chapter 4: Changing consumption patterns	-Annual energy consumption	-Proven fossil fuel energy reserves -Lifetime of proven energy reserves -Share of consumption of renewable energy resources	
Category: Environmental			
Chapter 9: Protection of the atmosphere	-Emissions of greenhouse gases		
Chapter 11: Combating deforestation	-Wood harvesting intensity	-Forest area change	
Category: Institutional			
Chapter 8: Integrating environment and development in decision-making			-Sustainable development strategies - Programme of integrated environmental and economic accounting -Mandated Environmental Impact Assessment -National councils for sustainable development
Chapter 39: International legal instruments and mechanisms			-Ratification of global agreements -Implementation of ratified global agreements

3.5. European Environment Agency

The European Environment Agency (EEA) is planning an annual environmental indicator report, and is currently carrying out feasibility studies, etc. The DPSIR framework is discussed. Smets and Weterings (1997) present this overview of the framework:

- the economic and social driving forces in the human system (Driving forces)
- the resulting stress on the environmental system (Pressures)
- the quality of the environmental system (State)
- modifications in the natural and human systems and materials caused by changes in the environmental quality (Impact)
- the societal responses to environmental states and impacts (Response)

A trail version of a EEA indicator report has been produced (Kristensen 1997). The purpose of that report is to provide a first indication of the overall appearance of an EEA indicator report and to give a presentation of the proposed structure and the content of the environmental issues.

In Kristensen (1997) the following indicators for climate change are proposed for the EEA environmental indicator report:

DRIVING FORCES	PRESSURE	STATE	IMPACT	RESPONSE
Energy consumption. **Transport.** **Agriculture.**	**Emission of greenhouse gases.** -Trend in CO_2 emissions -Trend in CH_4 emissions -Greenhouse gases emissions by source	**Atmospheric concentration of greenhouse gases.** -Trend in atmospheric concentration of greenhouse gases	**Change in temperature.** -Trend in global/ European temperature **Effects on human health and vegetation.**	**Energy efficiency.** **Energy taxes.** **Energy saving programmes.**

3.6. Canada

In Canada a report on a preliminary set of environmental indicators was published in 1991 (Environment Canada 1991). The Canadian approaches also organise the indicators according to pressure (stresses imposed on the environment by human activity, state (condition of the environment) and response (the way we manage in response to the stresses). The framework matrices of the Canadian indicator set include indicators for the three categories *environmental components, environment-related human health,* and *natural economic resources.*

Since the 1991 report, Environment Canada has published the indicators as SOE Bulletins in *The National Environmental Indicator Series*. The climate change and energy indicators presently included in the Internet version (http://www1.ec.gc.ca/) are:

Types of indicators			
CATEGORY	**Environmental conditions Ecological and socio-economic effects**	**Human activity Stress**	**Societal responses**
ENVIRONMENT COMPONENT/ECO-SYSTEM -Atmosphere • Climate change	Global and Canadian average temperature variations.	Carbon dioxide emissions from fossil fuel use. Global atmospheric concentration of greenhouse gases.	(No indicators at present)
NATURAL ECONOMIC RESOURCES -Energy	See Climate change, Acid rain and Urban air quality indicators.	Global and Canadian consumption of energy. Global and Canadian fossil fuel consumption.	

3.7. Denmark

The Ministry of Environment and Energy has for some years published an annual environmental indicator report covering seven issues and in the 1997 edition also a chapter on the family (households) (Miljø- og Energiministeriet 1997). No specific framework is mentioned in the report, and it contains mostly pressure and state indicators. The climate change indicators in the 1997 edition of this Danish report are:

- Global mean temperature
- Global emissions of CO_2 (distributed by coal, oil, natural gas and biogas)
- Emissions of CO_2 per capita in selected countries and regions
- Danish emissions of CO_2 (distributed by transport, households, manufacturing industries, trade and services, and refineries and power plants)

3.8. Finland

Statistics Finland has carried out a methodological study on aggregation of environmental data. This project is an initiative based on increasing international demand for more aggregated and policy-oriented information on environmental concerns and on their valuations in society. Environmental pressure data are aggregated into problem-specific indices (climate change, ozone depletion, acidification, and so on), and these indices are in turn combined in the overall Index of Environmental Friendliness. The results are presented in the report *«Index of Environmental Friendliness. A Methodological Study»* (Poulamaa et al. 1996). The model approach used in the study also secures the links to the pressures from the different economic activities, and consequently also the link to integrated environmental and economic accounting.

For the issue climate change, the emissions of the most important greenhouse gases (only CO_2 and CH_4 were considered in the study) were converted into CO_2 equivalents by using the GWP (Global Warming Potential) conversion factors defined by the IPCC (The Intergovernmental Panel on Climate Change). The CO_2 equivalents for the different greenhouse gases were then added together to the *Greenhouse Effect Index.*

The report *«Trends in the Finnish Environment. Indicators for the 1997 OECD Environmental Performance Review of Finland»* (Rosenström et al. 1996) is the first attempt to apply the core set of environmental indicators developed by OECD to the Finnish environmental conditions. The table below presents a summary of the climate change and energy indicators in the Finnish report.

Issues	**PRESSURE** *Indicators of environmental pressures*	**STATE** *Indicators of environmental conditions*	**RESPONSE** *Indicators of societal responses*
Climate change and energy	1.1 Domestic sources of energy 1.2 Total primary energy supply and consumption 1.3 Electricity supply by type of production 1.4 Total CO_2 emissions from the burning of fossil fuels and peat 1.5 Emissions of greenhouse gases 1.6 Weighted greenhouse gas emissions per unit of GDP	1.7 The ice-breaking date in the River Tornio 1.8 Annual mean discharge at the Muroleenkoski drainage basin	1.9 Consumption of energy per GDP and per capita 1.10 Environmental taxes and excise duties 1.11 Government energy research and development funding 1.12 Fiscal incentives to promote energy conservation

Finland has performed a voluntary test of the CSD indicators for sustainable development. The results of this exercise are presented in a recent report from the Finnish Environment Institute (Rosenström and Muurman 1997).

3.9. Norway

In the Norwegian environmental policy eighth so-called «result areas» have been defined:

1. Protection and use of biodiversity
2. Outdoor life
3. Cultural relics and cultural environments
4. Marine and freshwater pollution
5. Chemicals hazardous to health and the environment
6. Waste and recovery of waste
7. Climate change, air pollution and noise
8. International environmental cooperation, aid and polar regions

The indicators proposed for the result area *Climate change* (Ministry of Environment 1997) include:

«Result area» of environmental policy	**Examples of *state* indicators**	**Examples of *pressure* indicators**	**Examples of *response* indicators**
Climate change	- Global average temperature - Regional occurrence of extreme conditions like floods, storms, etc.	- Concentration of greenhouse gases in the atmosphere - Emissions of greenhouse gases	- Emissions of greenhouse gases per capita - Energy use per unit GDP - Use of fossil energy as a share of total energy use

3.10. Sweden

In a recent report from the Commission for Environmental Protection (Miljövårdsberedningen, SOU 1998:15) indicators or so-called «green key figures» for an ecologically sustainable society are proposed. The indicators are grouped according to the three goals for ecologically sustainable development defined by the Swedish government (efficient use of natural resources, protection of humans and the environment, and sustainable provision). The purpose of the «green key figures» is that they should give policy makers on all levels as well as the general public an indication of whether Sweden is developing in a sustainable direction or not. It is pointed out in the report that the proposed indicators are preliminary and that further development is necessary. The indicators most relevant in relation to the climate change issue are:

Green key figures for the efficiency goal
1. Energy use per capita related to GDP and energy use per sector related to the sectors' value of production.
2. Electricity use in December–February
Green key figures for the environment goal
6. Emissions of carbon dioxide distributed by sectors and related to the sectors' value of production.
Green key figures for the households', the enterprises' and other sectors' readjustment to an ecologically sustainable society
1. Share of inhabitants that walk, use a bicycle or use public transportation to and from work.
6. Household consumption of renewable energy in relation to the households' total energy consumption.
7. Number of inhabitants per car.

3.11. United Kingdom

In the comprehensive report *Indicators of Sustainable Development for the United Kingdom* (Department of the environment 1996) a set of indicators is presented for 20 key issues. In this report a modified PSR framework is adopted in order to try to make the framework more applicable for the more complex concept of sustainable development rather than the more limited environmental indicators. It is stated in the report that *«The pressure-state-response concept has been used as a tool in considering how to construct the indicators, but has not been used prescriptively»*.

The indicators in the report that are most relevant in relation to climate change are:

Key issues	**Key indicators**
Energy	Depletion of fossil fuels Capacity of nuclear and renewable fuels Primary and final energy consumption Energy consumption and output Industrial and commercial sector consumption Road transport energy use Residential energy use Fuel prices in real terms
Climate change	Global greenhouse gas radiative forcing rate Global temperature change Emissions of greenhouse gases Power station emissions of carbon dioxide

4. Suggested extended set of indicators for climate change

4.1. Introduction

The *pressure–state–response* (PSR) framework developed by OECD is widely used as a basic structure for environmental information. This includes comprehensive environment statistics reports, state of the environment reports and environmental indicator reports. There are, as pointed out in the previous paragraphs, several variants (DSR, DPSIR, etc.) of this basic framework, particularly in initiatives trying to consider indicators for the more complex concept of sustainable development.

In this report we have chosen to structure the indicators according to:
- *driving forces*
- *pressures*
- *state*
- *responses*

The *driving force indicators* present background information on natural conditions and human activities (economic, social) of relevance for the issue climate change (and most certainly also for other environmental and resource related issues or problems). The *pressure indicators* are the actual emissions or environmental impacts (stress) of the human activities. The *state indicators* are intended to describe the development and changes in the state of the environment, and the *response indicators* describe society's response either to reduce the pressures or to prevent or repair environmental damage. The responses can be reflected in environmental, general economic or sectoral policies, and the degree by which the responses are effective can for example be described by comparing emission levels with national or international targets. Effectiveness or performance can also be expressed by describing the development or trend of for example emissions per unit GDP, per inhabitant, etc.

4.2. Driving force indicators

Driving force indicators is a more recent concept that has been developed from or in addition to the pressure indicators. These indicators contain background or general basic information relevant to the theme in question, in this case climate change. Driving force information is often easier to find in statistical publications than data on pressure, and especially state and response indicators, since it generally has a longer history of production.

Driving-force information can be used in different ways, e.g.:

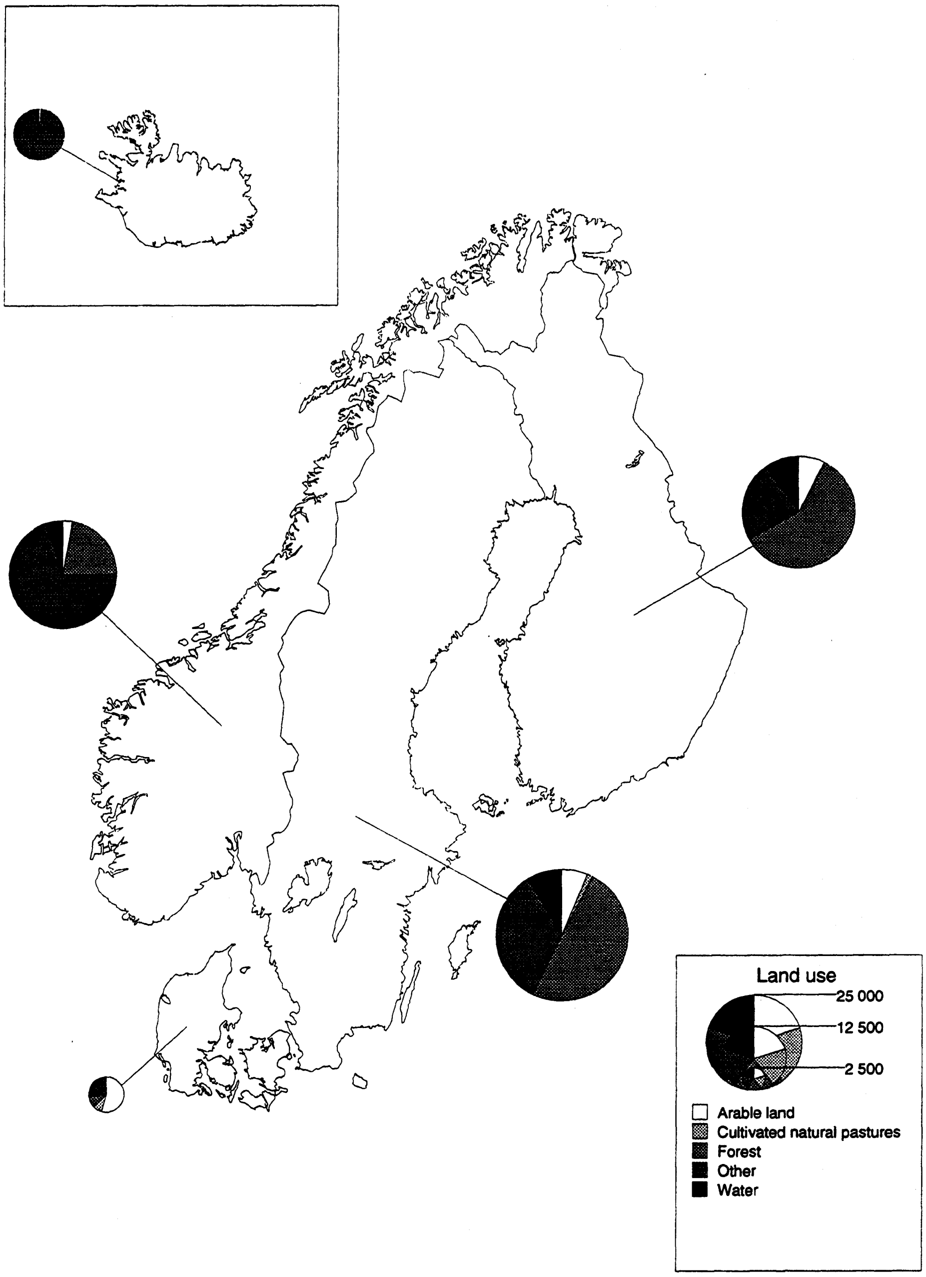
- as a basis for the calculation of pressure indicators, since the data often reflect the processes giving rise to the pressure;
- as indicators in themselves. The information is often useful in providing background information concerning the problem by putting everything in its context.

4.2.1. Climate and natural conditions in the Nordic countries

Land use in the Nordic countries

The land use pattern differs between the Nordic countries (figure 1). All the countries have some parts of arable land and pastures. Therefore agriculture – with domestic animal breeding – is a natural part of the landscape, even though the intensity differs. In Denmark and the southern parts of Sweden production of crop is very important. In Iceland and large parts of Norway on the other hand, the land is more barren and more suited for sheep breeding. Forests occupy the major parts of Finland, and are of great importance in Sweden and Norway as well. In Iceland, substantial areas are covered by glaciers. In the northern parts of Scandinavia there are large mountain areas where reindeer breeding, tourism and mining are important. The wooded areas are most important for the climate issue. Therefore the main focus here will be on forests and forest production.

Figure 1. Land use in the Nordic countries. 1000 hectares



Source: «Statistik uden grenser 1997» Nordic Statistics on CD-ROM 1997

Sweden has the largest wooded area of about 280,000 km^2. Finland has 233,000 km^2, Norway 119,000 km^2, Denmark 4,500 km^2 and Iceland only 1,400 km^2 of wooded area. Especially in Finland and Sweden – but also in Norway – the large wooded areas have been of great historical importance, and have had substantial influence on the industrial development.

The annual growth of forest measured as increased volume is a relevant indicator for carbon sinks (table 1). The table shows that the forest volume is increasing substantially in Finland, Norway and Sweden.

Table 1. Annual growth of forest. Million m^3 overbark

Country	1980	1985	1990	1995
Nordic total[1]	169	183	200	204
Denmark	3	..	3	3
Finland	63	68	74	75
Iceland	..	..	..	..
Norway	19	20	24	27
Sweden	84	95	99	99

Source: OECD 1997

[1] Excluding Iceland

Data quality: Good
Data availability: Good

Temperature

Denmark has a temperate, coastal climate. The temperature is seldom much below -5 degrees centigrade during winter.

Finland, Norway and Sweden have varying climates from temperate, coastal climates in the southern parts, to inland climate with cold winters in the North. However, the major parts of the population are living close to the coast, and in the southern parts of the countries.

Iceland is warmer than the geographical location would indicate, because of the North Atlantic Current reaching the south coast. The mean temperature in July is about 10 degrees centigrade and in January about 1 degree.

The temperature conditions in the Nordic countries affect how much energy is used for heating. In order to understand the differences between cold and warm years, energy consumption and the associated emissions can be adjusted with so-called degree-days. The degree-days are weighted so that the temperature in densely populated areas is more important than the climate in sparsely populated areas. In this way, a measure for how the energy consumption is affected by other factors can be obtained (see example in section 4.3.2. Adjusted emissions). However, data on e.g. yearly mean temperatures in different parts of the countries are not considered to be a good indicator of the need for heating.

Precipitation

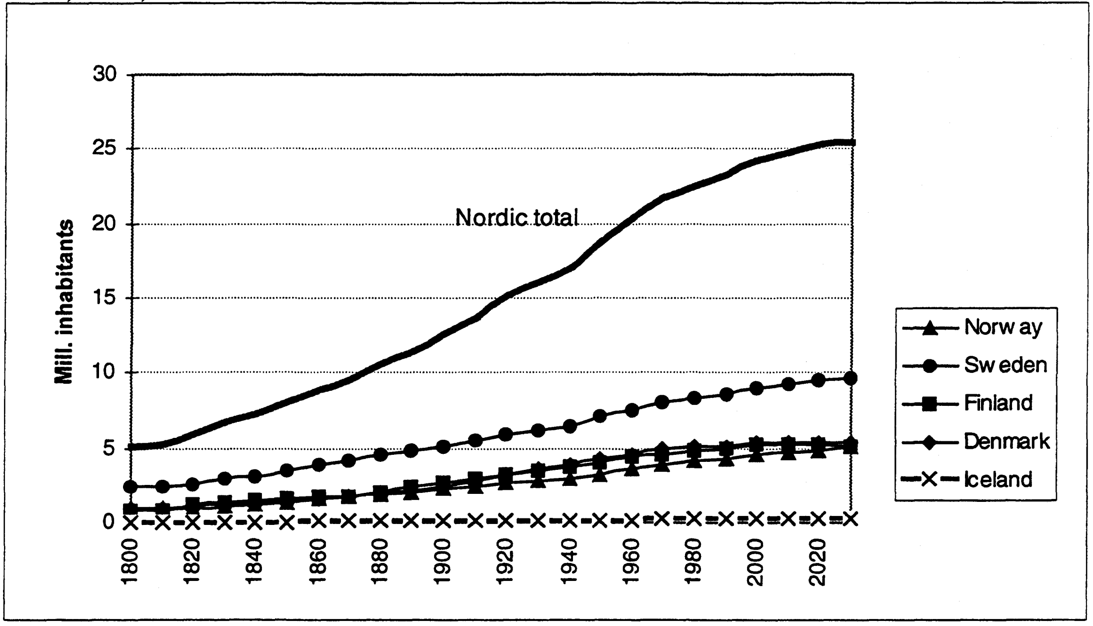
The precipitation was suggested as an indicator for the changes in availability of hydropower. However, since the data on yearly hydropower capacity is already available, this is considered to be a better indicator (see section 4.2.3. Natural resources). The hydropower is depending on the amount of water collected in the dams or reservoirs, with a complex linkage to the amount of rain and snow falling in different regions of Sweden and Norway. Therefore, the precipitation indicator was excluded.

4.2.2. Population

Population size and development

The population growth in the Nordic countries has been rather moderate during the last decades. Iceland has had the largest change, with an increase of nearly 30 per cent in the last quarter of a century. Population projections for the Nordic countries show small increases in the coming years (figure 2).

Figure 2. Population development since 1800, and population projections for the years 2000, 2010, 2020 and 2030. The Nordic countries.



Source: Yearbook of Nordic Statistics 1996

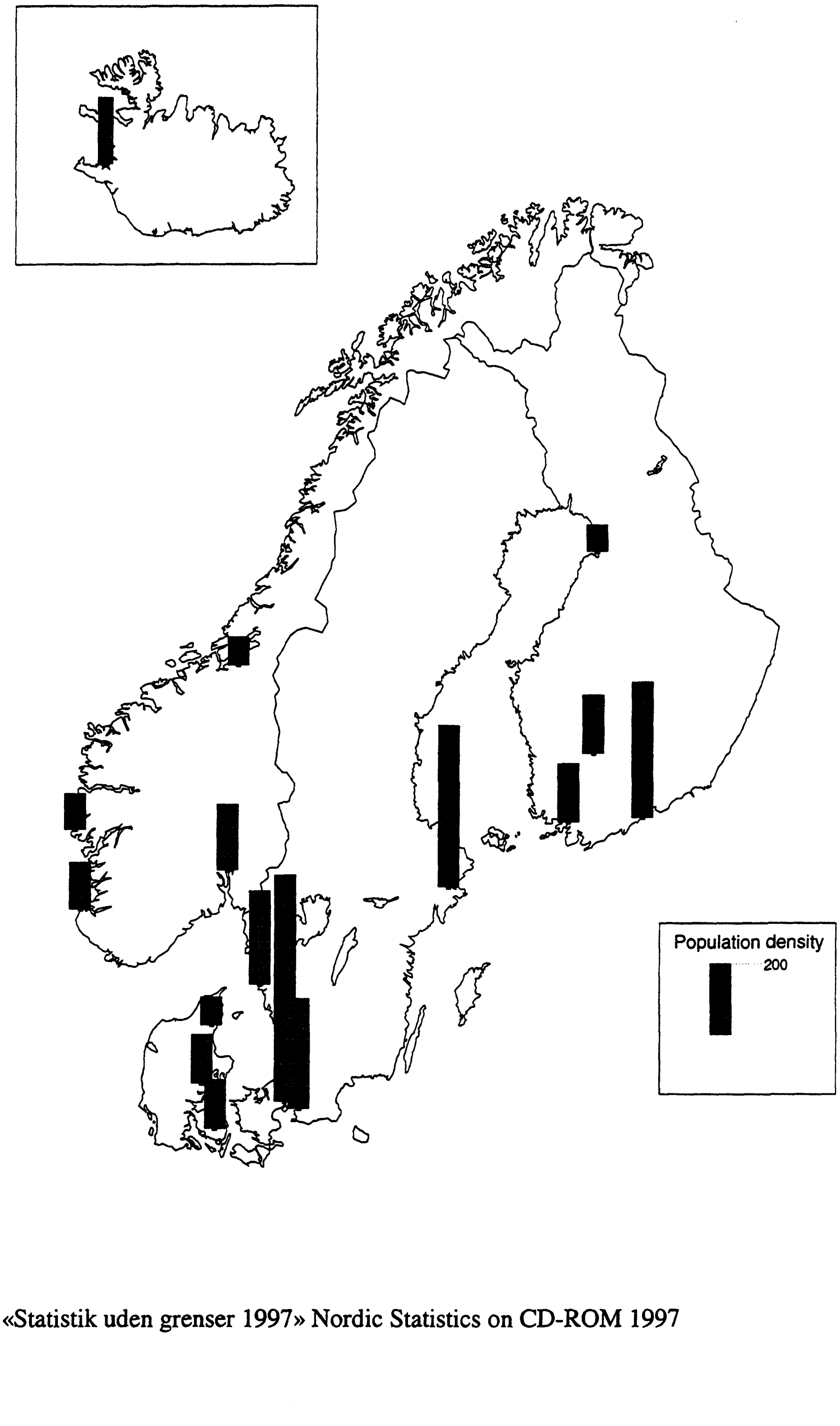
Data quality: Good
Data availability: Good

Population density

The population density differs considerably between the Nordic countries. Denmark has the highest population density with 124 inhabitants per km^2 of land. Sweden has 22, Finland 17, Norway 14, and Iceland only 3 inhabitants per km^2. The *national* population density, however, is considered to be of limited value as a climate change driving force indicator. Population density is mostly of interest for infrastructural planning, therefore large uninhabited areas are of less interest.

Population density in *major city regions* (figure 3) (for definitions of major city regions in the Nordic countries, see Nordic statistics on CD-ROM 1997) is an indicator of great importance for the planning of general infrastructure, public transportation and district heating. This, in combination with the part of the population living in major city regions (see below), explains much of today's infrastructure. It also indicates the future possibilities of planning, as the city regions keep growing.

Figure 3. Population density in the major city regions. Inhabitants per km^2



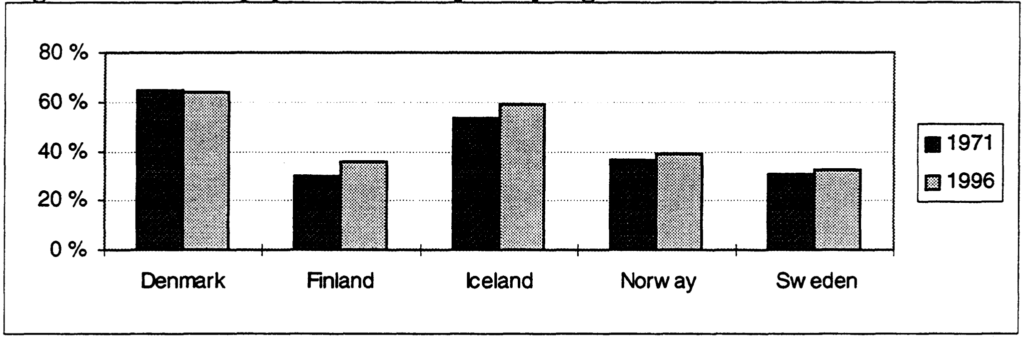
Source: «Statistik uden grenser 1997» Nordic Statistics on CD-ROM 1997

People living in urban areas often generate smaller per capita emissions of CO_2 because of public transportation and district heating, but also because living in big blocks of flats demands less per capita energy for heating.

Part of the population living in major city regions

In Denmark 63 per cent of the population live in major city regions. This is the highest share among the different Nordic countries, and it has been very stable during the last quarter of a century. All the other Nordic countries have had an increasing part of the population living in major city regions. In Iceland 59 per cent of the population live in the Reykjavik region. In Norway 38 per cent, Finland 35 per cent, and in Sweden 32 per cent live in the major city regions (figures 4 and 5). The ongoing urbanisation in all the Nordic countries (with the possible exception of Denmark) indicates smaller CO_2 emissions, ceteris paribus. In addition to the share of the population living in major city regions, it is of great importance to know the size of the population when planning infrastructural changes.

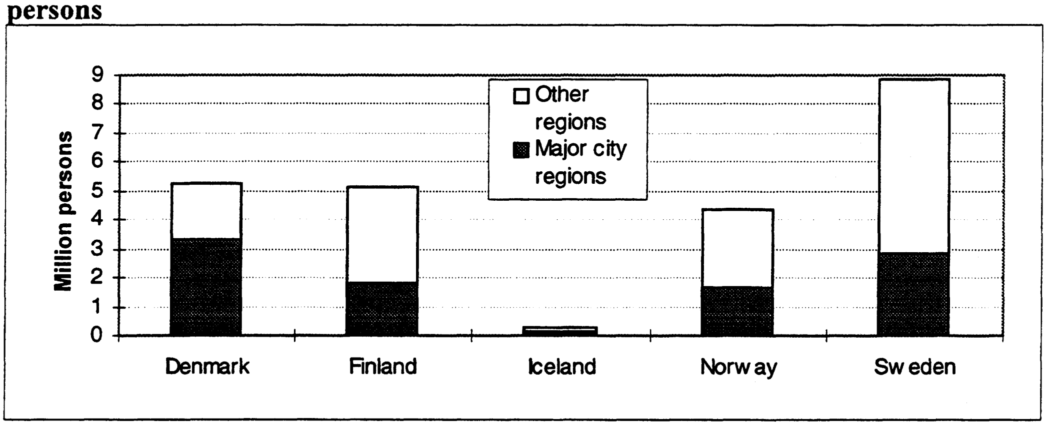
Figure 4. Share of population in major city regions. 1971 and 1996. Per cent



Source: Nordic Statistics on CD-ROM 1997

Data quality: Good
Data availability: Good

Figure 5. Part of national populations living in major city regions. 1996. Million persons



Source: Nordic Statistics on CD-ROM 1997

Data quality: Good
Data availability: Good

4.2.3. Natural resources

Extraction of some types of natural resources will lead to emissions of greenhouse gases, both during the extraction process and during the use of the natural resources. Furthermore, the types of energy used within a country are often given by the types of natural resources to be found. Consequently, the types and reserves of natural resources should be considered as a relevant driving force indicator. It is distinguished between renewable (table 2) and non-renewable (table 3) natural resources.

The Nordic countries are rich in natural resources. There are, however, great differences between the countries. Norway and Denmark have reserves of oil and gas. All the Nordic countries have very limited reserves of coal. Hydropower is especially developed in Norway and Sweden, and Iceland is utilising much thermal power. Sweden and Norway have the largest technical potential for further development of their hydropower resources. Sweden, Finland and Norway are all rich in forest (wood) resources. Forests cover more than half the land area of Finland and Sweden.

Table 2. Important renewable energy resources. Mid-1990s.

Country	Forest[1]			Hydropower		Thermal power
	Volume of standing wood	Area	Share of total land area	Developed	Potential	Developed
	million m^3	1000 km^2	Per cent	GW	GW	MW
Nordic total	5 571	521	-	..	..	50
Denmark	61	4	10	-	-	-
Finland	1 937	200	66	..	..	-
Iceland	-	0.3	0.3	1	..	50
Norway	745	73	24	27	9[2]	-
Sweden	2 828	244	59	16	..	-

[1] Forest area here is smaller than the wooded area in a country as it excludes parks, gardens, etc. (area with trees crowns covering less than 20 per cent of the area and areas used for other primary purposes than forestry).

[2] Excluding protected potential resources.

Sources: Forest: OECD Environmental data. 1997. Hydro and thermal power: Statistical yearbooks of the Nordic countries. Norway: Norwegian Water Resources and Energy Administration (NVE).

Data quality: Good
Data availability: Medium

Table 3. Proven reserves of various non-renewable energy resources and R/P-ratio in years in parenthesis. 1995

Country	Coal	Oil	Gas	Peat	Uranium
	1000 PJ	1000 PJ	1000 PJ	billion m^3	kt
Nordic total	..	50	56	29	2
Denmark	-	4 (15)	4 (23)	-	(43)[1]
Finland	..	-	-	23 (?)	2
Iceland	-	-	-	-	-
Norway	0.2 (20)	46 (8)	52 (43)	..	-
Sweden	..	-	-	6 (-)	0

[1] In Greenland.

Sources: Oil and gas: BP Statistical Review of World Energy 1996. Coal: Statistics Norway. Peat in Sweden: Statistics Sweden (Statistiska meddelanden Na 25 9601). Uranium: OECD/IAEA 1995.

Data quality: Medium
Data availability: Medium, but for minor reserves little data are available.

The ratio between the reserve and annual production indicates for non-renewable resources the number of years the proven reserves will remain, given no changes in prices, technology and rate of extraction. This ratio is frequently named the R/P-ratio. The ratio as illustrated in table 3 shows that the gas resources are likely to last longer than the oil given no changes in technology and prices. The experience so far is that new technologies and new discoveries cause the R/P-ratio to remain rather stable in spite of increased extraction, and it is consequently not a very good indicator.

The annual variations in hydropower production capacity due to precipitation and market conditions explain much of the energy transfer and other electricity production in the Nordic countries. The average annual hydropower production is shown in table 4. This is an alternative indicator to the developed power in table 2.

The normal production in Sweden will vary with about 20 per cent or 10 TWh. For extreme years the production can thus sink to 53 TWh or increase to 73 TWh (Naturvårdsverket 1991). During the last ten years the production in Norway has generally been higher than the mean production capacity (up to 10 TWh above); in 1996, however, the production was 9 TWh below this figure.

Table 4. Mean annual developed (normal) production capacity for hydropower. 1996. GWh

Denmark	Finland	Iceland	Norway	Sweden
-	12 608	4 950	112 597	63 645

Source: Nordel 1997

Data quality: Good
Data availability: Good

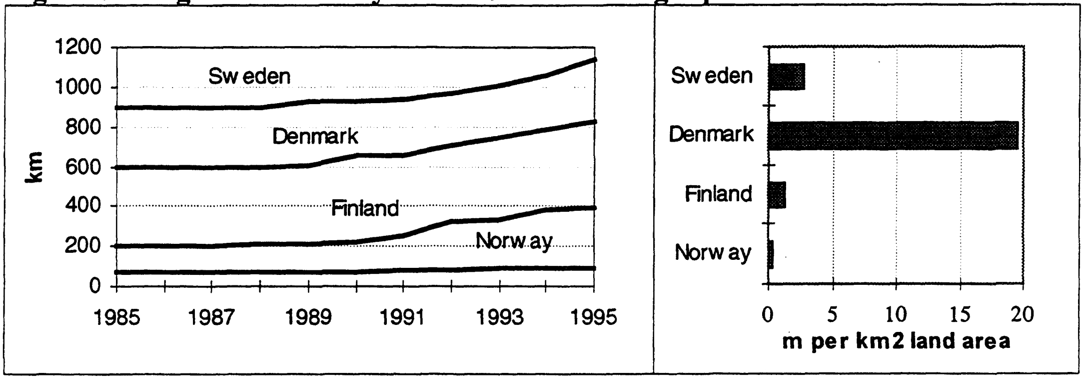
4.2.4. Transport, roads and infrastructure

Transport takes part in all levels of the society, commercially as well as privately. The transport sector is essential to the production and distribution of goods and services, as well as to trade and regional development. Despite the crucial importance of the sector, a problematic and not very sustainable situation has been allowed to evolve, especially in the larger urban and industrial areas.

Transport is never environmentally neutral and many factors influence the pressures and the impacts on the environment and the extent of these. The sector's consumption of fossil fuels is a main cause of a large number of environmental problems. Emissions from the sector – primarily from road and air traffic, but also from shipping – represent a very high share of the emissions of CO_2, see section 4.3.

Infrastructure components such as the number of vehicles or the road and railway network form a basic prerequisite for transport and should consequently be included in the indicator set. The total length of the road network increased substantially around the 1950s and has since then kept on growing but at much slower rate. The length of both the road and the railway network have remained relatively unchanged during the last ten years in all the Nordic countries. One exception is the length of motorways.

Figure 6. Length of motorways 1985-1995. km. Length per unit land area. 1995. m



Sources: International Road Federation (IRF), OECD and national statistical yearbooks

Data quality: Good
Data availability: Good

Between 1990 and 1995 the length of the motorways has increased with about 17 per cent in Norway, 25 per cent in Denmark and Sweden, and with 75 per cent in Finland. The length per unit land area is by far the highest in Denmark (figure 6).

The number of vehicles of different kinds is another indicator of interest in this context. Since 1970 the number of for example passenger cars in the Nordic countries has increased with between 40 and 90 per cent. Particularly during the first five years of the 1970s the number of cars per 1000 inhabitants increased heavily. In Sweden, for example, there were 283 passenger cars per 1000 inhabitants in 1970 and five years later there were 336 passenger cars per 1000 inhabitants. The increase since then has been much slower, and during the last 5–6 years the different vehicle stocks have remained at a relatively stable level in the various Nordic countries. There is however a tendency for an increasing number of heavier lorries in Sweden and Denmark.

Transport by railway is considered to be the least environmentally harmful mode of transport apart from walking and cycling. However, this is the only transport mode that has not had an increasing trend during the last 25–30 years. This might be explained by the wish of having «just in time» deliveries or «from door to door» deliveries of goods and merchandise. In addition, the freedom and speed of mobility that the passenger car represents also plays an important role in keeping the railway transport on an unchanged level.

The increasing number of vehicles and transport equipment, and the increasing road lengths have facilitated the mobility. Although the vehicles have become much more efficient and environmentally less harmful, the environmental effects have not diminished. Reasons giving rise to unchanged or increased air emissions are that people travel much more and farther today than they did in the past, and that there are long distances for people and goods to travel in the Nordic countries.

The transport performance – expressed in tonne-kilometres or passenger-kilometres – is a common and very important indicator used when comparing the efficiency between different modes of transport. This indicator is of course closely related to the changes in the vehicle stocks and transport patterns that have been described above. There have been large increases in the transport volumes the last 25–30 year period. Taking a closer look at the first half of the 1990s, the changes in transport performance are most notable in Sweden and Norway, according to the available statistics. The number of tonne-km in road transport of goods increased with close to 18 per cent in Sweden and with 29 per cent in Norway between 1990 and 1996 (table 5).

Table 5. Road transport of goods. 1990–1996. Million tonne-km

Country	1990	1991	1992	1993	1994	1995	1996
Denmark	10 700	10 400	10 800	10 000	10 800	10 900	..
Finland	25 700	24 200	22 800	24 100	24 800	..	..
Iceland	..	..	..	..	..	..	..
Norway	8 231	8 286	8 348	8 266	8 714	9 654	10 651
Sweden	26 519	25 368	24 285	25 908	..	29 324	31 185

Source: National statistics and yearbooks

Data quality: Good
Data availability: Medium

A similar tendency can be observed in Norway for passenger transport by air (table 6), but for other modes of transport of goods as well as passengers, the levels have remained stable since 1990.

Table 6. Domestic passenger transport by air. 1990–1996. Million passenger-km

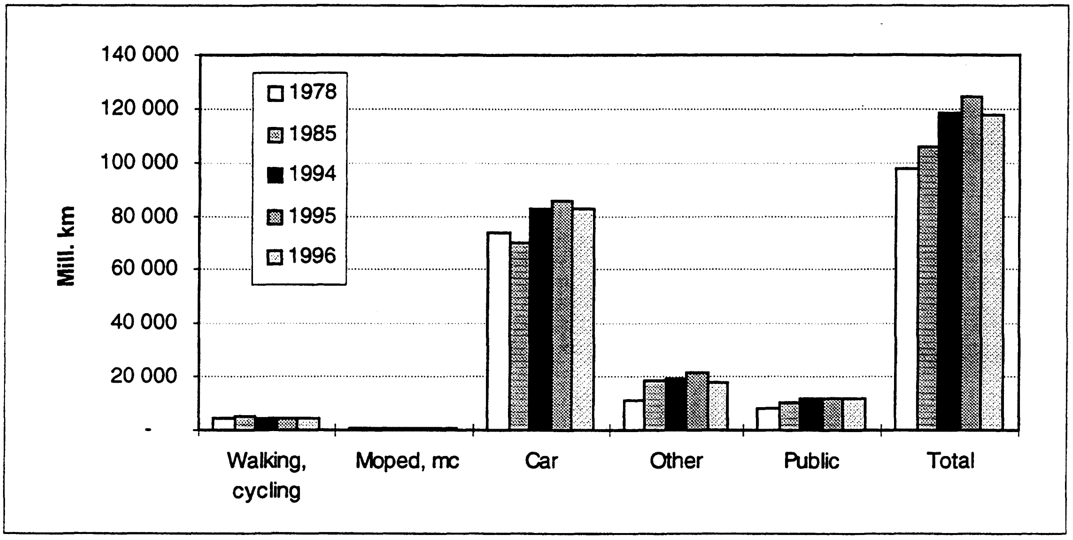
Country	1990	1991	1992	1993	1994	1995	1996
Denmark	500	400	500	400	500	500	..
Finland	1 000	900	900	800	800	900	800
Iceland	..	..	..	..	..	..	..
Norway	2 664	2 693	2 903	3 169	3 402	3 573	3 943
Sweden	3 396	2 813	2 740	2 870	3 067	2 798	2 750

Source: National statistics and yearbooks

Data quality: Medium
Data availability: Medium

In order to reduce CO_2 emissions from transport many different actions have to be taken. One is to change peoples' travelling patterns. Travel behaviour surveys are not regularly performed in all Nordic countries. Such a survey would, however, contribute to an indicator where changes in the travelling patterns could be monitored. Below is a graph showing the travel behaviour in Sweden in 1978, 1985 and 1994–1996 (figure 7). The total number of kilometres travelled in 1996 is about 20 per cent above the level of 1978. It is mainly the journeys by car that have contributed to this increase. There is a distinct change in the level between 1978/1985 and the results from 1994–1996 going in the «wrong» direction with reference to the CO_2 emissions.

Figure 7. Total length of personal journeys in Sweden by mode of transport. Million km



Source: The Swedish Travel Behaviour Survey (Riks-RVU)
The transport mode «Other» includes e.g. journeys by air, rail and ferry.

Data quality: Good
Data availability: Needs improvement (missing countries, no regularity, different definitions, etc.)

Transport of oil and gas by pipelines and by tankers (oil) has been increasing rapidly in Norway and to some extent in Denmark (tables 7 and 8) since the mid 1980s.

Table 7. Transport of oil and gas by pipelines. Million tonne-km

	1985	1990	1993	1994	1995	1996
Denmark	..	1 900	2 600	2 900	2 900	..
Norway, oil	..	2 055	3 390	4 049	5 261	5 131
Norway, gas	163	1 235	1 895	2 743	3 583	4 086

Source: National statistical yearbooks

Data quality: Good
Data availability: Good

Table 8. Transport by tankers. Million tonne-km

	1985	1990	1993	1994	1995	1996
Norway	2 555	4 313	5 065	5 870	4 999	9 297

Source: Statistical yearbook, Norway

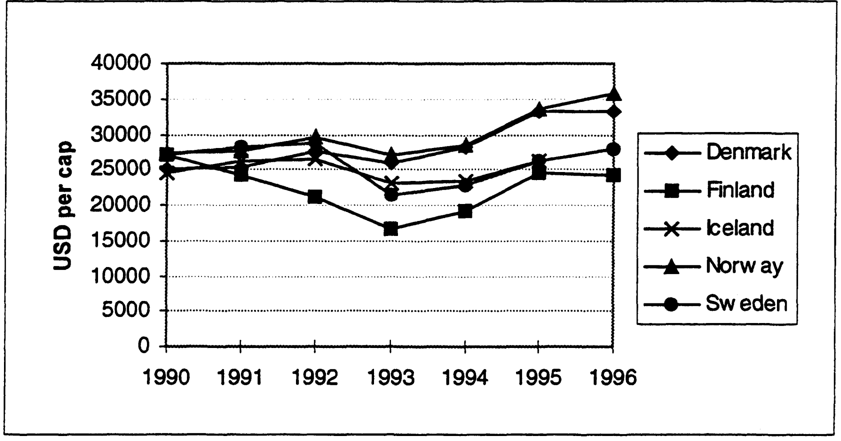
Data quality: Good
Data availability: Good

Particularly in Norway this increase in transport of oil and gas by tankers and pipelines constitutes a not negligible source of the greenhouse gas emissions. Consequently this transport performance should be included in the indicator set.

4.2.5. Economic conditions and production

The gross domestic product, GDP, enables a comparison of volumes of goods and services produced by different countries. In figure 8 the development during the 1990s can be followed. Norway has the highest GDP per capita along with Denmark. Finland has the lowest GDP per capita of the Nordic countries. All the Nordic countries had a decrease of the GDP around 1993. The trends are fairly similar in all the Nordic countries.

Figure 8. GDP per capita, in market prices. 1990–1996. USD



Source: Yearbook of Nordic Statistics 1997. Nordic Council of Ministers

Data quality: Good
Data availability: Good

Consumption expenditures on housing and heating vary between 15 and 35 per cent of the total consumption expenditures in the Nordic countries (table 9). Iceland and Finland spent less than the other Nordic countries, Norway and Sweden are in the middle, and Denmark spent most.

For transport and communication the figures are more even, and lie around 16 to 19 per cent of the total expenditures in 1990.

Table 9. Consumption expenditure of households on housing and heating, and transport and communication. 1990. Per cent of total consumption expenditure

Type of expenditure	Denmark	Finland	Iceland	Norway	Sweden
- Housing and heating	34.5	17.0	14.8	26.6	25.5
- Transport and communication	15.7	18.0	18.6	19.3	17.6

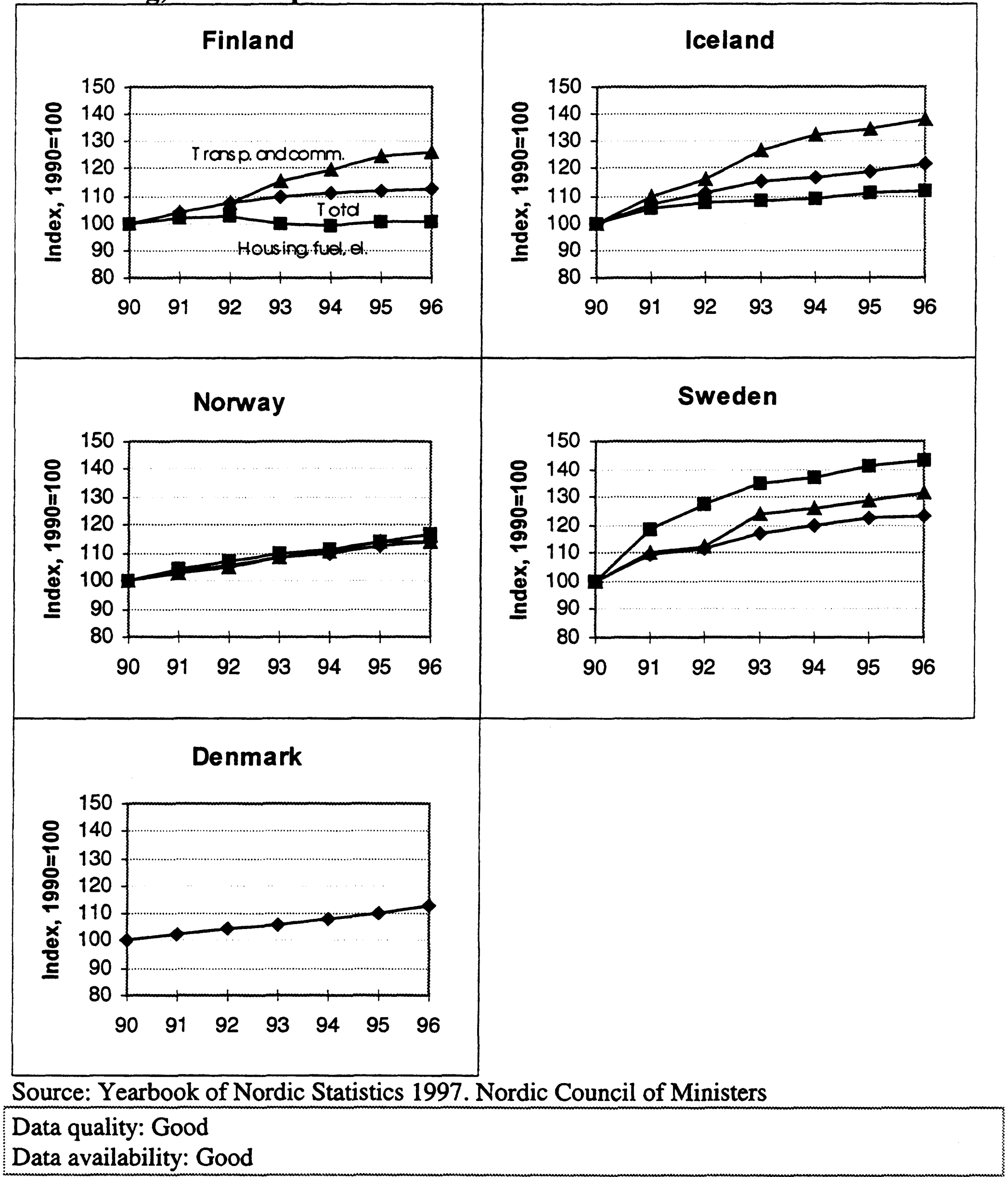
Source: Yearbook of Nordic Statistics 1995

Data quality: Good
Data availability: Good

Looking for time trends in consumer price indices (figure 9), it can also be noted that the consumer price index for housing, fuel and electricity in Finland has not changed much since 1990. For Sweden the index for housing, fuel and electricity has increased most, from 100 to

140 in six years. It is of course difficult to know how much of this price increase that is due to increases in the fuel price. For all countries (Denmark is not assessed) the consumption expenditures on transport and communication have increased relative to the total consumer price index.

Figure 9. Consumer Price Indices (1990=100) for total expenditure, for housing and heating, and transport and communication. 1990–1996

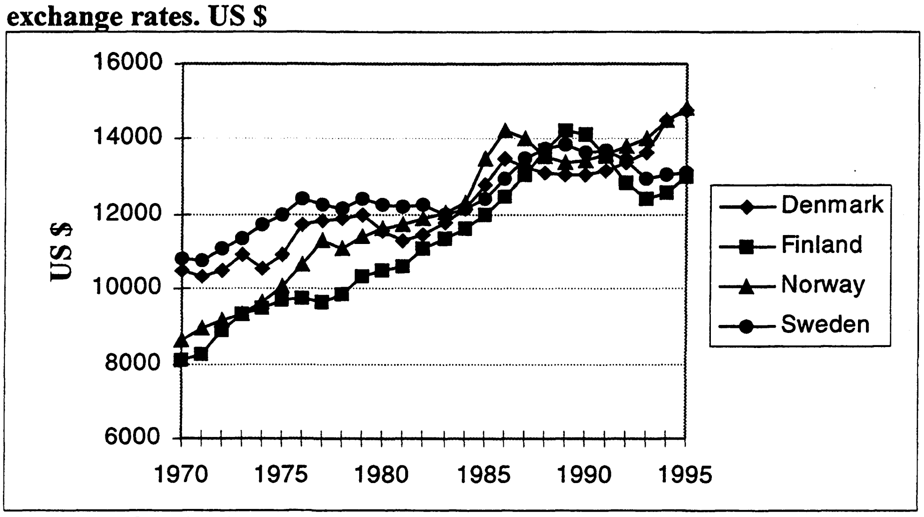


Source: Yearbook of Nordic Statistics 1997. Nordic Council of Ministers

Data quality: Good
Data availability: Good

The change in private consumption is an important driving force for climate issues as increased consumption will lead to more transport and more waste. The best indicator would be the household volume of consumption, but as comparable data are not available, we instead suggest the private consumption per capita in fixed prices (figure 10). The indicator shows that the consumption measured in monetary units has increased in all the Nordic countries. The present level (1995) is highest in Norway and Denmark and lowest in Finland and Sweden.

Figure 10. Private consumption per capita. 1990 price levels and exchange rates. US $

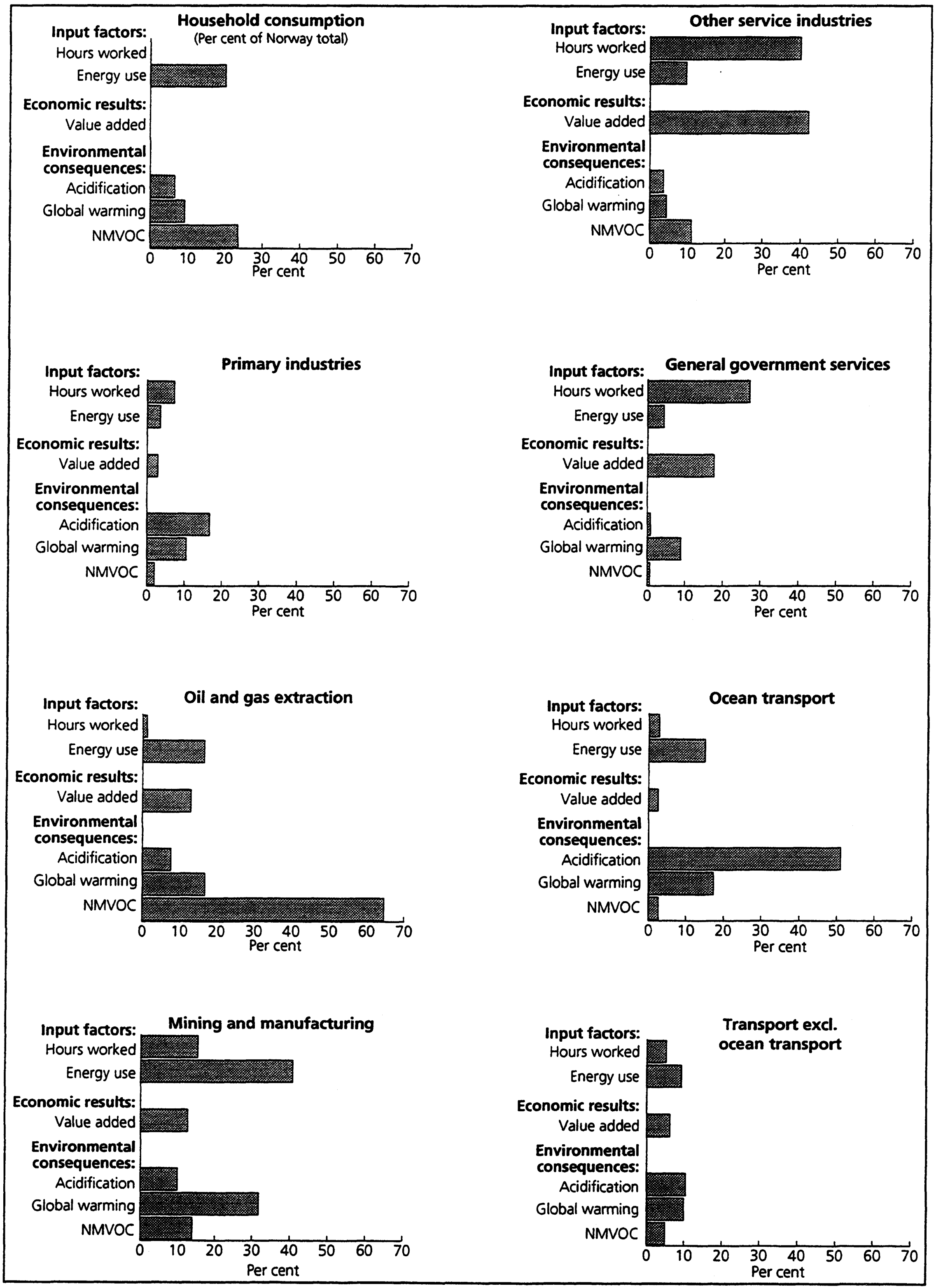


Source: OECD - National Accounts, Main Aggregates Vol.1, 1997

Data quality: Good
Data availability: Good

The NAMEA system, which connects national economic data with environmental data, is a valuable tool for creating indicators (section 2.3). Climate change is one of the themes in these accounts. Comparable data for the Nordic countries are not yet available, but will be in the future. Examples of indicators are shown here for Norway only (figures 11 and 12).

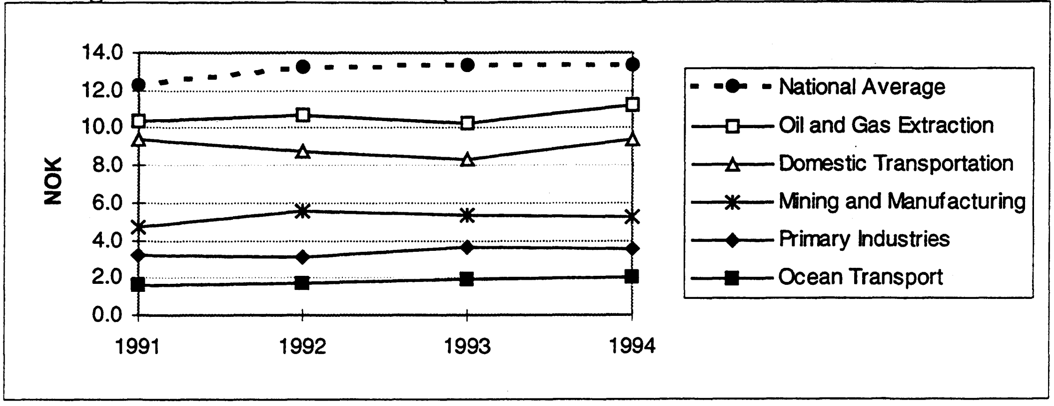
Figure 11. Household and industry profiles: Input factors, economic results and emissions to air. Shares of total for activities. 1993. Per cent



Source: Hass and Sørensen 1997

Data quality: Medium
Data availability: Medium

Figure 12. Value added (NOK) per kilogram CO_2-equivalents emitted for selected Norwegian industries. 1991–1994. (Constant 1993-prices)



Source: Hass and Sørensen 1997

Data quality: Medium
Data availability: Medium

Industrial structure and exports of goods

As can be seen in table 10, the importance of the different economic activities expressed as their contribution to GDP is fairly similar for the Nordic countries. Exceptions, where separate countries have different patterns, are the contribution from extraction of crude oil and natural gas (which is included in «mining and quarrying») in Norway, and the dominating role of fisheries as a basic industry for Iceland.

Table 10. Economic activity as part of GDP (at factor cost). 1991. Per cent

Economic activity	Denmark	Finland	Iceland	Norway	Sweden
Agriculture, forestry, fishing, hunting	4.2	5.6	11.7	4.7	2.6
Mining and quarrying	1.0	0.4	-	13.3	0.3
Manufacturing	18.9	21.0	15.9	15.0	20.4
Electricity, gas, water	2.1	2.6	3.7	3.7	3.3
Construction	5.4	8.6	7.4	4.3	7.6
Wholesale and retail trade, restaurants, hotels	14.0	12.2	12.5	9.9	10.8
Transport, storage, communication	9.2	8.4	6.9	12.1	7.4
Financing, insurance, real estate and business services	19.5	18.4	18.0	16.6	22.4
Other	25.8	22.7	23.8	20.5	25.2

Source: Yearbook of Nordic Statistics 1995. Nordic Council of Ministers

Data quality: Good
Data availability: Needs improvement. Not available in later editions of the Nordic Yearbook

Denmark

Denmark's industrial structure is characterised by a large number of rather small enterprises. Of the 7 500 industrial enterprises, 80 per cent have less than 50 employees, and only 1 per cent have more than 500 employees. This pattern has remained unchanged for decades and can be explained by the fact that Denmark never had any local raw materials. Heavy industries were never a part of the industrial sector, where the most important resource was the human one. Some of the bigger, specialised companies have merged to become of a size where they can make an impact internationally. Examples of industries where these changes have taken place are the electronics and telecommunications sector, dairy products and the biotechnological sector. The proportion of production destined for export is usually higher than 90 per cent (Eurostat 1993). The recovery in domestic demand from late 1993 onwards has led to a surge in both domestic production and imports. Increasing North Sea oil and natural gas production has continued to replace energy imports, as a result of which the share of energy in overall imports has been lowered from 17 to 4.5 per cent over the past decade. In addition, energy exports have been increasing, boosted further by the temporary cut-back of hydroelectric power in the other Scandinavian countries (OECD 1997b).

Finland

The structure of Finnish exports has changed a great deal over the current decade. As recently as in 1991, the export shares of the metal and engineering industry and the forest industry were approximately the same, i.e. about 40 per cent of merchandise exports. By 1995, the metal and engineering industry had increased its share to 47 per cent of the value of merchandise exports, while the forest industry had fallen to 36 per cent. The exports of metal and engineering industry products have grown most for telecommunications products, and machinery and equipment mainly intended for the manufacturing industry (Ministry of Finance 1996).

Iceland

The Icelandic economy is characterised by three features in particular: firstly, by the smallness of the domestic market; secondly by a lack of diversification in its economic activities; and finally by the country's location. The main source of economic growth in Iceland has been the fisheries sector. A decline in catches and/or foreign market prices for fisheries products has markedly affected the national economy in recent years. In spite of this, the fishing industry is still the country's principal export industry, accounting for about three-quarters of its total exports. Manufactured goods accounted for approximately 20 per cent of all exports in the period 1981–1993, the largest portion of these being products of power-intensive industries, which amounted to 11 per cent of the total (Eurostat 1996a).

Norway

The petroleum sector has continued to expand strongly, due to large investments in new production facilities. Norway has become the world's second largest net exporter of crude oil and natural gas liquids, after Saudi Arabia. Petroleum production now represents one-sixth of overall GDP, one-third of total exports and a quarter of total fixed investment. Petroleum exports aside, traditional merchandise exports in Norway have increased by over 30 per cent in real terms in the 1994–96 period, notwithstanding a short-lived downturn in 1995 due to weak demand in Europe. These outcomes were achieved despite a significant rise in relative unit labour costs between 1993 and 1995, as exports have shifted to strongly growing markets in the US, the UK and the Nordic countries, as well as to new markets in eastern Europe and south-east Asia. Most impetus for growth in traditional exports has been provided by the exports of fish. The exports of paper and paper products, as well as of iron and steel, aluminium and chemicals have also expanded significantly during the 1990s (OECD 1997a).

Sweden

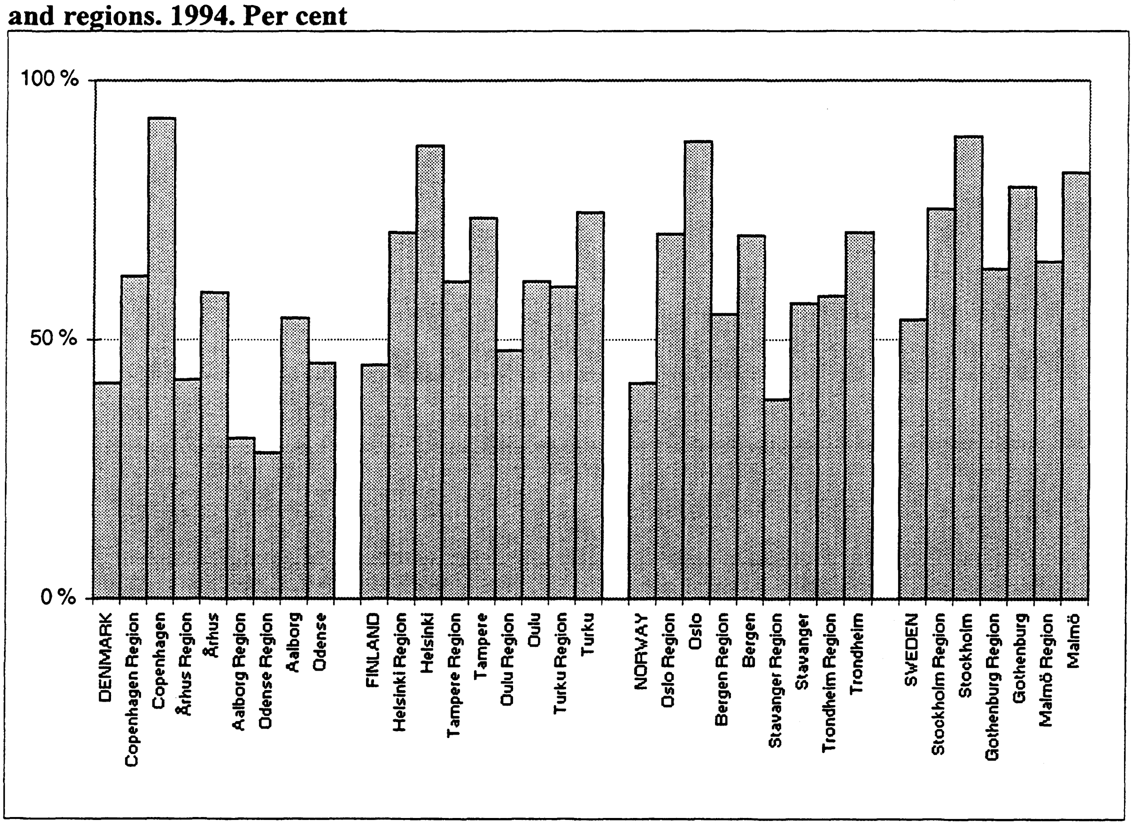
The growth in exports exceeded market growth over the 1993–95 period. Growth has been unevenly distributed among export categories. Export volumes and prices of paper products have been held back by weak international demand and competition from other depreciating countries, while more cyclically sensitive products such as metal products and machinery and equipment saw a growth of around 25 per cent volume in 1994 (OECD 1996). High-technology goods like electronic communication equipment, domestic appliances and pharmaceuticals are also important.

4.2.6. Housing and building structure

The number of dwellings in small houses compared with the number in big blocks of flats is a driving force indicator with relevance for the climate issue. The possibility of district heating is better in areas with high population density. This is also often where the big blocks of flats are situated. Dwellings in big blocks of flats generally demand less energy for heating. Heating is one of the main sources of CO_2 emissions in the Nordic countries, much because of the cold climate, but also because of internationally high housing standards with a high average residential area per capita.

In Sweden, as much as 54 per cent of the dwellings are in big blocks of flats. The other Nordic countries have a higher share of small houses (figure 13). Especially in Denmark and Norway, small houses represent a large part of the dwellings. Although Denmark has a large part of its population living in major city regions, a substantial amount of the dwellings is in small houses even in these regions.

Figure 13. Part of population in big blocks of flats. Country average and selected cities and regions. 1994. Per cent



Source: Nordic Statistics on CD-ROM (Nordic Council of Ministers)

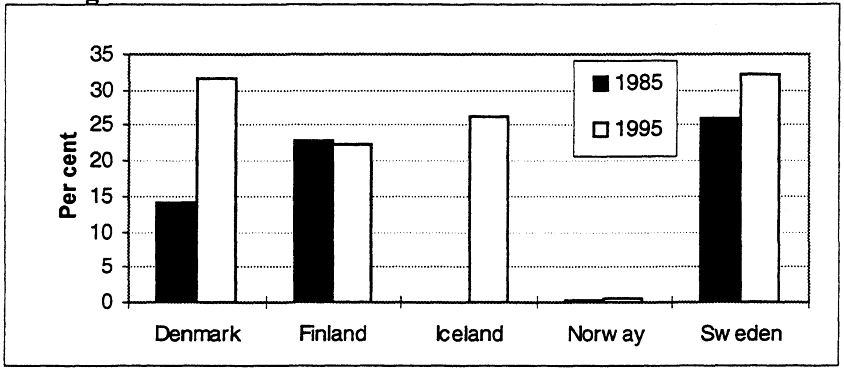
Data quality: Good
Data availability: Good

Heating

Heating with fossil energy is an important source of CO_2 emissions, and the possibility of district heating that may reduce these emissions is therefore of major interest. This, of course, presupposes that the district heating company does not primarily use fossil fuel.

Denmark and Sweden have the largest amount of district heating for dwellings. In Denmark the use of district heating has increased rapidly between 1985 and 1995. In Norway, district heating is at the present time of very little importance (figure 14).

Figure 14. District heating as part of total energy use for residential heating. 1985 and 1995. Per cent

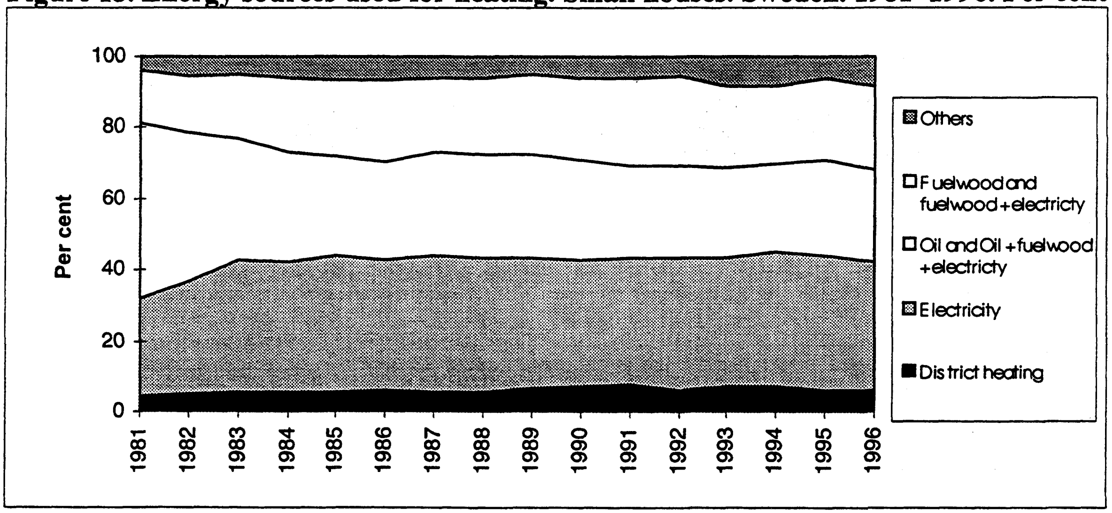


Source: Statistics Sweden

Data quality: Good
Data availability: Good

As discussed above, big blocks of flats do increase the possibilities of district heating. In Sweden, most of the energy for heating dwellings in big blocks of flats comes from district heating (figure 16). District heating is also the major heating distribution system for buildings not used for housing (figure 17). Only a small amount of dwellings in small houses has district heating; electricity and oil are more common in Sweden (figure 15).

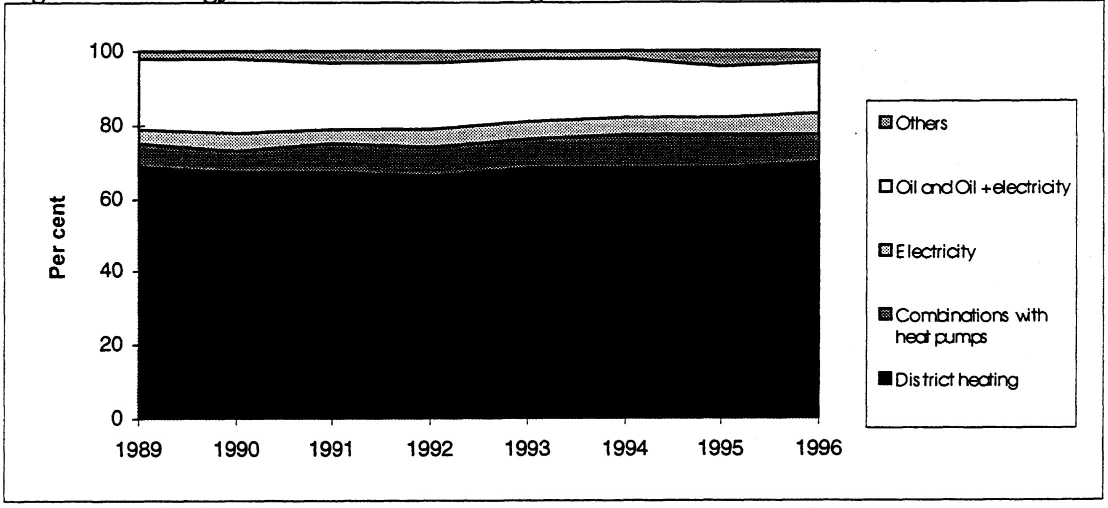
Figure 15. Energy sources used for heating. Small houses. Sweden. 1981–1996. Per cent



Source: Statistics Sweden

Data quality: Good
Data availability: Needs improvement

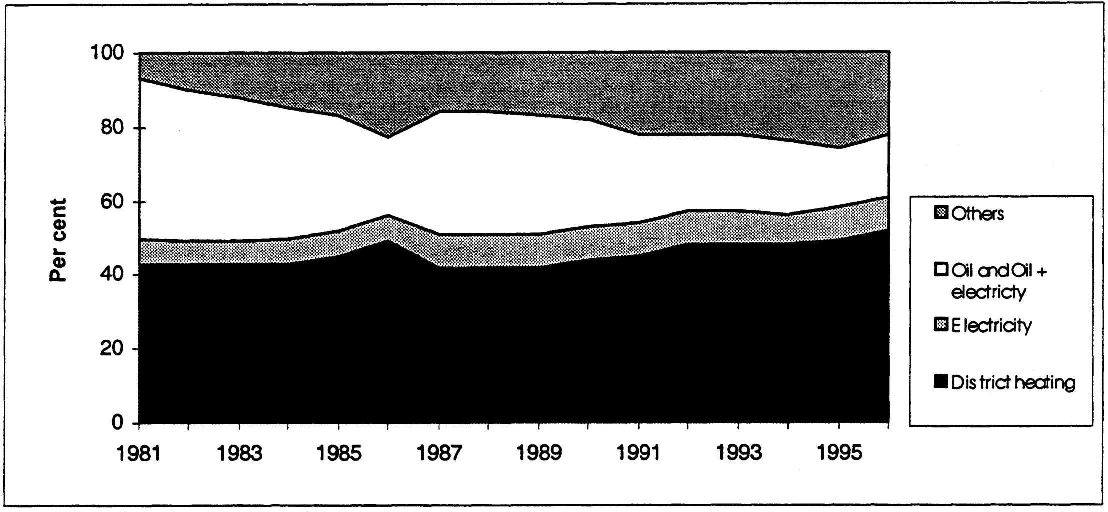
Figure 16. Energy sources used for heating. Blocks of flats. Sweden. 1989–1996. Per cent



Source: Statistics Sweden

Data quality: Good
Data availability: Needs improvement

Figure 17. Energy sources used for heating. Other buildings (non-residential). Sweden. 1981–1996. Per cent



Source: Statistics Sweden

Data quality: Good
Data availability: Needs improvement

Residential area

The residential area is also important for the energy consumption. The space per capita is often larger in small houses than in big blocks of flats. In Sweden in 1995 the residential area per capita was 39 m^2 for those living in big blocks of flats and 48 m^2 for those living in small houses. The total average in Sweden 1995 was 43 m^2 per capita (table 11). Finland has the smallest residential area per capita among the Nordic countries.

Table 11. Residential area per capita. m^2

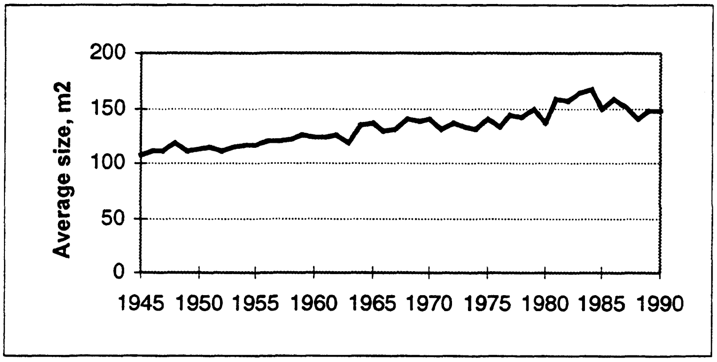
Country	Residential area m^2 per capita *(year)*
Denmark	49 *(1993)*
Finland	31 *(1993)*
Iceland	..
Norway	43 *(1990)*
Sweden	43 *(1995)*

Sources: Norway: Statistics Norway (Census of population and housing 1990); other countries: National Board of Housing Building and Planning

Data quality: Medium
Data availability: Needs improvement

Residential area per capita is internationally not a commonly used standard measure. For Iceland we present data about construction of residential housing, dwellings completed during the year (figure 18). The average size of completed dwellings increased until the peak in 1984. In the late 1980s the average size of completed dwellings decreased slightly. This might be an indicator in addition to residential area per capita, because it shows the changes very well. These changes can be caused by economic factors, political decisions or both. In Sweden for example, the governmental loans have been very important for the building structure. Data are, however, not available to allow comparisons over time and between countries.

Figure 18. Average dwelling size completed annually. Iceland. 1945–1990. m^2



Source: Statistics Iceland 1997a

Data quality: Good
Data availability: Needs improvement

4.2.7. Energy production and trade with energy

Production

Production of fossil energy products will in many cases lead to emissions of greenhouse gases. Most types of energy may be exported to other countries. Some types of energy export will require special infrastructure like pipelines and electricity wires. When fossil energy goods are exported, the corresponding potential emissions are also exported, but the emissions from the extraction process are book-kept with the country of production (IPCC 1997).

Table 12. Primary energy production (Indigenous production). 1995. PJ

Country	Coal	Oil	Gas	Electricity: Geothermal, wind, hydro and nuclear	Total	Total/capita GJ/capita
Total	106	6 315	1 381	1 761	9 599	403
Denmark	0	392	195	5	592	113
Finland	85	-	-	256	341	67
Iceland	-	-	-	58	58	216
Norway	8	5 959	1 186	437	7 590	1 741
Sweden	13	-	-	1005	1018	115

Source: Energy balances of OECD countries. 1994–1995

Data quality: Good
Data availability: Good

Norway is the main producer of primary fossil fuels among the Nordic countries. Norway, Sweden and partly Finland are the main producers of primary electricity (produced from primary renewable sources and nuclear energy) (table 12).

Secondary energy production (table 13) takes place independent of the primary production. Most countries have oil refineries, even though they do not all produce crude oil.

Table 13. Secondary energy production. PJ. 1995

Country	Electricity (From fossil fuels)	Heat (From fossil fuels)	Heat and electricity (From renewable resources and waste)	Petroleum products
Total	243	243	135	2 315
Denmark	125	94	30	422
Finland	90	91	30	509
Iceland	-	-	0	-
Norway	1	1	5	572
Sweden	27	57	70	822

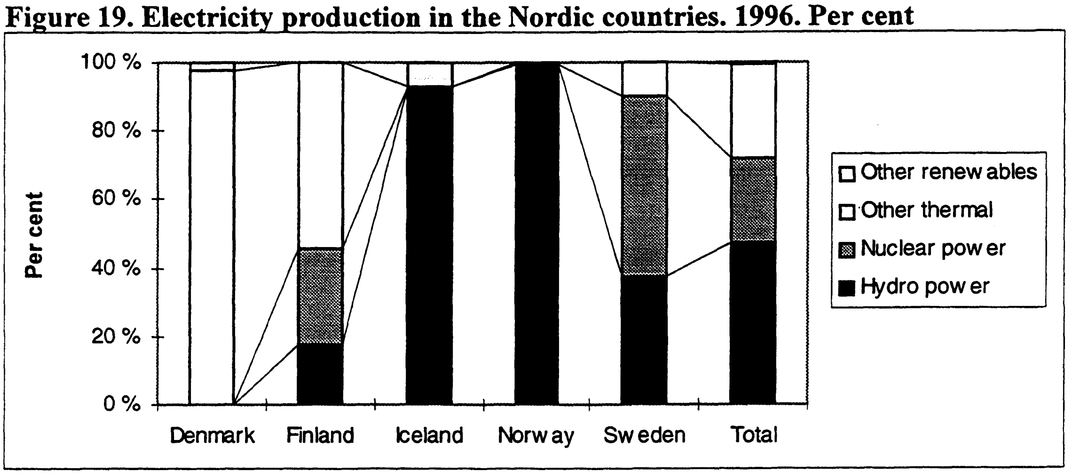
Source: Energy balances of OECD countries. 1994–1995

Data quality: Good
Data availability: Good

Denmark has the highest production of secondary electricity and heat from fossil fuels. Sweden has the highest production of heat and electricity from renewable secondary sources. Norway and Iceland have nearly no secondary production of electricity at all.

Much of the emissions in some of the Nordic countries are connected to electricity production. Presenting the data in two separate tables for primary and secondary production does not give a good overview of the methods of electricity production. It can be better summarised for example as in figure 19.

Figure 19. Electricity production in the Nordic countries. 1996. Per cent



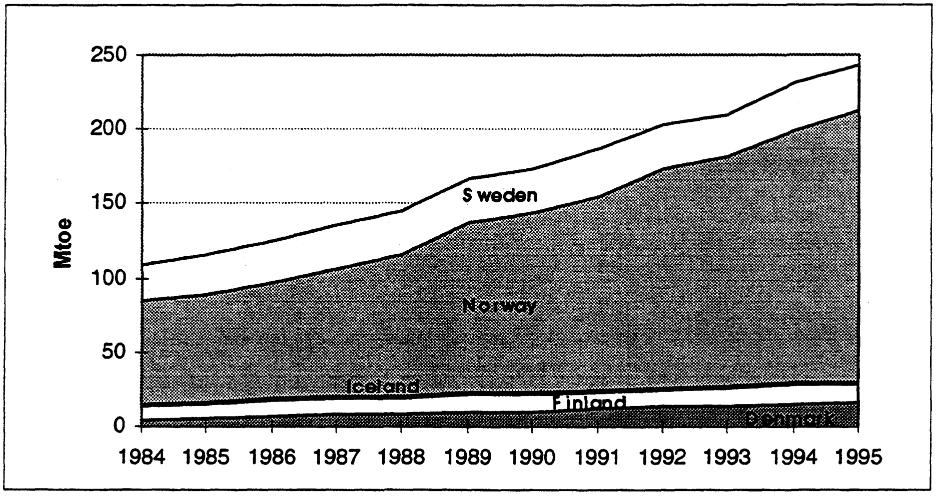
Source: NORDEL

Data quality: Good
Data availability: Good

This figure illustrates the large differences in methodologies for electricity production between the Nordic countries. Denmark is nearly 100 per cent based on thermal power plants, Norway and Iceland produce nearly all electricity from hydropower, while Finland and Sweden are using combinations of nuclear power, hydropower and thermal power plants.

As CO_2-emissions from energy production in especially Norway and Denmark are very significant, at least the primary energy production and secondary electricity production seem to be very relevant driving force indicators. The secondary energy production in refineries should be considered together with the driving force indicators for industrial production.

Figure 20. Primary production (Indigenous production) of oil, gas and electricity in the Nordic countries. Mtoe. 1984–1995



Source: Energy balances of OECD countries. 1995

Data quality: Good
Data availability: Good

The total Nordic energy production has increased substantially the last ten years (figure 20). The production has increased in all countries, and especially in Norway. The increased production explains much of the increase of CO_2 emissions in Norway, and is consequently a relevant driving force indicator for that country.

Trade

The foreign trade of energy is illustrated in table 14. For electricity the table also shows trade between the Nordic countries.

Table 14. Foreign trade with energy. Net import. 1995. Mtoe

	Coal	Oil	Gas	Electricity	Total
Denmark					
- Overall	7.9	1.6	-1.5	-0.1	7.9
- From Nordic countries	..	..	..	0.2	..
Finland					
- Overall	3.8	8.1	2.9	0.6	15.4
- From Nordic countries	..	..	..	0.3	..
Iceland					
- Overall	0.1	0.8	-	-	0.9
- From Nordic countries	..	..	..	-	..
Norway					
- Overall	0.9	-133.0	-24.8	-0.6	-157.5
- From Nordic countries	..	..	..	-0.6	..
Sweden					
- Overall	2.7	16.3	0.7	-0.2	19.5
- From Nordic countries	..	..	..	0.06	..

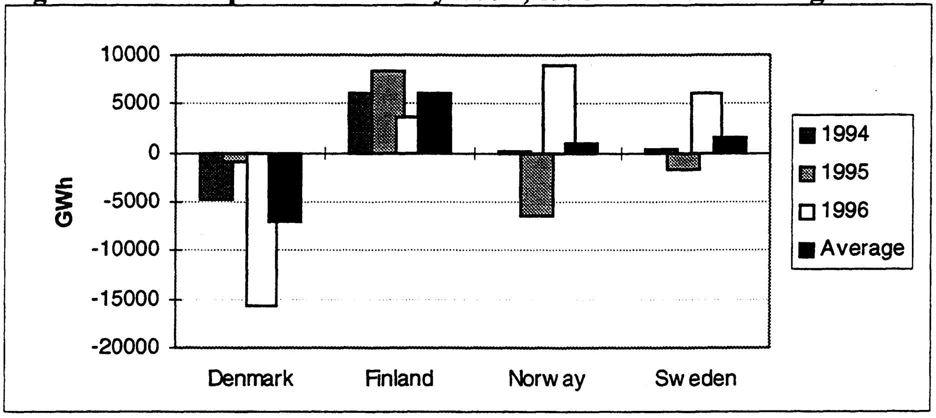
Sources: Energy balances of OECD countries 1994–1995 and NORDEL

Data quality: Good
Data availability: Medium

Norway is a significant net exporter of crude oil and natural gas, all the other Nordic countries are net importers. Especially Denmark, but also Finland and Sweden import coal. In 1995 all Nordic countries except Finland were net exporters of electricity. Most trade of electricity is within the Nordic countries.

Trade of energy does not lead to direct emissions of greenhouse gases (emissions are of course associated with connected transport (indirect emissions). Furthermore, there is usually a loss of energy during all transport). Still it is considered a partly relevant driving force indicator as it shows the transfer of carbon and electricity between Nordic countries, and is in this way giving an overview of the flexibility of the Nordic energy marked as well as the Nordic carbon balance. However, as the electricity marked between the Nordic countries is open and the production conditions are variable, trade of electricity is likely to vary a lot from year to year. Hence, one table does not give a very good picture of electricity trade between the countries. The three-year average trade of electricity is illustrated in figure 21. The figure illustrates very well the situation in 1996 where a reduced hydropower production in Norway and Sweden led to a very high import of thermal power exported from Denmark.

Figure 21. Net import of electricity. 1994, 1995 and 1996. Average 1994–1996



Source: NORDEL

Data quality: Good
Data availability: Medium

4.2.8. Production, use and trade of wood products

Production and use

The amount of forest production is an important indicator for several reasons. The forests are important CO_2 sinks in the Nordic countries. The production of pulpwood requires much energy. Furthermore, the forest is an important source of renewable energy in Finland, Norway and Sweden, and may become even more important in the future. CO_2 emissions from oxidation of wood products (e.g. fuel wood) are not considered as net emissions in any of the Nordic countries. The reason is that the harvested wood will be replaced by new trees fixing the same amount of carbon from the atmosphere in order to grow. Though CO_2 is released during e.g. combustion this CO_2 will be used by the new trees' photosynthesis and converted to carbon and stored. Consequently, the use of fuel wood may be an important driving force indicator as these replace use of fossil fuels. Use of wood products as a replacement for other materials (e.g. in buildings) may be regarded as a storage of carbon in addition to the forest storage. Trade of wood products represents a transfer of potential emissions that must be accounted for.

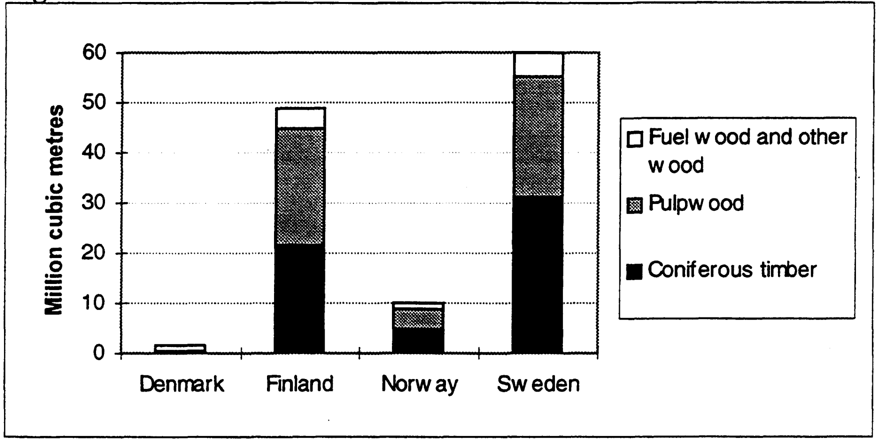
Table 15. Production of roundwood, fuelwood, wood products and charcoal. Mid-1990s

Country	Roundwood	Fuelwood and charcoal	Sawnwood and sleepers	Wood based panels	Wood pulp	Paper and paperboard
	million m^3	million m^3	million m^3	million m^3	million m^3	million tonnes
Total	113	10	27	3	23	22
Denmark	2	1	1	0	0	0
Finland	46	4	9	1	10	11
Iceland	-	-	-	-	-	-
Norway	9	1	2	1	2	2
Sweden	56	4	15	1	11	9

Source: OECD Environmental Data 1997

Data quality: Good, except for fuelwood
Data availability: Good

Figure 22. Estimated annual removals. 1995. Million m^3 without bark



Source: Yearbook of Nordic Statistics

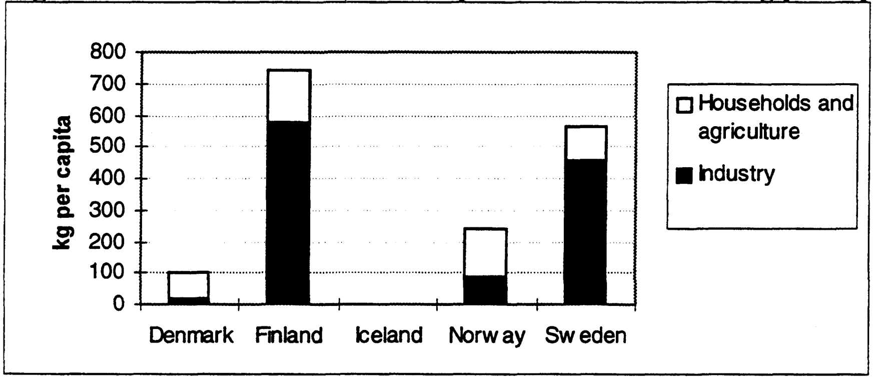
Data quality: Good, except for fuelwood
Data availability: Good

Sweden and Finland (table 15 and figure 22) have the largest forest production of the Nordic countries (about 90 per cent of the total annual harvest). The production consists mainly of pulpwood and coniferous timber. Sweden and Finland are the main producers of wood and wood products among the Nordic countries. They are also the main producers of pulp and paper. Only a small part of the production (Sweden 6 per cent, Finland 8 per cent, and Norway 10 per cent) consists of fuelwood. The amount of fuelwood produced is usually underestimated in official statistics as substantial amounts are collected or harvested for own use.

The production of wood and wood products is an obvious driving force indicator as it will indirectly influence the CO_2-emissions as wood replaces fossil fuels and wood products are storing carbon.

The residential and industrial use of fuelwood per capita according to the official energy balances is illustrated in figure 23.

Figure 23. Use of fuelwood, black liquor and wood waste[1]. kg per capita. 1995



Source: Energy balances of the OECD countries 1994–1995.

[1] Energy sectors excluded.

Data quality: Needs improvement
Data availability: Medium

The use of fuel wood, pulp and wood waste per capita is highest in Sweden and Finland. Especially the paper and pulp industries are using much bio-energy. This is a relevant driving force indicator for climate change as these are substitutes for fossil fuels.

Foreign trade

The foreign trade of wood and wood products is shown in table 16.

Table 16. Trade of forest products. Net imports. 1994

Country	Round-wood	Thereof: Fuelwood and charcoal	Sawnwood and sleepers	Wood based panels	Wood pulp	Paper and paper-board
	million m^3	million m^3	million m^3	million m^3	million tonnes	million tonnes
Denmark						
- Overall	0.2	0.1	2.2	0.5	0.0	0.6
- From Nordic countries	..	..	..	..	..	..
Finland						
- Overall	5.9	0.0	-7.0	-0.9	-1.4	-9.3
- From Nordic countries	..	..	..	..	..	..
Iceland						
- Overall	0.0	0.0	0.1	0.0	-	0.0
- From Nordic countries	..	..	..	..	..	..
Norway						
- Overall	2.9	0.3	0.0	-0.1	-0.5	-1.4
- From Nordic countries	..	..	..	..	..	..
Sweden						
- Overall	6.3	0.1	-10.4	0.1	-2.6	-7.4
- From Nordic countries	..	..	..	..	..	..

Source: FAO yearbook. Forest products. 1994

Trade within the Nordic countries is available by special request, but not published in any reports.

Data quality: Medium

Data availability: Medium, but figures for trade between Nordic countries are not easily available.

All countries, and especially Sweden and Finland, import roundwood. They are exporters of pulp and paper/paperboard.

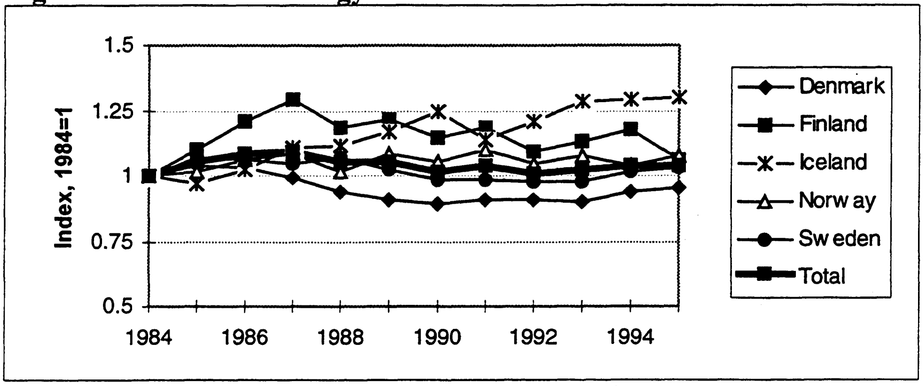
Potential emissions connected with traded wood products are suggested accounted for in a different manner to fossil fuels in the IPCC methodology. Note, however, that a methodology for wood product use and trade not yet has been approved. In the current suggested methodology the accounting principle will differ as to whether the exported carbon is in the form of roundwood, pulp, paper or furniture. The indicator should be revised when the IPCC methodology is finalised.

Trade of wood products is relevant as a driving force indicator as it influences each country's carbon budget.

4.2.9. Energy use

Energy use is an obvious driving force indicator being the most important source of greenhouse gas emissions. The level of energy use, the type of energy used and the industries using energy are important information. The end use of energy expresses all energy used in a country, except energy used for energy production. This means that energy used for production of crude oil and natural gas and as input in thermal power plants is excluded.

Figure 24. End use of energy. 1984-1995. Index. 1984=1

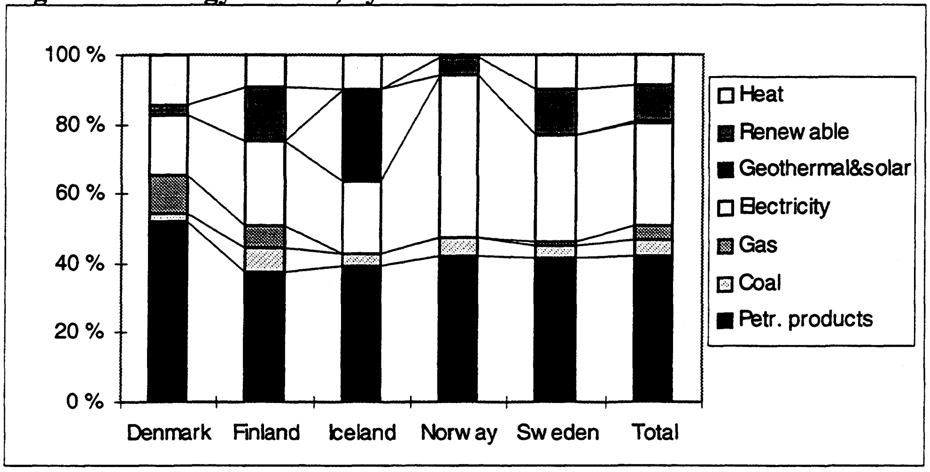


Source: IEA Energy balances of the OECD countries. 1984–1995

Data quality: Good
Data availability: Good

End use of energy has increased in all Nordic countries, except Denmark, since 1984. Iceland has had the largest relative increase in energy use (figure 24).

Figure 25. Energy end use, by commodities. 1995. Per cent

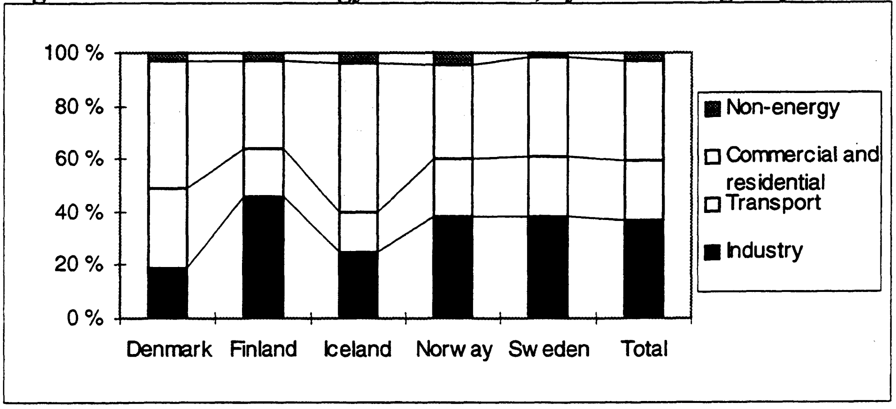


Source: IEA Energy balances of the OECD countries. 1984–1995

Data quality: Good
Data availability: Good

The type of energy used varies. Petroleum products are generally most important. Norway is very dependent on electricity and Iceland of geothermal energy. Denmark and Finland are using some gas (figure 25). The Nordic countries are not dependent on coal for end use. The energy use by type of energy is a relevant indicator as it shows the potential for switching fuels, but will vary somewhat from year to year.

Figure 26. End use of energy commodities, by consumer groups. 1995. Per cent

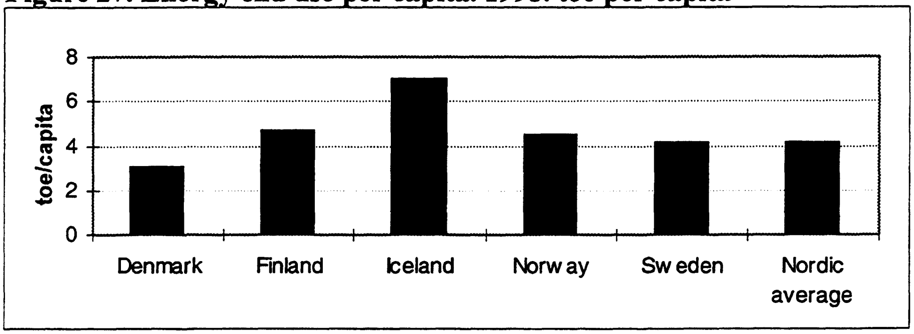


Source: IEA Energy balances of the OECD countries. 1984–1995

Data quality: Medium
Data availability: Good

Industrial energy consumption is important in all countries, and especially in Finland, Norway and Sweden. Denmark and Iceland have a large share of their energy use in the commercial and residential sector (figure 26).

Figure 27. Energy end use per capita. 1995. toe per capita



Source: IEA Energy balances of the OECD countries. 1984–1995

Data quality: Good
Data availability: Good

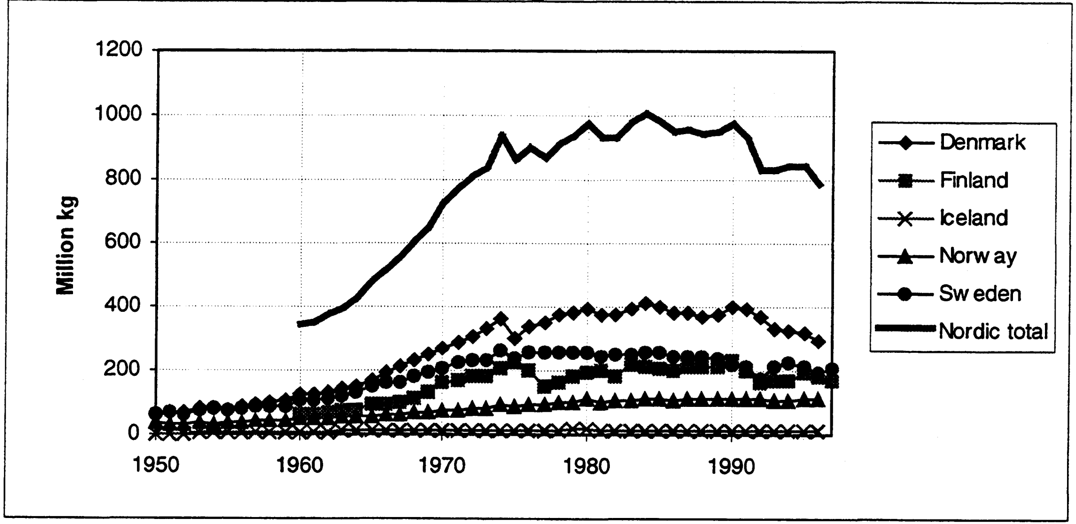
There are substantial variations in energy end use per capita between the Nordic countries (figure 27). In Iceland the energy use per capita is twice as high as in Denmark. Sweden, Norway and Finland are more even. This is a relevant driving force indicator and perhaps also a response indicator as it expresses the efficiency of energy use and partly the potential for changes. However, the indicator also reflects differences in industrial structure. Also note that energy use in the energy sectors is not included.

4.2.10. Other driving force indicators

Use of nitrogen fertilisers

Nitrous oxide is – after carbon dioxide and methane – the third most important greenhouse gas. Emissions of nitrous oxide are to a large extent determined by the use of fertilisers, both commercial nitrogen fertilisers and manure. We have chosen to present the use of nitrogen fertilisers – expressed as tonnes of nitrogen sold – as an indicator. The amount of animal manure applied is equally relevant, but due to lack of data, this is covered by the indicator expressing the number of domestic animals (see below). The amount of N-fertilisers sold in the Nordic countries has more than doubled since 1960, but since 1990 a decreasing trend can be observed (figure 28).

Figure 28. Sales of N-fertilisers. Million kg of N



Source: Several editions of Yearbook of Nordic Statistics, older figures from national statistical publications

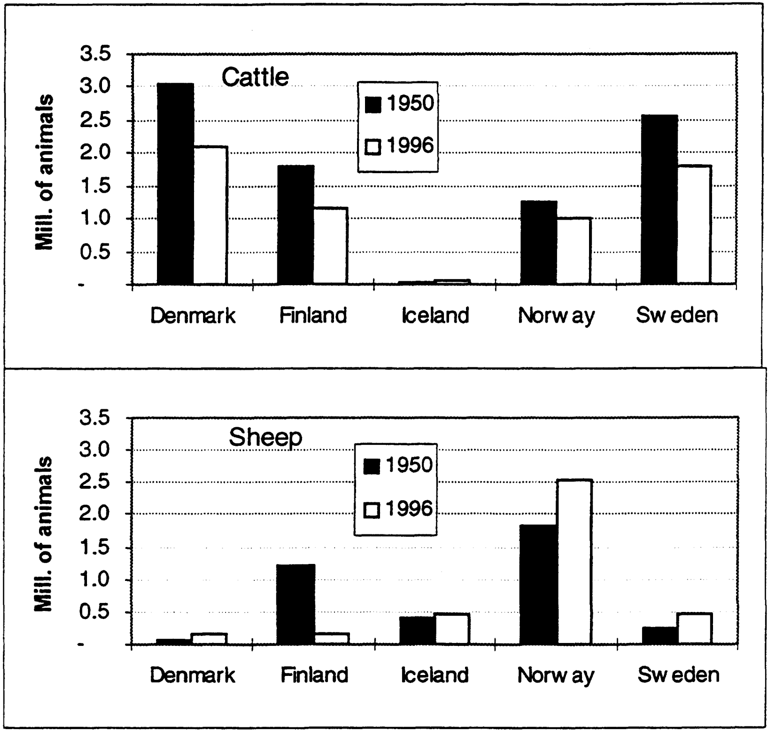
Data quality: Good (actual consumption figures would have been better, but are not easily available for all Nordic countries).
Data availability: Good

Number of domestic animals

Methane is the second most important greenhouse gas. Agriculture is a main source of methane emissions (see figure 35, page 66). In Sweden, 66 per cent of the human related methane emissions in 1996 derived from agriculture (SCB 1997). The main source is the metabolism of grass in the digestive process of ruminants. Manure is also a source of methane emissions.

The number of livestock cattle and sheep is therefore a driving force indicator of interest in all the Nordic countries. An issue that complicates this indicator is that the way the animals are kept substantially influences the emissions. Less grazing and more concentrated feed such as course grain, decreases the emissions of methane from metabolism. On the other hand, animals kept indoor eating concentrated feed contribute more by manure.

Figure 29. Number of cattle and sheep in the Nordic countries. 1950 and 1996. Millions of animals



Source: Yearbook of Nordic Statistics 1996 and 1997

Data quality: Good
Data availability: Good

Agriculture is important in all the Nordic countries. The main production, however, differs among the countries. Cattle breeding is common in the Nordic countries, especially in Denmark, with about 2 million cattle (figure 29).

Sheep breeding is very important in Norway and Iceland. Norway has about 2.5 million sheep. Iceland has about 0.5 million, same as does Sweden. In Denmark and Finland sheep breeding is of less importance.

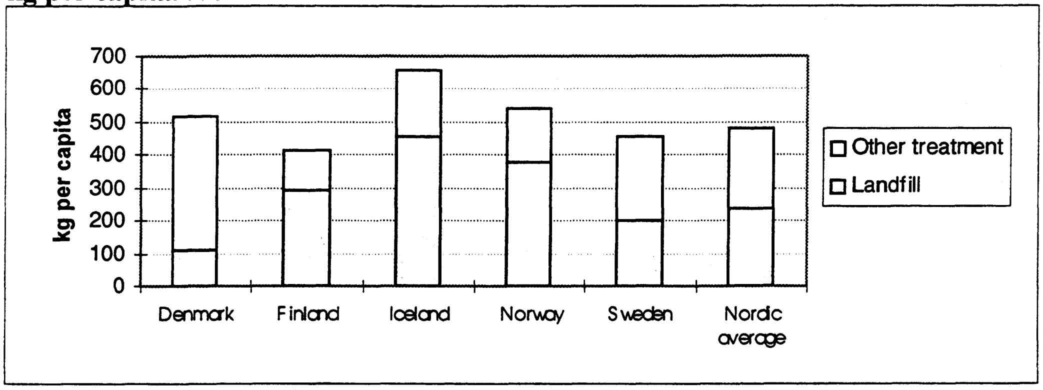
Deposition of municipal waste

To deposit waste in landfills is considered to be misuse of resources. The reason to make it a driving force indicator in this report is that deposition of municipal waste is a source of methane emissions. In Sweden, about 20 per cent of the anthropogenic emissions of methane is considered to originate from municipal waste in landfills, and in Norway this share is between 60 and 70 per cent (see also figure 35, page 66). Some technical measures like collecting gas generated in landfills have contributed to a decrease in methane emissions from municipal waste. Between 1990 and 1996 this reduction in methane emissions from landfills was about 28 per cent in Sweden (Naturvårdsverket 1997). Even though these figures are estimated with some elements of uncertainty, this sector changes rapidly. This makes municipal waste an interesting indicator.

The part of the municipal waste sent to landfills varies from 71 per cent in Finland, 69 per cent in Norway and Iceland, 44 per cent in Sweden and only 21 per cent in Denmark (figure 30). Even though Finland has the highest share of municipal waste for deposition, Iceland has the highest amount per capita.

There is a slowly increasing trend in the total amount of municipal waste in Norway and Sweden. Lack of data makes it difficult to follow the development in the other Nordic countries. There are also difficulties in comparing the countries, because the data often are based on different definitions and classifications.

Figure 30. Total amount of municipal waste and amount deposited in landfills. kg per capita. 1994



Sources: Nordic Council of Ministers 1997a and OECD 1997

Data quality: Needs improvement (lack of time series, different classifications and definitions).
Data availability: Medium

4.3. Pressure indicators

Emission data are the obvious choice as pressure indicators. In a majority of the indicator reports mentioned in chapter 3 the emission level of CO_2 (and/or the emission per capita) was chosen as the pressure indicator. In the Kyoto Protocol it was decided to include all greenhouse gases not covered by the Montreal Protocol. The base year shall be 1990 (1995 may be chosen for some of the gases), with individual goals for each country. It was also agreed to cover manmade sinks. Hence we would suggest to have a new indicator for pressure and include an indicator for sinks. As in some circumstances it might be relevant to consider adjusted emissions, this is also included.

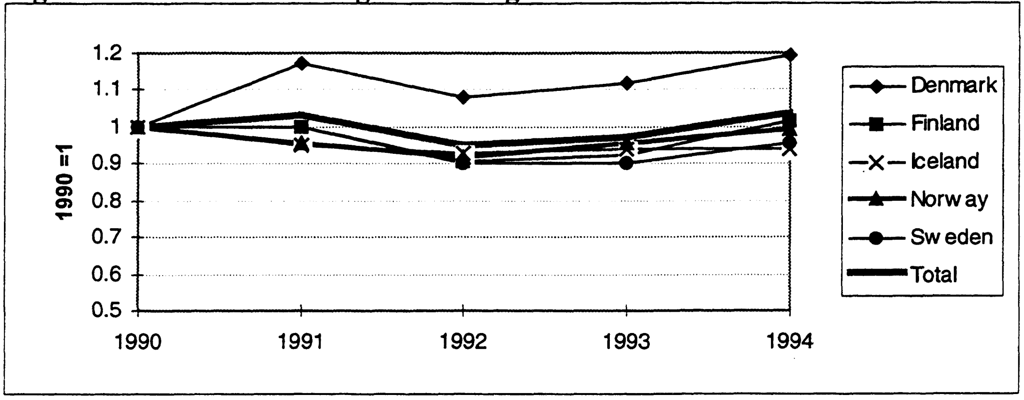
4.3.1. Actual emissions

Emission data for CO_2 are widely available. The only problem is that several sets of official data frequently exist. We would suggest to use the data reported to the United Nations Framework Convention on Climate Change (UNFCCC). There, all Nordic countries must report emissions of all greenhouse gases, while for example Eurostat statistics only include CO_2 and Corinair at present only CO_2, methane and nitrous oxide.

Global Warming Potential (CO_2-equivalents)

The emissions of various gases are weighted according to their Global Warming Potential (GWP). The GWP values are dependent on the time horizon. It is most common to use 100 years in total greenhouse gas emission calculations. The GWP values are standards recommended by IPCC (Intergovernmental Panel on Climate Change).

Figure 31. Emissions of all[1] greenhouse gases. Index. 1990=1



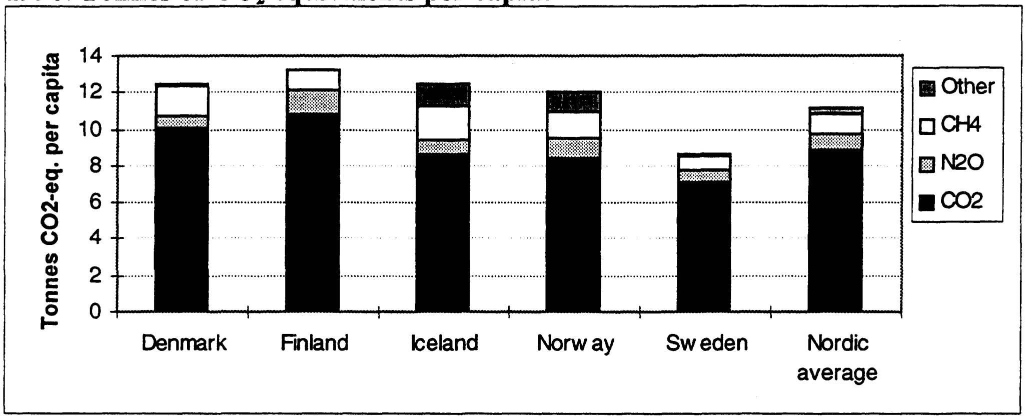
Source: UNFCCC

[1] Not all countries have reported all gases in all the years.

Data quality: Good, medium and needs improvement (depending on the type of gas).
Data availability: Good for some gases. Partly lack of data for others.

The total Nordic emissions of greenhouse gases have increased since 1990. Emissions in Denmark have increased more than in other Nordic countries (figure 31).

Figure 32. Emissions per capita (all gases weighted according to GWP). 1990. Tonnes of CO_2 equivalents per capita



Source: UNFCCC

Data quality: Medium (quality varies)
Data availability: Good for some gases. Partly lack of data for other gases in some countries.

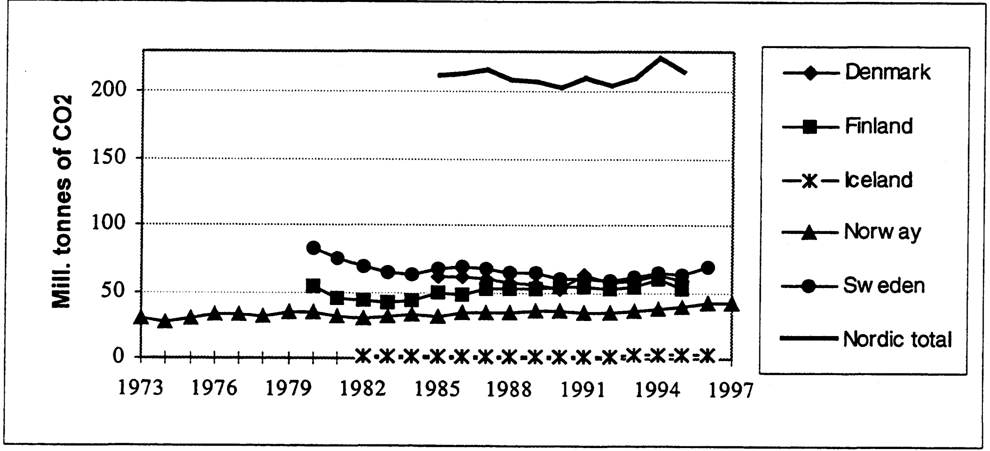
Finland has the highest emissions of CO_2 and total greenhouse gases per capita, while Sweden has the lowest. The emission figures per capita (figure 32) have a different profile from the energy end use per capita where Iceland has the highest figures and Denmark the lowest. This is due to the fact that different fuels are used and that energy use in the energy sectors is not counted in the energy end use but will lead to CO_2 emissions.

Not all countries report emissions of «other greenhouse gases». However, in the base year 1990 only Finland is missing of the Nordic countries according to the web site *unfccc.de*. Still, the reporting seems incomplete also for some of the other countries. For other years, the reporting is even less regular. The quality of the reporting is expected to improve in the coming years. For Norway and Iceland a quite high fraction of the overall greenhouse gas emission will be other greenhouse gases. Hence, the indicator will be less relevant by omitting them. As non-reported «other gases» probably will constitute a minor fraction of the total emissions, the indicator has a satisfactory quality though it will need improvement. 1990 is chosen as a base year as this is the year when reporting was most complete, however this year should be changed to a more recent one as this situation changes.

Carbon dioxide

For time series, the traditional graph (figure 33) – containing CO_2 only, but covering a longer period of time – should be considered used until better data on all greenhouse gases become available.

Figure 33. Emissions of carbon dioxide. Nordic countries. Million tonnes of CO_2



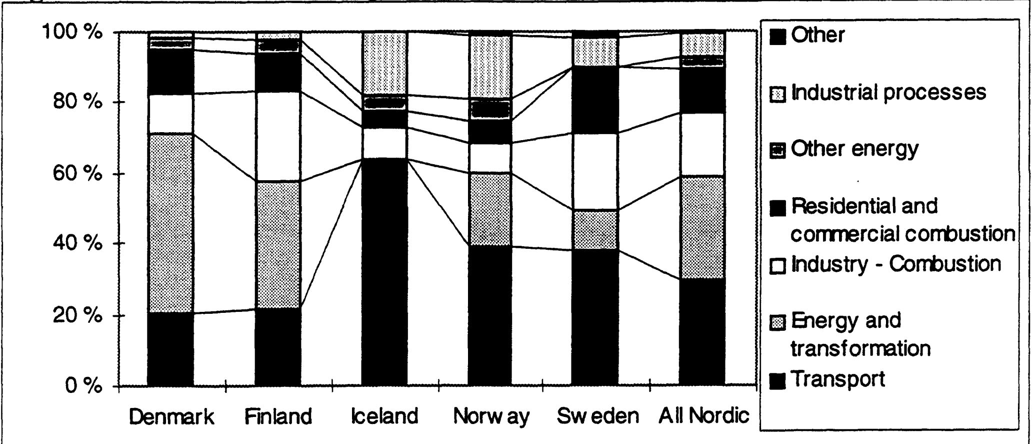
Source: Nordic Council of Ministers 1997a (supplemented by some recent national figures)

Data quality: Medium (length of time series needs improvement)
Data availability: Medium

In some analyses it might be relevant to distinguish between intrinsic CO_2 emissions in the country and emissions connected to exported products. Examples are emissions connected to production of cars, oil, gas and metals that are exported. This is to some degree a good indicator, but data are not available without special labour demanding analysis.

The sources contributing to CO_2-emissions vary between the Nordic countries. Denmark and Finland have high emissions from power plants, Iceland has very high emissions from transport (mainly fishing vessels) and together with Norway, industrial processes, while Sweden has quite high emissions from industrial combustion (figure 34).

Figure 34. Emissions of CO_2 per emission source. 1994. Per cent



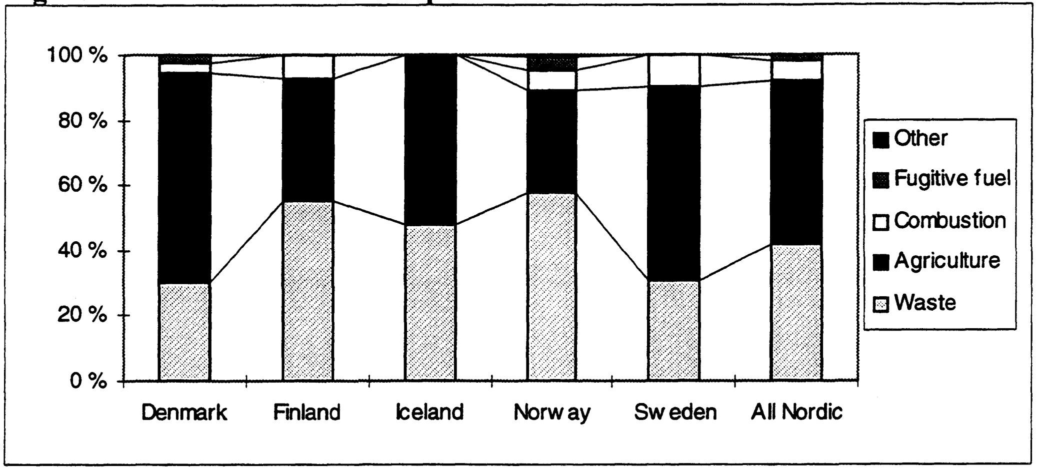
Source: UNFCCC

Data quality: Medium (but somewhat better than for CH_4 and N_2O)
Data availability: Good

Methane

Sweden and Denmark have the relatively highest emissions from agriculture, while Norway, Finland and Iceland have the highest emissions from landfills (figure 35). For Finland and Norway this may be due to much wood waste as well as a higher fraction of waste landfilled compared to Sweden and Denmark.

Figure 35. Emissions of methane per emission source. 1994. Per cent



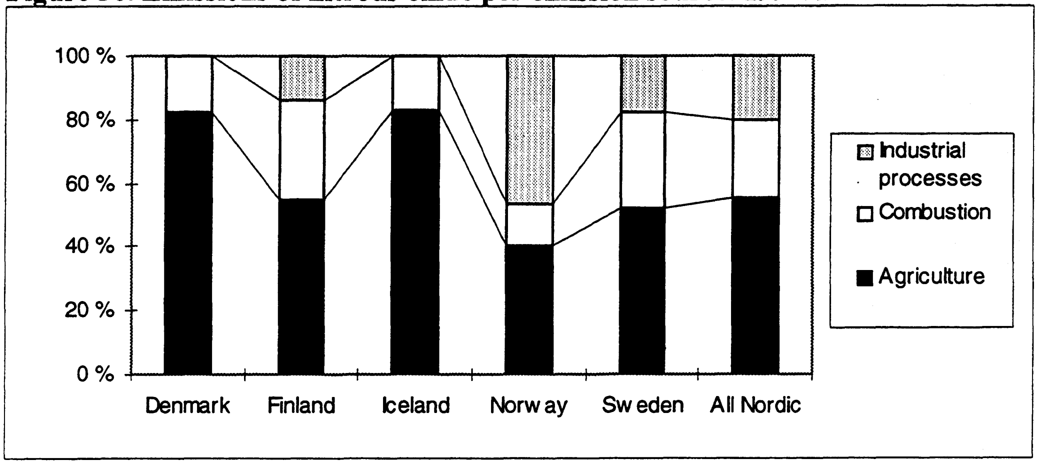
Source: UNFCCC

Data quality: Medium
Data availability: Good

Nitrous oxide

Agricultural activities are the main source of nitrous oxide emissions in all the Nordic countries (figure 36). Norway, with fertiliser production, has also high emissions of nitrous oxide from industrial processes. Sweden and Finland have high emissions from combustion.

Figure 36. Emissions of nitrous oxide per emission source. 1994. Per cent



Source: UNFCCC

Data quality: Medium
Data availability: Good

Other greenhouse gases

Currently the data on other greenhouse gases are incomplete. Finland has reported nothing according to the data on the web site *unfccc.de*, Denmark has reported SF_6 only, Iceland PFCs only, Sweden has reported PFCs and SF_6, while Norway has reported all. At this stage it therefore seems difficult to include sources of other greenhouse gases as an indicator.

We have in this indicator report focused on the direct greenhouse gases. Other gases may indirectly cause climate effects through forming greenhouse gases by chemical reactions or by other means. The gases frequently mentioned in this context are NO_x, CO, NMVOC and SO_2. These are not included in the Kyoto Protocol and in order to reduce the number of indicators we have not included them here.

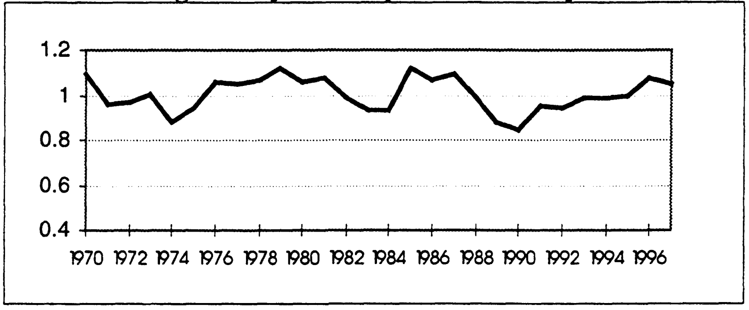
4.3.2. Adjusted emissions

Weather or temperature adjustments

When looking at trends of emissions of greenhouse gases, it is valuable to be able to distinguish several factors that influence energy consumption. One such factor is the annual variation in temperature, which has an impact on how much energy is used for warming houses. Several of the Nordic countries make adjustments on the energy consumption by relating it to a «normal year».

The method for making the adjustment is not internationally standardised, but is based on a concept known as «degree-days». During the winter season, the difference in degrees between the actual temperature and a certain chosen reference temperature is calculated, for a number of locations in the nation. The sum of these so-called degree-days, weighted with the population density for the locations where they were measured, is then compared to the mean value of degree-days for a chosen reference period (figure 37). A high degree-day number means a cold year. This measure is then used to make corrections for the energy consumption, but in slightly different ways for different countries. Since the variations in outdoor temperature only account for part of the variations in the energy consumption, depending on e.g. regulating systems and insulating properties of houses, different weighting factors are used to estimate this influence. For the issue of creating indicators for climate change, the correction should preferably be made directly for carbon dioxide emissions from heating of houses. However, the corrections are usually made on the energy consumption instead.

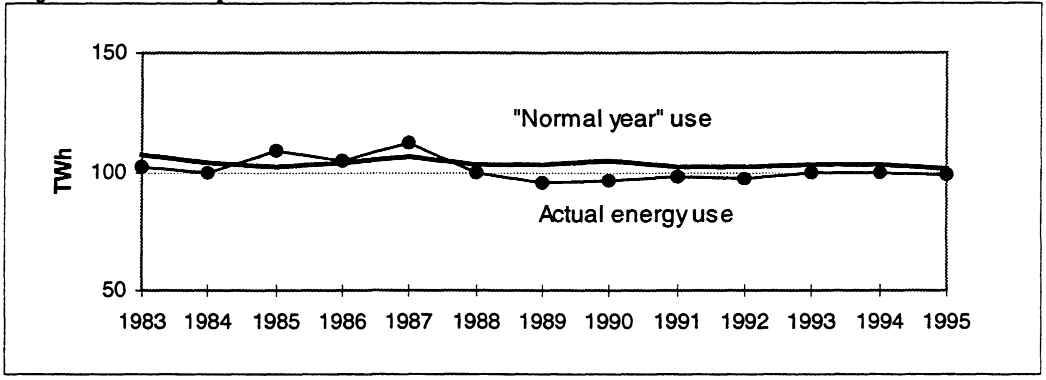
Figure 37. Number of degree-days divided by the «normal» number of degree-days of the period. Norway. 1970–1997



Source: Statistics Norway (Energy Statistics 1996)

Examples on how the correction with degree-days can affect the energy consumption curve are given in figures 38 and 39. In Sweden, three years were colder than the normal year (measured as the mean for the period 1961–1978). For Swedish district heat energy consumption, the variations from a normal year have been estimated to 10–15 per cent (Naturvårdsverket 1991).

Figure 38. Swedish energy consumption in dwellings and non-residential premises adjusted for temperature variations. 1983–1995. TWh

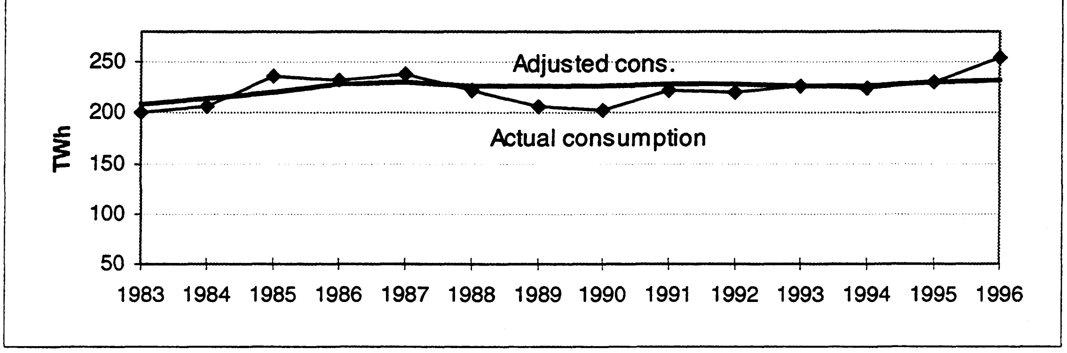


Source: Statistics Sweden (E 16 SM 9604 Swedish Energy Statistics)

Data quality: Good
Data availability: Needs improvement, not easily available for all countries

In figure 39, the *total* Danish energy consumption is shown, adjusted for temperature variations. For the years 1985, 1987 and 1996 the energy consumption was higher than in a normal year, and considerably lower in the years 1989–1991. The trend in the graph is very similar to the Swedish one.

Figure 39. Actual and adjusted energy consumption. Denmark. 1983–1996. TWh



Source: Danish Energy Agency

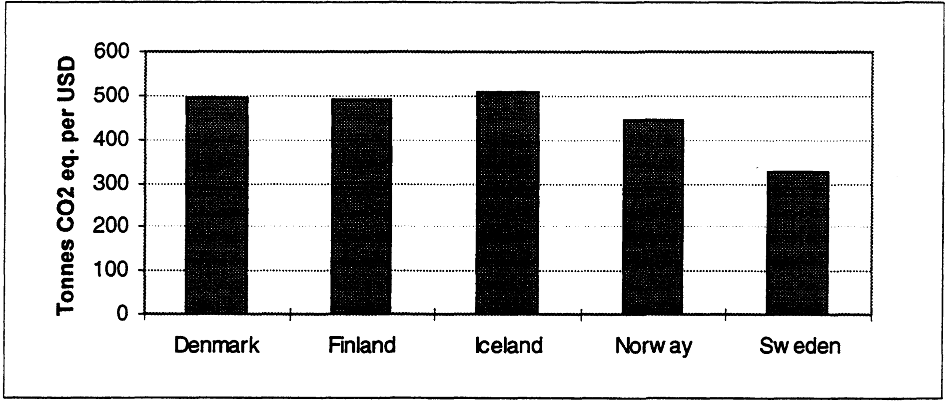
Data quality: Medium. Energy for heating of dwellings would be more appropriate
Data availability: Needs improvement. Not calculated for all countries

For Finland, data on degree-days are not available on a national level, only for 7 regions that would have to be weighted according to population in order to be used for adjustments.

GWP-emissions adjusted by economic activity

Another factor that is of interest to single out is the influence of the economy in a general sense. This can be made by dividing the emissions or the energy consumption with the GDP (gross domestic product) of the nation (figure 40). The size of GDP is a crude measure both for the consumption expenditure on housing, electric appliances and transportation, and for the industrial production and energy consumption. It is of interest as an overview indicator. However, it is important with complementing indicators that can single out the effects of trends in fuel mixes used, as well as the trends for the different activities mentioned above. Adjustment of the GDP-figures by using purchasing power parities (PPP's) could also be considered.

Figure 40. Emissions of CO_2-equivalents per unit GDP (USD current prices). 1990



Source: UNFCCC and Yearbook of Nordic Statistics 1997. Nordic Council of Ministers

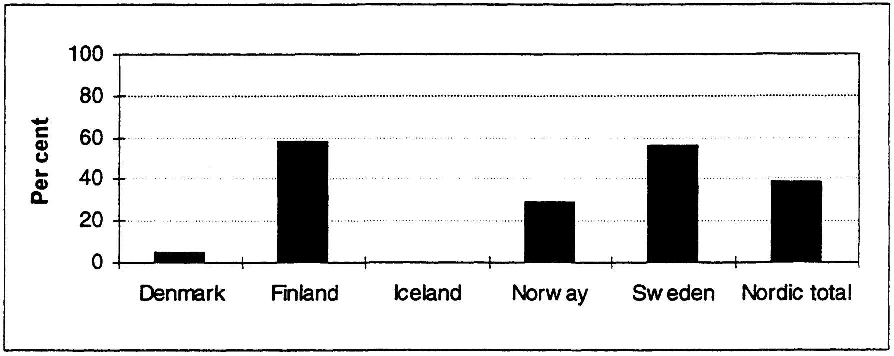
Data quality: Needs improvement, some gases are not included for some countries
Data availability: Needs improvement

4.3.3. Sinks of CO_2

Sinks of CO_2 will temporarily store circulating carbon. There are several natural sinks of carbon. Forest is currently considered as the only important sink that is possible to control. The Nordic forests are growing (table 1, page 34), mostly of natural reasons and partly due to management. This means that the increase each year is greater than the harvest and natural losses.

Carbon sinks from forest growth are reported to the UNFCCC, and data are available. We would suggest to state the sink indicator as per cent net sink of total anthropogenic emissions. However, the current published data do not follow the political «anthropogenic» or managed sink definition in the Kyoto Protocol, but they represent overall forest sink. Hence, the current indicator should be adjusted or complemented by another indicator when data become available.

Figure 41. Sinks of CO_2 in forest as a percentage of total anthropogenic emissions. 1994



Source: UNFCCC

Data quality: Needs improvement
Data availability: Good

All Nordic countries, except Iceland, have net forest sinks of CO_2, the average is around 40 per cent of the emissions. In Denmark, the sink is quite small (5 per cent), but in Finland and Sweden it is nearly 60 per cent (figure 41).

4.4. State indicators

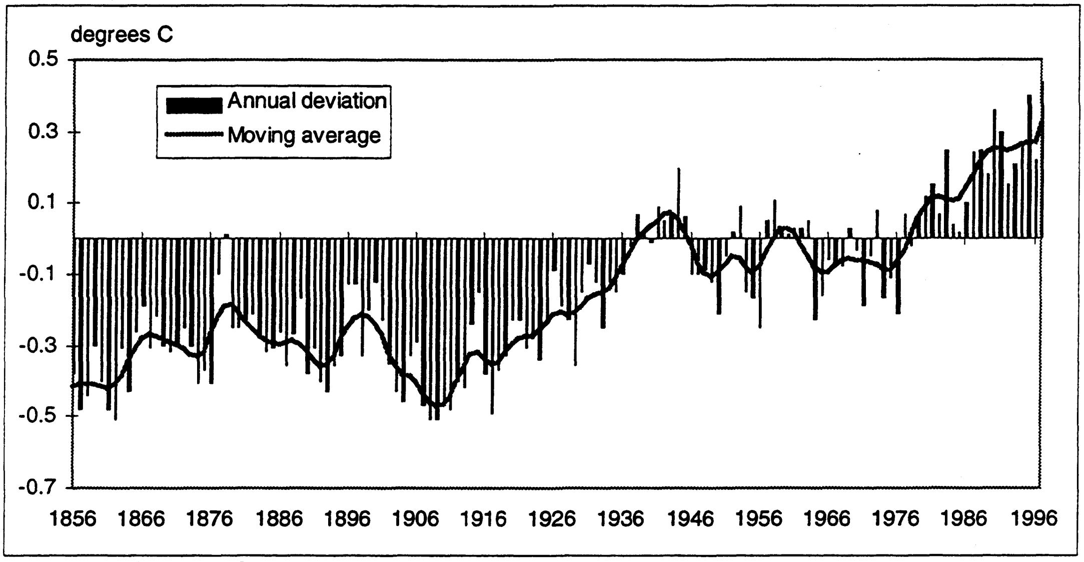
The main focus of this report is the background and driving force indicators, the pressures and the responses. Therefore, only some of the commonly used state indicators and also some potential indicators are presented in this chapter. The assessment of data quality and availability is beyond the scope of this project.

The state indicators in this report include aspects of the state or composition of the atmosphere, like concentration of gases, the climatic effects of atmospheric changes, e.g. temperature changes, and also the impacts of climate change on ecosystems, e.g. distribution or occurrence of species.

4.4.1. Global temperature

Change in the average global temperature (figure 42) is a very common indicator for climate change. It can be argued, however, that the interpretation of this indicator is somewhat ambiguous. The climatic system is very complex and there are large uncertainties concerning the actual effects of climate change, especially on a more regional level.

Figure 42. Changes in global mean temperature compared with the normal value for 1961–1990

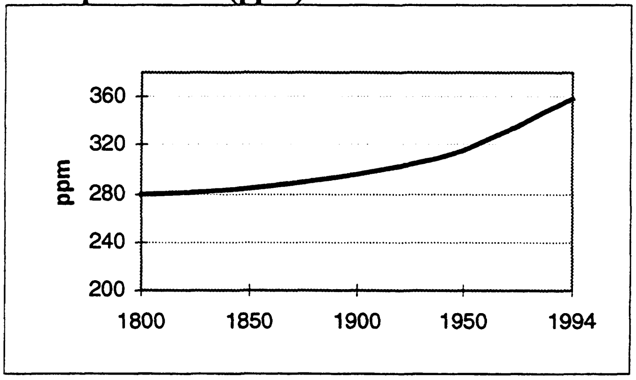


Sources: University of East Anglia and DNMI

4.4.2. Atmospheric concentration of carbon dioxide

This is also a very commonly used indicator for climate change. Being the most important of the so-called «greenhouse» gases, it is relevant to include this in a climate change indicator set (figure 43).

Figure 43. Atmospheric CO_2 concentration. Parts per million (ppm)

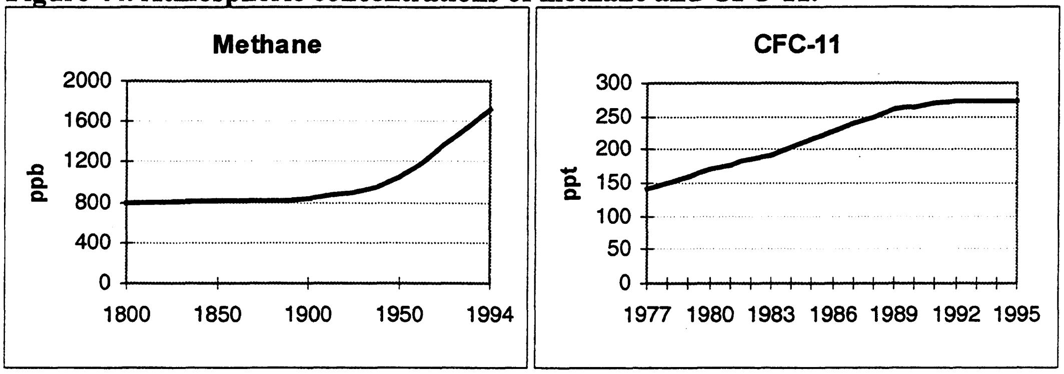


Source: IPCC

4.4.3. Atmospheric concentration of other «greenhouse» gases

The CO_2 concentration in the atmosphere can be supplemented by the concentrations of other important gases such as nitrous oxide (N_2O), methane (CH_4) and CFC's (figure 44).

Figure 44. Atmospheric concentrations of methane and CFC-11.

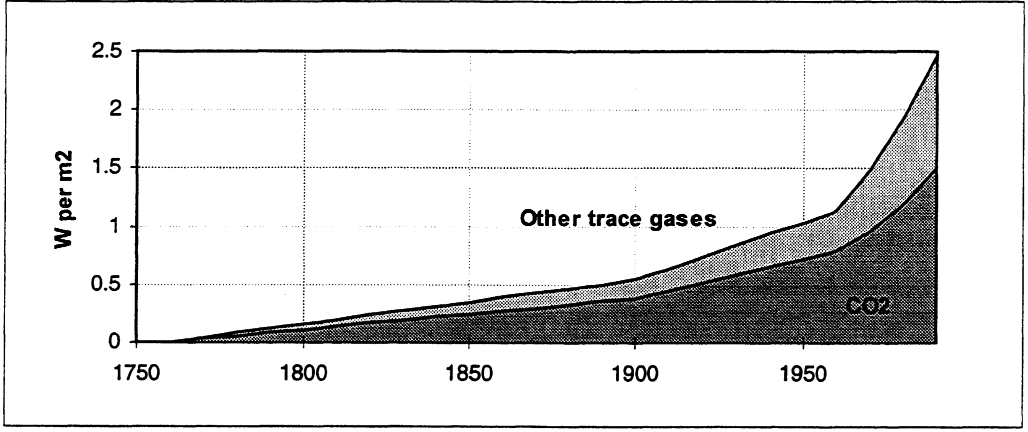


Sources: IPCC (Methane), NOAA/CMDL (National Oceanic and Atmospheric Administration/ Climate Monitoring and Diagnostic Laboratory) (CFC-11)

4.4.4. Radiative forcing

Measured at the top of the atmosphere, the Earth receives an energy flux from the sun amounting to 1376 W/m^2. In equilibrium the Earth must re-radiate the same amount of energy in order not to heat up or cool down. *Radiative forcing* is a measure of how much of the re-radiated energy that is trapped in the atmosphere due to the presence of greenhouse gases in concentrations above pre-industrial level (figure 45). In other words, radiative forcing measures the heating effect on the Earth and all its sub-systems from increases in concentration of greenhouse gases after the industrial revolution (Alfsen et al. 1992). This must be considered a useful indicator of climate change. However, in IPCC (1996) it is pointed out that there are limits to the utility of the globally averaged radiative forcing due to regional variations in the concentrations of tropospheric ozone and of tropospheric aerosols. It is probably also less easily understandable for some user groups of environmental indicators than for example changes in the global temperature.

Figure 45. Change in radiative forcing since 1765 due to changes in greenhouse gas concentrations. Watts per m^2



Source: Graph reproduced from Alfsen et al. 1992, original data IPCC.

4.4.5. Other state indicators

Below a short list of other potential state indicators for climate change is presented:

- Melting of polar ice
- Melting of permafrost
- Rise in ocean level
- Decrease (or increase) of glaciers
- Changes in precipitation patterns
- Frequency of extreme weather conditions
- Distribution or occurrence of selected species
- Increase of the coniferous timber line
- Changes in strength and direction of ocean currents (this may potentially have very important consequences for the Nordic climate and natural conditions).

4.5. Response indicators

The response indicator should make the link between the pressure and state indicators and express a suitable response to reduce the pressure/improve the state. In many cases is difficult to distinguish between a driving force indicator and response indicator as both may influence the pressure.

The types of measure chosen to reduce emissions of greenhouse gases will vary from country to country. Some will prefer administrative measures; regulations by law, emission limits, standards for energy use, etc. Other countries will rather choose economic measures, like taxes and revenues. In practice, a combination of the two groups of measures will be used. Furthermore, many of the measures may have a small benefit or have secondary benefits. Another problem with response indicators is that the effect on pressure often is due to other reasons than climate change policies. Examples are improved energy efficiency and carbon sinks due to forest growth in Finland, Norway and Sweden. These circumstances make it difficult to find a simple set of response indicators, and even more difficult to compare countries in their response strategies. It will also be expected that near future research will make more technologies relevant, and consequently the set of response indicators must be reconsidered. Also the emission reduction planning after the Kyoto commitments might make more indicators relevant.

A frequently suggested response indicator is the expenditures on air pollution abatement. However, we do not see this as a good indicator for climate change response as the expenditures are not well separated from other technical measures and the data are not easily available. Also high expenditures may indicate large environmental problems. Other suggested response indicators are very general like strategies, programs, research & development, public opinion, etc. These are not easy to measure, and do not necessarily fulfil the criteria above that they should lead to reduced pressure.

In the climate convention the measures are classified according to table 17. This table suggests a possible classification of the response indicators.

Table 17. Classification of measures to reduce emissions of greenhouse gases

CO_2	Cross sectoral Energy and transformation industries Transport Industry (energy related) Industry (non-energy) Residential, commercial and institutional Fugitive fuel Agriculture Land-use change and forestry
Methane	Waste management (including sewage treatment) Agriculture (non-energy) Fugitive fuel Industry (energy related) Industry (non-energy) Land-use change and forestry
Nitrous oxide	Industry (energy related) Industry (non-energy) Agriculture (non-energy) Transport Energy and transformation industries Land-use change and forestry

Source: UN 1997

In EEA (1997) response indicators are classified as:

- Societal responses
- Governmental responses
- Action taken by sectors
- Consumer and household responses

We have not here described any indicators for consumer and household responses. Examples of such indicators in EEA (1997) are «Energy efficient light bulbs as a percentage of total marked for light bulbs» or «marked share of energy efficient appliances as a percentage of total marked». Data for such indicators must be collected from the producers/importers or trade organisations and are outside the scope of this report.

4.5.1. Goals and agreements

Kyoto

In Kyoto the 1–10 of December in 1997 the third Conference of the Parties within United Nations Framework Convention on Climate Change was held. The purpose of the conference was to draw up measures for the developed countries in the form of emission restrictions for greenhouse gases for the period 2005–2020.

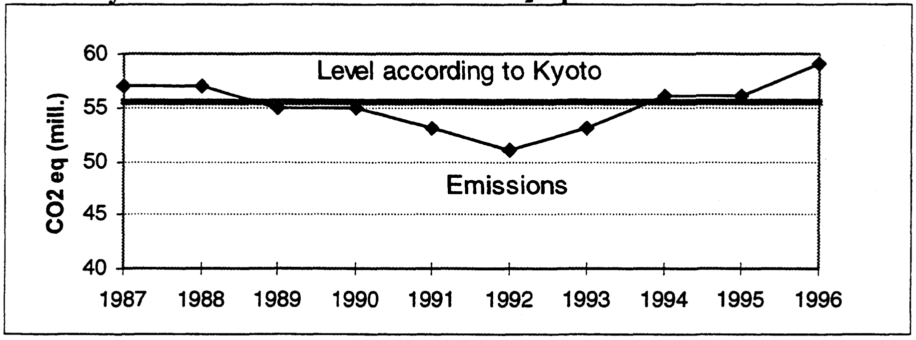
When the conference ended the Parties had agreed on an emission target for the period 2008 to 2012, based on 1990 emission levels. The greenhouse gases that are to be included are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), and they are to be aggregated to an anthropogenic carbon dioxide equivalent emission.

The European Union shall reduce the emissions with 8 per cent, USA with 7 per cent and Japan with 6 per cent. Together the developed countries have agreed on a 5.2 per cent reduction in comparison with 1990. The countries in the EU must jointly fulfil the commitment, but the burden for each member state will differ. How the respective emission levels will be allocated between the member states is going to be decided within the EU. Norway and Iceland have made a commitment to not exceed an increase of 1 respective 10 per cent from the base year.

Methodologies for estimating anthropogenic emissions by sources shall be those accepted by the Intergovernmental Panel on Climate Change (IPCC) and agreed upon by the Conference of the Parties. The Kyoto Protocol enters into force when at least 55 Parties to the Convention, which accounted in total for at least 55 per cent of the total carbon dioxide emissions in 1990, have deposited their instruments of ratification, acceptance, approval or accession.

An obvious choice of response indicator would be the actual emissions of greenhouse gases in the individual countries (and perhaps also emission projections) compared to the reduction requirements of the Kyoto Protocol. An example with figures for Norway is presented in figure 46.

Figure 46. Emissions of greenhouse gases in Norway compared to reduction requirements of the Kyoto Protocol. Mill. tonnes of CO_2 equivalents



Source: Statistics Norway 1998

Data quality: Medium
Data availability: Medium, not yet fully available in all countries

How to reach the goal

To reach the goal of reducing emissions of greenhouse gases countries have made special decisions or agreements. Below some examples of important national measures are presented. In Sweden the use of renewable energy sources is stimulated, the emissions of CH_4 from landfills shall be reduced by 30 per cent to the year 2000 by reductions of waste amounts and collection of methane from landfills. The government has suggested that from the year 2002 no combustible waste may be deposited, and from the year 2005 no organic waste shall be deposited. For HFC, PFC and SF_6 it has been suggested to implement restrictions for use in new areas, so that their share of greenhouse gas emissions, when counted as carbon dioxide equivalents, are not higher than 2 per cent in the year 2000. The Norwegian Government's strategy for the follow-up of the Kyoto Protocol has been described in a recent report to the Norwegian Parliament (Ministry of Environment 1998). The Norwegian Ministry of Environment has, for example, made an agreement with the aluminium industry to reduce the emissions of PFC-compounds from production with 55 per cent by the year 2005 with 1990 as a base year. Other national measures include CO_2 taxes, energy taxes, waste treatment taxes, concession treatment of large point sources based on the Pollution Control Act, information, education, etc. Iceland is about to make restrictions on import of the FC-compounds. Since

1997, it has not been allowed to deposit organic waste in Denmark. The country has a goal for afforestation, and no HFC-gases are allowed in fire-extinguishers onboard ships. Finland has a goal to increase the use of biofuels. All the Nordic countries are trying to reduce the amount of waste.

4.5.2. Response indicators for CO_2

Environmental taxes and prices of selected fuels

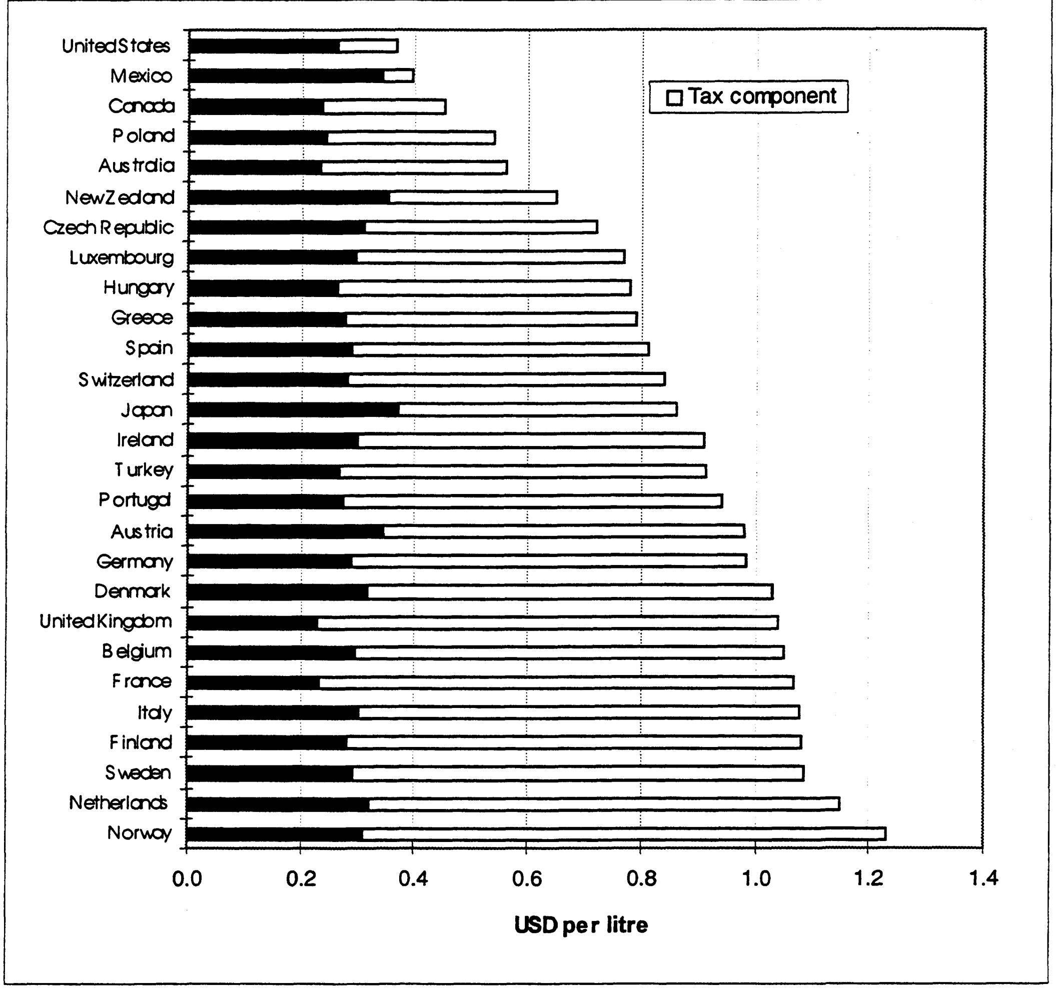
In order to implement the intentions of environmental policy, various instruments can be used where different forms of administrative regulations and economic instruments constitute the base. As the individual behaviour becomes increasingly important, more attention will be paid to information and education as useful instruments.

Carbon dioxide taxes are of vital importance as a means to reduce carbon dioxide emissions. Only Norway, Sweden, Denmark, Holland and Finland have used these kinds of taxes until now. The EU Commission has suggested different forms of common tax systems on carbon dioxide and energy, one in 1992 and another in 1995. Both were met with resistance, and it is thus unclear when and if the EU will get a common carbon dioxide tax. In 1997, another energy tax proposition was presented by the Commission. This now awaits further treatment. Other types of taxes on fuels exist in many countries however, such as energy taxes or taxes to reduce harmful substances in the fuels. In a study on energy taxes from 1993, the IEA concludes that the large energy consumers in industry are often not so heavily taxed, and that the taxes that do occur often are directed towards housing and transport. If substantial reductions of energy related emissions are wanted, the energy taxes will have to become more generally used for larger sectors of society (IEA 1993, as referred to in NOU 1996:9).

In Sweden, the carbon dioxide tax is primarily a source of income to the State, but it is also intended to stimulate a transition to renewable sources of energy. The carbon dioxide tax (combined with the energy tax on fossil fuels) has contributed to an increased use of biofuels, principally within the district heating sector. However, this increase has been partly offset by a reduced use of biofuels in industry. The reason for this effect is the differentiation between industry and other taxpayers, which directly gives incentives for an exchange of fuels between such sectors. The net effect in terms of emissions is hard to determine (Ministry of the Environment and Natural Resources 1994. The Swedish experience - taxes and charges in environmental policy).

Comparing prices on unleaded gasoline among the OECD countries, it can be noted that Norway has the highest prices, closely followed by the Netherlands, Sweden and Finland. Denmark is also fairly high up the scale. The tax component is the dominating reason for the high prices (figure 47). Both the price on gasoline and the tax component are of interest as indicators. The tax is an important policy instrument, that may be used to moderate the trend of more car traffic and larger and more fuel consuming cars.

Figure 47. Unleaded gasoline. Prices and taxes. US dollar per litre. Third quarter 1997.

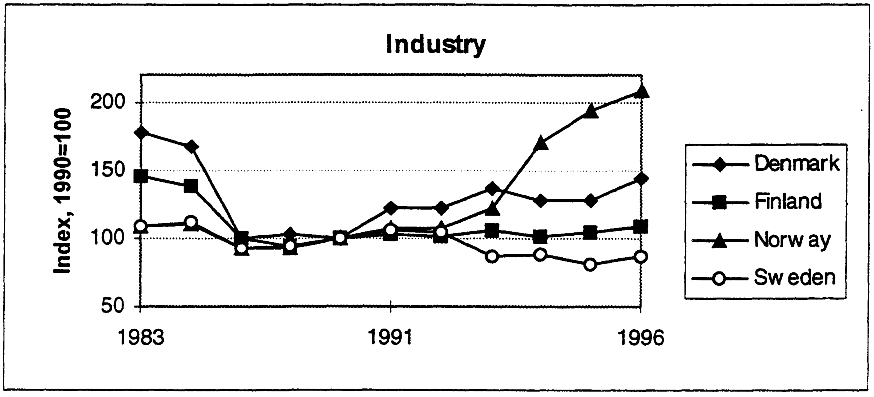


Source: OECD/IEA 1997

Data quality: Good
Data availability: Good

The indices on real prices for total energy use in industry show that Norway has more than doubled the energy price since 1990 (figure 48). The price of energy for Denmark's industry has also increased substantially, while the increase in Finland is more modest. For the Swedish industry the price has decreased after 1991, partially due to changes in the tax system. This is an interesting indicator showing the incentives for industry to become more energy efficient.

Figure 48. Indices of real energy prices for industry (total energy). 1983–1996. 1990=100

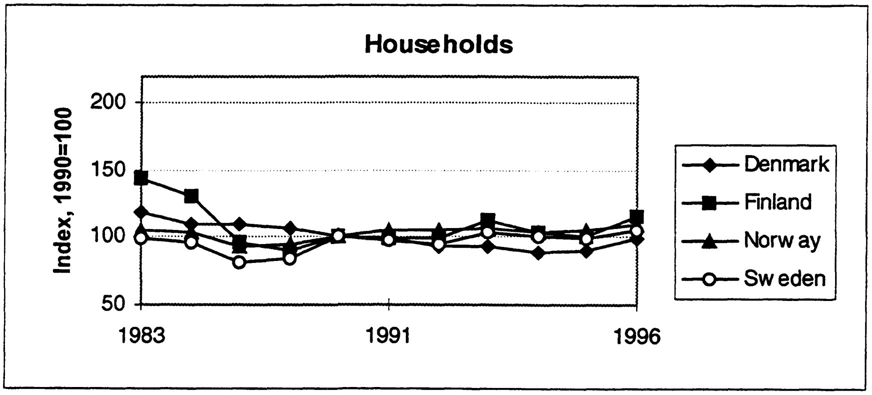


Source: OECD/IEA 1997

Data quality: Good
Data availability: Medium, Iceland is lacking

For households the indices show less variation during the time period 1983 to 1996 (figure 49). A decrease in prices can be noted for Denmark. Finland, Sweden and Norway all show a higher price level in 1996 as compared to 1990. This indicator shows the incentive for households to save energy.

Figure 49. Indices of real energy prices for households (total energy). 1983–1996. 1990=100



Source: OECD/IEA 1997

Data quality: Good
Data availability: Medium, Iceland is lacking

Table 18. Taxes[1] on electricity in the Nordic countries. 1997. Finnish Penni/kWh[2]

	Denmark	Finland	Iceland	Norway	Sweden
Electricity production					
- Hydropower	.	-	-	1.0	-
- Nuclear power	.	-	.	.	1.5
- Coal	-	-	-	-	1.5
- Gas	-	-	-	-	0.8
- Peat	.	-	.	.	-
- Heavy oil	-	-	-	-	1.4
Electricity consumption[1]					
- Industry	0.9–28.8	1.75	-	-	6.1 (3.9)
- Private	37.0/39.7	3.175	-	3.9 (0)	7.6 (3.9)

[1] The consumption taxes are divided into the following categories:
Finland: industry, other consumers;
Sweden: district heat producers (Northern Sweden), other consumers (Northern Sweden);
Norway: industry, other consumers. (The regions Finnmark and Nord-Troms are excluded from consumption paying taxes);
Denmark: industry and companies, electric heat consumers/other consumers.

[2] 1 SEK=0.67 FIM, 1 NOK=0.70 FIM, 1 DKK=0.78 FIM, 1 ISK=0.07 FIM

Source: Nordel 1997

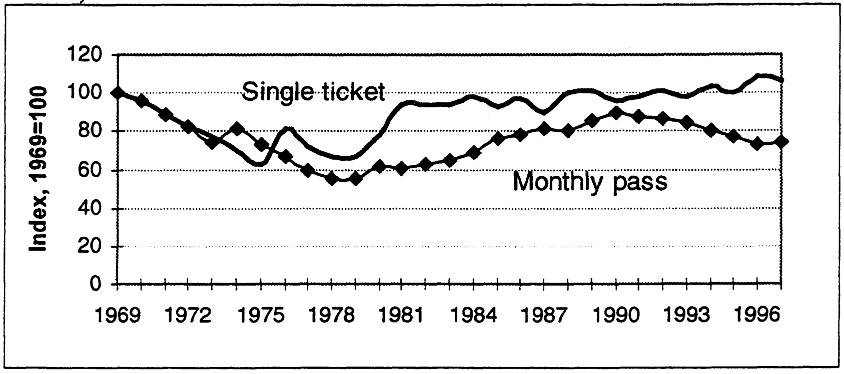
Data quality: Good
Data availability: Good

The taxes on electricity have undergone many changes during the last years. The creation of a Nordic electricity market is probably a drive towards harmonisation between the Nordic countries' tax systems for electricity, at least on the production side. As can be seen in table 18, Denmark is currently having the highest tax levels on electricity consumption, for most categories. Sweden also has high electricity taxes in comparison to the other Nordic countries. Iceland has planned some kind of carbon dioxide taxes for 1998. Peat for electricity production and biomass are not taxed in any of the Nordic countries. As electricity is used in many new products and electric appliances, taxes on electricity may serve as an incentive to buy energy efficient products. Therefore, the tax on electricity is an interesting response indicator.

Public transport

The price of public transport may, e.g. in combination with gasoline prices, be an indicator of societal response in order to reduce private car use or fuel consumption. Figure 50 illustrates the price development for public transport in the capital of Norway.

Figure 50. Prices of public transport in Oslo. Fixed 1979-prices. Index, 1969=100



Source: Oslo Sporveier (prices) and Statistics Norway (consumer price index)

Data quality: Good
Data availability: Medium (available at request)

Other relevant indicators of public transport are the number of passengers, vehicle-kilometres or passenger-kilometres in public transport, preferably compared to total figures.

New renewable energy sources

As a reaction to the problem with climate change and dependence on limited energy reserves, new renewable energy sources are developed. During the last years, new facilities for renewable energy sources such as wind energy, solar power, geothermal energy and landfill gas have been built in larger scales than for experiments. The exception from that in the Nordic countries is Iceland that always has had a substantial geothermal energy production. Hydropower and use of biofuels are also renewable energy sources but are not considered as *new* here. Use of heat pumps to make use of the heat in waste water from the industry and sewage treatment works, and also geothermal heat, can also be considered as a new renewable energy source. Data on energy production by heat pumps have not been found.

Table 19. Energy production from new renewable energy sources. 1994. ktoe

Country	Wind energy	Solar panels	Geothermal energy	Landfill gas	Total	Per capita	Part of total energy production Per cent
Denmark	98	4	2	7	111	0.02	0.78
Finland	1	0	0	1	2	0.0004	0.02
Iceland	0	0	22	0	22	0.08	1.59
Norway	1	0	0	0	1	0.0002	0.00
Sweden	6	0	0	0	6	0.0007	0.02

Sources: Renewable energy sources statistics, 1989–1994, and Statistical Yearbooks for Iceland and Norway.

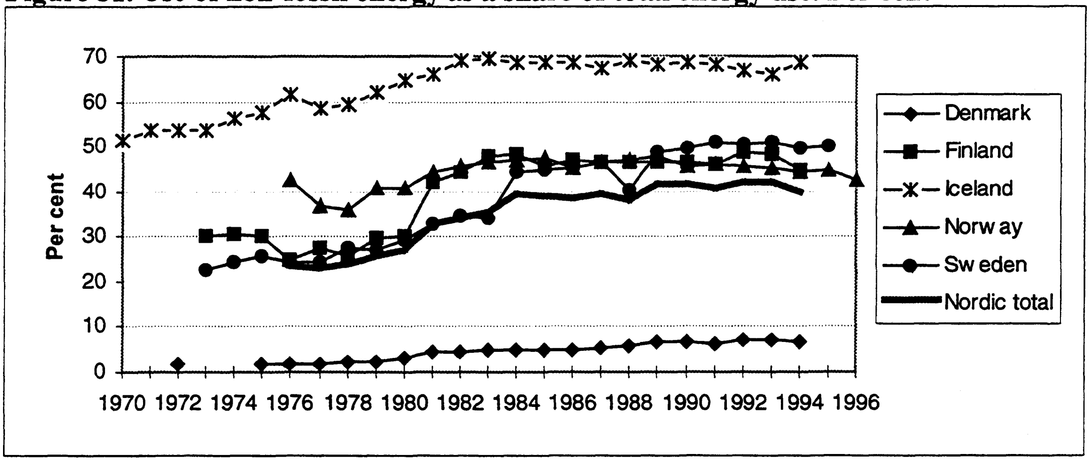
Data quality: Medium, there are some problems with data collection in some countries.
Data availability: Medium

Denmark and Iceland are the two countries that in 1994 had the highest production of energy from new renewable sources (table 19). More recent data for Sweden show an increasing production trend for wind energy and landfill gas. An increasing production can probably be expected in all the countries, and the share of the total energy production will rise.

Non-fossil energy use

There is yet no practical way of removing carbon dioxide from flue gases (new technologies – for example injection of carbon dioxide into ocean sediments – are however under development). The only way to reduce emissions is to burn less fossil fuels, and replace them by non-fossil fuels. In the Nordic environment indicator report from 1997, the use of non-fossil fuels as part of total energy use was chosen as one of the response indicator for the climate change issue (figure 51). Combined with information on the total energy use, this will give an indication of changes in the composition of energy consumption.

Figure 51. Use of non-fossil energy as a share of total energy use. Per cent



Source: Nordic Council of Ministers 1997a

Data quality: Medium
Data availability: Medium

Iceland has the highest percentage of non-fossil fuels with a level close to 70 per cent. Finland, Norway and Sweden have a share of about 45–50 per cent. Denmark had the lowest share in 1994 with only about 10 per cent.

Energy efficiency and energy intensity

The effect of technical measures to reduce CO_2 emissions is probably best expressed as the energy efficiency; output per unit energy used or energy intensities, energy use per activity unit. When the *energy efficiency* is expressed a high number indicates a high efficiency which is good. A high *energy intensity*, on the other hand, indicates a low energy efficiency. These indicators may be more or less aggregated. We suggest here to distinguish between energy production, industry, residential consumption and transport.

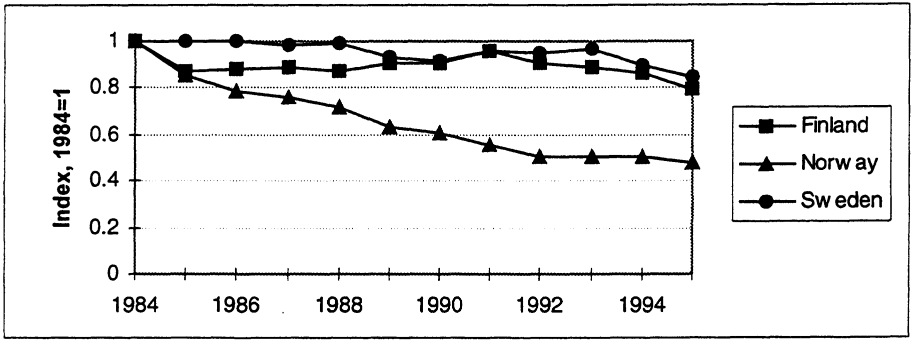
EEA (1997) is critical to the choice of these indicators as response indicators, and rather considers them as measures of pressure. However, the data on the actual responses, such as installation of energy efficient boilers, are not very often available. Consequently, due to the available data, we see energy efficiency as a good indicator. It should, however, be noted that this indicator might explain other factors than direct climate change measures.

Energy efficiency in power plants may be measured as heat and electricity output in GWh per PJ fossil input. We consider that it is appropriate to include both heat and electricity. The indicator for energy efficiency in power plants should preferably be expressed as a time series in order to show any changes over time. However, due to poor data availability and quality we have decided not to present any graph or table for this indicator. Anyhow, we still consider that it should be included in the indicator set.

For Norway, and partly Denmark, crude oil and natural gas primary energy production energy intensity would be a relevant indicator. For Norway, the energy use, and consequently also the CO_2 emission, per unit production of oil and gas has decreased by 23 per cent from 1986 to 1996.

In the IEA energy balances data for industrial energy consumption per industrial production index are given. Even though not all countries report this index, the data are readily available, and they are relevant as energy intensity response indicators.

Figure 52. Industrial energy use per production index. 1984–1995. Index 1984=1



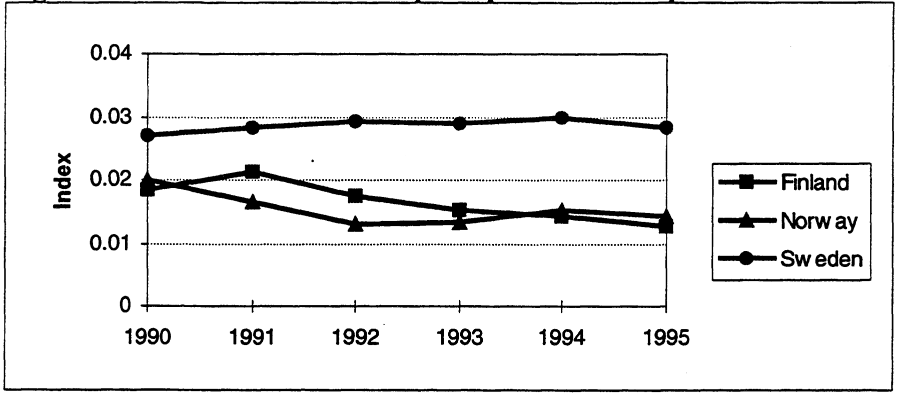
Source: IEA Energy statistics 1994–1995.

Data quality: Needs improvement
Data availability: Medium, not available for all countries

The industrial energy intensity has been decreasing (energy efficiency increasing) in the period in all Nordic countries that have reported data, but especially in Norway (figure 52).

An alternative indicator will be to just include the oil consumption rather than the total energy use. Sweden's oil consumption has been fairly constant during the period 1990 to 1995 when weighted by the industrial production index (figure 53). In contrast, Norway and Finland have consumed less oil relative to the industrial production index. Both for Sweden and Finland the years 1991 to 1993 had a lower industrial production compared to 1990, and a higher production the years 1994 and 1995. For Norway the whole period 1990–1995 showed an increase in the industrial production index. For Iceland and Denmark no assessment on industrial production indices was available.

Figure 53. Industrial oil consumption per industrial production index.



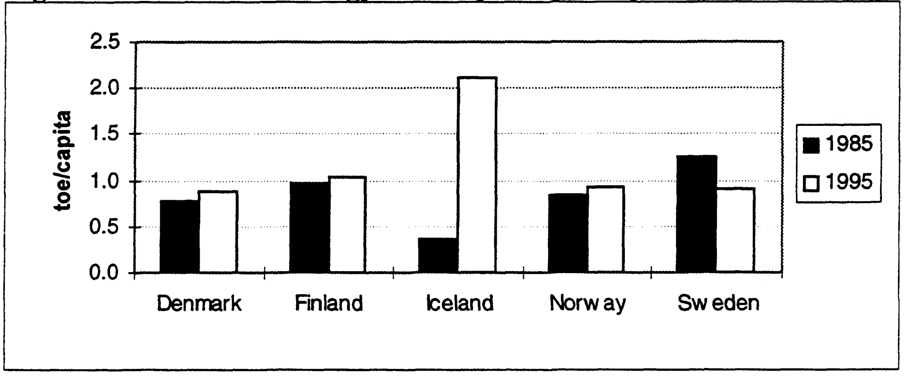
Source: OECD/IEA (IEA Energy Balances of OECD countries, 1994–1995)

Data quality: Needs improvement
Data availability: Medium, not available for all countries

An alternative, more specific, indicator would be energy used per (tonne) production of important commodities such as cars, metals, fertiliser, etc. However, such data are not presently available. Also the commodities produced in the Nordic countries will vary, and consequently more specific indicators will not facilitate comparison. Pulp and paper, cement and aluminium are candidates for common indicators. The energy required to produce 1 tonne of cement in Sweden is 4700 MJ while it has varied between 3600 and 4600 the last years in Norway.

A simple indicator for household energy intensity is residential energy use per capita.

Figure 54. Residential energy intensity. toe per capita. 1985 and 1995



Source: IEA Energy statistics 1994–1995

Data quality: Needs improvement
Data availability: Good

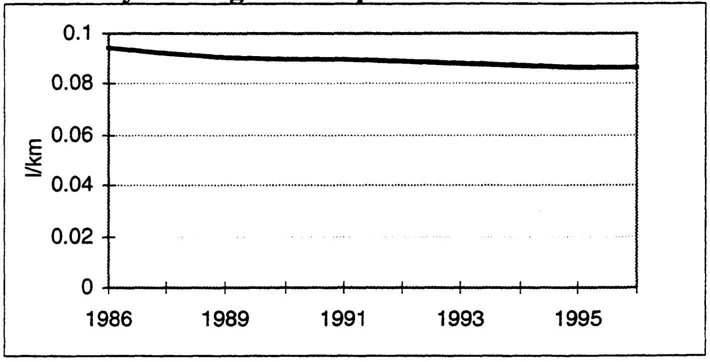
The residential energy intensity is by far the largest in Iceland. The other Nordic countries have fairly similar values. The energy intensity has increased in Norway, Finland, Denmark and Iceland during the last 10 years, but it has decreased in Sweden (figure 54). That means that many of the Nordic countries use more energy for heating per capita today than 10 years ago. This may be explained by higher residential space per capita, more electric equipment, higher temperature in dwellings and increased population. The rather dramatic change in the figures for Iceland from 1985 to 1995 may be explained by a change in methodology.

Transport

New car technologies will usually give lower fuel consumption per km than older ones. On the other hand, there is a tendency towards bigger cars for family use. The specific gasoline consumption is partly regulated by EU regulations, and partly it is a good sales argument for the car companies.

The data for this indicator are, however, not readily available. We present data for Norway only (figure 55), but this is considered to be representative for other Nordic countries as well.

Figure 55. Specific passenger car gasoline consumption in Norway. Average. Litres per km. 1986–1996



Source: Statistics Norway

Data quality: Medium
Data availability: Needs improvement, not directly available

The indicator shows that the passenger transport energy efficiency has increased during the last ten years. However, larger cars used for private transport as well as more driving, have lead to increased over all energy use for private transport.

An alternative indicator would be the road transport energy use taken from the energy balance divided by some activity indicator like passenger-kilometres or tonne-kilometres. However, as this transport energy use is used both for freight and passenger transport this is not straightforward. Transport energy use per capita is also a possibility, but this would be a less specific indicator.

Electric cars and alternative fuels

Electric cars do not directly cause emissions of greenhouse gases, but the production of electricity may do. The benefit on climate of the use of these cars therefore depends on both the type of and the efficiency of electricity production.

Table 20. Number of electric cars. 1997

Country	Number of electric cars	Number per 1000 inhabitants
Nordic total	..	..
Denmark	..	..
Finland	..	..
Iceland	..	..
Norway	137	0.03
Sweden	394	0.04

Sources: The Norwegian Directorate of Public Roads.
Swedish Research and Communication Board (www.kfb.se).

Data quality: Good
Data availability: Medium, not directly available

The number of electric cars in Norway and Sweden is small, but has increased substantially the last years (table 20).

Use of alternative fuels, like natural gas in buses and ferries, will also give lower CO_2-emissions than use of gasoline or diesel. However, the use of these vehicles is limited and it should not be used as a response indicator at this stage. This also applies to use of bio-diesel that does not generate net CO_2 at all.

Measures to increase forest growth

According to the Nordic countries' reports to the climate convention, all countries have ideas or plans to increase forest growth. However, it seems at this stage difficult to express this as a response indicator.

Potential indicators:

- Changes in forest areas: not very good as forest area is increasing in some countries without measures. However, this is an important indicator, though perhaps not a response indicator. Data are available
- Increase in forest density: an important indicator, but also expresses other factors (natural) than political responses. Data may be partially available
- Number of trees planted in non-forest, former forest and forest areas. This indicator is not well defined and data might easily not be very comparable. Data are partially available.
- Area converted to forest from other land use. Data are partially available.
- Area of forest protected: not very relevant as deforestation is not a problem
- Use of wood products: expressed in the driving force section. Measures to enhance the use of wood products are relevant, but not very significant at this stage.
- Per cent of harvested trees utilised. Data are probably not available.

4.5.3. Response indicators for CH_4

As can be seen in figure 35 (page 66), landfills and agriculture are the main sources of methane emissions in the Nordic countries.

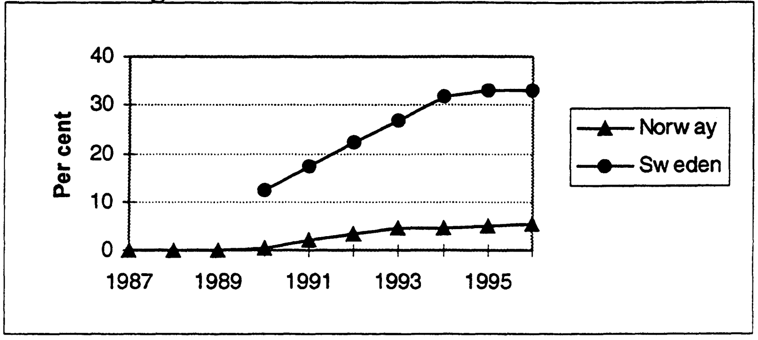
Taxes on waste deposition

Several of the Nordic countries are planning taxes on waste deposition. The level of tax should in the future be considered as an important response indicator as reduced deposition will lead to less methane generated from landfills.

Methane from landfills

The most usual measure to reduce methane emissions, besides reducing the amount of waste disposed of, is to collect the gas from landfills, and either use it as a fuel or to flare it. When the methane gas is flared the methane is reduced to CO_2 that has a lower GWP per molecule than methane. This measure also has other benefits like decreased smell and decreased danger of explosions. An indicator example is shown for Norway and Sweden (figure 56).

Figure 56. Collection of methane from landfills. 1987–1996. Per cent of generated methane



Sources: Statistics Norway and the Swedish Environmental Protection Agency

Data quality: Needs improvement
Data availability: Needs improvement, not directly available

The fraction of methane collected from landfills has increased substantially the last ten years. Sweden collects a higher fraction (30 per cent) of methane than Norway (5 per cent).

The part (preferably a time series) of the total amount of waste deposited on landfills (as presented in paragraph 4.2.10) could also be a relevant response indicator, as this would give an indication of changes in waste treatment of relevance for the climate change issue. In Norway and Finland a larger fraction of the waste is deposited in landfills than in the other Nordic countries.

Some countries will also emphasise the reduction of the amounts of waste generated as a measure to reduce methane emissions. This may be done by decreased consumption of commodities that will end up as waste, decreased use of packing materials and increased recycling. Reduced generation of waste may be controlled by taxes. Hence, indicators of measures to decrease the consumption of packaging materials would be relevant here. Also general indicators of consumption are relevant (see driving force indicators, section 4.2.5).

Recycling may or may not decrease the overall CO_2 emissions, depending on the transport energy demand for landfilling, recycling and virgin material, respectively, recycling energy demand and production from virgin material energy demand. It is not clear whether an indicator like «fraction of a certain material recycled» is a good response indicator or not. Many countries have goals on increased recycling.

Methane from animals

Measures for reducing the methane from animals and animal waste are only to a limited extent implemented in the Nordic countries. Some sketches of possible future indicators are mentioned here:

- Collection of methane from animal waste (manure). Only at a testing stage in the Nordic countries. Denmark currently collects about 1.5 per cent of their potential manure methane emissions (NERI 1997). This percentage is probably lower in the other Nordic countries.
- Altering of animal fodder
- Reduction in number of animals

Also the storing conditions of manure affect the emissions, but this has not been implemented as a methane reduction measure.

4.5.4. Response indicators for N_2O

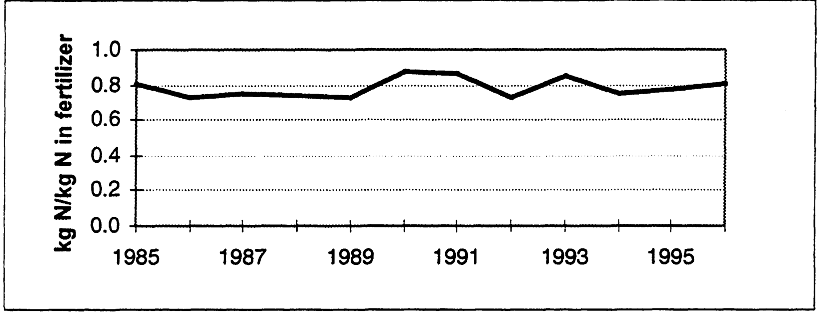
As shown in figure 36 (page 67), agriculture is the main source of nitrous oxide emissions in the Nordic countries. Industrial sources are also important in some countries.

Agriculture

No direct technical measures have yet been implemented in large scale in order to reduce these emissions. Due to various environmental reasons, farmers now get better information on how to reduce fertiliser use. Hence, crop output relative to use of mineral fertiliser may be considered as a relevant indicator. More indicators may become relevant in the future as measures to reduce nitrous oxide emissions are implemented.

The indicator, as illustrated for Norway in figure 57, does not show any clear trend. However, this may become a relevant indicator in the future if ideas or plans to reduce fertiliser use are implemented.

Figure 57. Output per unit fertiliser applied. Norway. 1985–1996



Source: Statistics Norway

Data quality: Needs improvement
Data availability: Needs improvement, not directly available

Manufacturing industries

As an indicator for technical measures to reduce nitrous oxide emissions from industrial processes, emissions per unit production should be considered. Nitric acid (HNO_3) is the main relevant commodity.

4.5.5. Response indicators for other greenhouse gases

HFC replaces the ozone depleting CFCs and HCFCs in cooling equipment, e.g. household refrigerators. Hence there are currently few response strategies implemented. Possible measures are taxes, substitution with new types of substances, collection and recycling, destruction and better maintenance of equipment. Possible indicators are consumption per capita, the amount recycled or destructed as a percentage of total consumption and tax per kilogram consumption. Currently recycling and destruction are not in use or very little used.

PFCs: The emissions may be reduced by decreasing the number of anode events in aluminium production, more use of pre-baked furnaces on the cost of Søderberg and reduced anode frequency. Hence, these could be possible indicators. However, the statistics are not likely to be available. The best indicator at this stage is probably emissions per unit of aluminium produced. Data for Norway show a 55 per cent decrease in emissions per produced unit from 1990 to 1996. This indicator is also relevant for Iceland.

SF_6: This substance is used during magnesium production, but also has other applications. Improved routines and maintenance may reduce emissions. The best response indicator for SF_6 will probably be emissions per produced unit and the indicators listed for HFCs.

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