3 Statistiske analyser Statistical Analyses

Natural Resources and the Environment 1993

Statistics Norway
Statistisk sentralbyrå

Natural Resources and the Environment 1993

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Energireserver
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Miljøøkonomi
Naturmiljø
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Preface

Statistics Norway (SN) compiles statistics on the state of the environment, as well as accounts for a number of important resources. Statistics Norway also develops methods and models to analyze the inter-relationships between socio-economic conditions, use of resources, and environmental conditions. The publication *Natural Resources and the Environment* contains an annual concentrated overview of this work.

Natural Resources and the Environment 1993 presents updated resource accounts for energy and emissions accounts for emissions to air, and some results of analyses based on these accounts. The report also includes key figures for fishing, sealing and whaling, agricultural pollution, forest resources and forest damage, municipal waste water treatment plants and waste management.

Statistics Norway wishes to thank all the institutions that have supplied data for *Natural Resources and the Environment 1993.*

The report is a joint publication from the Division for Resource Accounts and Environmental Statistics, Department of Economic Statistics, and the Natural Resources Division, Research Department. It summarizes much of the activities of these divisions during the last year. The report has been prepared by an editorial committee consisting of Ola K. Hunnes, who has administered the work, and Knut H. Alfsen, Tor Arnt Johnsen, Karine Nyborg, Toril Austbø, Per Schøning (up to 31 December 1993) and Henning Høie (from 1 January 1994). Mary Bjærum has translated the Norwegian version into English.

A comprehensive description of natural resources, pollution and the state of the environment in Norway will be presented in *"Naturmiljøet i tall 1994"* (The natural environment in figures, 1994), a report prepared by the Directorate for Nature Management, the State Pollution Control Authority and Statistics Norway jointly. This publication will be available in June 1994 (In Norwegian).

Statistics Norway
Oslo/Kongsvinger 5 April 1994

Svein Longva

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Part I Resources and the state of the environment 1993

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Introduction

Natural Resources and the Environment 1993 provides information on important Norwegian natural resources and the natural environment in the form of statistics (*parts I and III*) and analyses (*part II*). Most of the statistics have been elaborated by Statistics Norway, but data have also been obtained from other sources.

Part I and the associated appendix of tables making up *part III* present key figures for important resources and environmental conditions in Norway. The chapter on energy includes updated statistics on extraction and use of energy. Emissions to air are strongly linked to use of fossil fuels, and a chapter on air discusses trends in emissions to air in recent years. A fundamental question is whether Norway will be able to realize the defined targets for emissions of gases such as CO_2, SO_2 and NO_x. The figures on emissions of pollutants to air are also presented at municipal level.

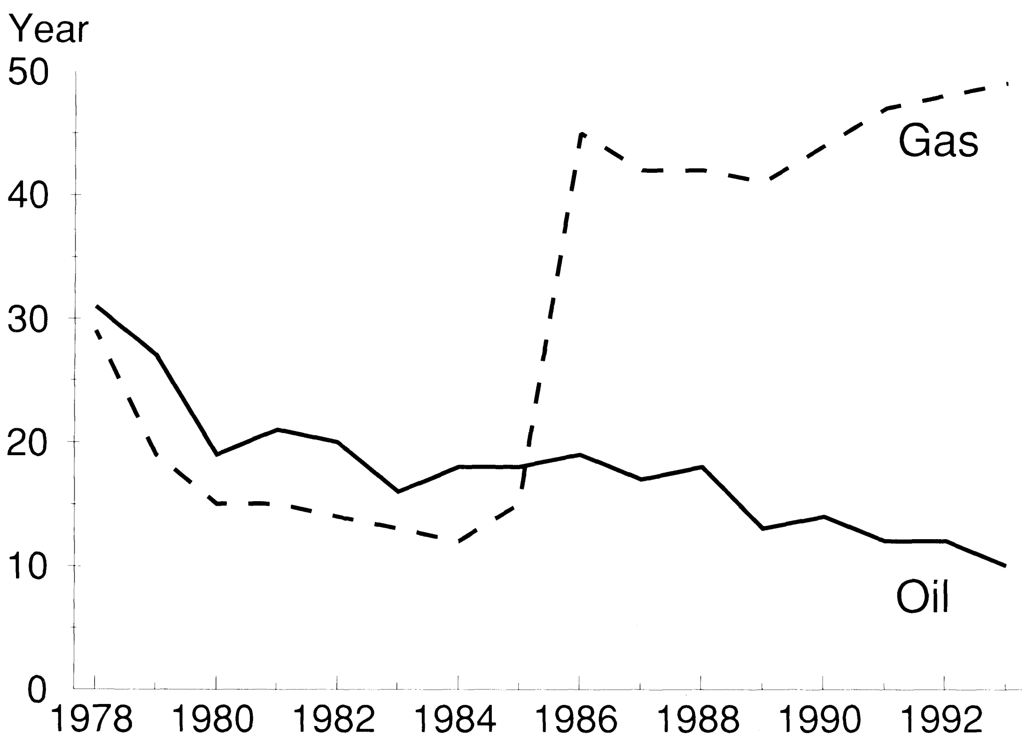
A chapter on fish presents figures on fish stocks and catches, and some key figures on fish farming, while the chapter on forests contains the most recent information on forestry and forest damage both in Norway and in the rest of Europe.

Norway has signed the North Sea Declarations, and has thus undertaken to halve discharges of nitrogen and phosphorus to the North Sea by 1995, with 1985 as base year. Natural Resources and the Environment 1993 contains new statistics and analysis results of relevance for monitoring discharges of nutrients into the North Sea. These statistics apply to pollution from agriculture, and discharges from municipal waste water treatment plants.

The chapter on waste presents results from a nationwide survey of collection and management of municipal waste, as well as statistics based on annual records of delivered amounts of hazardous waste. In the case of industrial waste, Statistics Norway intends to conduct a study this year which will provide comprehensive information next year.

Part II presents research work focusing on the interrelationships between use of resources, the environment and the economy. In this connection, important issues are the effect of economic growth on the natural environment, the cost to society of an impoverished environment, whether environmental goods can be priced in terms of money, and how exhaustible resources should be managed. The work has concentrated mainly on conditions in Norway, but some of the themes also refer to Europe and more far-flung countries.

Part I Resources and the state of the environment 1993



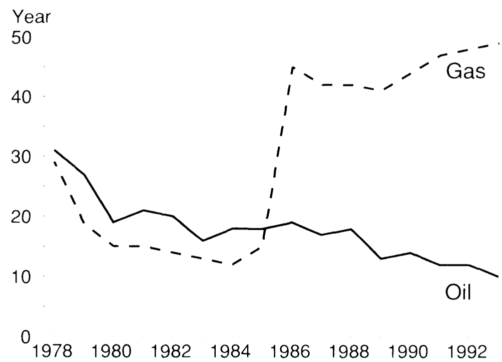
1. Energy

Petroleum extraction is at present Norway's most important industry. Norway is the largest producer of crude oil in Western Europe, and the third largest exporter of crude oil in the world. Only Saudi Arabia and Iran export more. Norway is also an important generator of hydropower. Over the last 20 years, domestic consumption of fossil sources of energy and of electricity has increased. This consumption has decreased in recent years, however, and we have also experienced a switch from use of heating oils to use of electricity.

1.1 Reserves

At the end of 1993 Norway's reserves of crude oil amounted to 1 209 million tonnes, accounting for 0.9 per cent of the world's total reserves of oil. The reserves of natural gas amounted to 1 356 billion Sm^3, and accounted for 1.4 per cent of the world reserves. Expressed in terms of oil equivalents, this gives a total reserve of about 2 500 million tonnes (Mtoe). With today's level of production and known production technology, the oil reserves in developed fields and in fields to be developed (license granted) on the Norwegian continental shelf will last for 10 years, while the gas reserves will last for 49 years. This ratio between reserves

Figure 1.1. Ratio between reserves and production of oil and gas (R/P ratio). Developed fields and licensed fields. 1978-1993. Year



Sources: Statistics Norway and Directorate of Petroleum and Energy

and production, the R/P ratio will change in the years to come, depending on rate of extraction, prices, new discoveries and new production technologies. Figure 1.1 shows the historical trend in these factors. The assumed reserves in fields that are not yet licensed are about 550 million tonnes of crude oil and about 1450 billion Sm^3 of natural gas. The R/P ratio, including fields that are not yet licensed is 15 years for crude oil and 101 years for natural gas.

Table 1.1. World reserves[1] of oil and gas. 1 January 1994. Billion toe

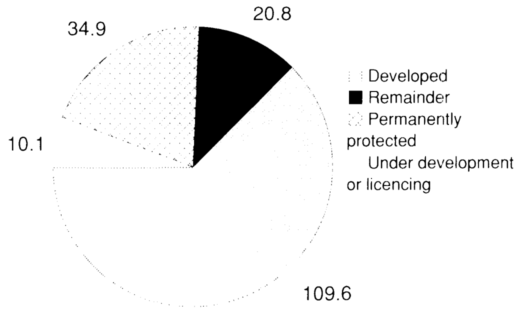
	Oil	Share	Gas	Share
World	135.0	1.000	125.4	1.000
North America	3.9	0.029	6.5	0.052
Latin America	16.9	0.125	6.7	0.054
Western Europe	2.2	0.017	4.8	0.038
Eastern Europe and CIS	8.0	0.059	50.4	0.402
Midle East	89.6	0.663	39.5	0.315
Africa	8.4	0.062	8.6	0.068
Asia and Australasia	6.0	0.045	8.9	0.071
OPEC	104.3	0.773	50.5	0.403
Norway	1.3	0.009	1.8	0.014

[1] The term "reserves" as used in this table is not the same as used in the text and the tables A1 and A2 in the appendix. For most countries, the reserves comprise discovered resources that can be exploited with today's technology and prices
Source: Oil and Gas Journal, 1993

On 1 January 1994 Norway had the largest proven reserves of both oil and gas in Europe, after Russia. In Western Europe (European OECD countries), 59 per cent of the oil reserves and 37 per cent of the gas reserves are located on the Norwegian continental shelf (table 1.1).

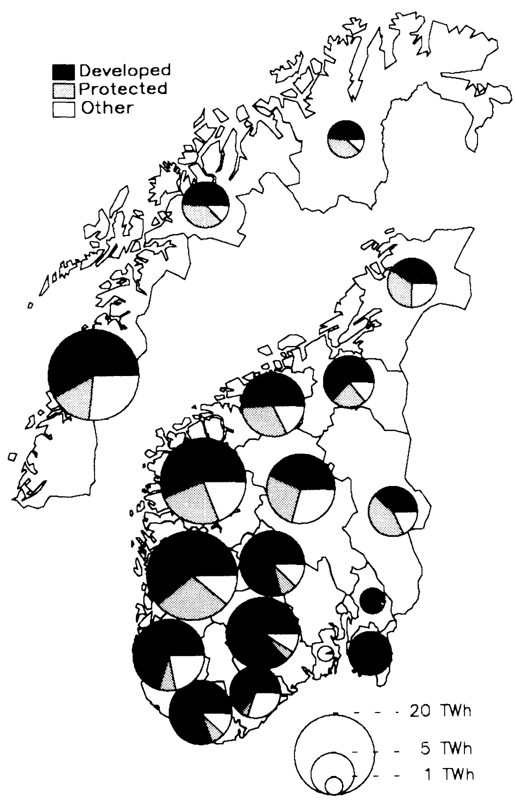
The hydropower reserves can be distributed between developed reserves, reserves for which a license has been granted or is being considered, protected watercourses and the remainder, i.e. the rest of the watercourses evaluated in the Master Plan for Water Resources. On 1 January 1994 the total economically exploitable water resources were 175.4 TWh. Of this amount, 109.6 TWh had been developed (average power potential, defined as the production capacity of the power stations in a year with normal precipitation) and 34.9 TWh was permanently protected (figure 1.2). This implies an increase in permanently protected reserves of about 57 per cent compared with the year before. In 1994,

Figure 1.2. Exploitable hydropower. 1 January 1994. TWh



Source: Norwegian Watercourses and Energy Administration (NVE)

Figure 1.3. Hydropower reserves in Norway, by county. 1 January 1994. TWh



Source: NVE

the average developed power potential is expected to increase by 0.5 TWh, mainly owing to the development of Meråker power station. The Norwegian counties with the highest average power potential are Hordaland and Nordland (figure 1.3).

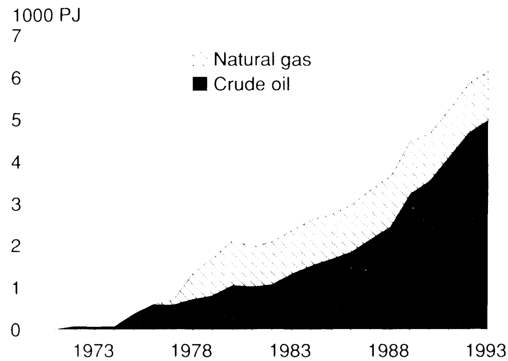
In 1987, the world's developed hydropower reserves amounted to about 2 632 TWh. Norway's share of this amount was 4.3 per cent. In Europe (CIS not included) the developed resources amounted to about 727 TWh, of which Norway's share was 15.7 per cent.

At the end of 1993 Norway's reserves of coal were about 12 million tonnes. At today's rate of extraction, the coal reserves will be exhausted after 36 years. At the end of 1992 the world's exploitable reserves of coal amounted to 1 039 billion tonnes. With the present rate of extraction the world's coal reserves will last for about 230 years. The largest reserves are located in the United States, CIS and China.

1.2 Production

In 1993, net production of crude oil, including condensates and natural gas liquids (NGL), amounted to average 2.37 million barrels per day (figure 1.4), or a total of 115.5 million tonnes. This is an increase of about 7 per cent compared with 1992. In November the production reached its highest peak, about 2.6 million barrels per day. The Statfjord, Gullfaks and Oseberg fields were the most important fields for the oil production as a whole in 1993. The Snorre, Gullfaks and Oseberg fields were the most important contributors to the *increase* in production. In 1994 the oil production is expected to increase by about 8 per cent compared with 1993. The reasons for the expected increase include start of production in the new fields Sleipner East, Gullfaks West, Statfjord East and North, and Tordis. Production from Snorre will also increase, and the Brage and Draugen fields will experience their first full year of production.

Figure 1.4. Extraction of crude oil and natural gas in Norway. 1970-1993. 1 000 PJ



Source: Statistics Norway

Net production of natural gas amounted to 24.8 billion Sm^3 in 1993, equivalent to about 24 Mtoe (figure 1.4). This is a reduction of about 12 per cent compared with 1992. The Ekofisk, Frigg and Statfjord fields were the most important contributors to gas production in 1993. There was a marked reduction in production on the Frigg field. An increase in production on the Snorre and Gullfaks fields, among others, and start of production on Sleipner, was not enough to compensate for this reduction. A strong increase in gas production is expected from 1996 onwards, if production is started on Troll East and Sleipner West as planned.

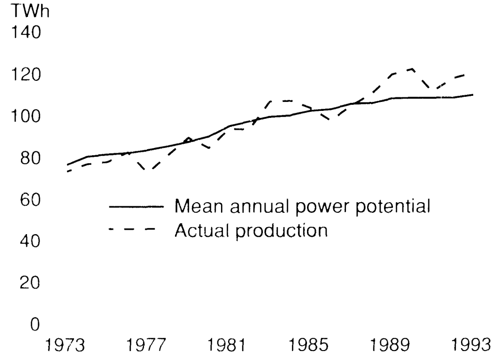
In 1993, Norway accounted for 3.6 per cent of the world production of crude oil and 0.8 per cent of the world production of natural gas (table 1.2), and was the next largest producer of crude oil in

Table 1.2. **Production of crude oil and natural gas in the world. 1993*. Mtoe**

	Oil	Gas
World	3168.6	2971.4
North America	505.6	667.6
Latin America	396.2	91.5
Western Europe	237.2	201.8
Eastern Europe and CIS	402.1	760.0
Midle East	961.8	108.6
Africa	337.4	68.8
Asia and Australasia	328.4	173.2
OPEC	1313.5	229.4
Norway	114.5	24.0

Sources: Oil and Gas Journal, 1994 and Petroleum economist, 1994

Figure 1.5. **Mean annual power potential and actual generation in the Norwegian hydropower system. 1973-1993. TWh**



Source: NVE

Europe, second to Russia, and the largest exporter of crude oil outside OPEC.

120.0 TWh electricity was generated in Norway in 1993. Of this amount, about 0.4 TWh was thermal power, the remainder was hydropower. Given the existing technical power potential the annual hydropower generation will vary with variations in the flow to the reservoirs. Both the average power potential and the actual power generation have increased substantially since the 1970s, owing to a strong expansion of capacity. In the last few years, the actual production has exceeded the average power potential because of very good flow of water to the reservoirs (figure 1.5).

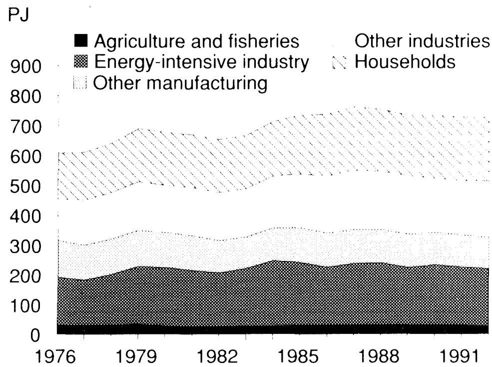
According to the preliminary figures, coal production in Svalbard amounted to 8 PJ in 1993, down from 11 PJ in 1992. Wood, wood wastes and paper waste are the most important biological fuels in Norway. The production of these fuels, including production for own consumption, amounts to about 38 PJ per year (this figure is uncertain). In 1992, energy amounting to about 4 PJ was produced for district heating from incineration of waste, and about 90 per cent of this amount can be regarded as bioenergy. It is estimated that methane gas equivalent to 7.6 PJ is generated every year in Norwegian landfills. About 6 per cent of this gas, equivalent to 0.5 PJ, is utilized as energy or is flared. Most of the methane is biogas.

1.3 Consumption

In 1992, energy consumption in Norway, the energy sectors and ocean shipping excluded, amounted to 727 PJ (figure 1.6 and table A4 in part III). In 1993, consumption increased to 744 PJ (provisional figure). During the period 1976 to 1987 consumption increased by an average of 2.1 per cent per year, but since 1987 it has decreased by 0.4 per cent per year. Private households accounted for the largest share of the consumption (figure 1.6), followed by energy-intensive industry.

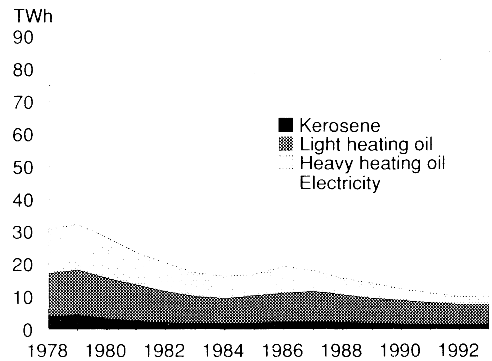
Total consumption of oil products has decreased by 21 per cent since 1976, in spite of an increase of 33 per cent in oil used for transportation. Consumption of oil for transportation now accounts for

Figure 1.6. Domestic energy consumption by industry. 1976-1992. PJ



Source: Statistics Norway

Figure 1.7. Electricity consumption, energy-intensive industry excluded, and sales of heating oil and kerosene. 1978-1993. TWh utilized energy



Source: Statistics Norway

79 per cent of the total oil consumption, as against 47 per cent in 1976. Sales of oil for stationary consumption decreased by as much as 69 per cent in Norway from 1976 to 1993. In 1978 these oil sales, calculated in terms of utilized energy, amounted to about 31 TWh, compared with only approximately 10 TWh in 1993 (figure 1.7). The reduction in consumption was particularly marked for heavy oils. During the same period consumption of electricity increased by 71 per cent, energy-intensive industry not included. The switch from use of heating oils to use of electricity was most marked during the first half of the 1980s. One reason was the high price of heating oils during the period, but another was the high investment costs for oil-based heating installations and high maintenance costs of existing installations.

In 1990, Norway accounted for 0.3 per cent of the world's total consumption of energy (table A7 in part III), and the OECD countries for about 50 per cent. Per capita consumption is clearly higher in Norway than the average for the world as a whole, and also higher than the average for the OECD countries.

However, energy intensity in Norway, measured as consumption of energy per unit of GDP, is only slightly higher than the average for the OECD countries. The composition of the energy consumption varies for the different parts of the world. However, oil, natural gas and coal are important sources of energy in all parts of the world.

Further information from: Kristin Rypdal and Lisbet Høgset.

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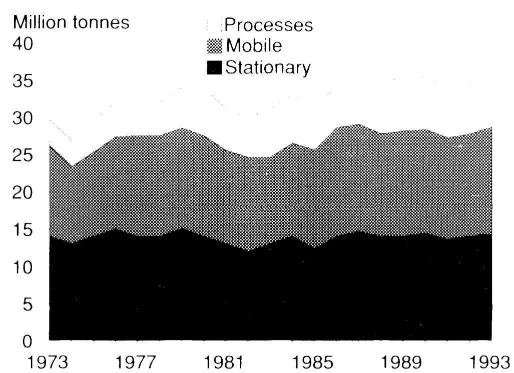
2. Air

Emissions of the greenhouse gases CO_2, CH_4 and N_2O may disturb the radiative energy balance of the atmosphere. SO_2, NO_x and NH_3 contributes to acidifiacation of the environment and thereby threaten fish stocks and vegetation, and deteriorate materials. Local pollution from SO_2, NO_x, NMVOC, CO and suspended particulates can have adverse effects on health. In recent years, emissions of these pollutants in Norway have been influenced by a high and growing level of activity in the North Sea. Norway has experienced a simultaneous increase in oil consumption for transportation, but a reduction in consumption of oil for heating, since many consumers have switched over to electricity. Therefore, aside from the petroleum activities, transportation has become the dominating source of emissions to air.

Figure 2.1. Emissions of CO_2 by source. 1973-1993*. Million tonnes



Sources: Statistics Norway and State Pollution Control Authority (SFT)

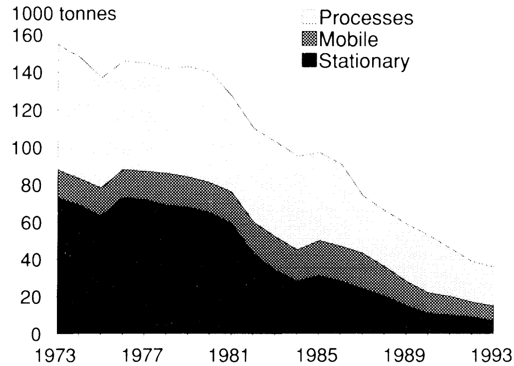
2.1 Trends in national emission levels

The level of emissions of the greenhouse gas carbon dioxide (CO_2) was the same in 1993 as in 1989 (figure 2.1). The emissions were somewhat lower in the intervening period, the main reasons being decreased consumption of oil both for transport and heating purposes, and reduced process emissions in the metals manufacturing and cement industries, owing to a lower level of production. Now, however, we have experienced an increase in oil consumption for transport, as well as a rise in production in the metals and cement industries. The reductions in 1973-1974, 1979-1980 and 1990-1991 coincide with the increases in oil prices. Norway's national target is to stabilize emissions to 1989 level by the year 2000. The possibility of realizing this target depends primarily on whether we succeed in limiting emissions from the oil activities. Oil-related activity is the dominating source of CO_2-emissions in Norway (29 per cent), followed by road traffic (24 per cent).

Emissions of ammonia (NH_3) and the greenhouse gas methane (CH_4) have remained stable in recent years, while emissions of the greenhouse gas nitrous oxide (N_2O) have decreased slightly. The most important sources of emissions of CH_4 are biological degradation of wastes (56 per cent) and domestic animal husbandry/domestic animal manure (32 per cent). Emissions of nitrous oxide (N_2O) and ammonia (NH_3) originate mainly from use of animal and mineral fertilizers in agriculture. Nitric acid manufacture is another main source of emissions of N_2O. However, the emission levels for these components are associated with a high degree of uncertainty.

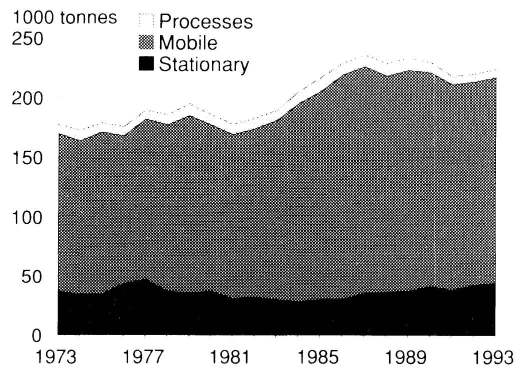
Emissions of sulphur dioxide (SO_2) have been reduced by 77 per cent from 1973 to 1993 (figure 2.2). The decrease from 1980 to 1993 amounts to 74 per cent. Thus the target in the Helsinki Protocol (30 per cent reduction) and the national target (50 per cent reduction) have both been achieved. The decrease in emissions from combustion can be explained by a reduction in the sulphur content of oil products, a reduction in consumption of oil products and a switch to use of lighter oil products and electricity, and more and better cleaning installations. In 1992, about 54 per cent of the SO_2-emissions originated from industrial processes. One of the main reasons for the decrease in emissions from such processes since the beginning of the 1980s is that several companies have been ordered to introduce cleaning technology, and some of the most polluting enterprises have been closed down. The main reason for the decrease in recent years is reduced

Figure 2.2. Emissions of SO_2 by source. 1973-1993*. 1 000 tonnes



Sources: Statistics Norway and SFT

Figure 2.3. Emissions of NO_x by source. 1973-1993*. 1 000 tonnes



Sources: Statistics Norway and SFT

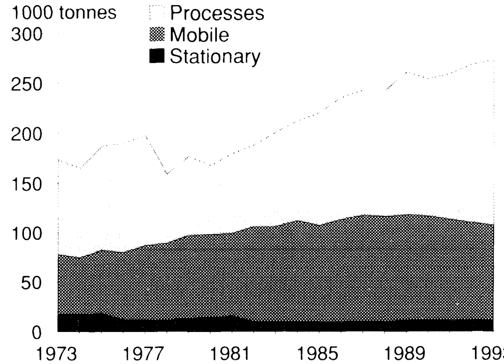
production within energy-intensive industry, the pulp and paper processing industry and cement manufacturing.

There was a marked increase in emissions of nitrogen oxides (NO_x) up to 1987 (figure 2.3), mainly due to increased use of private cars. From 1987 to 1993 the emissions have been reduced by about 5 per cent. The reduction in emissions in recent years can be explained by less flaring in the North

Sea, lower gasoline consumption, introduction of three-way catalytic convertors in cars, lower consumption by the fishing fleet and other shipping, and reduced emissions from industrial processes. It thus appears that Norway will be able to realize the target defined in the Sophia Protocol to stabilize emissions at 1987 level by 1994. In addition to this target Norway has defined a national target to reduce emissions by 30 per cent in relation to the 1986 level by 1998. If this target is to be achieved it will be necessary to stabilize (or reduce) consumption of fuel for transportation, accelerate the shifting out of the motor vehicle stock to vehicles fitted with a three-way catalytic convertor, and substantially reduce emissions from shipping. The dominating sources of NO_X-emissions in Norway today are road traffic (36 per cent) and shipping (35 per cent).

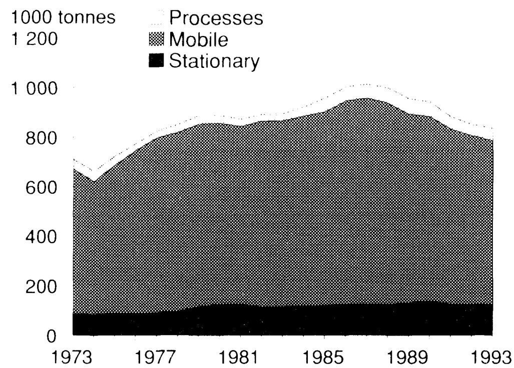
Emissions of volatile organic compounds other than methane (NMVOC) have increased substantially since the end of the 1970s (figure 2.4). The most important sources in Norway are evaporation from loading of crude oil (39 per cent), and emissions from gasoline cars and gasoline distribution (31 per cent). The increase in the emissions during the period can be explained by a higher level of activity in the North Sea, particularly loading of a larger quantity of crude oil, but also by increased use of gasoline cars during the period 1973-1987. For the Norwegian mainland as a whole and for the economic zone south of latitude 62°N, Norway is committed to the target defined in the Genèva Protocol, to reduce emissions by 30 per cent by 1999, with 1989 as base year. If emissions of NMVOC are to be reduced to this level it will be necessary to introduce further measures which will reduce emissions from loading of crude oil. More oil will probably be loaded in the years to come. A higher proportion of new gasoline cars which comply with more stringent exhaust emission criteria and measures to reduce evaporation of gasoline will help to reduce emissions of NMVOC.

Figure 2.4. Emissions of NMVOC by source. 1973-1993*. 1 000 tonnes



Sources: Statistics Norway and SFT

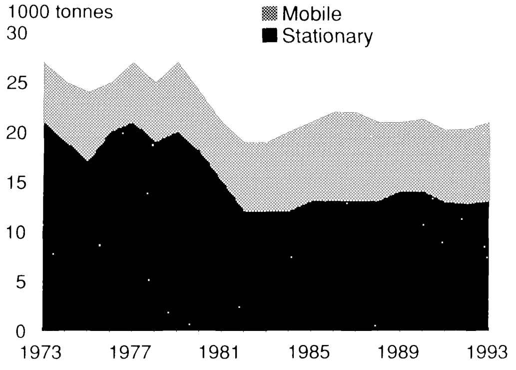
Figure 2.5. Emissions of CO by source. 1973-1993*. 1 000 tonnes



Sources: Statistics Norway and SFT

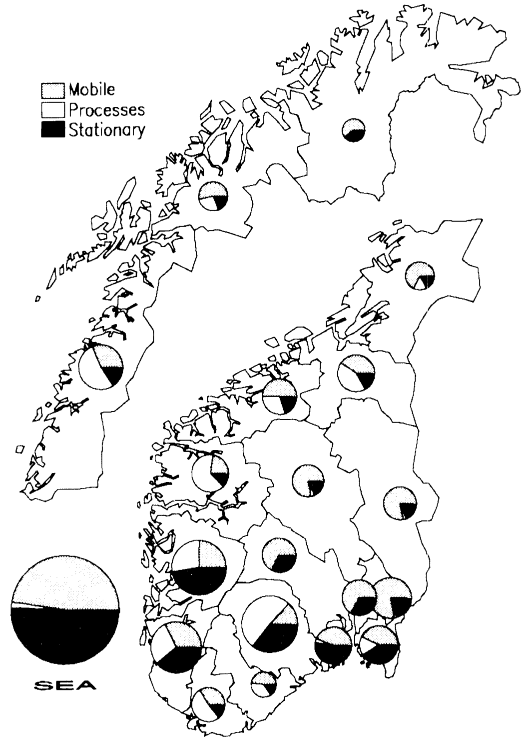
Emissions of carbon monoxide (CO) increased from 1973 to the mid-1980s (figure 2.5), but have clearly decreased in later years. The main reasons for the decrease are lower consumption of gaso-

Figure 2.6. Emissions of suspended particulates from combustion, by source. 1973-1993*. 1 000 tonnes



Sources: Statistics Norway and SFT

Figure 2.7. CO_2-emissions in 1991, by source. County



Sources: Statistics Norway and SFT

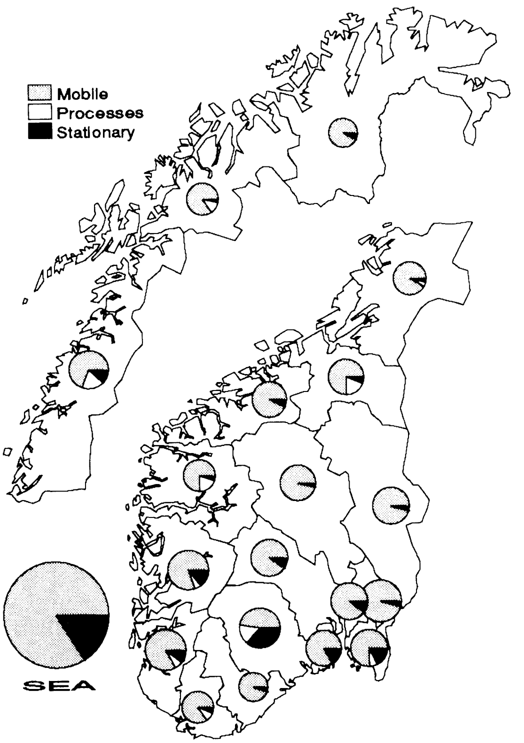
line and more cars with a catalytic convertor. Road traffic is the dominating source of emissions of CO (76 per cent).

Emissions of suspended particulates from combustion decreased considerably from 1973 to 1982 (figure 2.6). This can be explained by reduced consumption of heavy oils for heating purposes. During the 1980s and up to the present time, emissions from stationary combustion have increased slightly, owing to more burning of wood. In 1992, emissions from stationary combustion accounted for 63 per cent of the total emissions, most of this from burning wood for heating. Emissions from mobile combustion have increased during the period owing to a larger volume of road traffic and of ships traffic.

Emissions of lead have decreased by about 88 per cent from 1973 to 1993. Today, lead pollution in the air is much lower than the level that is assumed to cause harm to human health.

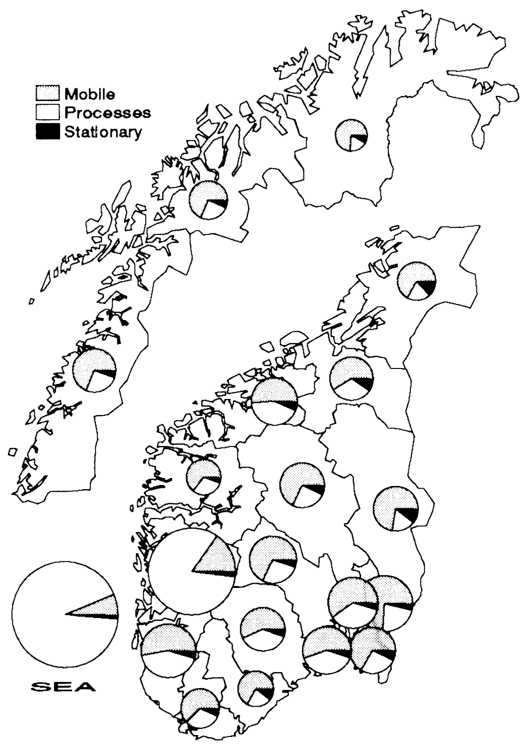
There has been a marked decrease of emissions of SO_2 in the OECD countries during the last 20 years. In Norway SO_2-emissions per capita are lower than the average for the OECD as a whole (see table B7 in part III). Per capita CO_2-emissions are also lower in Norway (see table B9 in part III). The main reason is that, in Norway, a very large proportion of the energy consumption is covered by electricity generated from hydropower. However, for the world as a whole, the per capita average is only half the average for Norway. NO_x-emissions per capita are higher in Norway than the average for OECD (see table B8 in part III). There are two main reasons for this; firstly the fact that a large share of the combustion in Norway takes place in gas turbines, and secondly the large amount of coastal

Figure 2.8. NO_x-emissions in 1991, by source. County



Sources: Statistics Norway and SFT

Figure 2.9. NMVOC-emissions in 1991, by source. County



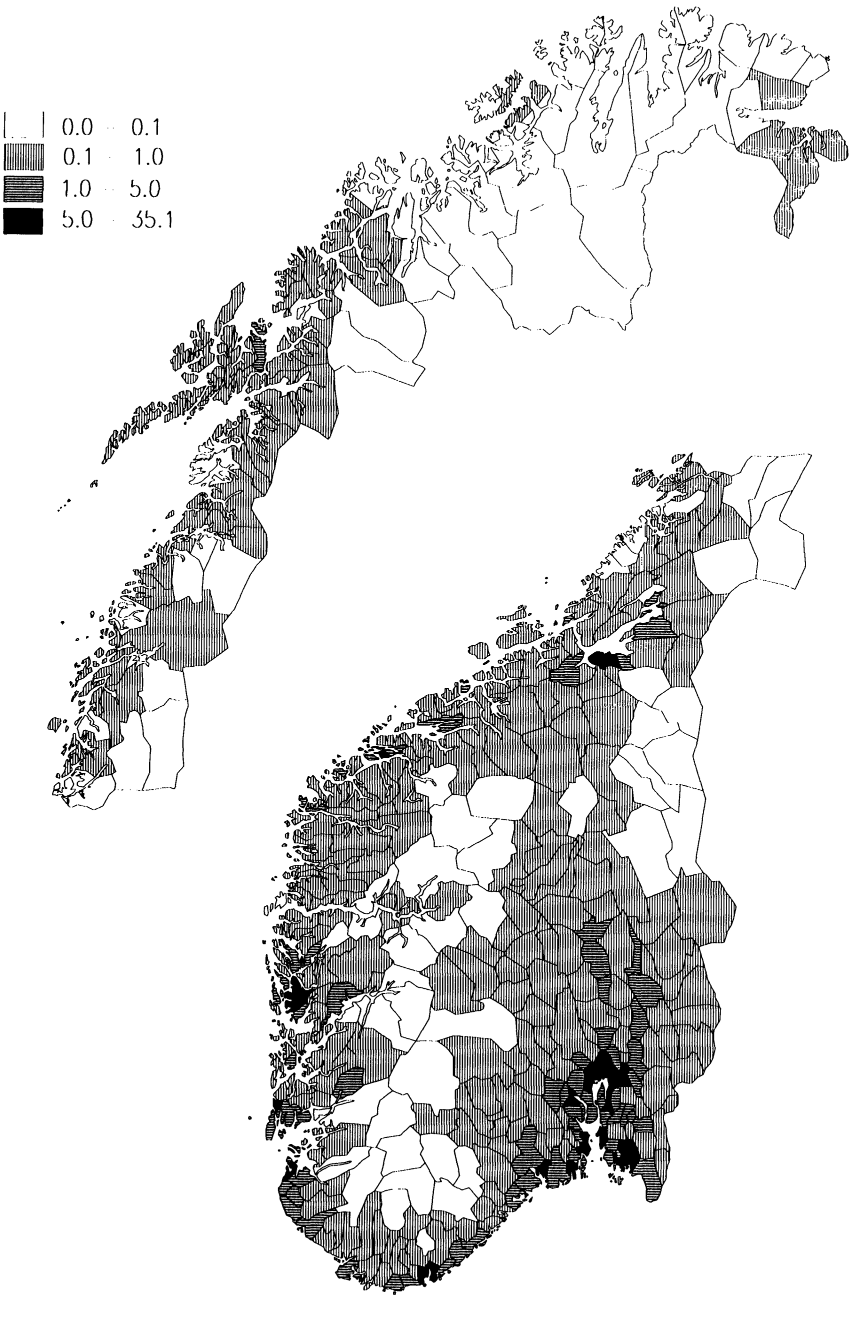
Sources: Statistics Norway and SFT

shipping. Both these sources lead to a high level of NO_x-emissions per unit of burned source of energy.

2.2 Regional emissions

On the Norwegian mainland, emissions of CO_2 are highest in Telemark (figure 2.7). Other counties with high levels are Hordaland, Rogaland and Nordland. In Hordaland and Rogaland the emissions originate primarily from oil refineries, while in Telemark and Nordland the main sources are emissions from metals industry, manufacture of fertilizer and production of cement. In addition are emissions from the petro-chemical industry in Telemark a large source. Emissions of CH_4 and NH_3 are highest in Rogaland, the main reason being double so high emissions from domestic animal husbandry and domestic animal manure than in most other counties. The coal mines on Svalbard constitute a large point source of emissions of CH_4. More than half the national emissions of N_2O come from commercial fertilizer manufacture in Telemark and Nordland. Østfold and Nordland are the counties with the largest emissions of SO_2 on the mainland (table B5 in part III), the main sources being the ferro-alloys and pulp and paper industries. In all counties the emissions of NO_x originate mainly from mobile sources of combustion (figure 2.8), and in Akershus, with the highest level of NO_x-emissions, mobile sources are

Figure 2.10. NO_x-emissions in 1991. Municipality. Tonnes per km²



Sources: Statistics Norway and SFT

responsible for 96 per cent. Nevertheless, emissions from industry imply that the counties of Rogaland, Telemark and Hordaland are also found among those with the highest levels of NO_x-emissions. Emissions of NMVOC (figure 2.9) are more than twice as high in Hordaland than in any other county, and originate mainly from industrial processes and loading and refining of oil. Road traffic is the dominating source of emissions of CO, with the greatest contribution from Akershus and Rogaland. The emmissions of particulates are highest in Akershus, Nord-Trøndelag og Sør-Trøndelag. The main sources being burning of wood for heating and road traffic.

CO_2-emission levels are higher in marine areas. Offshore sources account for more than a third of the total emissions in Norway (figure 2.7 and table B5 in part III). Stationary combustion on the oil fields and emissions from shipping account for respectively 51 and 47 per cent of the emissions from activity in marine areas. Marine areas also make the largest regional contribution to Norwegian emissions of SO_2, NO_x, NMVOC and particulates. Shipping is the main source of the emissions of SO_2, NO_x and particulates, but loading of oil from buoys at the oil fields is most important for emissions of NMVOC.

Among Norwegian municipalities, Oslo, Porsgrunn and Bergen had the largest emissions of NO_x in 1991. When the emissions are considered in terms of amount of NO_x-generated per km^2, then Porsgrunn and Stavanger head the list (see figure 2.10). Generally speaking, the emissions are largest per km^2 in municipalities with a high population density, and containing national highways. The largest NO_x-emissions per capita were recorded in Sørfold, Tysfjord and Porsgrunn, the main source being industrial processes. Some municipalities that have few inhabitants but contain national highways are also found high up on the list of municipalities with large emissions of NO_x per capita. Table B6 in part III shows emissions to air by municipality.

The regional figures *include* emissions in Norwegian territory from Norwegian ships and Norwegian aircraft engaged in international traffic, and foreign activities in Norway. The figures for national emission levels, however, *do not include* these emission sources. The methodology for calculating emissions to air is documented in Bang et al. (1993), Rypdal (1993) and Daasvatn et al. (1994).

Further information from: Kristin Rypdal, Trond Sandmo and Ketil Flugsrud (road traffic).

Literature:

Bang, J., E. Figenbaum, K. Flugsrud, S. Larsen, K. Rypdal and C. Torp (1993): - *Utslipp fra veitrafikk i Norge (Emissions from road traffic in Norway).* SFT-report No. 93/12. (Available also in English).

Daasvatn, L., K. Flugsrud, O. K. Hunnes and K. Rypdal (1994): Beregning av regionaliserte utslipp til luft (Estimates of emissions to air by region). To be published in Note Series, Statistics Norway, Oslo.

OECD (1993a): *OECD environmental data. Compendium 1993.* OECD, Paris.

OECD (1993b): Indicators for the integration of environmental concerns into energy policies. *Environmental monographs N°. 79.* OECD/GD (93) 133. Paris.

Rypdal, K., (1993): *Anthropogenic emissions of the greenhouse gases CO_2, CH_4 and N_2O in Norway.* Report 93/24. Statistics Norway, Oslo.

Sandnes, H., (1993): Calculated budgets for airborne acidifying components in Europe, 1985, 1987, 1988, 1989, 1990, 1991 and 1992. EMEP/MSC-W Report 1/93. Technical Report N°. 109. The Norwegian Meteorological Institute, Oslo, Norway.

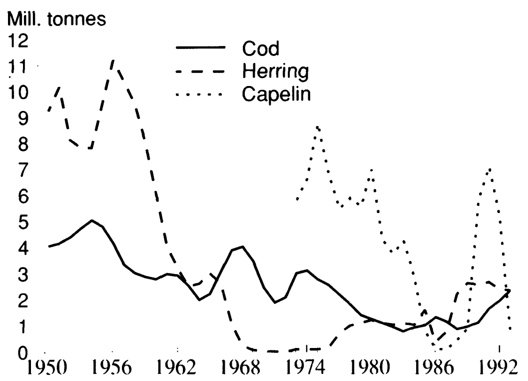
3. Fishing, sealing and whaling

The fisheries industry has undergone considerable rationalization since the 1930s. The number of fishermen has been reduced from about 120 000 to less than 30 000, and the vessels are now larger and fewer. The industry was dominated by the herring fisheries up to the end of the 1960s. Although capelin and other industrial fish species have accounted for the largest volume of the catch in recent years, cod fishing has been of greatest economic importance. The level of seal hunting and small whale hunting has been very low for a number of years.

Stock development

Norwegian spring spawning herring, Barents Sea capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Since the end of the 1960s, the stock sizes of all three species have reached historically low levels at times (figure 3.1). The stock of spring spawning herring was fished right down at the end of the 1960s. The capelin stock broke down in 1986/87, partly as a result of taxation, but also from natural causes. For cod, the stock size was low throughout the 1980s. In recent years, a positive development has been registered for both North-East Arctic cod and Norwegian spring spawning herring (table C1 in part III). The capelin stock increased rapidly after the breakdown in 1986/87, but is now at a very low level again.

Figure 3.1. Stock development for North-East Arctic cod[1], Norwegian spring spawning herring[2] and Barents Sea capelin[3]. 1950-1993. Million tonnes

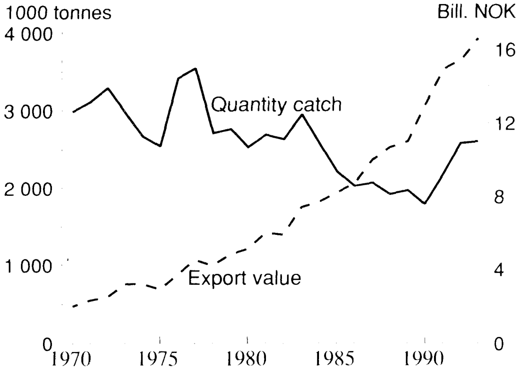


[1] Fish that are 3 years old or more. [2] Spawning stock.
[3] Fish that are 1 year old or more.
Sources: International Council for Exploration of the Sea (ICES) and Institute of Marine Research, Norway.

Catch and exports

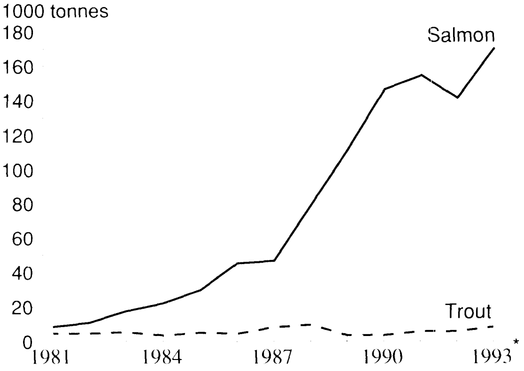
In 1993, the total catch (including crustaceans, molluscs and seaweed) in the Norwegian fisheries was 2.6 million tonnes (figure 3.2 and table C2 in part

Figure 3.2. Quantity of catch and export value. 1970-1993*. 1 000 tonnes and billion NOK



Sources: Statistics Norway and Directorate of Fisheries.

Figure 3.3. Rearing of fish. Slaughtered quantities of salmon and rainbow trout. 1981-1993*. 1 000 tonnes



Sources: Statistics Norway, Norwegian Fish Farmers' Association and Kontali AS.

III), with a first-hand value of NOK 6.0 billion. Exports of fish and fish products increased in 1993 to about 1.4 million tonnes with an export value of NOK 16.6 billion (figure 3.2). This quantity included exports of 131 000 tonnes of reared salmon with an export value of NOK 4.6 billion (table C5 in part III). The total export value of fish and fish products amounted to about 15 per cent of the total traditional export of commodities from Norway (i.e. commodity exports excluding crude oil, natural gas, ships and oil platforms).

Aquaculture

There has been a marked increase in production of reared fish since this activity was started in the early 1970s. The quantity of slaughtered salmon increased from 141 000 tonnes in 1992 to 170 000 tonnes in 1993 (figure 3.3). Trout production has remained fairly stable since 1980, and amounted to about 8 500 tonnes in 1993.

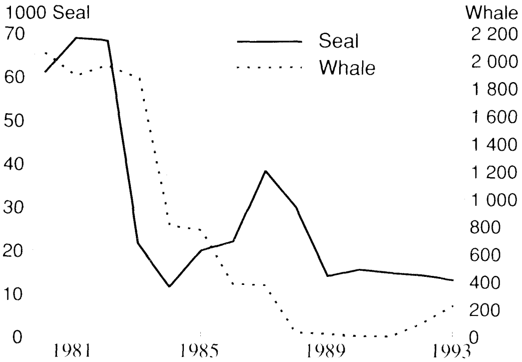
Sealing and whaling

Since 1983, Norwegian sealing has taken place mainly in the fields in the Jan Mayen area and the White Sea. The catch has been moderate, with a yield of about 10 000 - 40 000 animals per season (harp seal and hooded seal) (figure 3.4).

The Norwegian catch of small whales has consisted mainly of the baleen whale, the minke whale. Commercial whaling was discontinued after the 1987 season. The stock of minke whale in the North-East Atlantic was estimated to 86 700 individuals in 1989 (Schweder, Øien and Høst, 1993), which justifies whaling from a biological standpoint. The Norwegian authorities thus allowed a resumption of the traditional commercial whaling in 1993. During this season, 226 minke whales were caught out of a total quota of 296. Of this number, 157 whales were caught commercially.

Further information from: Frode Brunvoll.

Figure 3.4. Norwegian catches of seal and small whales[1]. 1980-1993



[1] During the period 1988-1992, catching for research purposes only.
Source: Directorate of Fisheries

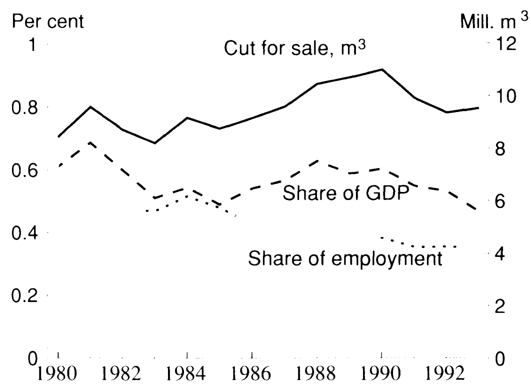
Literature:

Schweder, T., N. Øien and G. Høst (1993): Estimates of abundance of north-eastern Atlantic minke whales in 1989. Rep. Int. Whal. Commn. 43, 1993.

4. Forest

Norway has approximately 119 000 m^2 of forest, of which about 70 000 is productive forest. The productive forest area is distributed between about 125 000 forest properties. About 79 per cent of the productive forest is owned by private persons, and more than half the properties are operated in combination with agriculture. For hundreds of years Norwegian forests have been exploited intensively for export of roundwood, sawn timber and wood tar, and to produce charcoal. In addition, there is a long tradition of using the forests for domestic animal grazing and game hunting. Today, in economic terms, the forest is important first and foremost as a source of raw materials for the sawmilling and pulp and paper industries. The forest is also of major value for production of game species and as an area of recreation for a steadily more urbanized population.

Figure 4.1. Employment in forestry and share of GDP. Volume of roundwood cut for sale and industrial production 1980-1993*. Per cent and million m^3

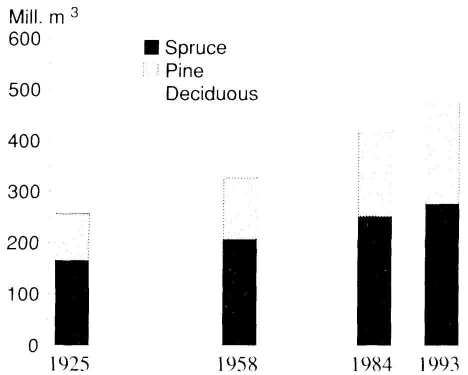


Source: Statistics Norway

Economic importance of forestry

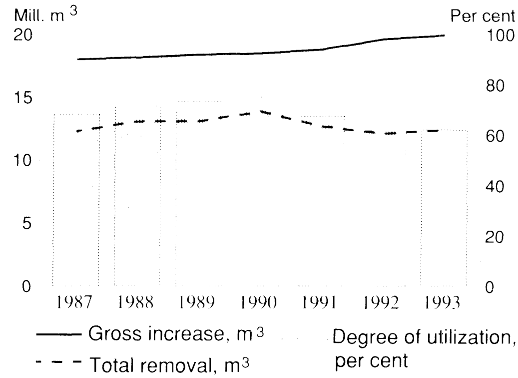
Employment in forestry (sawmilling and pulp and paper industry excluded), measured in terms of normal man-years for paid employees and self-employed persons, decreased from 9 400 man-years in 1979 to 6 100 man-years in 1993 (figure 4.1). Forestry thus accounted for 0.35 per cent of the total employment. Preliminary figures for 1993 show that 9.5 million m^3 was cut for sale and industrial production. This is an increase of about 2 per cent compared with the previous year, but the figure is still 13 per cent lower than in the peak year 1990. In spite of the increase of 2 per cent from the year before, lower prices led to a decrease in value of 13 per cent, from NOK 3.1 billion in 1992 to NOK 2.7 billion in 1993. Preliminary figures show that forestry accounted for 0.5 per cent

Figure 4.2. Cubic mass of forest according to the forest censuses in 1925, 1958 and 1984. Calculated cubic mass in 1993. Whole country. Million m³ without bark



Sources: Statistics Norway and Norwegian Institute of Land Inventory (NIJOS)

Figure 4.3. Gross increase, total removal and degree of utilization of cubic mass. Whole country. 1987-1993*. Million m³ and per cent



Source: Statistics Norway

of the Gross Domestic Product (GDP) in 1993.

Standing volume

The results of the forest censuses and calculations of the cubic mass show that the volume of standing forest increased by about 90 per cent from 1925 to 1993 (figure 4.2). The increase was particularly strong at the end of the period. An annual account of the cubic mass, *forest balance*, shows the calculated stock of timber at the beginning and end of the year, measured in terms of volume. The calculated forest balance for 1993 shows a standing cubic mass of forest of 596 million m^3 below the coniferous forest limit, calculated without bark, at the end of the year. This volume was distributed between 46 per cent spruce, 33 per cent pine and 21 per cent deciduous trees. In 1993 the *net increase* in cubic mass, not including bark, was 7.5 million m^3, or 1.3 per cent of the total cubic mass of standing forest (figure 4.3 and tables D1 and D2 in part III). The net increase was greatest for deciduous trees and pine.

The annual degree of utilization of forest resources can be calculated as the total annual amount of wood cut as a percentage of the gross increase in cubic mass. The annual degree of utilization decreased from 1990 to 1993, and was about 62 per cent in 1993.

A degree of utilization of less than 100 per cent leads to an increase in the cubic mass of forest, implying that a steadily increasing amount of CO_2 from the atmosphere is assimilated by trees. It is estimated that in 1993, 6.1 million tonnes of CO_2 was stored in trunks without bark, i.e. about 18 per cent of the country's anthropogenic emissions of CO_2. If carbon storage in bark, roots and other biomass is included, the forest is responsible for assimilating about twice this amount of CO_2.

Forest damage

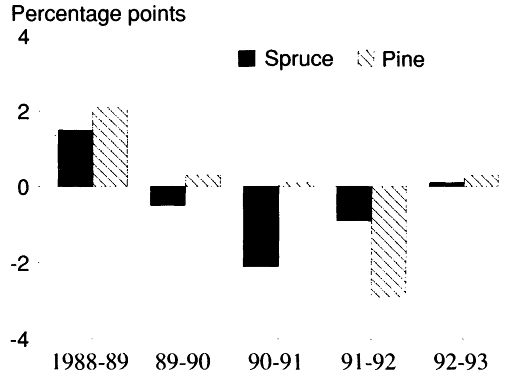
The results of the programme to monitor forest damage, recordings undertaken in nationally representative samples of forest in 1993 (Kvanmo and Sletnes,

1994) show forest health status for the country as a whole, measured in terms of average crown density and crown colour (tables D3 and D4 in part III). For spruce, the average crown density decreased from 85.1 per cent in 1989 to 81.7 per cent in 1993 (figure 4.4). The average crown density for pine remained around 86 per cent during the period 1989 to 1991, but decreased to 83.1 and 83.5 per cent in 1992 and 1993 respectively. In the case of pine, the decrease in the share of trees in the best crown density class sank by as much as 10.1 percentage points from 1991 to 1992. The crown colour of both spruce and pine has remained relatively stable, with only small annual variations during the period 1988 to 1993.

Since 1985 international cooperation has been established to record and monitor the effects of air pollution on forest. About 70 per cent of Europe's forest area is now covered by the investigations. About two-thirds of the surveyed trees were pine, spruce, silver fir, beech or oak. Experience from previous years shows that a defoliation of about 20 to 25 per cent does not necessarily indicate deteriorated health status, but can be regarded as a result of the natural adjustment of the trees to variations in climate and supply of nutrients. The results (CEE-UN/ECE, 1993) show, however, that 24 per cent of all the surveyed trees exhibited more than 25 per cent defoliation.

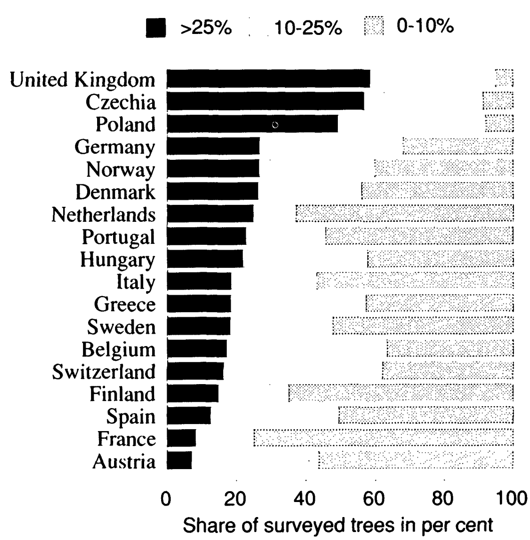
The results of the observations in the different countries show that the damage was particularly extensive in the United Kingdom, Poland and the earlier Czechoslovakia (figure 4.5). The main causes of the forest damage are presumed to be unfavourable weather, attacks by insects and fungi, forest fires and air pollution.

Figure 4.4. Annual variations in crown density of coniferous trees in Norway. 1988-1993. Percentage points



Source: Norwegian Institute of Land Inventory (NIJOS)

Figure 4.5. Distribution of surveyed trees by defoliation. All kinds of trees. Some European countries. 1992. Per cent



Source: CEE-UN/ECE 1993

Further information from: Ketil Flugsrud

Literature:

Kvanmo, H. and A. I. Sletnes (1994): *Rapport 1993. Program "Overvåking av skogens sunnhetstilstand" (Report 1993. Programme "Monitoring of Forest Health Status").* NIJOS Report 94/1. Norwegian Institute of Land Inventory (NIJOS), Ås. In Norwegian.

CEE-UN/ECE (1993): *Der Waldzustand in Europa. Ergebnisse der Erhebung 1992. Kurzbericht 1993.* Wirtschaftkommission der Vereinten Nationen für Europa - Kommission der Europäishcen Gemeinschaften. Brüssel - Genève.

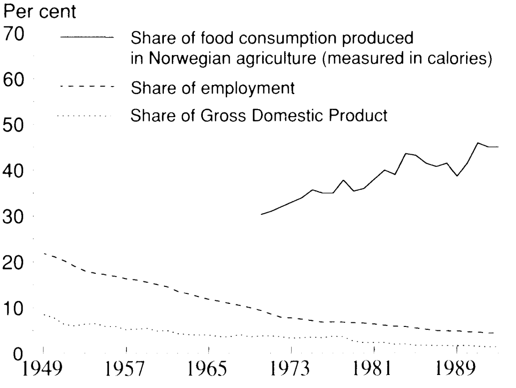
5. Agriculture

The importance of agriculture for the national economy has decreased in post-war years. Agriculture's share of total employment sank and of the Gross Domestic Product have decreased substantially, in spite of an increase in production. In 1992, agriculture accounted for 45 per cent of the anthropogenic inputs of nitrogen and 23 per cent of the inputs of phosphorus to the North Sea. The introduction of pollution-abatement measures in this sector indicate that the pollution from agriculture has decreased in recent years.

The importance of agriculture

In 1949, 21.8 per cent of the country's labour force was employed in agriculture. In 1993 the share had decreased to 4.3 per cent (figure 5.1). In absolute figures the number of normal man-years employed in agriculture decreased from about 300 000 in 1949 to about 75 000 in 1993. Agriculture's share of the Gross Domestic Product (GDP) has declined steadily in post-war years, from 8.5 per cent in 1949 to 1.7 per cent in 1993. For the period as a whole, this is about the same relative decrease as for employment. The share of the population's food consumption produced in Norwegian agriculture (measured in calories)

Figure 5.1. The importance of agriculture. Some indicators. Percentage of national figures. 1949-1993*



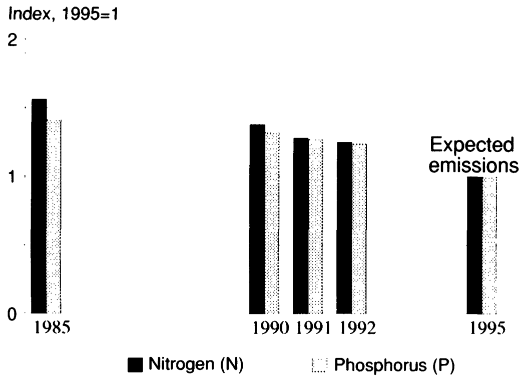
Source: Statistics Norway and National Nutrition Council

increased from 30 per cent in 1970 to 45 per cent in 1992 (The National Nutrition Council, 1993).

Pollution

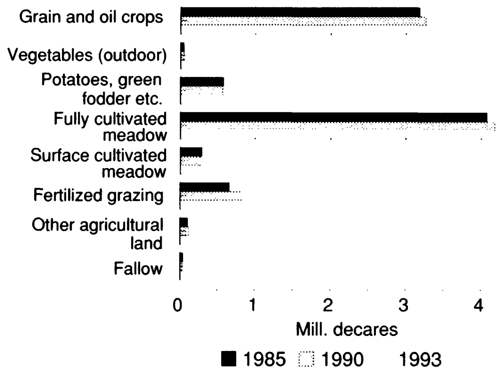
One of the most serious pollution problems caused by agriculture is the discharge of the nutrients nitrogen (N) and phosphorus (P) to water. Agriculture is also the source of extensive discharges of organic material, soil particles and various hazardous substances. Norway's anthropogenic inputs of nitrogen and phosphorus to the North Sea in 1992

Figure 5.2. Estimated discharges of N and P to the North Sea from agriculture in 1985 and 1990-1992 in relation to the expected emissions in 1995. Index



Source: SFT

Figure 5.3. Use of fully cultivated land. 1985, 1990 and 1993. Million decares



Source: Applications for production subsidies, Ministry of Agriculture

(runoff from county 01, Østfold, to county 10, Vest-Agder) were estimated to 23 000 tonnes nitrogen and 900 tonnes phosphorus (SFT). Of this amount, agriculture is responsible for 45 per cent of the inputs of nitrogen and 23 per cent of the inputs of phosphorus. Counties 01-10 are the Norwegian counties covered by the North Sea Treaty. This Treaty refers to the Ministerial Declaration of 1987, where the North Sea states decided, among other things, to half their discharges of nutrients by 1995, with 1985 as base year. Figure 5.2 shows the estimated inputs of N and P from agriculture seen in relation to the expected emissions of nutrients from agriculture in 1995. The sources of discharges of nutrients from agriculture can be traced to two types of sources; point discharges (leakages from fertilizer stores and silos) and diffuse discharges (area runoff). The calculations show that 90 per cent of the discharges are area runoff and 10 per cent come from point sources.

Land use

According to the figures stated in the applications for production subsidies, a total of 9.7 million decares of agricultural land was fully cultivated in 1993. About 4.9 million decares of this land drains into the North Sea (counties 01-10) (figure 5.3 and table E1 in the appendix). In 1993, 35.0 per cent of the cultivated land was used for grain production, while 44.7 per cent was fully cultivated meadow. There was a slight increase in the area of grain land and of fully cultivated meadow from 1985 to 1993, but a reduction in the amount of surface cultivated meadow. The area of fertilized grazing land in counties 01-10 has increased by as much as 45 per cent during the same period (table E1 in the appendix).

Soil preparation

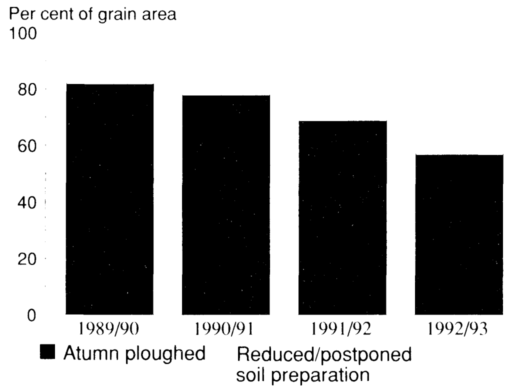
The share of autumn ploughed grain land decreased by 25 percentage points from autumn 1989 to autumn 1992, and was down to 57 per cent (figure 5.4 and table E2 in the appendix). The share of the grain land where *no soil preparation* (not even harrowing) took place in the autumn was 39 per cent. This share is expected to increase in autumn 1993. Less soil preparation in autumn leads to a marked reduction in soil erosion. The area used for autumn sown grain has increased from 108 000 decares in 1989/90 to 366 000 decares in 1992/93, and in the latter period accounted for about 10 per cent of the grain area. Prognoses from Statkorn for 1993/94 indicate a slight reduction in autumn sown grain area.

Fertilization

For the country as a whole sales of commercial fertilizer with phosphorus decreased by 40 per cent from 1985 to 1993, while sales of nitrogen fertilizer remained more or less the same. Seen in relation to the slight increase in the area of cultivated land during the period, this implies a considerable reduction in the average quantity of phosphorus fertilizer per decare, but about the same amount of fertilization with nitrogen. From 1989 to 1992, the sample censuses show a reduction in the share of meadow land with a very high or very low fertilization density, but a slight general increase in nitrogen fertilization of grain (figure 5.5).

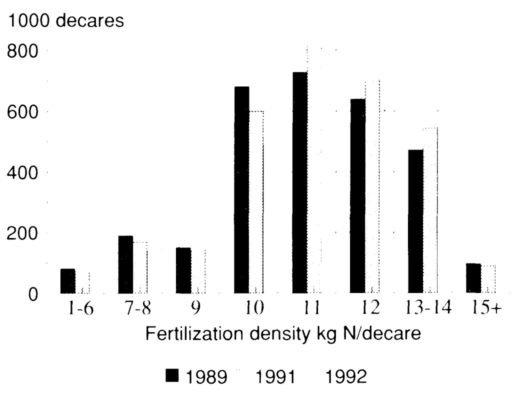
The number of domestic animals, and therefore the amount of manure, changed very little from 1985 to 1993. The amount of manure spread in the growing season, calculated in terms of nitrogen (N), increased from 80 per cent in 1989 to 85 per cent in 1992. The number of "surplus animal manure units" indicates the possible lack of spreading area for animal manure in relation to the requirements imposed by the authorities. The number of surplus animal manure units was reduced from 11 per cent of all animal manure units in 1985 to 8 per cent of all animal manure units in 1993

Figure 5.4. Autumn ploughed share of land used for grain and oil crops. 1989-1992. Per cent



Source: Statistics Norway

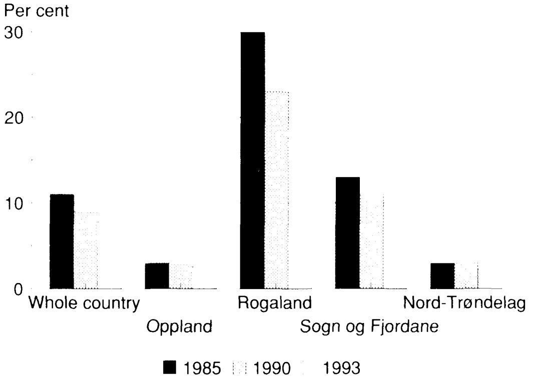
Figure 5.5. Area of land used for grain and oil crops by kg nitrogen (N) commercial fertilizer per decare. Counties 01-10. 1989, 1991 and 1992. 1 000 decares



Source: Statistics Norway

(figure 5.6 and table E3 in the appendix). There are large variations between counties. Reports from the county agricultural offices indicate that greater progress has been achieved in making local adjustments to the requirements concerning spreading area than shown by the calculations based on the applications for production subsidies.

Figure 5.6. Share of surplus animal manure units. Whole country and selected counties. 1985, 1990 and 1993. Per cent



Source: Statistics Norway

Further information from: Henning Høie

Literature:

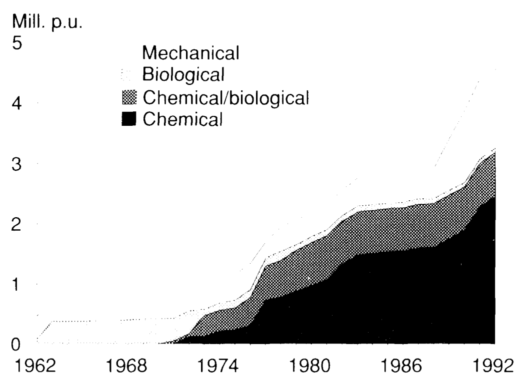
National Nutrition Council (1993): *Utvikling i norsk kosthold (Changes in the Norwegian diet).* National Nutrition Council, Oslo.

6. Waste water treatment plants

Statistics Norway and the State Pollution Control Authority (SFT) have jointly initiated annual registration of data from all waste water treatment plants in the country with a capacity of more than 50 population units (p.u.). The data are updated each year by the County Environmental Agencies. The registration includes information on size, purification principles, operation etc. From 1994 onwards the reporting will also include data on waste water from scattered settlements and comprehensive pollution accounting.

Most of the waste water treatment plants in Norway have been built during the last 30 years (figure 6.1). The earliest plants were based mainly on mechanical and/or biological purification processes. However, from the beginning of the 1970s it became more common to build plants with a chemical purification process for removal of phosphorus, and from the end of the 1970s a clear majority of the waste water treatment plants have included chemical and chemical/biological phases of purification. The main reason for the apparent increase in the purification capacity of the mechanical plants is a change in the definition of this type of plant.

Figure 6.1. Hydraulic capacity by purification principle. Norway. 1962-1992. Million p.u.



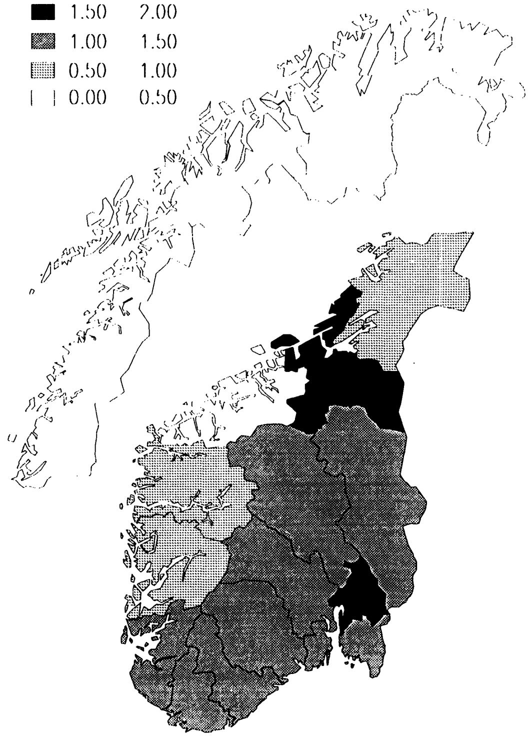
Source: Statistics Norway

In Eastern and Southern Norway a large share of the municipal waste water is purified in "high grade" plants (figure 6.2). These areas, as well as Sør-Trøndelag, are also the areas with the highest hydraulic capacity per inhabitant (figure 6.3). In Hordaland and northwards along the coast the greater part of the waste water is purified mechanically. Of a total of 1 680 waste water treatment plants in Norway, 13 have a hydraulic capacity of more than 50 000 p.u. These plants account for almost half the total registered

Figure 6.2. Hydraulic capacity distributed between mechanical and "high grade"waste water treatment plants. County. 1992

Source: Statistics Norway

Figure 6.3. Hydraulic capacity. County. 1992. P.u. per inhabitant



Source: Statistics Norway

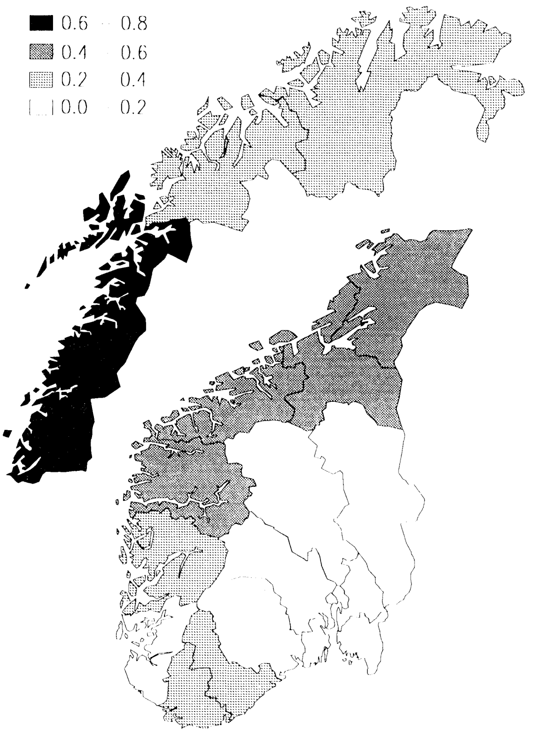
hydraulic capacity and load. Only 2 of these large plants are based on mechanical purification.

Phosphorus discharges from waste water treatment plants per connected p.u. reflect the effect of the high grade purification of the waste water in Eastern and Southern Norway (figure 6.4).

Discharge values for phosphorus and nitrogen are registered for waste water treatment plants which account for respectively 80 and 30 per cent of the total hydraulic load. The discharges from plants for which no analyses of phosphorus and nitrogen are available are calculated on the basis of information on hydraulic load and purification principle for each individual plant and data on water consumption and pollution quantities from SFT[1]. These calculations are associated with a high degree of uncertainty. Total discharges of phosphorus from the registered waste water treatment plants are calculated to 574 tonnes

[1]Water consumption is assumed to be 400 litres per person per day. The quantity of pollution per person per day is assumed to be 1.7 grammes for phosphorus and 12.0 grammes for nitrogen.

Figure 6.4. Discharges of phosphorus from waste water treatment plants. County. 1992. Kg per connected p.u.



Source: Statistics Norway

Table 6.1. Discharges of phosphorus (P) and nitrogen (N) from waste water treatment plants (tonnes) and the share of discharges calculated (per cent). County. 1992

County	P	Calculated	N	Calculated
Whole country	574	62	11 410	77
Østfold	8	22	762	100
Akershus	23	0	2 439	33
Oslo	8	8	750	1
Hedmark	5	4	508	98
Oppland	4	31	545	100
Buskerud	14	43	624	100
Vestfold	31	0	585	100
Telemark	16	54	524	100
Aust-Agder	17	1	211	100
Vest-Agder	35	87	397	71
Rogaland	66	90	1 236	100
Hordaland	77	96	685	82
Sogn og Fjordane	21	100	151	100
Møre og Romsdal	13	100	120	100
Sør-Trøndelag	154	48	1 170	100
Nord-Trøndelag	46	92	393	100
Nordland	13	57	115	45
Troms	13	97	140	100

Source: Statistics Norway

(table 6.1). The calculated quantity amounts to 62 per cent of this amount, with large variations between counties. The corresponding figures for nitrogen are 11 410 tonnes and 77 per cent.

Just over 80 000 tonnes of sludge from waste water treatment plants was reported as dealt with in 1992. Of this amount, as much as 66 per cent was used in agriculture (table 6.2). Almost a third of the registered sludge originated from the central waste water treatment plant in Akershus.

Table 6.2. Sludge from waste water treatment plants, by application. Norway. 1992. 1 000 tonnes dry matter

Total	81.6
Separate deposition	4.0
Landfills	19.5
Green areas	5.4
Agriculture	52.8

Source: Statistics Norway

Further information from: Arne Knut Ottestad and Bjørn-Vidar Grande.

Waste water treatment plants are traditionally grouped into three main categories, depending on purification principle: mechanical, chemical and biological. Some plants combine different basic forms of treatment.

Mechanical plants include sludge separators, screens, strainers, sand traps and sedimentation plants, and remove the largest particles from the waste water.

"High grade" plants are plants with a biological and/or chemical phase. The biological phase involves use of microorganisms to remove mainly easily degradable organic material. In chemical plants, various chemicals are added during the purification process in order to remove phosphorus. High grade plants are more effective than mechanical plants in reducing the amounts of the nutrient phosphorus and other pollutants.

Population equivalents (p.e.) means waste water from industry, institutions etc. converted into the quantity of waste water from an equivalent number of persons.

Population units (p.u.) means the number of permanent residents plus the number of population equivalents in a specific area.

Hydraulic capacity is the quantity of waste water a waste water treatment plant is designed to receive.

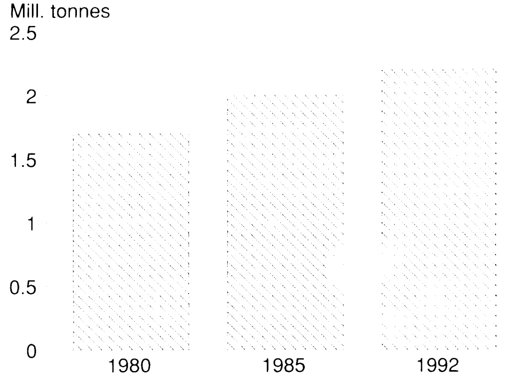
Hydraulic load is the quantity of waste water that a waste water treatment plant receives.

7. Waste

Waste represents a pollution problem and can be characterized as resources that have gone astray. The problems are connected to both existing and earlier management of waste.

The authorities have given high priority to the development of a system of annual statistics on waste and recycling of waste for the whole country. Statistics on municipal waste and industrial waste (waste from industrial activity and service activities) are elaborated by Statistics Norway in cooperation with the State Pollution Control Authority (SFT). In 1993, all Norwegian municipalities and waste management facilities supplied information on municipal waste and waste management. In the case of industrial waste, a comprehensive survey is to be conducted in 1994. With regard to hazardous waste, during the last few years SFT has undertaken nation-wide surveys of old waste disposal sites and A/S Norsk Spesialavfallselskap - NORSAS (Norwegian Hazardous Waste Corporation Ltd.), a company established specially to administer the management of hazardous waste in Norway, has registered the quantities of this waste delivered each year for disposal.

Figure 7.1. Total municipal waste. Norway. 1980, 1985 and 1992. Million tonnes



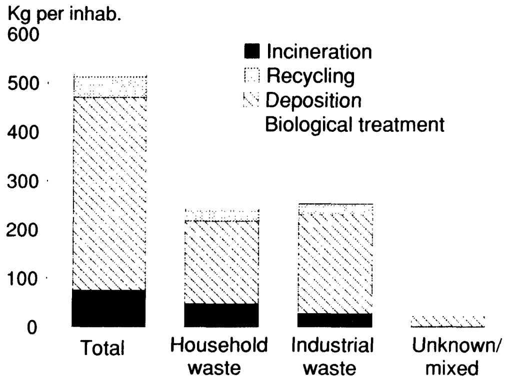
Source: Statistics Norway

7.1 Municipal waste

The term *municipal waste* is used to describe all waste dealt with by the municipal waste collection and management systems. A total of 2.2 million tonnes of municipal waste was collected in 1992. This is 0.2 million tonnes more than collected in 1985 (figure 7.1). Household waste accounted for 1.0 million tonnes of the municipal waste in 1992.

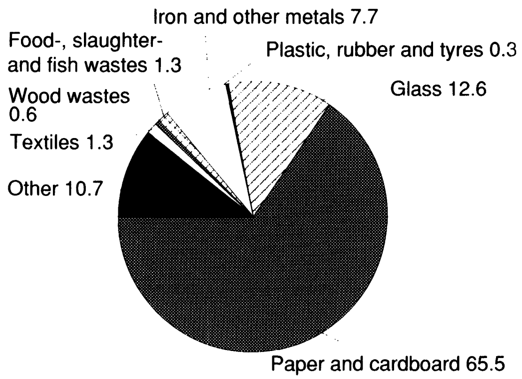
Only 8 per cent of the municipal waste was delivered for recycling of materials in 1992, while as much as 76 per cent

Figure 7.2. Treatment of municipal waste by type of waste. Norway. 1992. Kg per inhabitant



Source: Statistics Norway

Figure 7.3. Household waste delivered for recycling of materials, by material. Norway. 1992. Per cent



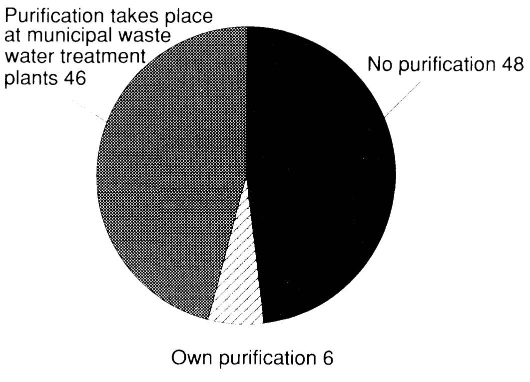
Source: Statistics Norway

was deposited on landfills (figure 7.2). The percentage recycled varies considerably from county to county. In terms of the share of the total quantity of municipal waste generated in the county, most waste was delivered for recycling in Vestfold and Vest-Agder, 22 and 19 per cent respectively. Manufacture of briquettes, or densified refuse derived fuels (D-RDF), explains the high percentage of waste recycled in Vestfold. In Finnmark, only 0.1 per cent of the municipal waste was delivered for recycling.

About three quarters of Norway's 439 municipalities collected waste for recycling of materials in 1992. Home composting has been organized in 55 municipalities, but only about 1 per cent of the households in these municipalities participated in the system.

Paper and cardboard accounted for 65 per cent of the household waste delivered for recycling in 1992 (figure 7.3). High percentages were also recorded for glass and for iron and other metals.

Figure 7.4. Municipal waste distributed according to treatment/no treatment of seepage. Norway. 1992. Percentage of the waste



Source: Statistics Norway

In 1992, about 50 per cent of the total quantity of municipal waste was received at municipal landfills with facilities for treating the seepage (figure 7.4). Treatment of seepage is undertaken mainly at large landfills.

7.2 Hazardous waste

Hazardous waste is waste which cannot be appropriately treated together with municipal waste because it can lead to serious pollution or risk of injury to persons or animals. Sites containing hazardous waste are ranked into five categories, depending on information on quantity and type of hazardous waste, degree of conflict with the surrounding environment and the need for follow-up investigations and measures:

Category 1: Sites requiring immediate investigations or measures.
Category 2*: The case is being considered by SFT.
Category 2: Need to be investigated.
Category 3: Need to be investigated in the event of any change of land use or recipient.
Category 4: No investigations needed.

Out of a total of 2 852 registered sites, hazardous waste has been found or is suspected to exist in 2 103 sites (Categories 1-3) (table 7.1). 33 per cent of these sites are municipal landfills, 26 per cent are industrial waste disposal sites and 28 per cent are defined as contaminated ground. Industrial or other commercial activities are responsible for most of the cases of disposal sites or contaminated ground suspected of containing hazardous waste. The percentage of the sites related to industry is highest in Categories 1 and 2*, dominated by the chemicals industry and metals manufacturing. The types of hazardous waste found in municipal landfills often originate from small and medium-sized enterprises, since in many cases the larger enterprises have established their own waste disposal sites. Probably, many sites with hazardous waste have still not been discovered.

Table 7.1. Landfills and contaminated ground containing hazardous waste, by category and type of site[1]. Norway. 1993

Type of site	Total	Category 1	2*	2	3	4
Total	2852	88	46	523	1446	749
Waste disposal sites						
Municipal	1041	13	1	154	536	337
Industrial	706	37	17	181	311	160
Other	622	18	8	84	261	251
Contaminated ground						
Industrial	449	26	22	103	297	1
Other	145	9	2	49	85	-
Waste disposal sites with contaminated ground	120	15	4	53	48	-

[1] In addition, 40 unranked sites in Finnmark
Source: SFT

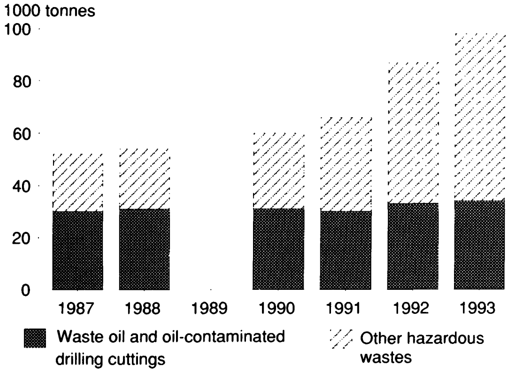
Table 7.2. Waste disposal sites and contaminated ground containing hazardous waste[1], by status as regards implementation of measures. Norway. 1993

	Measures not started	Investigation in progress	Measures in progress	Measures completed
Category 1	31	26	11	3
Category 2*	12	24	5	4

[1] Defence Establishment sites not included
Source: SFT

The results from the nation-wide registration of hazardous waste have provided a basis for preparing a plan of action to clean-up hazardous waste that has been deposited or discarded, as well as contaminated ground and contaminated sediments (SFT, 1992). The proposed

Figure 7.5. Delivered hazardous waste. Norway. 1987-1993. 1 000 tonnes



Sources: SFT and NORSAS

measures are intended to be implemented between now and the year 2000, and the goal is to reduce the risk of serious pollution from these sources to a minimum. For the sites given highest priority, work has already started to clean up 56 per cent of the sites in category 1 and 74 per cent of the sites in category 2* (table 7.2).

The quantity of hazardous waste *delivered* to approved systems for management of hazardous waste has increased in recent years (figure 7.5). The main reason for the increase is delivery of oil-contaminated drilling waste to recipient facilities in Western Norway.

Even though the quantity of hazardous waste is relatively small compared with the amount of municipal waste, hazardous waste represents a serious risk to the environment owing to the high concentrations of hazardous substances it contains.

Oily waste and oil-contaminated waste from drilling operations together comprise about 85 per cent of the total quantity of hazardous waste delivered to the system (table 7.3). Oil-contaminated waste from drilling operations includes oil-contaminated drilling cuttings from the petroleum activities. Even when waste from oil drilling operations is excluded, Hordaland and Rogaland are

Table 7.3. Delivered hazardous waste. Norway. 1993. Tonnes

1	Waste oil	34267
2.1	Oily waste from oil-water separators	10967
2.2	Oil-contaminated waste from drilling operations	36674
3	Oil emulsions	2051
4.1	Organic solvents containing halogen	202
4.2	Organic solvents without halogen	2820
5	Paint, glue, varnish and printer's ink	2821
6/7	Distillation residues and tars	407
8/9	Waste/batteries containing heavy metals	1245
10	Waste containing cyanide	33
11	Discarded pesticides	45
12	Waste containing PCBs	27
13	Isocyanates	22
14	Other organic wastes	1523
15	Strong acids	1535
16	Strong alkalis	267
17	Other inorganic wastes	3442
18	Aerosol containers	6
19	Laboratory waste	25
20	Unknown	1

Source: NORSAS

Table 7.4. Delivered quantities of hazardous waste by industry. Norway. 1993. 1 000 tonnes

Industry	Quantity
Not distributed by industry	1.7
Agriculture, forestry, hunting and fishing	0.2
Oil production and mining	43.0
Manufacturing industry	20.2
Electricity and water supply	1.5
Building and construction	2.6
Wholesale and retail trade, hotels and restaurants	9.5
Transportation, storage, post and telecommunications	6.4
Bank and finance, insurance, estate agents etc.	1.1
Public, social and private services	12.3

Source: NORSAS

among the counties delivering the largest quantities of hazardous waste.

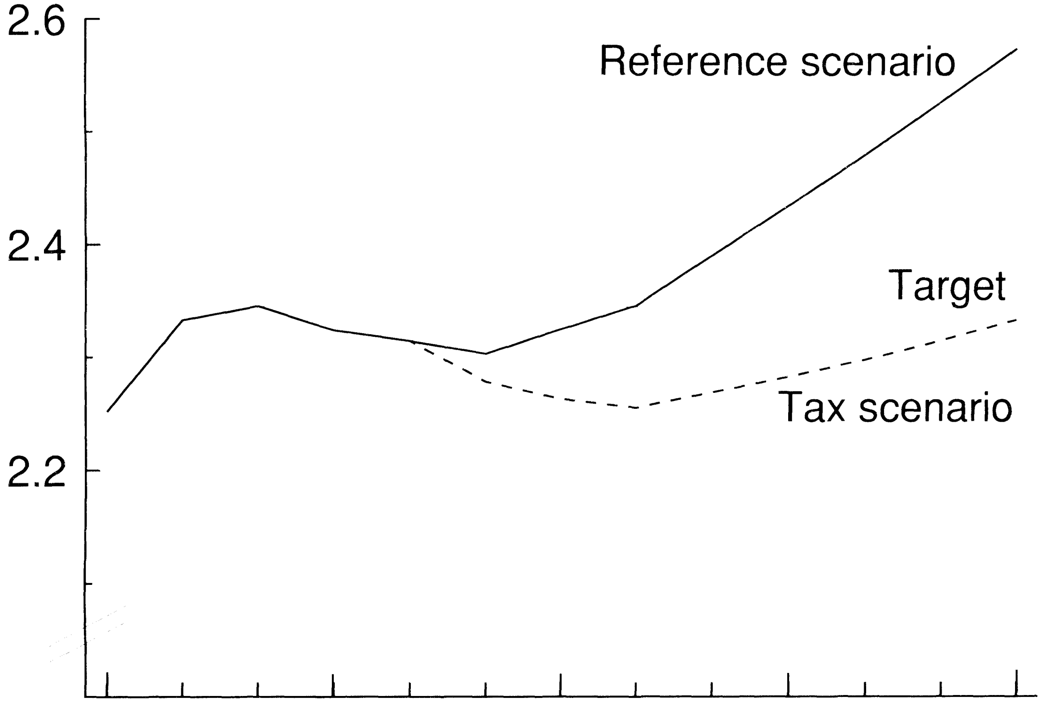
In 1993, 98 per cent of the hazardous waste could be distributed according to which types of industries or commercial enterprises delivered the waste. Oil extraction and mining accounted for the largest total deliveries. The figures were also high for manufacturing, wholesale and retail trade plus hotels and restaurants, and public and private services (table 7.4). When oily waste from drilling operations is excluded, the average amount of hazardous waste delivered by each company in 1993 was 5 700 kg. The average delivery varied considerably with the number of employees in the enterprise, and was much larger for large enterprises than for small ones.

Further information from: Astrid Busengdal (municipal waste), Ole Osvald Moss (hazardous waste) and Åse Kaurin (industrial waste).

Literature:

SFT (1992): *Deponier med spesialavfall, forurenset grunn og forurensede sedimenter. Handlingsplan for opprydding (Waste disposal sites with hazardous waste, contaminated ground and contaminated sediments. Clean-up plan).* Report 92:32, State Pollution Control Authority, Oslo. In Norwegian.

Part II Economic research on resources and the environment



Areas of research

1. Overview

The expanding economic activity since the industrial revolution has brought with it increasing pollution, encroachments into pristine nature, extermination of animal and plant species and exhaustion of scarce natural resources. In recent years, global environmental problems such as the greenhouse effect, and depletion of the ozone layer have become a cause of increasing concern. The economic research on resources and the environment in Statistics Norway focuses on the relationships between the environment and the economy. How does economic growth affect the environment and what are the costs of an impoverished natural environment? How should non-renewable resources be managed? Can environmental goods be priced in terms of money? These are some of the questions that are analysed. This chapter contains a summary of some of the research done at Statistics Norway in 1993.

In 1993, the work has consisted both of theoretical analyses and efforts to develop more practical tools to assist in the management of natural resources and the environment. It has concentrated mainly on conditions in Norway, but some of the themes also refer to Europe and more far-flung countries.

It is hoped that the knowledge obtained will be useful to political decision-makers and other participants in the public debate. Incorporating the knowledge into models is often an effective way of communicating the data to the decision-makers. If an increasing number of environmental conditions are included in the models used by the authorities, these conditions can be taken into account in the planning work in a way that would have otherwise been difficult to achieve. However, the models are inadequate as a means of informing the public. This publication has been prepared to inform a larger public about our activities. We wish to present a general picture of some important themes of study, and some results of our analyses in connection with the environment and resources.

First the different projects are placed in a broader framework. This overview is followed by a summary of the different projects, and the most important results, presented in the order they are referred to in the introduction. For a more detailed discussion of assumptions, methods and sources of data the reader is referred to the original publications, which are listed in the summaries.

In addition to the projects described here, various reports were also published in 1993 on work carried out in previous years. See the list of publications for further information.

1.1 The climate problem and energy consumption

Climate change is one of the most serious global environmental problem of our times. The main reason for the higher concentration of CO_2 in the world's atmosphere is the use of fossils as a source of energy. For this reason, Statistics Norway's work on the climate problem is closely connected to analyses of national and international energy markets. In 1993, analyses have been carried out of CO_2-taxes at national, regional and global level.

A CO_2-tax: A cheap way to finance public expenditure?

Statistics Norway has previously published studies of the effect of a CO_2-tax on the Norwegian economy and Norwegian emissions. An important point in many of these analyses is that a tax on CO_2 leads to reduced emissions of other pollutants as well, such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO) and particulates. While CO_2 is a greenhouse gas which contributes to possible anthropogenic changes in the global climate, SO_2, NO_x, CO and particulates are pollutants that cause harm to humans and damage to the environment and materials *near to* the site of the emissions. Therefore measures to reduce CO_2-emissions will also lead to local gains in the form of reduced harm to health and less damage to nature and materials.

Normally, a tax on goods and services leads to loss of efficiency in the economy. Therefore, the social cost of earning one more NOK, is often higher than one NOK. However, the report (2) referred to below shows that a tax on CO_2 may be a good way of financing public expenditure. One of the main conclusions is that, taking into account the local environmental gains obtained by reducing consumption of fossil fuels, the cost of obtaining an extra NOK is much *less* than one NOK when obtained by means of a tax on CO_2.

Are the CO_2-targets meaningful in an integrated energy market?

The different Nordic countries have different systems for generating electricity. Today, the Norwegian system consists entirely of hydropower; Sweden has a mixed system including hydropower, nuclear power and thermal power; while Denmark has a system based mainly on coal, but with some thermal power (thermal power plants where waste heat is used for district heating). The differences in investment and generation costs imply that increased trading in electricity between the Nordic countries can lead to more effective use of the existing power plants.

In (3), a Nordic electricity market model is used to analyse the effect of a Nordic CO_2-tax on the electricity markets and on emissions of CO_2 in the Nordic countries. If freer trading in electricity between the Nordic countries is permitted, it might well be more sensible for Norway to produce electricity based on natural gas, with the associated emissions, than for the other Nordic countries to expand their oil and coal-fired generation of electricity. Taking into account climate alone, it would obviously be even better if Norway were to develop as much hydropower as possible, but this would conflict with other environmental interests.

The effects of higher Nordic CO_2-taxes on the Norwegian electricity market are studied in (4). A macro-economic model is used in combination with a short-term production cooperation model for a Nordic and North German power system. Increased trade in electricity in the Nordic countries will imply that the Nordic electricity prices will vary in parallel. Since power production in other countries is based mainly on fossil fuels, the introduction of a CO_2-tax in the Nordic countries will lead to higher domestic prices of electricity. This raises the value of Norwegian hydropower.

Reports (3) and (4) study trading in electricity on an annual basis. In the model, producers and consumers adjust to prices that remain constant over a year, a week and a day. In a more realistic description of a market-based Nordic power system, the most important factors will be short-term variations in prices and short-term trading between the different countries. Report (5) describes a model for the Norwegian electricity market where prices vary over time. In this model, Norwegian electricity prices vary with the prices in other countries and the total utilization of capacity in the production system and the grid.

European climate policy, energy policy and acid rain

Power production is still a regulated industry in most European countries. For example, in many cases, coal is still used for thermal power production for political reasons. De-regulation of the power production could lead to increased use of natural gas in Europe. This would affect energy prices, energy consumption and pollution. The effects of a de-regulated European energy market have been studied by means of a European energy demand model developed by Statistics Norway.

In (6), this model is used to study the effects of EU's proposed carbon/energy tax. The taxes will not only affect energy consumption and CO_2-emissions in Western Europe, but also emissions, transportation and depositions of sulphur and nitrogen. This will reduce the need for costly measures to clean the emissions that cause widespread pollution damage.

Climate negotiations

Report (7) discusses negotiations concerning an international CO_2-treaty, and the effects of such a treaty if some countries *do not* participate. It sketches a scenario where a group of OECD countries cooperate to reduce emissions of greenhouse gases, and offer to pay non-participating countries to reduce their emissions. The report discusses what would be the opti-

Foto: Mittet Foto

mal policy for such a group. A model is also used to illustrate the possible effects on production and on CO_2-emissions.

Report (8) estimates the optimal CO_2-tax, based on the assumption that the damage caused by the enhanced greenhouse effect is connected either to the level of the concentration of CO_2 in the atmosphere, or to *changes* in the CO_2-concentration. The study explicitly takes into account the fact that fossil fuel is an exhaustible resource. The author discusses how the tax should vary over time given different assumptions, and how this will affect the rate of extraction of fossil fuels.

1.2 Traffic

Motor vehicle traffic is a source of considerable damage to the environment in our society, partly due to the associated emissions. In earlier reports Statistics Norway has tried to quantify the significance of changes in these emissions for people's health, see for example, Natural Resources and the Environment 1991. However, motor vehicle traffic has much more direct effects on people's health through the numerous accidents that occur in traffic every year. Report (9) assesses public health expenditures connected to traffic injuries to persons, and estimates the effect on the productivity of the labour force as a whole. Traffic injuries to persons lead to a loss of just over 23 000 man-years per year. The macroeconomic effects of injuries to persons are analysed.

If an attempt is to be made to reduce the negative effects of motor vehicle traffic it is important to understand the mechanisms behind people's purchase and use of cars. Report (10) studies to what extent Norwegian households' choice of car, and the number of cars, are determined by important economic variables such as income and prices.

Foto: Mittet Foto

Report (11) studies the effects of a possible CO_2-tax on the development path of motor vehicle traffic and other forms of transportation. The analyses have been conducted within a macro-economic model framework characterized by detailed modelling of production of, and demand for, transport and communication services.

1.3 Management of the environment and natural resources

Welfare, income and wealth

One interpretation of "sustainable development" is that coming generations must be ensured at least the same welfare as experienced by our generation. It is not stated, however, what conditions the term *welfare* should include. In Norway, *material* prosperity is closely linked to a high *level of income*. Large shares of this income come from utilization of natural resources such as forests, fish, hydropower, oil and gas. It should therefore be of interest to find out if this income can be maintained over time.

Today, the most commonly used measure of income is the *national product*. Many suggestions have been made for ways of correcting the national product with the aim of finding a better indicator of the level of *welfare* in society.

A standard definition of income, ascribed to the English economist John Hicks, is as follows: Income is the sum of money one can use in one year, for example, and be no worse off at the end of the year than one was at the beginning. Report (12) discusses whether such a definition is a reasonable indicator of welfare in society, and whether correcting the national product for deterioration of the environment can be justified on this basis.

Report (13) discusses possibilities of correcting the national product for activities intended to protect us against pollution and other loads caused by unfortunate social development. It is concluded that such corrections should *not* be made.

The value of the petroleum wealth
Income from export of oil and natural gas is important for the Norwegian economy. In this connection, it is of interest to calculate the value of the wealth of Norwegian petroleum resources. One of the factors determining the value of the wealth is the future pattern of development. What rate of extraction will be most profitable for society depends on

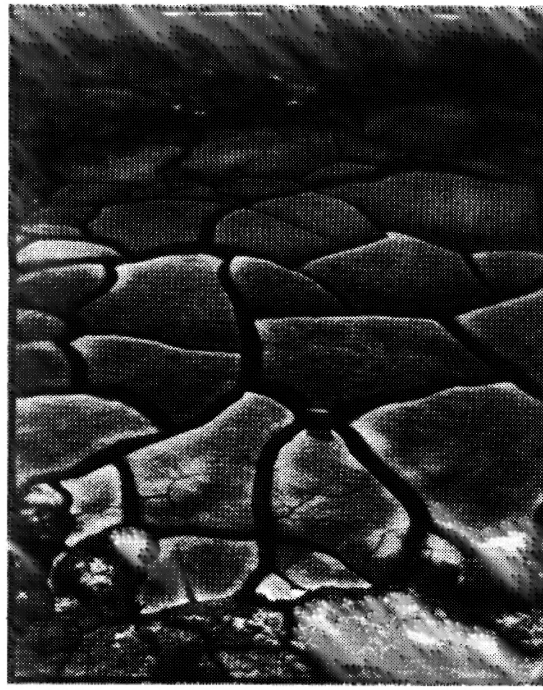


Foto: Mittet Foto

such factors as trends in future prices and costs, the resource base and evaluations where the welfare of the present generation is weighed against that of future generations. Little is known about these factors as yet. Report (14) shows briefly how the estimates of the gas and petroleum wealth have changed over the years. The main reason for the relatively large variations in the estimates is changes in price expectations.

Erosion and the value of soil
In many developing countries soil erosion is a major economic problem. In this context, soil can be regarded as an exhaustible natural resource, and assistance to these countries should help to ensure sustainable management of these natural resources.

Report (15) studies conditions in Nicaragua, and the implications of soil erosion for economic growth in a developing country where the economy is dominated by agricultural production. An important element of the study was the use of a macro-economic model to calculate the value of the soil for the economy as a whole. The model also describes how soil erosion affects other sectors of the economy in addition to agriculture. In (16) the soil wealth in Tanzania is estimated by means of a model for the country's agricultural sector. Both (15) and (16) conclude that erosion and "soil mining" represent a substantial economic loss to the individual developing country.

1.4 Pricing environmental goods

Natural resources such as oil and gas are sold in markets. This provides important information about the value of the resources. Normally, market prices are lacking for *environmental goods* such as pure air and clean water. The value of environmental goods is often estimated by means of surveys of *willingness to pay*. That is to say, questionnaire surveys where the interview objects are asked to estimate their own willingness to pay for a measure which would lead, for example, to cleaner air. The sum of the individual willingness to pay is often interpreted as the social benefit of the measure. In cost-benefit analyses it is often concluded that the measure is socially welfare-improving if the willingness to pay exceeds the cost of the measure. This way of aggregating costs and benefits does not take into account *who* wins or loses if the measure is effected. The ethical aspects of evaluating measures in this way are discussed in (17).

Foto: Mittet Foto

Do willingness-to-pay surveys favour the environmentalists?

Surveys of individual willingness to pay are often used to include goods that are not sold in markets in a cost-benefit analysis. However, report (18) points to a problem connected to analyses of this kind. The problem arises if conflicts of interest exist between different groups in society, and is connected to the aggregation that takes place when an indication of society's willingness to pay is derived from individual responses. Report (18) points to the importance of the *units* used to estimate the willingness to pay: monetary units such as kroner (NOK), or some form of "environmental unit", for instance, percentage improvement of air quality. If people are asked whether they are prepared to pay for a 50 per cent improvement of air quality, the willingness to pay is stated in monetary units. If the question is reversed, however, and they are asked how large a percentage improvement in air quality they would demand if they were asked to pay 100 NOK for instance, then the willingness to pay is defined in terms of "environmental quality units".

Report (18) shows that environmentalists, that is to say, groups that place a high value on environmental goods, will be favoured when society's willingness to pay is measured in monetary units, while those who are not so concerned about nature will gain when the willingness to pay survey is based on "environmental quality units". Calculations show that this effect can be considerable. The users of this information should note that the apparently unproblematic choice of measuring unit could be of major significance for which interest groups are weighted, or favoured, in the aggregation.

1.5 Environment and economic growth

Sustainability is closely connected to how one chooses to distribute goods, for instance natural resources, over time (between generations). Up to now, most of Statistics Norway's models have been more or less static models that have not taken into account the dynamic aspect of environmental and resource problems. Report (19) presents a new macro-economic model which explicitly deals with the dynamic aspect. The model also takes into account that a more polluted environment reduces people's capacity for work and the lifetime of materials. Moreover, a poor environment reduces general well-being. The model can be said to provide an alternative approach to the problem of value setting, since it quantifies the negative impacts of poor environmental quality on production of goods and services. It also estimates the welfare effect of changes in the environment, given different assumption of what "welfare" means.

Report (20) discusses the link between the environmental policy and economic growth from a more theoretical angle. It has been found that in economies that are very dependent on the status of the environment and resources, as in many developing countries, better management of natural resources and the environment will not necessarily lead to a *permanently* higher rate of economic growth. This is because measures to protect the environment will not be sufficiently effective in the long run.

Analyses in 1993

The climate problem and energy consumption

2. What does it cost to raise taxes?

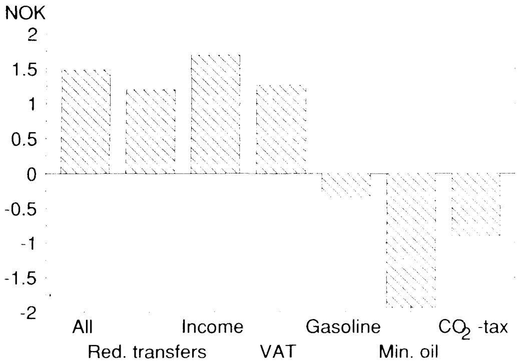
Public activities are financed to a large degree through duties and taxes. Normally, taxes on goods and services in a society leads to loss of efficiency in the economy. Therefore the social costs connected to obtaining one extra krone (NOK), often amount to more than one NOK (or any other monetary unit used in the model). However, the cost of raising the taxes varies, depending on which taxes and duties are altered. Environmental taxes in particular will be an effective form of taxation for obtaining revenue for public expenditures.

In many cases, higher taxes or duties will lead to an economy that functions less effectively than before the taxes were raised. However, environmental taxes and certain other taxes and duties help, for instance, to reduce pollution and other environmental problems. These problems impose costs on the economy in the form of adverse effects on health and damage to materials and the nature. Therefore, environmental taxes can help to make the economy function more effectively, or result in other effects (for example an improvement in air quality) which the households regard as desirable.

Information about what it costs to increase taxes is important when analyzing tax reforms, and can be obtained, for example, from analyses based on models which describe how the Norwegian economy works. If the assumptions on which the model is based are reasonable, the analysis will provide an indication of the cost to society of raising the level of various taxes and duties. The MSG-model (Multi-Sectoral Growth Model - an applied general equilibrium model of the Norwegian economy), developed at Statistics Norway, assumes that, when taxes are increased, households and enterprises change their pattern of behaviour. In the model, how much less of a good one can buy when its price is raised is determined on the basis of historic experience of price increases. The model also takes into account that production and consumption pollute the environment.

Figure 2.1 shows some results from analyses of what it costs to increase taxes, based on the MSG-model (see Brendemoen and Vennemo (1993a,b) for a more detailed presentation of assumptions and

Figure 2.1. Cost of increasing taxes and duties by one NOK



results). The model assumes that a tax or duty is increased by one NOK. If the economy functions just as effectively after the increase, then this tax increase costs the households exactly one NOK. If the economy functions less effectively, however, the increase in the tax costs more than one NOK.

We see that heavy tax items such as higher income tax and increased VAT or transfers lead to reduced efficiency in the economy. The same applies if all taxes are increased by the same percentage.

On the other hand, if we increase the tax on gasoline and the tax on mineral oils, or introduce a tax on CO_2 itself[1], the economy works more effectively and/or other gains occur which the households consider to be just as valuable as income. This is because, by increasing these taxes, polluting input factors become more expensive and people therefore use less of them. This reduces the load on the environment, and also accidents and other traffic problems.

The social costs connected to increases in the different taxes and duties can vary considerably. For example, the model indicates that the total cost of raising income tax is NOK 1.70 for the first NOK of the increased revenue from income tax. But if the tax on mineral oil is increased, then the economy gains NOK 1.94 for the first NOK of the increased revenue from taxes. A tax on gasoline and a tax on CO_2 also give gains. It is unlikely that every NOK of the increased revenue from environmental taxes will produce the same gain as the first one. However, the figures provide an argument for increasing the tax on fossil sources of energy and reducing income tax.

Project personnel: Anne Brendemoen and Haakon Vennemo

Project documentation: Brendemoen, A. and H. Vennemo (1993a): "The marginal cost of funds in the presence of external effects". Discussion papers No. 99, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway (NORAS - Norwegian Council for Applied Social Science Research) through the research programme on taxation.

References:

Brendemoen A. and H. Vennemo (1993b): "Hva koster det å øke skattene?" (What does it cost to increase taxes?). Økonomiske Analyser 8/93, 22-28. (In Norwegian).

[1] An ideal CO_2-tax is a tax where all goods containing CO_2 are taxed equally in relation to their CO_2-content. The present CO_2-tax does not satisfy this requirement.

3. Electricity trading and emissions of CO_2 in the Nordic countries

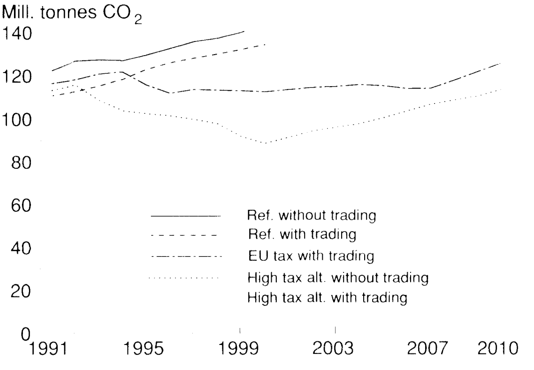
Coordination of electricity generation in the Nordic countries through effective trading in electricity can lead to a more cost-effective reduction of Nordic CO_2-emissions than would be achieved by national measures and no trading in electricity. This has been demonstrated using a Nordic energy market model which describes supply and demand for different types of energy in the Nordic countries.

Although the Nordic countries[1] have co-operated for many years on exchange of electricity there is little integration as yet of these countries' markets. However, the question of integration and trading has become more relevant in the light of the policy on climate, the deregulation of the Norwegian electricity market and the planned deregulation of the electricity market in Sweden. It is well known in connection with the efforts to meet the targets for reductions in CO_2-emissions that such problems are solved ineffectively when measures are introduced by individual countries independently.

Statistics Norway has developed a partial equilibrium model of the Nordic electricity market, integrating the interaction between the demand for electricity and consumption of heating oils. In the model, the countries are linked by a transmission grid, implying that electricity can be traded at a specified cost of transmission. Non-discriminating third party access to the transmission and distribution networks is assumed. The power generation technology is different for existing

[1]Iceland is not included in the model. The energy market in Iceland cannot be integrated easily into the Nordic energy market.

Figure 3.1. Emissions of CO_2 in the Nordic countries, given different tax regimes. Million tonnes CO_2



and new capacity. The available technologies in the model are hydropower, wind energy, nuclear power and conventional thermal power. Consumers and producers maximize utility and profit respectively. This leads to cost-effective solutions, where electricity is generated as cheaply as possible and the customers pay the same price, corrected for differences in cost of transmission.

Three different tax scenarios are analysed. In scenario 1, the reference scenario, the effective rates of taxes on fuel and on final consumption of electricity are kept constant at 1991 level. In scenario 2, (the EU scenario), the national tax rates are replaced by a tax on CO_2 itself, at the level proposed by the EU commission (NOK 138 per tonne CO_2 in year 2000). In scenario 3, the high tax scenario, the tax is increased up to NOK 350 per tonne CO_2 in year 2000. All three scenarios are simulated with trading in electricity, while the reference scenario and the high tax scenario are also simulated with no trading in electricity. For practical reasons the reference scenario is simulated up to the year 2000, where-as the horizon for the other alternatives is the year 2010.

In the EU-scenario, total emissions of CO_2 in the Nordic countries increase from about 117 million tonnes in 1991 to 125 million tonnes in year 2010. In year 2000, however, the emissions in this scenario are as low as 112 million tonnes. Although this alternative leads to a clear reduction of emissions in relation to the refenrece scenario, there is no stabilization of emissions. The figure shows, however, that a further rise in the level of taxation up to the level described in the high tax scenario is more than sufficient to achieve stabilization. If trading in electricity is blocked, the high tax alternative leads to substantially higher emissions. The emissions then become almost equal to those produced in the EU-scenario given trading in electricity, but in the EU-scenario the costs are much lower. Therefore, trading in electricity between the Nordic countries makes it possible to reduce emissions of CO_2 more cost-effectively than if trading does not take place.

The reduction in emissions is achieved mainly because generation of electricity in the Nordic countries becomes less polluting. Norwegian hydropower, and in several countries including Norway, power generated using natural gas, are expanded as a substitute for coal-fired or oil-fired thermal power. It is assumed that the nuclear power is maintained. If the nuclear power is scaled down before the year 2010, this will make it even more necessary to expand the conventional thermal power, and to develop alternative technologies more rapidly.

Project personnel: E. Gjelsvik, T. Johnsen, H. T. Mysen and B. H. Vatne.

Project documentation: Gjelsvik, E., T. Johnsen and B. H. Vatne (1994): "Nordisk energimarkedsmodell med handel". (Nordic energy market model, with trading). (In Norwegian). Published in the series: Nordic seminar and working reports from the Nordic Council of Ministers.

Project financed by: Nordic Council of Ministers.

4. An international tax on CO_2, effects on the electricity market and emissions in Norway

In an open electricity market, where electricity can be exported and imported freely, a higher tax on CO_2 in other countries could lead to higher electricity prices in Norway. An international tax on CO_2, combined with trading in electricity could imply that heating oil would be cheaper than electricity for heating purposes in Norway. This is because, in other countries, generation of electricity is based to a large extent on coal, and CO_2-emissions per unit of energy from combustion of coal are relatively high compared with CO_2-emissions from combustion of heating oils. Moreover, more energy units of coal are required than energy units of heating oil to produce heat equivalent to that produced by one kWh of electricity. This means that, per unit of energy, a tax on CO_2 has a stronger impact on electricity generated in coal-fired plants than on oil used directly for heating.

Norwegian electricity production is based almost 100 per cent on hydropower. Therefore, a CO_2-tax in Norway alone will not affect the price of electricity in this country directly, but only indirectly, since alternative sources of energy such as heating oil become more expensive. The tax on CO_2 will increase the price of fossil fuels more than the price of electricity. This will reduce consumption of oil products and thus also Norwegian emissions of CO_2.

The situation is different in our neighbouring countries. While, in Denmark, electricity generation plants are coal or oil-fired, Sweden and Finland have some hydropower plants and some nuclear power plants. Germany generates a large amount of thermal power based on fossil fuels and nuclear power, but has little hydropower. In these countries a tax on CO_2 will lead to higher prices of electricity. The price of the fossil fuels used directly for heating purposes will also rise.

If more trading in electricity between the countries is allowed, there is reason to believe that the prices of electricity in the different countries will vary more in parallel than they do today. In particular, an international tax on CO_2 will cause a rise in the price of electricity in Norway. CO_2-emissions from combustion of coal are higher than from combustion of oil or kerosene. In addition, the energy loss in coal-fired power production is greater than in residential heating based on oil and kerosene. Therefore, a CO_2-tax combined with free trade in electricity will, in isolation, make it more favourable to use oil and kerosene for heating purposes in Norway, and this will lead to an increase in emissions of CO_2.

However, the higher *price of energy* will also lead to reduced *total* energy consumption, and this will help to reduce CO_2-emissions. Finally, changes in energy prices will affect the growth potential to varying degrees in the different sectors of the economy. This will also affect emissions of CO_2. A model-type analysis is necessary to study the total effect of an international tax on CO_2 in a situation where electricity can be traded freely across national boundaries.

Table 4.1. Table 4.1. Estimate of thermal power costs abroad[1] (Denmark) with different CO_2-taxes. 1992 prices

	Costs other than fuel costs øre/kWh		Tax NOK/tonne CO_2	Fuel efficiency	Total costs, øre/kWh	
	Fixed	Variable			Low	High
Existing coal-fired power plants	0	3	75	0.35	20	35
	0	3	150	0.35	27	42
	0	3	350	0.35	45	60
New coal-fired power plants	15	1	75	0.44	30	42
	15	1	150	0.44	35	47
	15	1	350	0.44	49	62
New gas-fired power plants	10	1	75	0.50	21	32
	10	1	150	0.50	23	35
	10	1	350	0.50	31	42

[1] Period of use 6000 hours and interest rate 7 per cent. The fuel costs for coal and gas before tax are fixed at 10 NOK/GJ (low alternative) and 25 NOK/GJ (high alternative).

Important elements of such an analysis are assumptions about what it costs to produce electricity abroad. Table 4.1 shows assumptions for thermal power generation abroad (Denmark) and coal and gas-fired thermal power given three different CO_2-taxes and two assumptions of gas and coal prices. The table shows the costs at existing and new coal-fired plants, and at a new gas-fired plant. The fixed costs at the existing coal-fired plant are independent of whether the plant is operated or not, and are therefore fixed at 0. For the new thermal power plants, all costs are included.

The effects of CO_2-taxes on production, trade and use of electricity, and on emissions of CO_2 in Norway, have been studied by means of two models; Statistics Norway's macro-economic equilibrium model MSG-EE (Multi-Sectoral Growth - Energy and Environment) and the NVE's (Norwegian Watercourses and Energy Administration) operation simulation model (production cooperation model) for the power systems in the Nordic countries and Northern Germany.

The three tax levels in table 4.1 correspond to the three alternative calculations in the model. The horizon is the year 2010. In the *reference scenario* it is assumed that the CO_2-tax in Norway remains at today's level (NOK 150 per tonne CO_2) up to the year 2010, and that the CO_2-tax in other countries is raised to about 50 per cent of the Norwegian tax over the same period of time. The *harmonized tax scenario* considers the effect of harmonizing the Norwegian and the foreign taxes on CO_2 (reducing the tax in Norway and increasing the tax abroad) in 1993, and afterwards increasing the taxes at the same rate up to the year 2000, when it is assumed that the tax has reached the level of the Norwegian tax prior to harmonization. In the *high tax scenario* it is assumed that, through the period 1993-2000, the CO_2-tax is increased both in Norway and abroad, but most rapidly abroad, so that, from the year 2000, the taxes at home and abroad are the same. The tax is further increased from NOK 200 per tonne CO_2 in the year 2000 to NOK 350 per tonne CO_2 in the year 2010.

The calculations assume that the price of coal, like the price of crude oil, remains constant at NOK 10 per GJ during the simulation period. The price of natural gas is also assumed to remain constant throughout the simulation period, at a gas price of 90 øre/Sm^3 or NOK 25 per GJ. A higher price of coal and/or lower price of gas will make new gas power more attractive than existing coal-based power, also with lower taxes on CO_2.

The results of the calculations show that the price of electricity becomes higher in

Table 4.2. Percentage change from the reference scenario in the year 2010. Norway

	Harmonization scenario	High tax scenario
Export of electricity	343	1144
Hydro power development	3	10
Electricity consumption	-1.5	-5.3
Consumption of fossil fuel	0.7	-7.0

Table 4.3. Changes in CO_2-emissions in relation to reference scenario. Year 2010. Million tonnes

	Harmonization scenario	High tax scenario
Norway	0.1	-0.5
Abroad	-5.0	-16.5
Net effect	-4.9	-17.0

the harmonized tax and high tax scenarios than in the reference scenario, see table 4.2. This makes it more profitable to export power from Norway, given these scenarios. Lower electricity consumption in Norway also leads to increased export. In the harmonized tax scenario the export is estimated to 7.1 TWh, and in the high tax scenario to 19.9 TWh in the year 2010; much higher than the level of 1.6 TWh in the reference scenario.

Increased export becomes possible with increased generation of electricity and lower domestic consumption. In the harmonized tax scenario the generation capacity of Norwegian hydropower is 3 per cent (3.5 TWh) higher in the year 2010 than in the reference scenario. In the high tax scenario the capacity reaches a level that is 10 per cent higher than in the reference scenario by the year 2010. In the harmonized tax and high tax scenarios the price of electricity in Norway increases in relation to the price of fossil fuel for heating purposes (heating oil/kerosene), because it becomes more expensive to produce electricity abroad with a higher tax on CO_2 (and because the CO_2-tax has less impact on the price of oil for direct use). A higher price for electricity turns the energy consumption away from use of electricity to use of heating oil and kerosene. At the same time, total energy consumption is reduced because of the higher price of energy in general.

The changes in domestic emissions of CO_2 are relatively small, and to all intents and purposes follow changes in the consumption of fossil fuels, see table 4.3. The biggest effect is seen in the high tax scenario, where domestic emissions of CO_2 from stationary sources are 0.5 million tonnes lower than in the reference scenario. At first sight it may seem surprising that such a high tax on CO_2 as simulated in the high tax scenario leads to such small reductions in emissions. It must be remembered, however, that, with a tax on CO_2, the price of electricity increases more than the price of fossil fuels. A higher relative price of electricity and a higher total price for energy pull in opposite directions. The reason why the emissions in Norway become reduced at all in the high tax scenario is that the effect of a higher price of energy, leading to a lower total energy consumption, is slightly stronger than the effect of the higher price of electricity.

The changes in CO_2-emissions abroad are much stronger than in Norway. In the harmonized tax scenario the CO_2-emissions abroad are 5 million tonnes lower in the year 2010 than in the reference scenario. In the high tax scenario, export of electricity helps to make the CO_2-emissions abroad 16.5 million tonnes lower than in the reference scenario in the year 2010.

Project personnel: Thore Jarlset (NVE), Tor Arnt Johnsen and Bodil Merethe Larsen.

Project documentation: Jarlset, T., T. A. Johnsen and B. M. Larsen (1993): "Skatt på CO_2-utslipp i Norden. Virkninger for norsk krafteksport og bruk av olje til oppvarming i Norge" (A tax on CO_2-emissions in the Nordic countries. Effects on Norwegian exports of electricity and use of oil for heating in Norway). *Økonomiske Analyser 7/93.* (In Norwegian).

NOE (1993): "Fossile brenslers plass i det norske energimarked" (The place of fossil fuels in the Norwegian energy market). Report from the Ministry of Industry and Energy 27.09.1993. (In Norwegian).

Project financed by: Ministry of Energy and Industry, Norwegian Petroleum Institute and Ministry of Environment.

5. Variations in demand for electricity and in electricity prices over the year

The demand for electricity varies in the course of the day, the week and the year, depending on variations in temperature, 24-hour rhythms, fluctuations in the economy and other conditions. It is costly to start and stop thermal power plants. Therefore, in the countries that use thermal power (based on coal and gas), variations in demand will mean varying costs of production. In a free market, this leads to varying prices. If the production capacity is to be utilized fully, prices should vary over a day and a week in a hydropower system too. Over the year, the price of electricity should vary with flow of water to the reservoirs. If the Norwegian hydropower system is interconnected to thermal power systems abroad, the alternative value of Norwegian power will vary in step with the prices abroad.

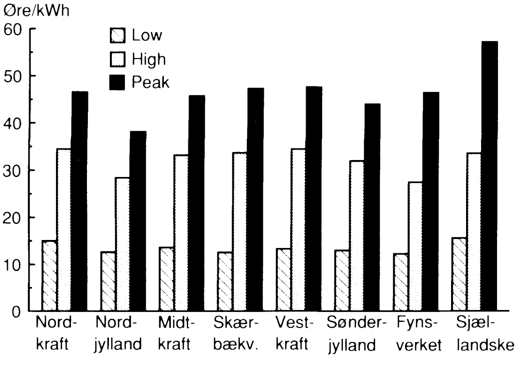
In this project, a simulation model is being developed for the Norwegian energy market where electricity prices vary over a year, a week and a day as a function of variations in demand and in flow of water to the reservoirs in Norway, and as a result of changes in prices abroad. When the model has been fully developed it can be used to study variations in equilibrium prices during each period, based on existing capacities and the cost of expanding capacity.

In Norway, hydropower generation can be regulated up or down easily, in step with variations in demand. Today, there is considerable surplus capacity in the Norwegian power system at certain times, e.g. even in periods of the day with peak load, see Vognild (1992). Some of the Norwegian hydropower is sold on a short-term or spot market. The price of spot power in Norway varies over the year as a result of variations in supply and demand in this market. The decision of the power producers to sell or not to sell in this market is based to a large degree on an evaluation of the value of the water at any time. The water value is the cost of storing one unit of water for later use, or the alternative cost of using water for hydropower generation today instead of tomorrow. The water value is typically low in periods with full reservoirs.

Up to now, electricity from Norway to other countries has been exported on a short term basis (exchange). After the deregulation of the Norwegian market in 1991, sellers of Norwegian electricity have become more interested in obtaining long-term contracts for delivery to other countries. The price represents the alternative value of the electricity produced in Norway.

The Swedish and Danish markets are still regulated, however. This means, for one thing, that Norwegian electricity suppliers cannot offer electricity to buyers in these countries *directly*. Therefore, for the time being, any export of electricity from Norway takes place to power companies, mainly Vattenfall in Sweden and Elsam in Denmark. Deregulation of the electricity markets in Sweden and Denmark would give Norwegian sellers greater opportunity to sell power also to local power plants or to final consumers in these countries. This could mean that Norwegian suppliers would achieve higher export prices than obtained at

Figure 5.1. Wholesale prices on the electricity market in Denmark. 1992. Danish øre/kWh



present. It looks as though the Swedish energy market may be deregulated in 1995. Possible deregulation in Denmark is dependent on developments within EU, and at the moment it seems that deregulation is improbable within the Union in the immediate future.

Figure 5.1. shows that, in many regions of Denmark, the difference between peak and off-peak price is more than 30 øre/kWh. The tariffs in the figure refer to gross sales and can theoretically include shadow prices of transmission capacity. Tariffs for electricity supplied from the power station show about the same variation as the prices in figure 5.1, see Konkurrensrådet (1993).

Today, a large share of Norwegian purchasers of power are offered electricity at a constant price over a day, week and year. This means that the users are not presented with the alternative cost (in the form of spot price/export price) when they use the electricity. This leads to ineffective adjustment, where the price is not the same as the marginal cost. Up to now, time-of-use prices in the electricity market have been obstructed by high administrative fees and costly metering technologies. The purchasers have estimated the cost of installing meters capable of dealing with time-of-use prices to be greater than the gains to be achieved by offering electricity to customers at a more correct price in the short term.

Two conditions will help to change this situation in the long term. Firstly, the large variations in electricity prices at power station cause an increase in the loss incurred by not offering electricity to consumers at the correct price. Secondly, the cost of metering equipment is decreasing. Technological advances have led to steadily better systems being offered in the market. Two-way meters are already being installed in Norway. So far these are most relevant for commercial users but, as time goes on, it is expected that households will also be connected up to these systems.

In order to study trends in the electricity market as a result of increased use of time-of-use prices, work has been done in 1993 on developing a simulation model where the year is divided into three periods: weeks 1-18, weeks 19-40 and weeks 41-52. Each of these three periods is divided in turn into a peak and an off-peak period. The peak load period covers periods of the week when the demand is at its highest, i.e. during daytime and on weekdays. The off-peak period covers night-time and weekends. At the moment, the model includes 35 production sectors that demand electricity. Based on various data sources we have distributed the power consumption of these sectors between the six periods. Prices were established for each sector during each period. In the first version of the model, the price sensitivity within and between the different time periods has not been estimated on the basis of historical data. It may be relevant to do this at a later stage of the project. For example, the effects on the demand for electricity and on power generation in Norway can be studied on the assumption that the equilibrium prices in Norway should be the same as electricity prices abroad, corrected for transmission costs.

Project personnel: Tor Arnt Johnsen and Bodil Merethe Larsen

Project documentation: Johnsen, T. A. and B. M. Larsen (1993): "Electricity market model with disaggregated time structure", project memorandum, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway, through the research programme Economy and Ecology, "SAMMEN" Project.

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Vognild, I. H. (1992): "Effektutveksling med utlandet" (Exchange of power with other countries". (In Norwegian).

Konkurrensrådet (1993): *Undersøgelse av energiområdet* (Investigation of the energy sector). Konkurrensrådet (Price Regulation Board), Copenhagen. (In Danish).

6. Energy policy, climate-related measures and acid rain in Western Europe

The carbon/energy tax proposed by the EU will be doubly beneficial; it will lead to a reduction in emissions of carbon dioxide (CO_2) in Europe, and also to reduced emissions of other pollutants such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x). The carbon/energy tax can thus make it cheaper to reach the emission targets for SO_2 and NO_x, as defined in international agreements such as the Helsinki and Sophia protocols. In addition, a carbon/energy tax will make it more costly to maintain the present regulation of the energy sector. Deregulation of power production in Western Europe will make it easier to realize all the objectives (for CO_2-emissions, and for SO_2- and NO_x-emissions) than if power production is regulated, as it is today.

Combustion of fossil fuels leads to emissions to air of the greenhouse gas CO_2, and of SO_2 and NO_x, which lead to acid rain and associated problems in large parts of Europe. With today's technology it is possible to clean the sulphur and nitrogen emissions by means of post-installed technical cleaning equipment, but this cannot be done for CO_2.

Most European countries have signed international agreements to limit SO_2- and NO_x-emissions. The goal, as defined in the so-called Helsinki Protocol, is to reduce SO_2-emission by 30 per cent by 1993, with 1980 as base year. In the Sophia Protocol, the goal is to stabilize emissions of NO_x at the 1987 level. Both these protocols are, or soon will be, a matter for renegotiation. In addition, the EU has proposed that CO_2-emissions should be stabilized at the 1990 level by the year 2000 and in this connection has also proposed a combined carbon/energy tax.

Since SO_2- and NO_x-emissions are also reduced as a result of CO_2-abatement measures, it is of some consequence in which order the measures are introduced, i.e whether the CO_2-abatement measures or the measures to reduce acid rain are introduced first. It will be far more costly to achieve the goals if measures to clean sulphur and nitrogen emissions in accordance with the protocols are introduced first, and a carbon/energy tax is introduced later. In other words, if technical measures to reduce SO_2 and NO_x are introduced before a CO_2-tax is imposed on use of fossil fuels, this implies that the emission targets for the three gases will be achieved at much greater cost than necessary.

The benefits of a carbon/energy tax have been studied by means of the energy demand model SEEM (Sectoral European Energy Model), developed by Statistics Norway, and by a model called RAINS (Regional Acidification Information and Simulation Model) developed by the International Institute for Applied Systems Analysis (IIASA).

SEEM is used to determine the pathway for the demand for coal, oil and gas in six sectors in each of nine Western European countries; the "big four" (Germany (West), Great Britain, France and Italy) and the four Nordic countries (Sweden, Denmark, Finland and Norway). These countries accounted for approximately 80 per cent of the energy consumption in OECD Europe in 1989. The base year for the simulations is 1988, and the horizon is the year 2000. We consider the envisaged trend in energy consumption without the introduction of EU's carbon/energy tax (*reference scenario*) and the trend if such a tax is imposed as from 1993 (*tax scenario*). SEEM is used to estimate CO_2-emissions in the two scenarios. Based on the pathways obtained from SEEM, the RAINS model calculates emissions of SO_2 and NO_x in the European countries. Furthermore, given energy consumption and emissions in the two scenarios, RAINS also estimates how much it will cost in the form of cleaning technology to achieve the emission targets for SO_2 and NO_x.

In the SEEM model the demand for the different kinds of fuel is highly dependent on fuel prices and therefore taxes, and on economic growth. The price of electricity is determined in the model. It is assumed in the first place that power production takes place in accordance with each country's official plans, since the energy markets in Western Europe are influenced to a large degree by national regulations.

The reference scenario assumes moderate economic growth during the first half of the 1990s and stronger growth towards the turn of the century. It also assumes a very low relative increase in the import price of coal (0.18 per cent annual increase), while the corresponding prices for oil and gas are assumed to increase by about 2 per cent annually during the period.

These and other assumptions are identical in the reference scenario and the tax scenario. In other words, we have ignored the possibility that the EU-tax, which is intended to be revenue neutral, will affect total economic growth and the price of fossil fuels prior to tax. The carbon/energy tax proposed by the EU Commission is superimposed on the existing tax on energy. It is intended to consist of two components, one based on the carbon content and the other on the energy content of the fuel. In our analysis we have assumed that the carbon and the energy component each account for 50 per cent of the tax. In the tax scenario the EU tax is phased in as from 1993, and is assumed to increase by one dollar per year from a level corresponding to 3 dollars per barrel of oil in 1993 to 10

Figure 6.1. CO_2-emissions in the reference and the tax scenario. Billion tonnes CO_2

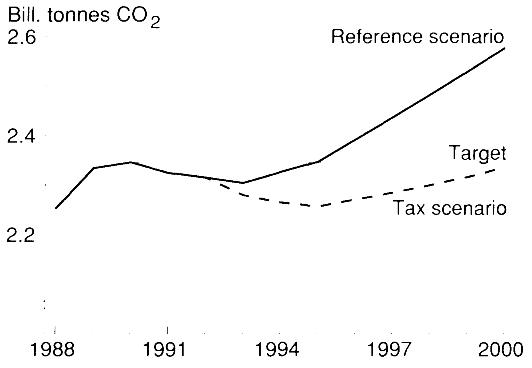
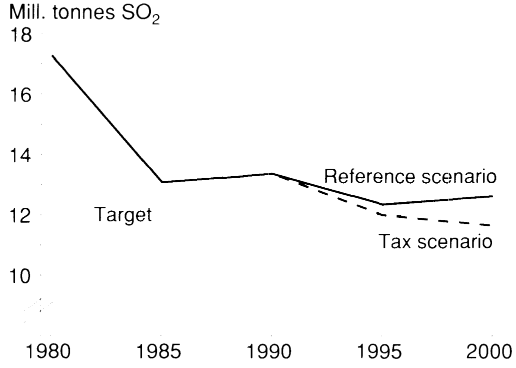


Figure 6.2. SO_2-emissions in the reference and the tax scenario. Million tonnes SO_2



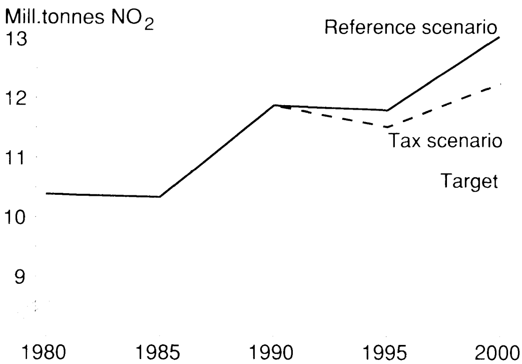
dollars (1993 prices) per barrel of oil at the turn of the century.

Figure 6.1 shows the simulated emissions of CO_2 for the model countries as a whole, with and without the EU tax. In the reference scenario the CO_2 emissions accelerate rapidly towards the turn of the century. In the year 2000, the emission level is 10 per cent higher than the level in 1990, i.e. 10 per cent above the stabilization target. The increased emissions are associated with increased economic growth, and one of the main sources is generation of thermal power based on natural gas and oil. The introduction of EU's carbon/energy tax reduces use of all sources of energy. The associated reduction in emissions is just sufficient to meet the target of CO_2 stabilization target by the year 2000. However, in the tax scenario, CO_2-emissions show a rising trend at the turn of the century. If the stabilization target is to be maintained in the long term, the EU tax will have to be raised also beyond the year 2000.

Figure 6.2 indicates a six per cent decrease in emissions of SO_2 from 1990 to year 2000 in the reference scenario. This reduction takes place in spite of an increase in consumption of fossil fuels during the period. This is because oil consumption decreases in countries with relatively high consumption of sulphurous heavy oils and increases in countries which use mainly lighter oils with a lower content of sulphur. In the tax scenario, the emissions are 7.4 per cent lower than in the reference scenario in the year 2000, and are therefore lower than the target. The main reason is emission reductions in the thermal power and industrial sectors, since the tax leades to reduced use of brown coal and heavy oil in these sectors.

Figure 6.3 indicates that, in the reference scenario, the increase in NO_X-emissions follow about the same path as for emissions of CO_2. The carbon/energy tax does not reduce NO_X-emissions enough to achieve the stabilization target. The reduction of 6.4 per cent from the level in the year 2000, as shown in the reference scenario, is less than half of what is required. This is connected to the already high tax on fuel for road transport, implying that a carbon/energy tax

Figure 6.3. NO_x-emissions in the reference and the tax scenario. Million tonnes NO_2



will lead to a relatively small change in the prices of fuel. Furthermore, in the transportation sector there are few possibilities of changing from gasoline and diesel to other forms of fuel.

The RAINS model gives cost figures for various technological emission-abatement measures with a given energy consumption. According to RAINS, reducing NO_x-emissions from the reference scenario level in the year 2000 to the emission target level will cost about 4.1 billion 1991-DM annually. When the EU tax is introduced, these costs are more than *halved*, to 1.7 billion 1985-DM. In the case of SO_2-emissions, the EU tax implies that the emission target can be met without introducing cleaning technology.

The above results are based on the assumption that, to all intents and purposes, thermal power production takes places in accordance with the official plans. However, if the energy producers are permitted to produce energy by the cheapest method, that is to say, with the cheapest fuels, the emissions will be further reduced. In the case of CO_2 and NO_x, deregulation alone would lead to a reduction of about 3 per cent, while SO_2-emissions would be reduced by as much as 13 per cent. Deregulation of thermal energy production would lead to cheaper electricity. This would tend to increase power production and thereby emissions but, in spite of this, a change from polluting and relatively costly thermal power based on coal to cheaper and cleaner gas-based thermal power production would lead to a reduction of total emissions, and therefore also of the cost of necessary cleaning.

Project personnel: Knut H. Alfsen, Hugo Birkeland, Eystein Gjelsvik and Morten Aaserud.

Project documentation: Alfsen, K. H., H. Birkelund and M. Aaserud (1993): "Secondary Benefits of the EC Carbon/Energy Tax", Discussion Papers No. 104, Statistics Norway, Oslo.

Project financed by: Ministry of Environment

7. Coalitions and international CO_2-agreements

An international agreement to restrict emissions of CO_2 can be very difficult to achieve. For this reason, it may be useful to study the effects of a CO_2-treaty that is not signed by all countries in the world. With such an agreement, the participants, in addition to reducing their own emissions, may be interested in paying non-participating countries to introduce measures to reduce their emissions. The optimal strategy with regard to emissions and side payments is derived for the cooperating countries over a horizon of more than 200 years. A treaty signed by the OECD countries only will be of limited significan-

ce, but will obviously be better in a global context than no treaty at all.

Most of the studies that try to quantify the costs and benefit of international abatement of CO_2-emissions assume that all countries sign an international CO_2-treaty. Experience both from the conference on Environment and Development in Rio de Janeiro and from the theory concerning stable coalitions[1] of countries under international environmental agreements, indicates that it will probably be very difficult to get all countries to participate in an agreement to restrict global emissions of CO_2. There is a possibility, however, that a group of countries (a coalition) could sign an agreement, and in addition, by means of side payments, make it profitable for non-cooperating countries to introduce emission-abatement measures.

Some relevant questions are then; what is the optimal strategy for the coalition, what is the global loss when all countries do not participate, and how is the coalition's choice of abatement level affected by the number of countries that are committed to the cooperation?

It is assumed that a group of OECD countries have committed themselves to cooperating to reduce CO_2-emissions. The cooperating countries (the coalition) decide how much CO_2 they will emit, and offer non-participating countries transfers of money if they restrict emissions to defined levels. The reduction of emissions will reduce the accumulation of CO_2 in the atmosphere, and thus also the global warming. It is assumed that an increase in global warming will have an adverse effect on the economy in the form of costs connected to a rise in the ocean level, adverse effects on health, desertification, changes in agriculture, changed water supply, etc. The cooperating countries thus face two trade-offs: (1) increasing their own current emissions increases production and consequently the potential for consumption today, but reduces the prospective standard of living, because of global warming. (2) paying the non-cooperating countries to reduce their emissions reduces the coalition's current potential for consumption but, on the other hand, the emission reductions in the non-cooperating countries will reduce climate change, which will contribute to higher consumption and a higher standard of living in the future.

The coalition chooses emission reductions and side payments to give maximum welfare to the cooperating countries. The welfare at any time is assumed to depend on consumption. Increased production leads to higher consumption, while increased global warming has a negative effect on consumption. In the evaluation of welfare, current consump-

Table 7.1. The different coalition regimes

	Regime 1	Regime 2	Regime 3	Socio-economic optimum
Regions in the coalition	EU ROECD	USA EU ROECD	EU ROECD	USA EU ROECD EX-USSR China India Rest
Regions to be compensated	USA EX-USSR China India Rest	EX-USSR China India Rest	USA EX-USSR China India	

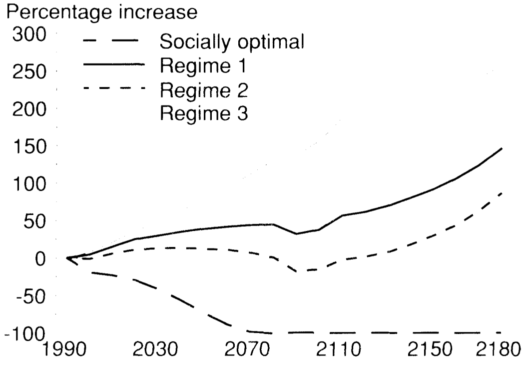
[1]A stable coalition is a coalition which no country finds it profitable to leave. Nor do the countries that are not members of the coalition want to join it.

tion weighs heavier than consumption in the future, but the model takes into account consumption within a period with a horizon of more than 200 years. The model is based mainly on production data from OECD's GREEN model (Burniaux et al. (1992) and damage data from Fankhauser (1992).

In the model the world is divided into the following regions: USA, EU, the rest of OECD (ROECD), the earlier Soviet Union (Ex-USSR), China, India and the rest of the world (REST). Table 7.1 shows the different coalition regimes that have been analysed. Under regimes 1 and 2, side payments are offered to all the non-cooperating countries, while under regime 3, this offer is made to the largest countries only (REST does not receive any side payments).

The analysis shows that even if a limited CO_2-treaty might have a significant influence on CO_2-emissions and therefore also on the economy in the long term, it will not meet the recommendations by international conferences such as the Toronto conference in 1988 and the Rio conference in 1990 (see figure 7.1). The Toronto conference recommended an

Figure 7.1. Global CO_2-emissions relative to 1990 level. Percentage increase



emission reduction of 20 per cent with 1988 as base year. The Rio conference recommended stabilizing emissions at 1990 level. However, the most likely alternative to a limited treaty seems to be a breakdown of international negotiations, leading to high emissions and considerable damage in the long term. Therefore a treaty signed by only a group of countries will still be important, and side payments to countries outside the coalition can be kept within politically acceptable limits, which would make such a measure politically feasible.

Including the USA in the coalition will have relatively little influence on climate change in the long term, despite the fact that, today, USA accounts for almost 25 per cent of the global emissions of CO_2. This is because of the potential increase in emissions from developing countries, especially China. Therefore, even if a limited treaty between a group of countries is an important alternative to no agreement at all, it is necessary to stress the importance of future abatement of emissions in the major developing countries. Although side payments can help to reduce these emissions, the potential increase in emissions is so great that the global damage could be considerable.

Project personnel: Snorre Kverndokk

Project documentation: Kverndokk, S. (1993): "Coalitions and side payments in international CO_2 treaties", to be published in E. C. van Ierland (ed.): *International environmental economics, theories and applications for climate change, acidification and international trade,* Elsevier Science Publishers, Amsterdam. Also published as Discussion Paper No. 97, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway, through the research programme Economy and Ecology, Methodology Project.

References: Burniaux, J. M., J. P. Martin, G. Nicoletti and J. Oliveira Martins (1992): "The Costs of Reducing CO_2 Emissions: Evidence from GREEN", Working Paper No. 115, OECD, Department of Economics and Statistics, Paris.

Fankhauser, S. (1992): "Global Warming Damage Costs: Some Monetary Estimates", GEC Working Paper 92-29, Centre for Social and Economic Research on the Global Environment (CSERGE), University College London and University of East Anglia.

8. Extraction of fossil fuels and the effects of global warming

How a global tax on CO_2 should develop over time depends, for one thing, on the assumptions made about the relation between emissions and damage to the environment. In this project the optimal carbon tax is studied in the light of two different assumptions of the cause of the negative environmental effect: one which relates the damage to the concentration of CO_2 in the atmosphere and another which relates the damage to changes in this concentration. These two assumptions give totally different carbon tax pathways. It is explicitly taken into account that fossil fuels, a main source of the CO_2-emissions, are exhaustible resources, which affects the supply of fossil fuels over time. Finally, we study extraction of fossil fuels if a perfect non-polluting substitute (backstop) is available for these fuels.

Most economic analyses of global warming concentrate on the external effects of combustion of fossil fuels, without taking into account that these resources are exhaustible. This paper combines the theories of external effects and non-renewable resources in order to analyse various aspects of the greenhouse effect.

In the first model used, the negative effects of global warming are related to the CO_2-concentration. In the model, the exhaustibility of fossil fuels implies increasing extraction costs as more resources become exhausted. The model shows the optimal emission path, i.e. the path that gives the greatest discounted welfare over an infinite horizon in time. In this case, the welfare at any time is defined as the benefit to society of using fossil fuels, minus the extraction costs and the damage caused by global warming. The model is described in more detail in Kverndokk (1993).

A carbon tax can be used to realize this solution. The tax is made equal to the discounted marginal damage during all future periods of time. In the optimal path, the concentration of CO_2 will initially increase, but will gradually fall towards its pre-industrial level. It is found that the carbon tax will take a similar course, but will reach its maximum point *before* the atmospheric concentration starts to fall.

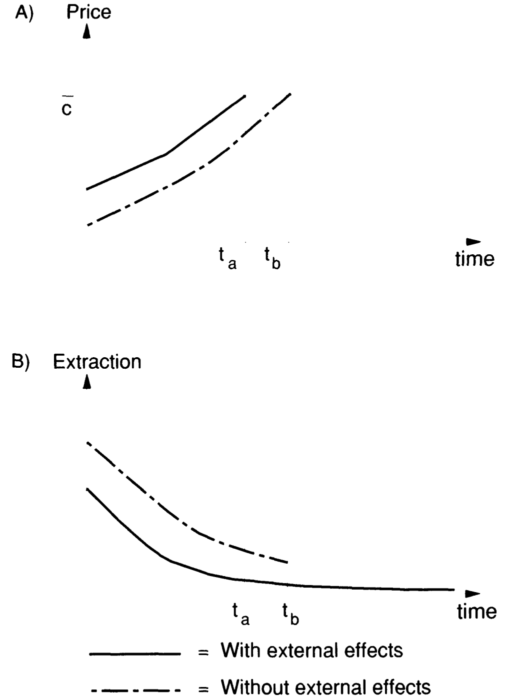
It can be argued, however, that a large part of the damage caused by global warming is due to rapid *changes* in climate, and not necessarily the level of the atmospheric stock of CO_2. In the long term, plants and animals can adjust to changes in climate, but if these changes are too quick the costs of adjustment are high. Therefore we have also studied a case where global warming is assumed to depend on changes in the concentration of CO_2 in the atmosphere, and not on the level of concentration. The change in the atmospheric concentration is defined as current emissions minus a certain natural reduction of the already existing stock, since the lifetime of CO_2 in the atmosphere is limited. It is assumed that this natural reduction increases as the content of CO_2 in the atmosphere increases.

Changing the assumption completely changes the desired emission path. In the first model, a higher atmospheric concentration represents a cost in the form of increased global warming. In the second model, a higher concentration could, in contrast, be beneficial, if the stock of carbon rises over a sufficiently long period. This is because, if the damage is due to changes in concentration, increased emissions at a certain point in time can even out the stock over time, and the damage is thereby reduced. In the model, increased emissions lead to a higher future concentration, and thus also higher natural reduction. This effect can in fact imply that, under certain conditions, it may be profitable to subsidize CO_2-emissions today, instead of taxing them.

Both this model and the first one must be regarded as extremes. Probably the damage from global warming is caused both by the CO_2-concentration and the rate of change. Moreover, we have used very simplified models, while the greenhouse effect comprises many complex interrelationships, some of which are not yet fully understood.

Finally, we have also studied how extraction of fossil fuels is affected by the existence of a perfect non-polluting substitute, or backstop, taking into account that combustion of fossil fuels contributes to

Figure 8.1. Optimal extraction of fossil fuels and consumer prices when carbon-free technologies are available



the greenhouse effect. Such backstops include wave energy, wind energy, solar energy and fusion energy. We assume that the substitute is available in unlimited quantity and at a fixed price (equivalent to a fixed marginal production cost).

The traditional theory considers the situation without taking into account the effects on the environment. In a situation with free competition, the fossil fuels are extracted right down to the point where the price of these is the same as that of the backstop. When this happens, the resource is completely depleted (it does not pay to extract any that remains in the ground), and consumers therefore switch to the backstop.

Figure 8.1 compares the price path and extraction with and without external greenhouse effects. When the external effect is taken into account it is assumed that an optimal carbon tax will be introduced, as described above. It is then assumed that the damage from global warming is positively related to the atmospheric concentration of CO_2, and that the carbon tax will thus have the properties described in the first model above.

The consumer price, the price the consumer pays for fossil fuels, equals the production price plus the optimal tax. The consumer price increases gradually as more fuel is extracted, and eventually reaches the price of the backstop (at time t_a when we take into account the external greenhouse effects and at time t_b when we disregard these effects. In the figure the price of the substitute is fixed at $\bar{c}$). If consumers then stop using fossil fuels, the concentration of CO_2 in the atmosphere will start to fall. This leads to a drop in the optimal tax and therefore the consumer price, and fossil fuels again become attractive. In other words, it will not be profitable to stop using fossil fuels even when the consumer price is the same as that of the perfect substitute. Production and consumption of fossil fuels will continue at a rate where the consumer price remains constant, and is the same as the price of the backstop. It is seen that the total extraction is the same, with and without the effects of global warming. However, the negative effects of consumption of fossil fuels make it pay to slow down the extraction and distribute the consumption over a longer period of time.

Project personnel: Snorre Kverndokk

Project documentation: Kverndokk, S. (1993): "Depletion of Fossil Fuels and the Impacts of Global Warming", Discussion Papers No. 107, Statistics Norway, Oslo.

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Traffic

9. Road traffic, accidents and labour supply

One of the positive effects of climate measures that help to reduce fuel consumption is fewer road traffic accidents causing injuries to persons. This has a positive impact on the economy and thus reduces the costs of a tax on CO_2. The positive effects are connected to less sick leave, fewer invalids and reduced mortality, as well as reduced public costs for treatment of traffic accident victims. For example, it is estimated that traffic accidents in 1990 caused a loss of about 23 000 man-years. The associations between fuel consumption, traffic accidents, labour supply and public health expenditures are studied within the framework of a general equilibrium model for the Norwegian economy.

The Institute of Transport Economics has recently developed a social accounting system for injuries to persons (Hagen (1993)). By integrating this information into the macroeconomic model MSG-EE (Multi-Sectoral Growth Model, Economy and Environment) it is possible to calculate the trend in fuel consumption, the number of injuries to persons and the reduction in the labour force. Integration of the costs of traffic accidents into a general equilibrium model like MSG-EE will also indicate the indirect effects of sick leave and disability.

The calculations include loss of labour man-years due to absence from work because of traffic injury to oneself or one's children, disability and death. Thus the costs of injuries to persons in traffic are estimated only by the reduction in the total supply of labour. The calculations do not place any value on the loss of welfare represented by pain, discomfort or impaired health. Medical treatment and nursing of traffic accident victims are included to the extent these are covered by public budgets. The calculations do not include the material costs of traffic accidents.

Table 9.1 shows the number of traffic injuries and loss of labour force as a result of these injuries in 1990. The calculations of loss of man-years are based on information and assumptions concerning participation in employment, and the composition of the injured persons by age and sex. The greater part of a total loss of 23 151 man-years is explained by losses due to death or disability. This is because the age profile of the group that either dies or becomes disabled in traffic accidents is such that an average of 39 man-years is lost for each victim.

The Institute of Transport Economics has carried out a statistical study of the relationship between the number of personal injuries and various explanatory variables such as traffic volume, use of safety

Table 9.1. Traffic injuries and loss of man-years in 1990 in Norway

	Persons	Loss of man-years
Total no. traffic injuries	33900	23151
Traffic mortalities	332	7254
100 per cent disabled	477	10146
50 per cent disabled	272	2888
Sick leave in first year after accident		1350
Absence from work due to traffic injuries to children		167
Productivity loss for persons who have returned to work after a traffic accident		1346

belt, road maintenance, climatic conditions, safety measures etc., see Fridstrøm and Bjørnskau (1989). Gasoline consumption was used as an indication of traffic volume. It was shown that the number of traffic injuries increased in step with gasoline consumption, all other factors remaining constant.

When the density of traffic decreases, the number of accidents involving injuries to persons increases. Thus expanding the road network does not seem to reduce risk in traffic. Measures such as introduction of safety belts reduced the risk of personal injuries by 20 per cent from 1974 to 1986.

The results from Fridstrøm and Bjørnskau have been used to model the number of traffic injuries as a function of fuel consumption and traffic density. It is assumed that climate and driving behaviour remained unchanged during the period to which the calculations apply. Fuel consumption is defined in the MSG-EE model. The total number of kilometres driven is calculated for a given trend in the energy efficiency of gasoline and diesel. Traffic density is determined by distance driven and size of the road network measured in km, which is assumed to follow a trend based on historical data and information on the extent of road building according to the Norwegian Roads Plan 1994-1997.

A reference scenario for economic growth, which neglects the fact that higher fuel consumption leads to more road accidents to persons, has been compared with an alternative scenario which takes into account the impact of injuries to persons on the labour force and the public budgets. Roughly speaking, the projections are based on a previous study by Statistics Norway of climate

Table 9.2. Results for some main variables

	Annual growth in reference path. 1988-2020. Per cent	Deviation from the reference path. 2020. Per cent
GDP, fixed prices	1.7	-0.32
Labour stock	0.3	-0.32
Fuel consumption, road transport	1.0	-0.33
Injured in traffic	1.4	-0.22

measures in Norway, see Moum (1992). The horizon stretches to the year 2020.

An increase in traffic accidents above base year level leads to higher public expenditures within the health sector. The model is designed so that the public sector passively adjusts expenditures to the number of accidents. Given fewer accidents than in the base year, public expenditures can be reduced accordingly and can be used in the private sector. This opens up for an additional gain, since taxes often imply a marked loss of efficiency, see project (2).

Without feedbacks, an economic growth of 1.7 annually leads to an increase in gasoline consumption and therefore transport activity throughout the simulation period. This implies an increase in the number of traffic accidents of 1.4 per cent per year. Given feedbacks, this increase in traffic accidents leads to a decrease in the labour force and an increase in public expenditures for treatment of traffic accident victims. This will initially reduce the economic growth, partly because of a reduction in the stock of available labour, and partly because the public sector will take resources from the private sector, where productivity is assumed to be higher. However, seen in isolation, this contractive effect will lead to lower transport activity and fewer traffic accidents, and will thus counteract the initial effect. The total effect is a reduction of 0.3 per cent in the Gross Domestic Product by the year 2020. The effect via reduced supply of labour is far stronger than the effect via increased need of resources in the public sector.

Project personnel: Solveig Glomsrød, Runa Nesbakken and Morten Aaserud

Project documentation: Glomsrød, S., R. Nesbakken and M. Aaserud (1994): "Modelling impacts of traffic accidents on labour supply and public health expenditures in a CGE model". To be published in the series Discussion Papers, Statistics Norway, Oslo.

Project financed by: Ministry of Environment

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10. Choice of number of private cars in Norwegian households

Use of private cars is a source of air pollution. Taxes on car purchases, keeping a car and use of cars are a source of revenue to the State to the sum of NOK 25 billion annually. An adjustment of the motor vehicle taxes with the aim of reducing use of private cars is discussed regularly. In this connection it is important to find out what factors determine how many cars a Norwegian household wishes to own. The results presented here are based on a model where the main explanatory variables are demographic conditions such as age, number of children and adults in the household, in addition to the economic variables level of income and cost of keeping a car. The number of cars a household wishes to own is also affected by place of residence, number of family members in paid employment and whether the family has access to a company car.

The number of private cars in Norway has shown a marked increase since 1960. In that year there were only 225 000 private cars registered in Norway, implying 16 persons per car. In 1991, the number was more than 1.6 million, implying average 2.6 persons per car. Private cars undoubtedly lead to greater welfare for the individual household. On the other hand, there are few goods that have as many negative indirect impacts as cars do. Pollution, noise, traffic accidents, wear of roads and queues all represent a considerable cost to society every year. If the manufacture of the car is excluded, which is very energy-intensive and thus also a source of pollution, the external effects are connected to the use of cars, and not to the stock of cars. However, the stock of cars and the use of the cars are closely connected. The number of

Table 10.1. Estimated probabilities and changes in these probabilities with changes in explanatory factors

	0 car	1 car	2 cars	3 cars
Estimated probabilities of choice	0.126	0.767	0.135	0.002
No. adults	-0.0217	-0.0407	0.0610	0.0014
No. children	-0.0211	0.0402	-0.0184	0.0014
Age	0.0033	-0.0019	-0.0014	-0.0001
City	0.0725	0.0006	-0.0705	-0.0026
Company car	0.1980	0.0064	-0.1616	-0.0428
No. employed	-0.0363	-0.0157	0.0498	0.0023
Cost and income elasticities	-1.106	-0.036	1.194	2.264

private cars increased by 6.8 per cent per year during the period 1960-1991. The use of the cars, measured in terms of number of person/kilometres, increased by an average of 7.1 per cent per year.

Statistics Norway has developed a model that describes whether a household decides to own one, two, three or no private car(s). The choice is assumed to depend on economic variables such as household income and average annual cost of keeping a car. The cost of keeping a car consists of insurance cost, road licence and annual depreciation. The model also includes demographic variables such as number of adults in the household, number of children under the age of 18, the age of the household's main provider and the number of employed persons in the household. Finally, the decision to own a car is also affected by whether the household has access to a company car, and whether the place of residence is one of the following cities, Oslo, Bergen or Trondheim. The model has been estimated on the basis of data on 1500 households extracted from the Consumer Survey for 1985.

More than 60 per cent of the households in the sample own one car, while about 15 per cent own two cars and two per cent own three cars. Twenty-three per cent of the households do not own a car at all. Table 10.1 gives estimates of the probability of a household choosing to own 0, 1, 2 or 3 cars. The probabilities for the 4 choices add up to 1, and apply to an average household. The probability of choosing to own 1 car is more than 75 per cent, while the probability of choosing 2 cars is about the same as the probability of choosing no car at all - 13 per cent. The probability of choosing to own 3 cars is very small.

Table 10.1 shows the effects of changes in each explanatory factor on the choice probabilities, all other explanatory factors remaining unchanged (partial changes). In principle, the estimated effects agree with the effects one would expect to find. More adults in the household helps to reduce the probability of choosing 0 car or 1 car rather than 2 or 3 cars. A larger number of children increases the need to have a car in the first place, while one extra child reduces the wish to own more than one car. A possible explanation is that the household spends a larger share of its income on other goods because of the larger number of children. High age (age of the main provider) undoubtedly helps to raise the probability of not having a car, while the probability of other choices decreases. One of the reasons for this result may be that the frequency of possessing a driving licence decreases with increasing age.

If a family lives in a city, this tends to pull in the direction of not owning a car, possibly because of better public transport services in the larger towns. Similarly, access to a company car tends to make people choose not to own a car. The effect of having a company car on the choice of not owning a car is three times as strong as the effect of living in a city. A larger number of employed persons in a household makes it less probable to own 0 or 1 car than to own 2 or 3 cars.

As far as income and the cost of keeping a car (price) are concerned, the effects are stated in terms of elasticities (percentage change in probability of choice as a result of 1 per cent change in income or the cost of keeping a car). It is a property of the model that these elasticities are symmetrical; the table shows the income elasticities. The price elasticities are obtained by changing the sign. The calculations show that the higher the income the fewer there are that choose not to own a car; the number who choose to have 1 car remains almost unchanged, but the probability of choosing 2 or 3 cars increases. Overall, the expected number of private cars will increase by 0.4 per cent if all households experience a 1 per cent increase in income, or if the costs of maintaining a car are reduced by one per cent. These results should be taken into account when discussing the effects of changes in the cost of a road licence or in the purchase tax on private cars. For instance, the road licence accounts for about 10 per cent of the annual cost of maintaining a car. According to the model, if this tax were to be removed the number of private cars would increase by just over 4 per cent. However, the environmental impacts of a change in the taxes will also depend on the families' decisions with regard to using the cars they own. This has not been analysed in the present project, but could be an appropriate subject for further research.

Project personnel: Anne Brendemoen and John Dagsvik

Project documentation: Brendemoen, A. (1994): Car Ownership Decisions in Norwegian Households". To be published in the series Discussion Papers, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway, through the programme Economy and Ecology, "SAMMEN" Project.

11. Changes in transport and communications with a tax on CO_2

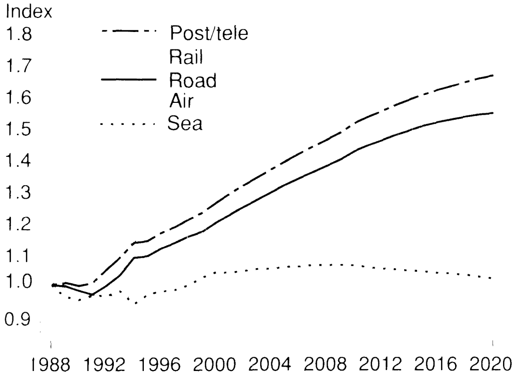
A higher tax on fossil fuels will reduce the extent of transport and communications in the Norwegian economy, except for the use of postal and telecommunication services. Private households will make less use of private cars for transport and more use of public transport. A possible increase in the tax would reduce the increase in pollutant emissions. Such a tax would have a stronger impact, however, on consumption of oil for heating purposes.

About 40 per cent of the total CO_2-emissions in Norway originate from transport and communications. The extent of the emissions varies considerably, however, for the different forms of transport and communications. In the macro-economic equilibrium model MSG-EE (Multi-Sectoral Growth - Economy and Ecology), the transport and communications sector consists of five different forms of transport/communications. The emissions from postal and telecommunications services and from the railways are very small, while road transport, sea transport and air transport cause considerably emissions, e.g. of CO_2, NO_x, CO and particulates.

In this study, MSG-EE is used to analyse how a CO_2-tax on fossil fuels would affect the development of transport and communications up to the year 2020. The model is used to develop a reference scenario where no specific measures are taken to reduce CO_2-emissions, over and above the tax already imposed. In an alternative scenario the CO_2-tax is assumed to increase by 7 - 8 per cent per year. This is about what it would take to stabilize Norwegian emissions of CO_2 at 1990 level by the year 2020. See Holmøy et al. (1994) for a more detailed description.

The growth of transport/communications in the reference scenario depends on the growth in the general level of activity, and on changes in the economic structure and pattern of consumption. When industries that use little transport in their production grow in relation to industries requiring much transport, the transport will increase to a less extent than the production. The model does not take into account possible switches between different forms of transport *within* a particular sector. In the reference scenario, the total transport increases by an average of about 1.4 per cent per year during the period 1988 to 2020, while the Gross Domestic Product increases by an average of about 1.6 per cent per year, see figure 11.1. This means that, as a whole, society becomes less dependent on transport.

Figure 11.1. Growth of the different forms of transport and communications in the reference scenario, 1988-2020. Indexes, 1988 = 1



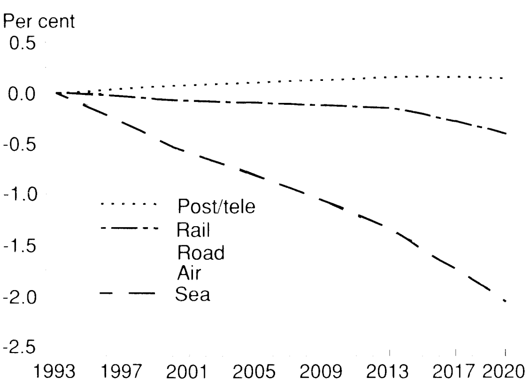
The use of transport by private households increases by about 2 per cent per year, while in the production sector transport increases by 0.4 per cent per year. The demand for transport by private households is very important. This demand accounts for as much as 40 per cent of all road and rail transport and about 20 per cent of all air transport and use of post and telecommunications. The growth in consumption, slightly more than 2 per cent per year, means that the growth of air transport and post and telecommunications is stronger than for the other forms of transport. The high sensitivity of air transport, road transport and post and telecommunications to changes in income implies stronger growth for these forms of transport than for transport by road and rail. Private households increase their demand for air transport by about 2.5 per cent per year, their use of post and telecommunications by about 2.4 per cent per year and their use of road transport by about 2 per cent per year.

Of the industrial sectors, it is the private services sector in particular that contributes to the strong increase in air transport, owing to the strong growth in production of these services. The commodity trade sector, with a growth of about 2 per cent per year, accounts for about 25 per cent of all use of post and telecommunications. In addition to private households, this sector accounts for the strong growth in the use of post and telecommunications.

Growth in consumption (and substitution between forms of transport in private households) and the above-mentioned changes in the composition of the economic structure, implies that air transport will show the strongest growth up to the year 2020, with a growth rate of 1.7 per cent. Post and telecommunications come second, with a total average growth of 1.6 per cent per year, and thirdly road transport with a growth of 1.4 per cent per year. Rail transport increases by an average of about 0.7 per cent per year, and the growth in sea transport is almost like zero.

The demand for transport is somewhat lower in the tax scenario than in the reference scenario. The strongest reductions are found for sea, road and air transport. This is because the cost of fossil fuel accounts for a relatively high proportion of the costs of sea and air transport. This means that a tax will have the strongest impact on the prices of air and sea transport, see figure 11.2. The relatively strong reduction in road transport is explained by reduced use of private cars by private households. The economic structure is turned towards less transport-intensive industries. As far as households are concerned, the picture is more complex. In the model, the households can shift between different forms of transport. A relatively strong substitution effect between the different forms of transport in private households implies that, with a higher price of fuel, the households reduce their use of private cars and increase the use of post, telecommunications, railways, trams, metro and taxies.

Figure 11.2. Percentage changes in use of transport between the reference scenario and the CO_2-tax scenario. 1993-2020



CO_2-emissions and other emissions from transport activities are affected by a tax on fossil fuel. However, in 2020, mobile emissions of CO_2 are only 1 per cent lower in the tax scenario than in the reference scenario. This is because it is assumed that no substitution occurs within the different sectors away from forms of transport requiring large amounts of fossil fuel. The impacts on industry are also moderate because, for most industries, transport costs account for only a small share of the total costs.

Project personnel: Torstein Bye and Bodil Merethe Larsen

Project documentation: Larsen B. M. (1994): "Transportanalyser i makromodeller. Simulering av modellene MSG-EE og TRAN" (Transport analyses in macromodels. Simulation of the models MSG-EE and TRAN). To be published as an article in *Økonomiske Analyser*, Statistics Norway, Oslo. (In Norwegian).

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Management of the environment and natural resources

12. Hicksian income and "green" GDP

It has been maintained that the national product should be corrected for environmental damage and extraction of natural resources, in order to provide a better measure of what is called the "Hicksian income". Hicks (1946) defined income as the amount a person can consume during a particular period and still expect to be as well off at the end of the period as he was at the beginning. However, it all depends on what one means by "as well off". In this article we take a look at some definitions of this term. It can be argued that "as well off" cannot be said to mean as well off in terms of welfare (equally contented), but only that a person has the same amount of economic resources at the end of the period as at the beginning. This implies that Hick's conception of income cannot be used as justification for correcting the national product for damage to the natural environment.

At first sight, "income" may seem to be an non-problematic term that does not require further definition. On second thoughts we find, however, that several questions have to be answered. We do not think of the money a person withdraws from a bank in the course of a week as income. But what about the amount a forest owner earns by felling trees, or the amount Norway earns by extracting oil? These are the kinds of situations that Hicks tries to explain.

Hicks pointed out straight away that, in many connections, "income" is a term that is difficult or impossible to define precisely. He uses an example to illustrate this.

The starting point is a person who is paid NOK 10 per period as return on capital. (Hicks does not specify the unit, but let us use NOK). He could receive, for example, an annual return of 10 per cent interest on a capital of NOK 100. If, the year after, the interest rate falls to 5 per cent, however, the same capital will only give a return interest of NOK 5. If this drop in interest was known in advance, the person could have used NOK 5.20 and saved NOK 4.80 during the first year. This would increase the capital, and the return would then be NOK 5.20 in the second year as well. The person would then be equally well off in spite of the fall in interest rate. In the same way, it is possible to correct for a general increase in prices. However, if different prices change at different rates there is no fully satisfactory way of making this correction.

Note that in this argumentation Hicks connects "as well off" with the quantity of the economic resources (how much one can use in relation to the level of prices). There is no indication that "as well off" means that we experience the same welfare (are equally contented). Given this interpretation it would be necessary to make some extra adjustments to the income. For example, should the income of a person who has been deserted by his/her spouse in the course of a year be corrected for the loss of welfare this implies? This raises the question - have we moved too far from the original meaning of the term "income"?

Hick's concept of income is often referred to in support of the proposal to correct the national product or the national income for deterioration of the environment. Since environment is not a good that is sold in the market, such a correction implies having to define more precisely what is meant by "better off".

Even if we clarify what is meant by *an individual* being "better off", it still is not clear what is implied by saying that the nation as a whole is "better off", because some individuals could be better off and others could be worse off. This question is discussed in more detail in Brekke (1993) and Brekke et al. (1993) (see projects 17 and 18). Let us now assume that there exists a single individual who is representative of the whole nation.

What is meant by "better off"? A usual interpretation in economic theory is based on what a person would choose when faced with a situation with two alternatives. If the person means that an income of NOK 100 000 and a high environmental standard are just as good as an income of NOK 150 000 and a low environmental standard, then this person is equally well off under both alternatives[1].

However, this interpretation of "better off" cannot be applied without reservation when comparing the situation at two different points in time. Assume that a person prefers a high income and a poor environment to low income and a good environment at a specific point in time. It is impossible, however, for a person to choose between experiencing the first alternative one year and the other in another year. For there to be any meaning in comparing the two alternatives, we must either keep to a particular point in time or specify alternatives where both income and environmental quality are specified for both the years. It is therefore impossible to deduce from any *choice* that the person will be better off on the day he experiences a specific combination.

This problem can be avoided given certain assumptions about the preferences. However, in this case it is necessary to exclude, for example, formation of habits. Many surveys show poor correlation between such assumptions and observable behaviour.

In other words, Hicksian income is difficult to define if by "as well off" one means "equally high welfare" or "equally contented". Therefore income should be defined rather as a measure of available economic resources, and income and welfare should be regarded as separate concepts. In this case, a proposal to correct the national product or the national income for changes in environmental quality cannot be justified by means of the concept of Hicksian income.

Project personnel: Kjell Arne Brekke

Project documentation: Brekke, K. A. (1994); "National wealth and Hicksian Income in the Debate on Green GDP". To be published in Discussion Papers, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway, through the research programme Economy and Ecology, Methodology Project.

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[1]This interpretation assumes implicitly that a person acts out of own interest, and that this is the only possible situation. For a discussion of the relationship between choice and preferences, see Sen (1993).

Discussion Paper No. 84, Statistics Norway, Oslo.

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Hicks, J. (1946): *Value and Capital*, Second edition, Oxford at the Clarendon Press, Oxford.

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13. Defensive expenditures and correction of the national product

If increased pollution leads to increased expenditure on environmental measures, or new international conflicts make it necessary to raise expenditures on defence, these increases in expenditures do not imply that the welfare of the population is higher than before the changes took place. Several economists have therefore argued that the national product should be corrected for such ***defensive expenditures****. Nordhaus and Tobin (1972) further maintain that the figure should also be corrected for the disamenities of urbanization, because they mean that higher incomes in the towns than in the country do not necessarily express higher welfare. Here we point out that there is very little point in including in the national product only goods from which people "derive direct benefit", since in practice it is impossible to separate these goods from the rest.*

Nordhaus and Tobin assume that people do not value cleaning costs as such, but value the clean environment that these produce. Correspondingly, it is national security, not defence expenditures, that is of value. They therefore argue that if the national product is corrected for the use of resources which is not valued directly by the population, this gives a better measure of changes in welfare.

Cobb and Daly (1989) define defensive expenditures as expenditures to correct the negative side effects of production, for example, pollution. They also recommend correcting the national product in order to estimate changes in welfare.

In practice, however, it is impossible to decide which expenditures are defensive. Becker (1976) points out that a household can be regarded as a "small factory" which uses consumer goods as input factors to produce goods that are actually valued. For example, we do not value flour directly, but rather the meals we can produce with flour as one of the input factors. Therefore, are the expenditures on flour defensive? In fact the meal itself may not be what we actually value, but rather the good taste and the feeling of satisfaction that the meal produces.

Yearly changes in the national product, minus defensive expenditures, only represent changes in welfare if the level of "real goods" that are produced remains unchanged from year to year. Here, "real goods" means, for example, environmental quality or degree of national security. In this case, the environmental measures must always be exactly sufficient to keep the state of the environment unchanged, regardless of changes in pollution. If the environmental measures are not sufficient to prevent deterioration of the environment in the course of the year, the national product minus the costs of the environmental measures will not reflect the change in welfare.

Thus, to know anything about changes in welfare, a corrected national product has to be supplemented by information indicating, for example, whether a change has occurred in the state of the environment or the national security. On the other hand, one can then just as well present an uncorrected national product, supplemented by information on changes in external conditions (pollution, international conflicts).

Nordhaus and Tobin also correct the national product for urbanization. We can understand the idea behind this correction if we visualize a person who, all other things being equal, prefers to live in the country rather than in the town. He can obtain a much better wage in the town, however, and given the difference in wages he regards town and country as equally good alternatives. If he moves from the country into the town, he experiences no change in welfare. However, the national product increases because he now gets a higher wage. Norhaus and Tobin suggest correcting the national product to give the right picture of an increase in welfare in such cases.

Cobb and Daly also suggest correcting for urbanization. However, they use an approach which takes into account only the negative aspects of urbanization, while ignoring the positive aspects of living in a town. Nordhaus and Tobin use a model for people's choice of residential area in an attempt to estimate how much extra income people demand before they will live in an urban area. It can be shown, however, that, when they do this they use those who are *least* contented in the town as representative of the whole town population. In addition to correcting for the compensation demanded in the form of extra income, they also correct the national product for several other conditions, including travel costs. However, it is to be expected that people take into account possible higher travelling costs in the town than in the country when deciding how much extra income they demand to compensate them for moving into town. In this case, the two corrections are an example of double counting.

For a further discussion of the interpretation of the national product as a measure of welfare, see project (12).

Project personnel: Hanne A. Gravningsmyhr and Kjell Arne Brekke

Project documentation: Gravningsmyhr, H., and K. A. Brekke: "Adjusting NNP for instrumental or defensive expenditures. An analytical approach". To be published in Discussion Papers, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway, through the research programme Economy and Ecology, Methodology Project.

References:

Becker, G. S. (1976): *The Economic Approach to Human Behavior*, University of Chicago Press, Chicago, I.L.

Cobb, J. B. and H. E. Daly (1989): *For the Common Good*, Green Print, London.

Nordhaus, W. and J. Tobin (1972): *Is Growth Obsolete?* National Bureau of Economic Research, General Series 96E, Columbia University Press, New York.

14. Revenues from extraction of petroleum

An often discussed question is whether Norway is tapping her petroleum wealth, thereby contributing to a situation where coming generations are worse off than the generations of today. Extraction of oil and gas, which are exhaustible reserves, implies that the reserves are physically reduced. On the other hand, the value of the wealth is also changed, as a result of reevaluations based on new estimates of future prices, costs and reserves.

The petroleum wealth is often defined as the present value of future revenues from sales of petroleum, minus the present value of operating costs, including a normal return on real capital in the sector. This equals the present value of the future *petroleum rent* (i.e. the extra return on extraction of petroleum compared with other economic activity). Another variable similar to the petroleum wealth, but easier to estimate, is the *present value of future net cash flow*. This consists of the income from production minus operating and investment costs in a specific year. The value of the wealth and the present value of future net cash flow will depend to a large degree on expectations as regards trends in oil prices. Through the period 1973-1993, the estimates of future oil prices have varied considerably, as shown in figure 14.1.

The price estimates in the figure are taken from various official publications: Long-term Programme, Revised National Budget, and special reports for specific years. In general, figure 14.1 shows that the expectations regarding the future level of prices are based to a large extent on the observed price at the time the expectation was formed.

Figure 14.1. Actual oil price and expected oil prices 1973-1993. 1993 NOK per barrel of crude oil

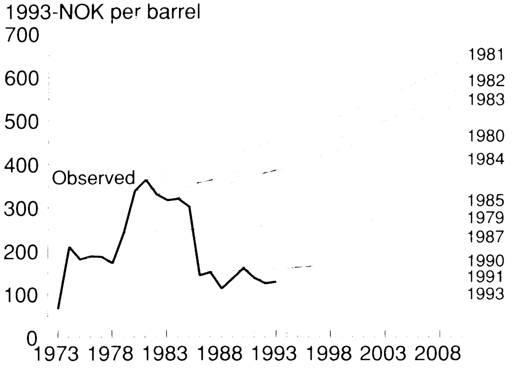

Figure 14.2. Estimate of net cash flow from Norway's petroleum activities 1973-1993. Billion 1993 NOK

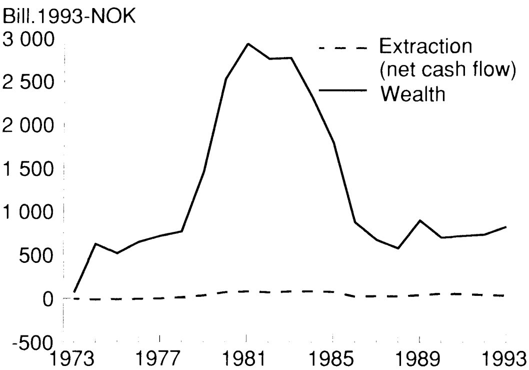

Figure 14.2 shows changes in the present value of net cash flow from Norwegian petroleum activities, calculated by using at each historic point in time the oil prices that were expected at that point in time (see figure 14.1).

The figures for the period 1973-1993 are taken from Aslaksen et al. (1990), while the figures for 1990 and 1992 are taken from the Revised National Budget. The

Long-term Programme 1993-1997 is the source of the figures for 1993. Up to 1989 the calculations carried out by Statistics Norway (then the Central Bureau of Statistics) were based on summarized information on production and costs. As from 1990 the estimates have been prepared by the Ministry of Energy and Industry and the Ministry of Finance, and are based on detailed information on reserves, production profile and cost estimates for the different oil and gas fields. This means that some of the variation in the estimates from 1989 to 1990 can be explained by improved and more detailed basic data. A figure for the wealth were not published in 1991.

The main reason for changes in the present value of net cash flow from year to year is a change in price expectations. During the period 1973-1993, the net cash flow varied from -15 to a peak of 80 billion NOK in 1984. In figure 14.2 the net cash flow is compared with the total present value of the net cash flow (wealth). The figure shows large variations at times in the present value of the net cash flow, seen in relation to the variation in net cash flow for the different years. The same applies to the relation between the petroleum rent and the petroleum wealth.

For certain years, owing to changed expectations regarding oil prices, the changes in the estimates of the present value of net cash flow have been so large that the *change exceeds Norway's gross national product*. In other words, the uncertainty about future oil prices is so big that correcting the GDP for changes in the oil wealth will make the GDP very difficult to interpret.

In a sustainable perspective, however, it will be desirable to know whether the nation ought to save more in order to compensate for extraction of resources. If one disregards uncertainty, a management that does not reduce the real value of the wealth implies only being able to use the return, or the *permanent income* from the wealth. However, the large variation in the estimates of the wealth in figure 14.2 shows that such a management rule is imprudent when applied to the petroleum wealth.

Brekke (1991) analyses the management of the petroleum wealth assuming uncertain oil prices. The decision rule that is studied is a further development of the management rule connected to permanent income. The decision rule is based on the assumption that current consumption should be a weighted sum of consumption in the previous year, the return from a petroleum fund and the petroleum wealth. In this connection a petroleum fund is defined as accumulated operating balance. Bye et al. (1994) conclude that the policy that has been followed so far cannot be said to conflict with this kind of long-term rule of management.

Project personnel: Pål Børing

Project documentation: Børing, P. (1992): "Oljerente og oljeformue" (Oil rent and oil wealth), unpublished memorandum, Statistics Norway, Oslo. (In Norwegian).

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Bye, T., Å. Cappelen, T, Eika, E. Gjelsvik and Ø. Olsen (1994): *Noen konsekvenser av petroleumsvirksomheten for norsk økonomi* (Some consequences of the petroleum activities for the Norwegian economy). Report 94/1, Statistics Norway, Oslo. (In Norwegian).

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15. Costs of erosion in Nicaragua

Soil erosion is a serious environmental problem in Nicaragua, as in many other poor countries. Heavy rain and cultivation of annual crops giving poor vegetation cover on steep slopes leads to extensive loss of productive soil every year. However, the economic impacts of this loss affect others as well as the farmers. Calculations indicate that, with the prevailing cultivation pattern and practices, soil erosion can lead to an almost 15 per cent reduction of the GDP over a 10-year period, compared with a baseline scenario without loss of productivity from soil erosion.

Statistics Norway and Instituto Centroamericano de Administracion de Empresas (INCAE - School of Business Administration) in Nicaragua have cooperated on a project to shed light on the relation between the extent of soil erosion and opportunities for economic growth in Nicaragua in the long term. A model has been developed which describes (schematically) economic activity in 26 economic sectors, 11 of them agricultural sectors.

Productivity in the agricultural sectors, that is to say, the amount that can be produced on a piece of land with given resources of capital and labour, is assumed to depend on the extent of soil erosion. Erosion depends in turn on *what* is cultivated and *where* it is cultivated. Perennial crops on flat ground are less erosive than annual crops cultivated on steep slopes. With the prevailing pattern of production, the productivity loss in the agricultural sector is estimated to vary between 0 and 2.5 per cent per year. Production of bananas, sugar and rice cause little erosion, while production of foods like beans and maize are very erosive and lead to high loss of productivity. The productivity loss is particularly high for maize and beans, because these are annual crops which are cultivated mainly on steep slopes.

In the model, the labour market is assumed to be in disequilibrium. It is also assumed that the supply of capital is determined by the amount that is saved, and does not necessarily equal the demand for capital. In other respects the model is an equilibrium model, that is to say, it assumes a balance of supply and demand.

The effects of the productivity loss induced by soil erosion can be illustrated by comparing two scenarios for economic growth; one scenario taking into account the effect of erosion, and another scenario where the effect of erosion is ignored, a usual procedure in extrapolations of economic activity. This kind of comparison shows that erosion can have strong impacts on macroeconomic variables such as GDP and private consumption, see figure 15.1 and table 15.1.

The loss of productivity in the agricultural sectors as a result of erosion implies that the sectors produce less, while the costs per produced unit increase. Therefore the agricultural sectors demand fewer goods from other sectors of the economy, and production will also decline in sectors other than agriculture. This will lead to a reduction of 25 per cent in the demand for labour over a period of 10 years. The trade unions occupy a very strong position in Nicaragua. It is therefore assumed in the calculation that the wages of industrial workers will be adjusted to the cost of living. Erosion and the consequent increase in food prices will raise the cost of living by about 20 per cent. Wages will not be reduced because of an increased unemployment, but are about 20 per cent higher in the scenario with erosion than in the scenario without erosion. This means that part of costs of erosion are borne by other sectors, which thus reduce their level of activity. The distributional effects of this situation on the different sectors of society are indicated in table 15.2.

Even if the result for small-scale farmers and agricultural workers is fairly good compared with other groups of society, we cannot ignore the fact that even a small reduction in income is difficult to bear for this poor group of people. In addition, it is possible that the decrease in income and increase in unemployment in the towns serves to counteract migration from rural districts to the towns. In this case, the income of the small-scale farmers and agricultural workers has to be divided between a larger number of individuals, which leads to a relatively

Figure 15.1. Development of GDP 1990-2000. Index. 1990=1

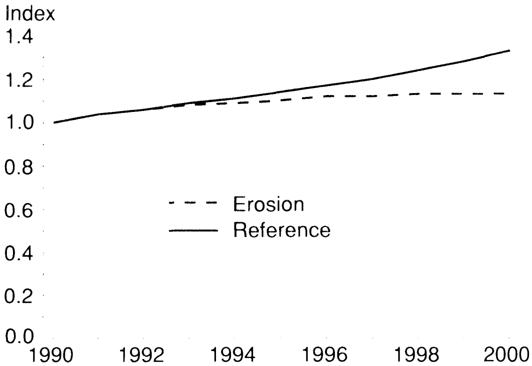

Table 15.1. Impacts of erosion on some main macroeconomic variables. Deviations from a reference scenario with no erosion after 10 years. Per cent

Gross domestic product (GDP)	-14.5
Import	-11.3
Export	-14.5
Private consumption	-13.7
Investments	-23.7

Table 15.2. Impacts of erosion on distribution of income. Percentage deviation from the scenario without erosion after 10 years. Per cent

Category	Deviation of income
Small-scale farmers and agricultural workers	-9
Industrial workers	-13
Traders etc. (minor capitalists)	-17
Capitalists	-16
Total	-14

stronger decrease in per capita income for this class than for others.

The calculations show that soil erosion can be a serious *social problem*. Therefore the development strategy for developing countries such as Nicaragua should consider the possibilities of limiting the extent of future soil erosion. For example, erosion could be limited substantially by changing the cultivation localities for the different kinds of crops.

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Project documentation: De Franco, M. A., S. Glomsrød, H. Høie, T. Johnsen and E. M. Castillo (1993): "Soil erosion and economic growth in Nicaragua", Internal Notes 93/22, Statistics Norway, Oslo.

Project financed by: Norwegian Agency for Development Assistance - NORAD.

16. Soil wealth in Tanzania

Today, the agricultural sector accounts for 61 per cent of Tanzania's gross domestic product (GDP). Owing to loss of nutrients and erosion of the soil, this income cannot be maintained in the long term.
A comparison of the return on the soil wealth with the current income shows that the income from agriculture has been over-estimated by 20 per cent.

During cultivation, nutrients are lost from the soil as a result of erosion, leaching and harvesting of crops. Erosion implies removal of the actual top soil. This leads to reduced root depth and generally poorer growing conditions. With the present farming practices used in Tanzania today, the nutrients in the soil are not replaced, and the soil is "mined away" by erosion. Even though the nutrients can be replaced later in the form of commercial fertilizer, it can take thousands of years to rebuild the depth of the soil. From this point of view, the soil in Tanzania is an exhaustible resource, just like oil and gas in Norway. Just how much of Norway's oil revenues should be regarded as ordinary income and how much as "extraction of the oil wealth" has been a matter of discussion for some time. This issue is analagous to the matter of the "soil wealth" in Tanzania.

We have used a simple long-term resource management model for agriculture in Tanzania to estimate permanent income from the agricultural sector (the share of the income not originating from "extraction of the wealth"), given different assumptions. We have also estimated shadow prices of nutrient content and root depth, i.e. the value of the nutrient content and root depth to agriculture. In the model, Tanzania is regarded as a small, open economy. This implies that all prices, including the interest rate, are determined on the world market, and that the country is too small to influence these prices. For many areas of Tanzania this assumption is probably not very appropriate. For this reason, the calculations should be regarded as a rough estimate of the long-term impacts of the current policy.

Today the productivity of the soil decreases by between 0.5 and 3 per cent annually. If this process is not stopped, the income from agriculture will be strongly reduced over time. However, by saving some of this income, either in the form of domestic real capital or foreign bonds, it is possible to create other sources of income to compensate for future loss of income from agriculture. The calculations indicate that, in order to maintain today's income in the future, it will be necessary to save about 15 per cent of the income from agriculture. The remaining 85 per cent is equivalent to income in the Hicksian sense, see project (12). When the nutrient content of the soil is depleted by removing crops without replacing the nutrients, the nutrient quality of the soil will gradually be further reduced. The situation is worsened by nutrients being leached out of the soil by erosion. This process is called soil mining. Although this is one of the main reasons for loss of productivity under the present policy, it can be avoided by using commercial fertilizer. Therefore, with an optimal policy, there is no justification for correcting the estimates of income from agriculture.

Reduction of soil (root) depth is a more serious problem in the long term, even with optimal adjustment. The soil has been developed over thousands of years by weathering of rock, and cannot be replaced today in a profitable way. Therefore the process is irreversible. In the case of maize cultivation in the southern highlands we found that up to 20 per cent of the income had to be saved to compensate for loss of root depth. This estimate assumes that the labour cannot be used in any other way. Other assumptions give lower figures.

We have also calculated the value of the annual loss of root depth to 10-25 USD per hectare for maize cultivation in the southern highlands. This means, for example, that a measure that reduces the annual erosion by half would be profitable if the costs did not exceed half of these calculated values. By comparison, the capital stock is estimated to 24 USD/ha in the same area.

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Project documentation: Brekke, K. A. and V. Iversen (1994): "Soil Wealth in Tanzania". To be published in Discussion Papers, Statistics Norway, Oslo.

Project financed by: The Research Council of Norway through the research programme Economy and Ecology.

Pricing environmental goods

17. Cost-benefit analyses and environmental pricing: a moral-philosophical criticism

It has been asserted that placing a value on environmental goods will provide better information on what environmental measures should be initiated. Here it is argued that the moral-philosophical basis for using willingness to pay analyses combined with cost-benefit analyses is controversial. It is discussed whether it is possible in practice to separate efficiency and distributional considerations. If not, then it is impossible to decide what would be socially efficient without also taking a standpoint on the distributional effects.

Most environmental goods, such as clean air and clean water, are not sold in markets and thus have no market value. However, in recent years relatively advanced methods have been developed to estimate people's *willingness to pay* for environmental goods. In cost-benefit analyses, the willingness to pay for a particular project is regarded as a measure of the benefit of the project. If the total willingness to pay for an environmental project is greater than the cost, it is concluded that the project is *socially desirable*.

However, it is controversial from an ethical point of view to use the sum of individual willingness to pay as an expression of the desirability of a project. In spite of this, little attention seems to have been awarded to the moral-philosophical implications of cost-benefit analyses.

Using willingness to pay as a measure of utility is based on the economic theory of consumer behaviour. If a consumer chooses to pay a specific sum of money in order to increase the supply of environmental goods, e.g. cleaner air, this indicates that the benefit he derives from this clean air is greater than the benefit he would have derived if he had used the money in another way. If a consumer is willing to pay more for project A than for project B we can conclude that project A means more to him than project B does.

The problem becomes more complex however when we try to compare the benefit to different persons. If person 1 is more willing to pay for a measure than person 2 is, this does not necessarily mean that person 1 derives greater *benefit* from the measure than person 2 does. If person 1 has a lot of money she would perhaps be able to pay a large sum without this affecting her standard of living to any degree, but the situation could be the opposite for person 2. Therefore a higher *total* willingness to pay for project A than for project B does not necessarily imply that project A gives greater total benefit. Such an interpretation would mean giving greater weight to the interests of the rich than to the interests of the poor (assuming that one unit of money means less to a rich person than to a poor person).

A usual reason for using cost-benefit analyses in spite of these arguments is that, if the total willingness to pay exceeds the costs, the benefit of the measure will be sufficient to allow those who become better off as a result of the measure to pay compensation to those who become worse off. If such compensation is paid, this would mean that no-one would be worse off than before, while some would be better off. In this case it would not be very controversial to propose that the measure should be initiated.

However, normally compensation is not paid, for many reasons. If people know that the willingness to pay that they report will be used as a basis for payment of compensation or recovery of benefit, it will be in their interest not to tell the truth. It will then be difficult to find out who are the losers and how much they should be compensated. It will also be difficult to measure the total willingness to pay. Moreover, it can be costly to distribute income between individuals. It is often maintained that the authorities can use income policy instruments to correct any unfortunate distributional effects of the measure. It is not very realistic to believe, however, that the system of taxes and transfers would be changed to take into account the distributional effects of a specific project.

It has been maintained that projects where the total willingness to pay is greater than the costs should be introduced even without compensation, because if many such projects are implemented everyone would probably be better off in the long term. This argument assumes that cost-benefit analyses do not produce systematic distortions between groups. As explained above, it can be maintained that the method systematically favours high income groups at the cost of low income groups. Brekke (1993), see project (18) shows that, in willingness to pay surveys, the choice of money as the measuring unit will systematically favour persons who are concerned about the environment in relation to persons who are more concerned about material values. If environment is a "luxury good", both of these distortions will favour high income groups. There are indications that environment could be in the nature of a luxury good, but no attempt has been made to quantify this here.

When compensation is not paid, a policy cannot be chosen on the basis of efficiency, and then corrected for undesirable distributional effects. In this case the project must be regarded as a "package" solution which causes changes in both efficiency and distribution. Any evaluation of whether a project is desirable or not will then make it necessary to weigh the interests of different persons or groups. Cost-benefit analyses can be justified on the basis of a utilitarian moral philosophy, that is to say, that society's objective is to maximize *the sum* of individual benefit. This means that it does not matter *who* wins or loses by a project, or whether the loss and the gain is distributed between a few people or between many, as long as the sum of the benefit exceeds the sum of the loss. It must also be assumed that all individuals derive equally great benefit from a slight change in income.

There cannot be said to be any general support for utilitarianism as a moral philosophy. Some people mean that, when evaluating a measure, utility to people who are poorly off should weigh heavier than utility to people who are better off. Other people point out that it is necessary to take into account not only utility, but also such factors as freedom, rights and obligations. For example, some people will mean that "society at large" does not have the right to use land that has traditionally been used by indigenous peoples, or that our generation has a duty to leave our natural heritage in just as good a condition as it was when we received it. Such considerations are not included in a utilitarian evaluation.

It is important to consider environmental issues and economy combined when taking decisions. It would be an advantage, however, if the facts were presented in a way that put the decision-makers in a position to base their final decisions on their own ethical standpoints. Otherwise there is a risk that the decision-maker is sceptical of the results of the analyses and derives no benefit from the information provided. Much of the background information from cost-benefit analyses will be relevant regardless of ethical standpoint. Such information may perhaps be of greater interest, however, if *not* aggregated into one number describing the social desirability of the project.

For example, information on *willingness to pay* can be presented with emphasis on differences between groups, rather than as average willingness to pay. This has been done in many cost-benefit analyses already. The information on *costs* could give greater weight to *who* will have to carry the costs.

In some connections it will also be of interest to evaluate the measure by means of *economic models*. Glomsrød et al. (1994), see project (9), gives an example. They use a macro-economic model to estimate how labour productivity and public health expenditures would be affected by a higher tax on gasoline which would reduce the number of accidents. This means that they obtain an estimate of the effects of an environmental measure on production of goods and services.

Such a method provides no information on the welfare effect of a better environment. It is an open question, however, whether the decision-makers find it easier to relate to a sum of money, i.e. total willingness to pay, rather than information on the expected physical effect of the measure on the natural environment. Therefore, an alternative to calculations of willingness to pay for environmental goods could be *environmental indicators measured in terms of physical units*. This kind of approach leaves the actual value setting, i.e. weighing the environment against other considerations, to the elected politicians, while still providing a basis for a critical discussion of the decisions that are made.

Project personnel: Kjell Arne Brekke, Annegrete Bruvoll, Hilde Lurås and Karine Nyborg.

Project documentation: Brekke, K. A., A. Bruvoll, H. Lurås and K. Nyborg (1993): "Nytte-kostnadsanalyser og miljøprising. En moralfilosofisk kritikk" (Cost-benefit analyses and environmental pricing. A moral-philosophical criticism), *Sosialøkonomen No. 7/8, 1993.* (In Norwegian).

Project financed by: The Research Council of Norway, through the research programme Economy and Ecology, Methodology Project.

References:

Brekke, K. A. (1993): "Do Cost-Benefit Analyses Favour Environmentalists?", Discussion Papers No. 84, Statistics Norway, Oslo.

Glomsrød S., R. Nesbakken and M. Aaserud (1994): "Modelling impacts of traffic accidents on labour supply and public health expenditures in a CGE model". To

be published in Discussion Papers, Statistics Norway, Oslo.

18. Environmental prices and measuring units

The pricing of changes in the environment in cost-benefit analyses assumes comparing different individuals' willingness to pay for the change. However, the choice of unit of measurement is of major significance for the result of this comparison. Different measuring units will systematically favour different groups.

Already in 1951, the well-known economist Kenneth Arrow pointed to the problems of consistency associated with aggregating different individuals' ranking of alternatives to obtain a ranking for the group as a whole. In fact, given reasonable requirements for how such an aggregation should be carried out, it is impossible (Arrow 1951). Cost-benefit analyses of environmental changes involve such an aggregation of rankings. There is thus no fully satisfactory theoretical basis for cost-benefit analyses[1]. Instead, they are based on pragmatic arguments. One of the main arguments is that, although there may be unfortunate sides to cost-benefit analyses in some projects, the sum of many small projects with positive net benefit will benefit all.

[1]Cost-benefit analyses can be defended in theory by assuming that an individuals' willingness to pay measures how much benefit the individuals derive from the measure to be evaluated, and that one NOK has an equal value for all individuals. This involves not only using information on each person's ranking of alternatives, but also assumptions on how much benefit the specific individual obtains if one alternative is chosen in preference to another. However, in this case, the moral-philosophical basis for the analyses may be open to question, see Brekke et al. (1993).

The choice of measuring unit is not important for the aggregation of the total benefit to an individual. However, it has been found that when the changes in benefit for *several individuals* are aggregated, the choice of unit is very important. Let us consider a society with two individuals: a and b. They consider improving the environment by one unit, for example 0.1 per cent lower concentration of pollution in the atmosphere. (It does not matter in this case how the state of the environment is measured). The cost of the project is divided equally between the two, i.e. 1 NOK each. Person a is willing to pay 100 NOK for this improvement, while person b is willing to pay only 0.01 NOK. Thus, together they are prepared to pay 100.01 NOK, while the cost is only 2 NOK. A cost-benefit analysis would therefore conclude that the project is a good one.

An alternative is to investigate how much environmental improvement the persons demand in order to accept the cost. Person a is willing to pay the cost, even if the improvement to the environment is only 0.01 units. Person b, on the other hand, demands an environmental improvement of as much as 100 units before he will accept the cost. Together they demand an improvement of 100.01 units, but the improvement is only 1 unit. Calculated in this way the project is a poor one.

The difference in these methods of calculation is systematic. Person b does not want the project. When money is used as the unit this benefit minus cost is -0.99 NOK, while the net benefit to person a is 99 NOK. Since person b values the environment much lower than money, a much higher figure will be needed to reflect his loss in terms of this unit, and the reverse for person a. Therefore, in terms of environmental quality units, person b's loss is 99 units, while person a's benefit is 0.99 units. A small change in benefit for an individual will be magnified to a large figure if the measuring unit is of small value to this individual. This means that even if the *final result* is calculated in the same unit (e.g. NOK) in both methods, the conclusions of the analysis may deviate considerably. If money is chosen as unit in preference to environment, this will systematically favour those who value money little compared with the environment, since even small changes in benefit will correspond to large sums for such individuals.

Strand (1985) has estimated the willingness to pay, measured in NOK, for a 50 per cent reduction in air pollution from cars. Based on Strand's data, the individual's willingness to pay is converted into environmental quality units and afterwards summated. Finally the sum was converted into NOK. It was found that the total willingness to pay is 22 times higher when NOK is used as the unit of aggregation rather than environmental quality units.

Although it is correct that the sum of many small projects will even out some of the unfortunate distributional effects of the projects individually, systematic differences as explained above will remain, regardless of choice of measuring unit. Therefore this argument cannot be used to select the measuring unit. However, the choice of measuring unit has such great implications for the results that putting a value on the environment seems to be so coincidental as to raise doubts about the usefulness of the whole procedure.

Project personnel: Kjell Arne Brekke.

Project documentation: Brekke, K. A. (1993): "Do Cost-Benefit Analyses Favor Environmentalists?", Discussion Papers No. 84, Statistics Norway, Oslo.

Project funding: The Research Council of Norway, through the programme Economy and Ecology, Methodology Project.

References:

Arrow, K. J. (1951): *Social Choice and Individual Values*, Wiley, New York, 1951, 2nd ed. 1963.

Brekke, K. A., A. Bruvoll, H. Lurås and K. Nyborg (1993): "Nytte-kostnadsanalyser og miljøprising. En moralfilosofisk kritikk" (Cost-benefit analyses and environmental pricing. A moral-philosophical criticism). *Sosialøkonomen No. 7/8, 1993* (In Norwegian).

Strand, J. (1985): "Verdsetting av reduserte luftforurensninger fra biler i Norge" (Pricing of reduced air pollution from cars in Norway), Memorandum No. 1, 1985 Department of Economics, University of Oslo. (In Norwegian).

Environment and economic growth

19. New model: Environment and economic growth

In a situation with increasing economic activity it is important to study the restrictions imposed on growth by the environment. Previous models developed by Statistics Norway have not explicitly taken into account the economic impacts of a depleted environment. Here we present a recently developed model which incorporates such considerations, e.g. increased morbidity and reduced productivity as a result of air pollution. The model can be used to study the two-way link between the economy and the environment, given a growing economy.

The economy and the ecology are interrelated. In popular terms, the ecology may limit economic activities, according to many people especially in the long term. Correspondingly, the ecology is influenced by economic activity. This has led to a search for methods and models that can be used to study the interaction between economic activity, growth and the environment. This study is an attempt to create such a model for Norwegian conditions.

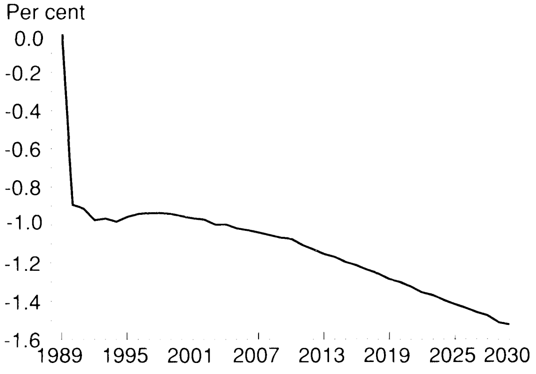
The model differs from Statistics Norway's other macro-economic models in several ways. It assumes that consumers and manufacturers know, to the same extent as the Government, how a number of economic variables will develop in the future, and that they take this into account when deciding how to act. In addition, certain relations between the state of the environment and economic activity are explicit in the model. The effect of uncertainty about the future has not been incorporated into the model as yet. The model is more aggregated than the MSG-model (Multi-Sectoral Growth Model), for example.

Several of the most well-known associations between the economy and the ecology are not as important when Norway is considered in isolation. This applies, for example, to global warming, deforestation and desertification. The extent of these problems cannot be explained by the Norwegian economy. Therefore they are treated in the model as one of several influencing factors from the world around us. An *interaction* between the economy and the environment assumes that the each of the elements influences the other, and in a Norwegian context it then becomes most appropriate to study local and national environmental problems.

The model focuses on two interactions between the economy and the environment: i) Emissions to air lead to reduced air quality. This leads to adverse effects on health which affect the productivity of labour, and increased corrosion which leads to higher capital costs. These effects have a reciprocal effect on the economy, together with the effects of traffic.

ii) Road traffic, estimated in the model by fuel consumption, leads to disturbance from noise. Traffic also has other so-called indirect effects. Wear of roads, accidents and queues are specified in the model. Wear of roads leads to higher costs in the public sector. The other effects are assumed to influence the well-being of private households so they would consider it an advantage if noise,

Figure 19.1. Percentage deviation in GDP as a result of the interaction between the economy and the environment



accidents and traffic queues could be reduced.

Figure 19.1 shows the estimated deviation in GDP for the period 1995 to 2030, with and without interaction with the environment. If we take into account that the environment affects the economy, the GDP is reduced. This is because corrosion, wear of roads and reduced productivity make it more difficult to produce. Corrosion and wear of roads imply that we must use more of our economic resources on maintenance, leaving less for productive investments.

The figure shows that the GDP-level lies about one and a half per cent lower in 2030 if we take into account the interaction between the economy and the environment. This is not very much, considering that the GDP increases by an average of 2 per cent per year. According to this model, the error we make by not taking into account the environment is equivalent to about three quarters of a year's economic growth. It must be underlined, however, that, so far, only some specific measurable environmental impacts have been incorporated into the model.

See also project (9), where some feedbacks from the environment to the economy are studied using the macro-economic model MSG-EE.

Project personnel: Haakon Vennemo and Mona Hansen

Project documentation: Vennemo, H. (1993): "A dynamic applied general equilibrium model with environmental feedbacks". Manuscript available from the author.

Project financed by: The Research Council of Norway, through the research programme Economy and Ecology, Methodology Project.

20. Does improved environmental policy increase economic growth?

New economic growth theory tries to take into account that investments in one part of the economy can have positive side effects on another part of the economy. The theory of endogenous growth can shed new light on the effects of the environment on economic growth in the long term. Given specific assumptions, it can be shown that increased investments in environmental capital can lead to a higher ***level*** *of production and consumption. However, after an initial phase of strong growth, the* ***rate*** *of economic growth will be no higher than if the investments in the environment had been lower.*

Many developing countries are characterized by serious pressures on the environment, while, in primary industries in particular, the environment is an important factor in production. The ecological relationships in the natural environment are often comprehensive and complex. Therefore environmental degradation in one area can have adverse effects in other places. This means that the persons responsible for the environmental degradation avoid having to pay the full cost of their actions; part of the costs are paid by their countrymen or by later generations.

To what degree will a better environmental policy have a positive effect on the economy? Will such a policy lead to increased *growth* of the economy, or will it, in the long term, cause "only" an increase in the *level* of economic activity? According to new economic growth theory, increased investments in human capital (knowledge and skills) lead to a permanent change in the rate of economic growth. The question is whether investments in environmental conservation will have an equally beneficial effect.

In order to study the effects of environmental conservation on long-term economic growth we have constructed an endogenous growth model which takes into account the state of the environment. The model assumes that the persons in the economy maximize the utility of their consumption over time. They can decide themselves how much they will consume at any time, but the consumption is assumed to take place at the expense of investment in measures to protect the environment. Therefore higher consumption today reduces the potential for production and consumption in the future. The persons can also choose how much working time they will allocate to production and how much to acquisition of knowledge and skills. Increased knowledge increases the return from future production.

The production takes place with input of several factors: The first, effective input of labour, depends on how much skills and knowledge the labourer possesses and how much of his working time is allocated to production. The state of the environment also affects production. In addition to the factors which the individual can regulate himself, it is assumed that the level of knowledge in society in general and the quality of the environment will have positive (external) effects on production. It is thus assumed that increased knowledge in an enterprise does not benefit only the enterprise, but also the rest of society. Furthermore, a poor environment in one place will have a negative effect on production in other places. These effects imply that unregulated adjustment, adjustment "without" initiatives by the authorities to improve the environment and enhance knowledge, will deviate from the optimal solution for society, since it is assumed that the individual will not take into account the benefit to others.

The model assumes that the amount of knowledge and skills in the economy increases by a constant percentage rate with a constant share of working time allocated to learning. The change in environmental quality is brought about partly by investments, and partly because of the nature's own ability for self-purification and repair. This ability is assumed to increase with an improvement in environmental quality in the area itself and in neighbouring areas.

It was found, that given these assumptions, an optimal environmental policy will not give permanently higher economic growth than would be achieved with unregulated development. However, a good environmental policy might give higher growth rate in the initial phase, and thus raise consumption to a higher level than would have occurred with unregulated development. Afterwards the rate of growth will be as before. On the other hand, an optimal policy to increase human capital (knowledge and skills) leads to greater economic growth over the whole period, that is to say, it leads to a permanent change in the rate of growth.

The reason for this asymmetry between the effects of an environmental policy and a policy to increase human capital is the way the model expresses development of knowledge and environmental quality over time. It is assumed that the relative increase in knowledge is permanently changed by a permanent change in the share of the working time spent on learning. Reduced consumption will increase the relative growth in environmental quality in the short term. However, this relative effect of increased investment in environmental capital will gradually decrease, and one ends up with the same relative growth rate as before. The realism of the assumptions in the analyses varies from country to country, and is difficult to estimate without carrying out calculations for specific cases.

Project personnel: Knut Einar Rosendahl

Project documentation: Rosendahl, K. E. (1994): "Does improved environmental quality enhance economic growth? Endogenous growth theory applied to developing countries". To be published in the series Discussion Papers, Statistics Norway, Oslo.

Part III Appendix of tables

Stationary combustion	13.6	12.9	1.4
Oil extraction	6.5	2.3	0.1
--Natural gas	5.3	2.1	0.0
--Diesel combustion	0.3	0.1	0.0
--Flaring	0.9	0.2	0.0
Gas terminals and oil refineries	1.9	0.3	0.1
Other industry	2.9	0.4	0.8
Dwellings, offices etc.	2.1	9.8	0.5
Incineration of waste	0.1	0.1	-
Processes and evaporation	6.8	273.0	12.6
Oil and gas activities	0.3	8.4	-
--Ventilation, leakages etc.	0.0	5.2	-
--Oil loading	0.3	2.9	-
--Gas terminals and oil refineries	0.0	0.3	-
Gasoline distribution	0.0	-	-

Table A1. Reserve accounts for crude oil. Developed fields and fields to be developed. 1988-1993. Million tonnes

	1988	1989	1990	1991	1992	1993
Reserves per 1/1	855	1000	982	1111	1112	1222
New fields	143	-	103	93	94	4
Re-evaluation	58	56	108	2	122	98
Extraction	-56	-74	-82	-93	-106	-116
Reserves per 31/12	1000	982	1111	1112	1222	1209
R/P ratio	18	13	14	12	12	10

Sources: Petroleum Directorate (OD) and Statistics Norway

Table A2. Reserve accounts for natural gas. Developed fields and fields to be developed. 1988-1993. Billion Sm^3

	1988	1989	1990	1991	1992	1993
Reserves per 1/1	1247	1265	1261	1233	1274	1381
New fields	10	-	15	54	138	1
Re-evaluation	38	27	-15	14	-2	1
Extraction	-30	-31	-28	-27	-29	-28
Reserves per 31/12	1265	1261	1233	1274	1381	1356
R/P ratio	42	41	44	47	48	49

Sources: OD and Statistics Norway

Table A3. Extraction, conversion and use[1] of energy sources. 1992*. PJ. Change in per cent

	Coal and coke	Fuel wood, wood waste, black liquor, waste	Crude oil	Natural gas	Petroleum products[2]	Electricity	District heating	Total	Average annual change in per cent 1977-1991	Average annual change in per cent 1991-1992
Extraction of energy sources	11	-	4525	1180	57[3]	421	-	6194		
Energy use in extraction sectors	-	-	-	-119[4]	-11	-6	-	-136		
Import and Norwegian purchases abroad	42	0	48	-	423	5	-	518		
Export and foreign purchases in Norway	-9	0	-3980	-1057	-427	-36	-	-5510		
Stores (+Decrease -Increase)	-3	.	-26	.	0	.	.	-29		
Primary supply	41	0	567	4	42	384	-	1038		
Petroleum refineries	6	-	-581	-	538	-2	-	-40		
Other energy sectors, other supplies	-1	38	-	-	8	0	6	51		
Registered losses, statistical errors	0	0	14	-4	6	-25	-2	-10		
Registered use outside energy sectors	46	38	-	-	594	356	4	1039	0.8	-1.2
Domestic use	46	38	-	-	283	356	4	727	1.3	-0.4
Agriculture and fisheries	0	-	-	-	25	2	0	28	-0.2	-3.4
Energy-intensive manufacturing	36	0	-	-	54	102	0	192	1.8	-2.5
Other manufacturing and mining	10	20	-	-	22	54	1	106	-0.5	-2.8
Other industries	-	-	-	-	107	79	2	188	1.3	4.4
Private households	0	18	-	-	75	119	1	213	2.0	-0.5
Ocean transport	-	-	-	-	312	-	-	312	-0.2	-3.4

[1] Includes energy sources used as raw materials.
[2] Includes liquefied petroleum gas, refinery gas and excess gas from petrochemical industry. Coke includes petrol coke.
[3] Natural gas liquid and condensate from Kårstø.
[4] Includes gas terminal.
Source: Statistics Norway

Table A4. Use of energy sources outside the energy sectors and ocean transportation. 1976-1993. PJ. Change in per cent

Energy source	1976	1980	1985	1987	1988	1989	1990	1991	1992*	1993*	Average annual change in per cent 1976-1987	1987-1993
Total	607	679	737	764	753	735	736	730	727	744	2.1	-0.4
Electricity	241	269	329	335	339	340	349	356	356	365	3.0	1.4
Firm power	232	265	312	321	323	320	324	330	328	335	3.0	0.7
Surplus power	9	4	17	15	16	20	24	27	28	30	4.8	12.2
Oil total	300	294	263	284	271	262	245	237	233	237	-0.5	-3.0
Oil other than for transportation	159	138	80	84	77	64	58	56	51	50	-5.6	-8.3
Gasoline	9	3	0	-	0	0	-	0	0	0	.	-
Kerosene	17	16	9	11	10	8	7	7	7	7	-3.9	-7.3
Medium distillates	66	63	43	45	42	38	36	36	34	34	-3.4	-4.6
Heavy oil	66	56	28	29	25	18	16	13	10	9	-7.2	-17.7
Oil for transportation	141	156	183	200	195	198	186	181	182	187	3.2	-1.1
Gasoline, aviation gasoline, jet kerosene	74	81	92	102	103	103	100	97	96	95	3.0	-1.2
Medium distillates	64	70	83	90	85	89	83	81	84	89	3.1	-0.2
Heavy oil	3	5	7	8	6	6	4	3	2	3	9.3	-15.1
Gas[1]	1	41	52	56	52	43	52	51	50	50	44.2	-1.9
District heating	.	.	2	3	3	3	3	4	4	4	.	4.9
Solid fuel	65	74	91	86	88	87	88	81	84	88	2.6	0.4
Coal, coke	47	48	57	50	53	51	50	45	46	50	0.6	-
Wood, wood waste, black liquor, waste	18	26	34	35	34	36	38	36	38	38	6.2	1.4

[1] Includes liquefied gas. From 1990 also excess gas from petrochemical industry.
Source: Statistics Norway

Table A5. Electricity balance[1]. 1975-1993. TWh. Change in per cent

	1975	1980	1985	1990	1991	1992*	1993*	Average annual change in per cent 1975-1985	1985-1993
Production	77.5	84.1	103.3	121.8	111.0	117.5	120.0	2.9	1.9
+ Imports	0.1	2.0	4.1	0.3	3.3	1.4	0.8	47.6	-18.5
– Exports	5.7	2.5	4.6	16.2	6.0	10.1	8.6	-2.1	8.1
= Gross domestic consumption	71.9	83.6	102.7	105.9	108.2	108.8	112.2	3.6	1.1
– Consumption in pumping plants	0.1	0.5	0.8	0.3	0.6	0.6	0.5	20.8	-5.4
– Consumption in power stations, losses and statistical differences	7.1	8.0	10.0	7.9	7.6	8.0	8.6	3.6	-1.8
= Net domestic consumption	64.7	75.1	91.9	97.7	100.0	100.2	103.0	3.6	1.4
– Surplus power	3.2	1.2	4.8	6.7	7.4	7.8	8.2	4.0	6.9
= Net firm power consumption	61.4	73.9	87.1	91.0	92.6	92.4	94.8	3.6	1.1
– Energy-intensive industry	26.2	27.9	30.0	29.6	28.4	27.4	27.6	1.4	-1.0
= Regular consumption	35.2	46.0	57.1	61.5	64.2	65.0	67.2	4.9	2.1
Regular consumption, adjusted for temperature	36.3	45.1	54.6	65.4	65.6	67.3	67.3	4.2	2.6

[1] Statistics Norway's electricity statistics are used up to and including 1992. For 1993, the figures are preliminary figures from NVE, with some adjustment: Regular consumption is calculated on the basis of the percentage change in relation to NVE's figures for 1992. This implies an upwards adjustment of net consumption of firm power and a downward adjustment of the loss.
Sources: Statistics Norway and NVE

Table A6. Average prices[1] of electricity[2] and selected petroleum products. Delivered energy. 1983-1993

Heat energy	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993*
Heating products:											
Price øre/kWh											
Electricity[3]	26.9	30.5	32.7	35.6	37.9	41.7	43.5	45.7	46.5	46.6	48.7
	(23.4)	(26.5)	(28.5)	(31.6)	(34.3)	(37.2)	(38.6)	(41.4)	(42.2)	(41.6)	(43.0)
Heating kerosene	31.8	32.5	32.8	24.8	25.0	25.7	28.3	33.9	40.1	37.4	37.8
Fuel oil no. 1	26.2	26.9	27.2	19.4	19.6	19.7	21.6	26.6	31.9	28.3	28.0
Fuel oil no. 2	25.0	25.7	25.7	18.1	18.3	18.8	20.7	25.7	30.8	27.2	26.9
Heavy fuel oil	14.8	17.7	17.8	10.4	12.4	11.7	14.7	19.1	23.3	23.6	22.4
Transportation products:											
Price øre/litre											
Super gasoline	492.5	520.9	512.8	476.0	510.0	536.0	578.5	642.8	741.0	795.0	836.0
Regular gasoline	480.2	505.3	501.8	.	.	.	.	.	.	.	.
Unleaded gasoline	.	.	521.2	457.0	489.0	503.0	540.5	596.9	681.2	722.5	764.5
Auto diesel	272.3	280.3	282.0	207.6	210.0	214.0	233.0	285.9	341.0	326.0	403.0

[1] All taxes included. [2] Households and agriculture.
[3] The figures in parentheses comprise the variable part of the price (the energy part of the H4-tariff).
Sources: Statistics Norway, NVE and Norwegian Petroleum Institute

Table A7. World consumption of energy

	1970 Mtoe	1980 Mtoe	1990 Mtoe	1991 Mtoe	Per unit GDP (1991) (toe/1000 US$)	Per capita (1991) (toe per capita)
Whole world	4860.9	6453.5	7779.0	..	..	..
OECD	2983.6	3622.1	4002.9	4138.2	0.32	4.49
Norway	13.9	18.9	21.5	21.7	0.38	5.10
Denmark	20.2	19.5	18.3	20.1	0.28	3.90
Finland	18.1	25.0	28.5	28.9	0.45	5.74
Sweden	38.0	41.0	47.8	49.4	0.42	5.73
France	147.3	190.7	221.2	232.3	0.28	4.07
United Kingdom	207.7	201.2	211.8	218.1	0.29	3.78
Germany	304.6	359.2	355.1	347.4	..	4.35
Turkey	12.2	31.8	53.1	54.0	0.33	0.94
Canada	132.1	192.1	210.7	211.8	0.51	7.84
USA	1545.9	1801.0	1919.9	1933.2	0.43	7.65
Japan	256.4	345.6	428.3	438.4	0.23	3.54
Ethiopia	..	..	..	0.8	..	0.002
Nicaragua	..	..	..	0.7	..	0.21
India	..	..	..	152.8	..	0.19

Sources: OECD 1993a, OECD 1993b and UNEP 1992

Table B1. Emission to air by sector. 1991. 1 000 tonnes unless specified otherwise

	CO_2	CH_4	N_2O	SO_2	NOx	NH_3	NM-VOC	CO	Pb	Par-ticu-lates
	Mill. tonnes								Tonnes	
Total	33.9	288.8	14.9	45.4	220.4	39.1	254.8	880.1	182	20.2
Energy sectors	9.3	16.9	0.2	4.5	36.1	0.0	104.0	7.6	2	0.4
Extraction of oil and gas[1]	7.4	10.8	0.1	1.0	32.7	0.0	95.9	5.5	0	0.2
Extraction of coal	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.2	0	0.0
Oil refineries	1.6	0.1	0.1	2.7	1.9	0.0	7.6	0.0	0	0.1
Electricity and water supply[2]	0.2	0.1	0.0	0.7	1.4	0.0	0.5	1.8	2	0.2
Manufacturing and mining	9.5	1.5	6.9	29.8	26.7	0.3	21.5	61.1	3	1.9
Oil well drilling	0.3	0.2	0.0	0.2	5.0	0.0	0.4	0.4	0	0.1
Pulp and paper industry	0.3	0.2	0.3	2.9	1.4	0.0	0.2	1.8	0	0.4
Manufacture of industrial chemicals	1.8	0.9	6.2	6.0	2.9	0.3	1.7	30.8	0	0.1
Manufacture of mineral products	1.4	0.0	0.1	2.6	5.9	0.0	0.2	0.9	0	0.3
Manufacture of iron, steel and ferro alloys	2.8	0.0	0.0	10.0	5.8	0.0	1.3	0.1	2	0.0
Manufacture of other metals	2.0	0.0	0.0	4.9	1.8	0.0	0.6	18.3	0	0.1
Manufacture of metal products, boats, ships and platforms	0.2	0.0	0.0	0.3	0.9	0.0	11.7	1.4	0	0.1
Manufacture of wood, plastic, rubber, graphic and chemical products	0.2	0.1	0.1	1.2	0.9	0.0	3.9	5.3	0	0.7
Manufacture of consumer goods	0.6	0.0	0.1	1.7	2.2	0.0	1.6	2.1	0	0.2
Other	15.1	270.3	7.8	11.1	157.6	38.8	129.2	811.4	177	17.8
Building and construction	0.5	0.0	0.0	0.4	5.6	0.0	4.2	4.9	1	0.5
Agriculture and forestry	0.8	92.6	6.5	0.7	8.3	38.4	2.6	9.7	1	1.1
Fishing and hunting	1.4	0.4	0.1	1.7	29.7	0.0	1.1	2.7	0	0.5
Land transport, domestic	2.0	0.1	0.2	1.7	21.0	0.0	4.3	22.0	3	2.4
Sea transport, domestic	1.2	0.3	0.1	2.8	26.8	0.0	1.0	1.9	0	0.5
Air transport, domestic	1.0	0.0	0.1	0.1	2.9	0.0	0.4	2.4	2	0.
Other private services	1.9	0.4	0.2	1.0	15.2	0.1	25.7	122.7	32	0.6
Public activities (municipal)	0.3	165.3	0.0	0.2	0.3	0.0	0.1	0.5	0	0.0
Public activities (state)	0.5	0.1	0.0	0.3	4.2	0.0	0.4	2.5	0	0.1
Private households	5.6	11.2	0.6	2.2	43.7	0.3	89.5	642.1	137	12.0

[1] Includes gas terminal, transport and supply boats. [2] Includes emissions from waste incineration plants.
Sources: Statistics Norway and SFT

Table B2. Emission to air by source. 1991. 1 000 tonnes unless specified otherwise

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb	Par-ticu-lates
	Mill. tonnes								Tonnes	
Total	33.9	288.8	14.9	45.4	220.4	39.1	254.8	880.1	182	20.2
Stationary combustion	13.6	12.9	1.4	9.8	39.5	-	10.6	123.9	2	12.9
Oil extraction	6.5	2.3	0.1	0.3	25.6	-	0.9	4.8	-	0.1
--Natural gas	5.3	2.1	0.0	0.0	14.1	-	0.5	3.8	-	0.0
--Diesel combustion	0.3	0.1	0.0	0.3	5.8	-	0.4	0.4	-	0.1
--Flaring	0.9	0.2	0.0	0.0	5.8	-	0.0	0.5	-	0.0
Gas terminals and oil refineries	1.9	0.3	0.1	0.4	2.2	-	0.7	0.3	-	0.1
Other industry	2.9	0.4	0.8	6.5	8.1	-	0.8	6.6	0	1.6
Dwellings, offices etc.	2.1	9.8	0.5	2.3	2.5	-	7.9	112.0	-	11.1
Incineration of wastes	0.1	0.1	-	0.3	1.0	-	0.3	0.3	1	0.0
Processes and evaporation	6.8	273.0	12.6	25.5	7.9	38.8	145.6	48.6	2	..
Oil and gas activities	0.3	8.4	-	-	-	-	101.6	-	-	..
--Ventilation, leakages etc.	0.0	5.2	-	-	-	-	3.6	-	-	..
--Oil loading	0.3	2.9	-	-	-	-	90.4	-	-	..
--Gas terminals and oil refineries	0.0	0.3	-	2.4	-	-	7.6	-	-	..
Gasoline distribution	0.0	-	-	-	-	-	9.2	-	-	..
Pulp and paper industry	-	-	-	1.6	-	-	-	-	-	..
Chemicals manufacturing	1.0	0.9	6.1	5.3	1.6	0.3	0.9	30.6	-	..
Cement, other minerals manuf.	0.6	-	-	0.7	-	-	-	-	-	..
Metals manufacturing	4.4	-	-	14.9	6.3	-	1.3	18.0	2	..
--Ferro alloys	2.6	-	-	9.8	5.7	-	1.3	-	-	..
--Aluminium	1.5	-	-	4.1	0.6	-	-	-	-	..
--Other	0.3	-	-	1.1	-	-	-	18.0	-	..
Agriculture	0.2	92.5	6.5	-	-	38.4	-	-	-	..
Landfills (waste)	0.1	165.2	-	-	-	-	-	-	-	..
Evaporation of solvents	0.1	-	-	-	-	-	31.6	-	-	..
Other process emissions	0.0	5.9	-	0.6	-	-	0.9	-	-	..
Mobile combustion	13.6	2.9	0.9	10.0	173.0	0.4	98.6	707.5	178	7.3
Motor vehicle traffic	7.9	1.7	0.6	3.3	80.4	0.3	79.2	664.9	171	4.0
-Gasoline-driven	5.3	1.6	0.3	1.0	51.9	0.3	74.9	649.1	171	0.7
--Passenger cars	4.9	1.5	0.3	0.9	47.4	0.3	69.2	601.4	158	0.7
--Light commercial vehicles	0.3	0.1	0.0	0.1	4.0	0.0	5.1	41.0	11	0.0
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.7	1	0.0
-Diesel-driven	2.6	0.1	0.3	2.3	28.4	0.0	4.3	15.8	0	3.3
--Passenger cars	0.3	0.0	0.0	0.2	0.9	0.0	0.3	1.1	0	0.5
--Light commercial vehicles	0.3	0.0	0.0	0.3	1.2	0.0	0.4	1.3	0	0.6
--Heavy vehicles	2.1	0.0	0.3	1.8	26.3	0.0	3.6	13.4	0	2.2
Motorcycles, mopeds, scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.4	2	0.0
Motorized tools	0.7	0.1	0.0	0.6	11.2	0.0	1.7	5.9	0	1.4
Railways	0.1	0.0	0.0	0.1	0.6	0.0	0.1	0.2	0	0.1
Air traffic	1.2	0.0	0.1	0.2	3.6	-	0.6	3.1	2	0.2
Ships and boats	3.6	1.0	0.2	5.8	77.1	-	11.8	20.0	3	1.5
--Coastal traffic, pleasureboats etc.	2.0	0.6	0.1	3.9	42.5	-	10.3	17.0	3	1.0
--Fishing fleet	1.4	0.4	0.1	1.7	29.7	-	1.1	2.7	0	0.5
--Mobile oil rigs etc.	0.2	0.0	0.0	0.2	4.9	-	0.4	0.4	0	0.1

Sources: Statistics Norway and SFT

Table B3. Emissions to air by main source and main sector. 1991. 1 000 tonnes unless specified otherwise

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb	Par-ticu-lates
	Mill. tonnes								Tonnes	
Total	33.9	288.8	14.9	45.4	220.4	39.1	254.8	880.1	182	20.2
Energy sectors	9.3	16.9	0.2	4.5	36.1	-	104.0	7.6	2	0.4
- Stationary combustion	8.6	2.6	0.2	1.4	28.9	-	2.0	5.5	1	0.3
- Mobile combustion	0.3	0.1	0.0	0.8	7.1	0.0	0.5	2.2	1	0.1
- Processes/evaporation	0.3	14.3	-	2.4	-	-	101.6	-	-	..
The primary industries	2.2	93.0	6.6	2.3	38.0	38.4	3.7	12.3	2	1.6
- Stationary combustion	0.1	0.0	0.0	0.3	0.1	-	0.0	0.1	-	0.0
- Mobile combustion	1.9	0.5	0.1	2.1	37.9	0.0	3.7	12.2	2	1.6
- Processes/evaporation	0.2	92.5	6.5	-	-	38.4	-	-	-	..
Manufacturing and mining	9.5	1.5	6.9	29.8	26.7	0.3	21.5	61.1	3	1.9
- Stationary combustion	2.9	0.5	0.7	6.1	8.0	-	0.7	6.4	-	1.5
- Mobile combustion	0.6	0.1	0.1	0.5	10.8	0.0	1.3	6.1	1	0.4
- Processes/evaporation	6.1	1.0	6.1	23.2	7.9	0.3	19.5	48.6	2	..
Service industries[1]	7.4	166.2	0.7	6.6	75.9	0.1	36.0	156.9	38	4.2
- Stationary combustion	0.9	0.0	0.2	0.9	0.7	-	0.1	0.6	-	0.1
- Mobile combustion	6.4	0.9	0.5	5.7	75.2	0.1	21.4	156.3	38	4.1
- Processes/evaporation	0.1	165.2	-	-	-	-	14.5	-	-	..
Private households	5.6	11.2	0.6	2.2	43.7	0.3	89.5	642.1	137	12.0
- Stationary combustion	1.2	9.8	0.3	1.2	1.7	-	7.8	111.4	-	11.0
- Mobile combustion	4.4	1.4	0.2	0.9	42.1	0.3	71.8	530.7	137	1.0
- Processes/evaporation	0.0	-	-	-	-	-	10.0	-	-	..

[1] Includes Building and construction and landfills

Sources: Statistics Norway and SFT

Table B4. Emissions to air by source. 1992*. 1 000 tonnes unless specified otherwise

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NM-VOC	CO	Pb	Par-ticu-lates
	Mill. tonnes								Tonn	
Total	34.3	293.1	13.1	37.5	219.6	39.8	265.2	851.5	150	20.3
Stationary combustion	14.0	13.1	1.4	8.9	41.6	-	10.9	123.8	1	12.8
Oil extraction	7.0	2.5	0.1	0.3	27.6	-	1.1	5.2	0	0.1
--Natural gas	4.2	2.2	0.0	0.0	15.4	-	0.6	4.2	0	0.0
--Diesel combustion	0.4	0.1	0.0	0.3	7.2	-	0.5	0.5	0	0.1
--Flaring	0.8	0.2	0.0	0.0	5.0	-	0.0	0.5	0	0.0
Gas terminals and oil refineries	2.3	0.3	0.1	0.1	3.4	-	0.9	0.2	0	0.1
Other industry	2.6	0.4	0.8	6.1	7.0	-	0.7	6.5	0	1.5
Dwellings, offices etc.	2.0	9.8	0.5	2.0	2.3	-	7.8	111.6	0	11.1
Incineration of wastes	0.1	0.1	0.0	0.3	1.2	-	0.3	0.3	1	0.0
Processes and evaporation	6.6	277.1	10.6	20.1	6.6	39.4	158.4	46.3	2	..
Oil and gas activities	0.4	9.2	-	-	-	-	114.7	-	-	..
--Ventilation, leakages etc.	0.0	5.2	-	-	-	-	3.6	-	-	..
--Oil loading	0.3	3.5	-	-	-	-	102.2	-	-	..
--Gas terminals and oil refineries	0.0	0.4	-	2.5	-	-	8.9	-	-	..
Gasoline distribution	0.0	-	-	-	-	-	8.9	-	-	..
Pulp and paper industry	-	-	-	0.7	-	-	-	-	-	..
Chemicals manufacturing	1.0	0.8	4.2	5.1	1.0	0.4	0.9	32.3	-	..
Cement, other minerals manuf.	0.6	-	-	0.5	-	-	-	-	-	..
Metals manufacturing	4.2	-	-	11.1	5.6	-	1.3	14.0	2	..
--Ferro alloys	2.4	-	-	7.3	5.0	-	1.3	-	-	..
--Aluminium	1.5	-	-	3.0	0.6	-	-	-	-	..
--Other	0.3	-	-	0.8	-	-	-	14.0	-	..
Agriculture	0.2	94.4	6.5	-	-	39.0	-	-	-	..
Landfills (waste)	0.1	165.6	-	-	-	-	-	-	-	..
Evaporation of solvents	0.1	-	-	-	-	-	31.6	-	-	..
Other process emissions	0.0	7.0	-	0.3	-	-	0.9	-	-	..
Mobile combustion	13.7	2.9	1.0	8.5	171.4	0.4	95.9	681.4	147	7.5
Motor vehicle traffic	8.0	1.6	0.6	3.3	79.7	0.4	76.6	638.6	140	4.2
-Gasoline-driven	5.1	1.6	0.3	1.0	48.9	0.4	72.0	621.4	140	0.7
--Passenger cars	4.8	1.5	0.3	0.9	44.6	0.4	66.4	574.9	130	0.6
--Light commercial vehicles	0.3	0.1	0.0	0.1	3.9	0.0	5.0	40.1	9	0.0
--Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.5	1	0.0
-Diesel-driven	2.9	0.1	0.3	2.4	30.8	0.0	4.6	17.2	0	3.5
--Passenger cars	0.3	0.0	0.0	0.2	1.1	0.0	0.3	1.3	0	0.5
--Light commercial vehicles	0.4	0.0	0.0	0.3	1.4	0.0	0.5	1.5	0	0.7
--Heavy vehicles	2.2	0.0	0.3	1.8	28.4	0.0	3.8	14.4	0	2.3
Motorcycles, mopeds, scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.6	2	0.0
Motorized tools	0.7	0.1	0.0	0.6	11.3	0.0	1.7	5.9	0	1.4
Railways	0.1	0.0	0.0	0.1	0.6	0.0	0.1	0.2	0	0.1
Air traffic	1.3	0.0	0.1	0.1	3.8	-	0.6	3.2	2	0.2
Ships and boats	3.5	1.0	0.2	4.4	75.8	-	11.7	19.9	3	1.5
--Coastal traffic, pleasureboats etc.	2.1	0.6	0.1	3.1	44.4	-	10.4	17.2	2	1.0
--Fishing fleet	1.3	0.4	0.1	1.2	27.7	-	1.0	2.5	0	0.5
--Mobile oil rigs etc.	0.2	0.0	0.0	0.1	3.6	-	0.3	0.3	0	0.1

Sources: Statistics Norway and SFT

Table B5. Emissions[1] to air by county and main source. 1991. 1 000 tonnes. CO_2 in mill. tonnes

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particu-lates
Total	36.0	289.6	15.1	77.6	282.0	39.1	257.0	883.8	21.2
Of this total, ships and aircraft engaged in international traffic	2.0	0.8	0.2	32.2	61.6	-	2.2	3.7	1.0
Østfold									
-Mobile combustion	0.5	0.1	0.0	0.4	5.6	0.0	5.8	40.6	0.3
-Stationary combustion	0.5	0.6	0.2	1.5	1.3	-	0.6	7.1	0.9
-Processes/evaporation	0.2	11.2	0.3	3.4	0.5	1.5	2.4	0.0	..
Akershus									
-Mobile combustion	1.1	0.2	0.1	0.5	10.7	0.0	11.3	82.0	0.6
-Stationary combustion	0.3	0.6	0.1	0.4	0.5	-	0.6	7.8	0.8
-Processes/evaporation	0.0	16.7	0.3	0.1	0.0	1.3	3.5	0.0	..
Oslo									
-Mobile combustion	0.6	0.2	0.0	0.5	6.8	0.0	6.9	53.4	0.4
-Stationary combustion	0.3	0.4	0.1	0.4	0.8	-	0.4	3.9	0.4
-Processes/evaporation	0.0	2.8	0.0	0.0	0.0	0.0	4.3	0.0	..
Hedmark									
-Mobile combustion	0.6	0.1	0.0	0.3	6.7	0.0	5.7	43.8	0.5
-Stationary combustion	0.2	0.9	0.1	0.3	0.3	-	0.8	11.6	1.2
-Processes/evaporation	0.0	13.5	0.5	0.0	0.0	2.5	1.4	0.0	..
Oppland									
-Mobile combustion	0.6	0.1	0.0	0.3	6.0	0.0	5.2	40.0	0.4
-Stationary combustion	0.1	0.6	0.0	0.2	0.2	-	0.6	7.7	0.8
-Processes/evaporation	0.0	19.7	0.6	0.0	0.0	3.6	1.9	0.0	..
Buskerud									
-Mobile combustion	0.6	0.1	0.0	0.4	6.6	0.0	6.3	47.9	0.4
-Stationary combustion	0.3	0.6	0.2	0.7	0.7	-	0.4	5.9	0.6
-Processes/evaporation	0.0	11.9	0.2	0.4	0.0	1.0	2.6	0.0	..
Vestfold									
-Mobile combustion	0.5	0.1	0.0	0.3	5.0	0.0	5.3	36.7	0.3
-Stationary combustion	0.6	0.3	0.1	1.1	1.1	-	0.5	4.3	0.6
-Processes/evaporation	0.0	8.9	0.2	0.4	0.0	0.8	3.9	0.0	..
Telemark									
-Mobile combustion	0.4	0.1	0.0	0.6	4.7	0.0	4.2	29.9	0.2
-Stationary combustion	1.1	0.5	0.1	0.3	3.7	-	0.4	5.5	0.6
-Processes/evaporation	1.5	8.5	4.1	0.8	1.4	0.9	2.8	18.0	..
Aust-Agder									
-Mobile combustion	0.2	0.0	0.0	0.1	2.2	0.0	2.6	16.9	0.1
-Stationary combustion	0.1	0.5	0.0	0.1	0.1	-	0.4	5.9	0.6
-Processes/evaporation	0.2	6.2	0.1	2.9	0.0	0.5	0.9	25.3	..

Table B5 (cont.). Emissions[1] to air by county and main source. 1991. 1 000 tonnes. CO_2 in mill. tonnes

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particu-lates
Vest-Agder									
-Mobile combustion	0.3	0.1	0.0	0.3	3.1	0.0	3.2	20.7	0.2
-Stationary combustion	0.1	0.4	0.0	0.2	0.2	-	0.3	4.6	0.5
-Processes/evaporation	0.4	10.1	0.1	1.9	0.3	0.9	1.6	0.0	..
Rogaland									
-Mobile combustion	0.8	0.2	0.1	0.9	8.5	0.0	7.5	56.3	0.4
-Stationary combustion	0.9	0.7	0.1	0.7	1.1	-	0.6	6.6	0.7
-Processes/evaporation	0.7	35.8	1.0	1.3	0.6	6.5	6.1	0.0	..
Hordaland									
-Mobile combustion	0.7	0.2	0.1	0.9	7.8	0.0	7.4	52.6	0.4
-Stationary combustion	1.4	0.7	0.1	0.8	1.4	-	1.0	7.0	0.8
-Processes/evaporation	0.8	28.2	0.4	2.4	0.5	2.2	31.1	0.0	..
Sogn og Fjordane									
-Mobile combustion	0.2	0.0	0.0	0.2	2.7	0.0	2.3	16.7	0.2
-Stationary combustion	0.1	0.2	0.0	0.4	0.2	-	0.2	2.5	0.3
-Processes/evaporation	0.7	11.0	0.4	2.7	0.7	2.3	1.1	0.0	..
Møre og Romsdal									
-Mobile combustion	0.5	0.1	0.0	0.5	5.2	0.0	4.6	33.6	0.3
-Stationary combustion	0.2	0.7	0.0	0.4	0.3	-	0.6	7.6	0.8
-Processes/evaporation	0.3	14.7	0.5	0.5	0.1	3.2	3.9	0.0	..
Sør-Trøndelag									
-Mobile combustion	0.4	0.1	0.0	0.3	4.8	0.0	4.2	31.9	0.3
-Stationary combustion	0.2	0.8	0.0	0.4	0.4	-	0.7	9.2	0.9
-Processes/evaporation	0.5	13.7	0.5	3.1	1.2	3.2	2.3	5.3	..
Nord-Trøndelag									
-Mobile combustion	0.4	0.1	0.0	0.3	4.0	0.0	3.3	24.9	0.3
-Stationary combustion	0.1	0.9	0.0	0.2	0.2	-	0.7	9.6	1.0
-Processes/evaporation	0.1	11.8	0.6	0.2	0.2	3.7	1.0	0.0	..
Nordland									
-Mobile combustion	0.5	0.1	0.0	0.5	5.8	0.0	5.0	36.0	0.4
-Stationary combustion	0.3	0.5	0.0	0.4	1.0	-	0.4	5.4	0.6
-Processes/evaporation	0.9	19.0	2.5	3.9	1.7	2.5	1.9	0.0	..
Troms									
-Mobile combustion	0.3	0.1	0.0	0.2	3.3	0.0	3.2	24.6	0.2
-Stationary combustion	0.1	0.4	0.0	0.2	0.1	-	0.3	4.2	0.4
-Processes/evaporation	0.2	8.8	0.2	0.9	0.5	1.1	1.2	0.0	..
Finnmark									
-Mobile combustion	0.2	0.0	0.0	0.2	1.9	0.0	1.9	12.5	0.1
-Stationary combustion	0.1	0.2	0.0	0.4	0.2	-	0.2	2.6	0.3
-Processes/evaporation	0.0	6.6	0.2	0.6	0.0	1.1	0.5	0.0	..

Table B5 (cont.). Emissions[1] to air by county and main source. 1991. 1 000 tonnes. CO_2 in mill. tonnes

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particu-lates
Svalbard									
-Mobile combustion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
-Stationary combustion	0.1	0.0	0.0	0.4	0.1	-	0.0	0.1	0.1
-Processes/evaporation	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	..
Sea									
-Mobile combustion	6.1	1.7	0.4	34.5	133.4	0.0	5.0	10.1	2.3
-Stationary combustion	6.5	2.3	0.1	0.3	25.8	-	0.9	4.8	0.1
-Processes/evaporation	0.2	8.0	0.0	0.0	0.0	0.0	71.1	0.0	..

[1] Does not include emissions from activities outside Norwegian territories and in air space higher than 1000 metres

Sources: Statistics Norway and SFT

Table B6. Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Total	35960	77572	281994	256958	.	.	.	.
Of this total, ships and aircraft engaged in international traffic	2017	3224	61604	2158	.	.	.	.
Østfold	1230	5323	7377	8785	1.368	1.896	5.16	0.03
Halden	73	337	625	1123	0.565	1.047	2.86	0.02
Fredrikstad	165	971	728	899	24.280	18.190	6.33	0.03
Moss	157	1035	763	760	17.845	13.149	6.46	0.03
Sarpsborg	410	2646	1960	1574	7.056	5.228	8.88	0.04
Hvaler	9	4	65	162	0.049	0.744	2.69	0.02
Borge	56	119	397	438	1.593	5.297	4.72	0.03
Aremark	6	4	58	52	0.012	0.203	4.20	0.04
Marker	16	9	153	152	0.025	0.416	4.81	0.05
Rømskog	2	1	16	16	0.007	0.101	2.77	0.03
Trøgstad	18	10	156	203	0.053	0.823	3.77	0.03
Spydeberg	17	9	145	169	0.071	1.081	3.97	0.03
Askim	39	26	229	322	0.391	3.463	3.08	0.02
Eidsberg	39	22	337	398	0.094	1.466	4.23	0.04
Skiptvet	8	5	74	85	0.049	0.793	2.71	0.02
Rakkestad	29	17	237	271	0.040	0.562	4.07	0.03
Rolvsøy	14	8	109	158	0.277	3.745	2.49	0.02
Kråkerøy	16	9	96	239	0.361	4.000	2.13	0.01
Onsøy	35	20	259	447	0.176	2.275	2.73	0.02
Råde	35	17	320	405	0.165	3.046	5.86	0.05
Rygge	51	36	351	489	0.527	5.090	4.24	0.03
Våler	16	8	140	184	0.033	0.586	3.89	0.03
Hobøl	18	9	160	239	0.067	1.140	4.60	0.04
Akershus	1450	978	11123	15359	0.213	2.425	3.44	0.03
Vestby	42	22	387	442	0.164	2.907	3.76	0.03
Ski	63	34	517	696	0.210	3.189	2.82	0.02
Ås	62	31	551	750	0.302	5.454	5.22	0.05
Frogn	30	16	235	293	0.187	2.705	2.88	0.02
Nesodden	23	12	152	463	0.206	2.537	1.76	0.01
Oppegård	44	24	340	573	0.711	10.009	2.14	0.02
Bærum	339	145	2276	2967	0.769	12.042	3.77	0.03
Asker	137	72	1094	1663	0.742	11.275	3.29	0.03
Aurskog-Høland	42	23	351	391	0.026	0.391	3.32	0.03
Sørum	51	25	432	614	0.124	2.172	4.51	0.04
Fet	28	14	226	415	0.102	1.638	3.26	0.03
Rælingen	40	161	287	304	2.826	5.041	2.93	0.02
Enebakk	18	9	136	249	0.048	0.694	2.19	0.02
Lørenskog	51	33	358	691	0.479	5.266	1.93	0.01
Skedsmo	142	164	994	1396	2.191	13.254	4.19	0.03
Nittedal	44	23	361	451	0.128	1.993	2.70	0.02

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Gjerdrum	9	5	76	93	0.060	0.924	2.48	0.02
Ullensaker	116	50	888	956	0.202	3.552	6.45	0.05
Nes	53	30	433	526	0.049	0.709	3.38	0.03
Eidsvoll	84	64	753	1077	0.166	1.945	5.12	0.05
Nannestad	23	14	178	235	0.044	0.547	2.86	0.02
Hurdal	11	6	98	113	0.022	0.377	4.27	0.04
Oslo	974	958	7610	11621	2.244	17.822	2.15	0.02
Hedmark	804	573	6993	7927	0.022	0.268	4.29	0.04
Kongsvinger	61	38	531	625	0.039	0.550	3.54	0.03
Hamar	77	53	531	784	0.160	1.596	3.04	0.02
Ringsaker	127	100	1039	1242	0.088	0.923	4.10	0.03
Løten	29	20	276	300	0.054	0.760	4.22	0.04
Stange	90	55	793	872	0.086	1.237	5.15	0.05
Nord-Odal	16	10	144	167	0.021	0.304	3.01	0.03
Sør-Odal	41	27	338	355	0.056	0.706	5.53	0.05
Eidskog	28	23	269	317	0.038	0.444	4.43	0.04
Grue	26	18	233	251	0.023	0.300	4.47	0.04
Åsnes	34	20	311	341	0.020	0.310	3.97	0.04
Våler	21	27	173	179	0.039	0.255	4.94	0.04
Elverum	64	40	546	668	0.033	0.451	3.70	0.03
Trysil	33	34	323	364	0.011	0.109	4.50	0.04
Åmot	22	16	203	213	0.012	0.157	4.97	0.05
Stor-Elvdal	34	20	328	314	0.009	0.154	10.30	0.10
Rendalen	17	10	168	156	0.003	0.055	6.90	0.07
Engerdal	9	5	87	89	0.003	0.045	5.25	0.05
Tolga	10	10	84	82	0.009	0.076	5.37	0.05
Tynset	32	24	297	297	0.013	0.163	6.07	0.06
Alvdal	17	13	162	150	0.014	0.176	7.07	0.07
Folldal	8	8	78	76	0.007	0.062	4.33	0.04
Os	9	5	80	82	0.005	0.080	4.39	0.04
Oppland	712	494	6234	7671	0.021	0.259	3.90	0.03
Lillehammer	69	52	513	716	0.114	1.132	3.04	0.02
Gjøvik	99	61	792	1078	0.095	1.231	3.78	0.03
Dovre	25	19	230	228	0.014	0.162	8.05	0.08
Lesja	18	13	168	138	0.006	0.077	7.40	0.07
Skjåk	13	7	132	152	0.004	0.064	4.97	0.05
Lom	12	6	114	143	0.003	0.060	4.43	0.04
Vågå	18	14	173	210	0.011	0.138	4.62	0.04
Nord-Fron	25	20	232	251	0.018	0.208	4.16	0.04
Sel	31	18	274	284	0.021	0.317	4.87	0.04
Sør-Fron	15	8	140	168	0.012	0.203	4.26	0.04
Ringebu	33	18	331	307	0.015	0.270	6.54	0.06

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Øyer	27	15	266	263	0.024	0.429	5.99	0.06
Gausdal	20	12	177	194	0.011	0.154	3.08	0.03
Østre Toten	48	54	368	431	0.114	0.777	3.39	0.03
Vestre Toten	40	32	314	548	0.125	1.247	3.02	0.02
Jevnaker	18	12	130	341	0.061	0.660	3.17	0.02
Lunner	27	29	279	322	0.108	1.027	3.35	0.04
Gran	43	25	376	436	0.037	0.570	3.45	0.03
Søndre Land	25	17	210	310	0.026	0.317	4.03	0.03
Nordre Land	24	14	219	282	0.014	0.234	3.38	0.03
Sør-Aurdal	16	9	158	168	0.009	0.148	4.51	0.04
Etnedal	8	4	78	77	0.010	0.180	5.09	0.05
Nord-Aurdal	30	16	281	333	0.019	0.325	4.73	0.04
Vestre Slidre	9	5	82	79	0.012	0.192	3.47	0.03
Øystre Slidre	12	7	113	127	0.009	0.142	4.01	0.04
Vang	8	5	86	84	0.003	0.058	4.76	0.05
Buskerud	922	1488	7273	9279	0.109	0.532	4.09	0.03
Drammen	147	177	1156	1466	1.313	8.567	2.88	0.02
Kongsberg	76	63	554	977	0.083	0.731	3.62	0.03
Ringerike	105	87	848	1080	0.061	0.594	3.87	0.03
Hole	28	14	259	295	0.103	1.936	6.38	0.06
Flå	13	6	129	133	0.009	0.193	11.04	0.11
Nes	16	9	146	159	0.012	0.194	4.73	0.04
Gol	20	11	187	205	0.022	0.362	4.84	0.04
Hemsedal	13	7	125	119	0.011	0.177	8.18	0.08
Ål	20	24	163	175	0.024	0.160	4.17	0.03
Hol	23	12	206	218	0.007	0.122	4.91	0.04
Sigdal	16	10	142	298	0.012	0.175	4.36	0.04
Krødsherad	18	9	165	170	0.035	0.631	7.58	0.07
Modum	39	23	313	415	0.050	0.680	3.24	0.03
Øvre Eiker	68	49	573	610	0.116	1.358	4.63	0.04
Nedre Eiker	50	28	336	540	0.248	2.948	2.64	0.02
Lier	118	156	824	1314	0.550	2.900	6.29	0.04
Røyken	33	17	232	408	0.164	2.193	2.30	0.02
Hurum	84	763	562	328	4.863	3.577	10.57	0.07
Flesberg	13	7	130	140	0.014	0.245	5.28	0.05
Rollag	8	4	78	75	0.010	0.182	5.32	0.05
Nore og Uvdal	14	8	144	155	0.003	0.063	5.06	0.05
Vestfold	1102	1848	6000	9683	0.864	2.804	5.52	0.03
Borre	55	35	399	613	0.512	5.874	2.45	0.02
Holmestrand	79	27	315	427	0.322	3.750	8.62	0.03
Tønsberg	386	622	1432	3228	5.921	13.640	12.38	0.05
Sandefjord	126	191	722	1417	1.606	6.066	3.53	0.02
Larvik	169	433	1176	1401	0.871	2.366	4.46	0.03
Svelvik	51	179	197	193	3.195	3.521	8.65	0.03

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Sande	80	275	485	536	1.582	2.790	11.52	0.07
Hof	12	7	98	111	0.045	0.659	4.46	0.04
Våle	29	15	259	384	0.172	3.014	7.51	0.07
Ramnes	10	5	93	99	0.039	0.679	2.99	0.03
Andebu	12	7	107	138	0.037	0.582	2.84	0.02
Stokke	37	21	313	424	0.184	2.722	4.08	0.03
Nøtterøy	35	21	231	431	0.349	3.918	1.96	0.01
Tjøme	9	4	57	166	0.120	1.540	2.28	0.01
Lardal	12	7	115	116	0.026	0.424	5.20	0.05
Telemark	2953	1770	9762	7399	0.125	0.688	18.12	0.06
Porsgrunn	1939	1189	5545	1313	7.524	35.095	62.49	0.18
Skien	124	294	879	1303	0.408	1.218	2.62	0.02
Notodden	41	24	333	432	0.028	0.391	3.36	0.03
Siljan	6	3	52	72	0.016	0.255	2.92	0.02
Bamble	628	22	973	1963	0.077	3.461	45.90	0.07
Kragerø	41	101	340	496	0.347	1.168	3.86	0.03
Drangedal	14	9	126	141	0.009	0.126	3.11	0.03
Nome	25	39	168	203	0.099	0.431	3.67	0.02
Bø	13	8	111	140	0.030	0.425	2.87	0.02
Sauherad	15	8	140	155	0.029	0.491	3.53	0.03
Tinn	21	26	290	253	0.013	0.151	3.04	0.04
Hjartdal	9	5	87	95	0.007	0.117	5.15	0.05
Seljord	15	8	136	155	0.012	0.203	4.79	0.04
Kviteseid	13	8	127	145	0.013	0.202	4.67	0.04
Nissedal	7	4	65	71	0.005	0.083	4.79	0.04
Fyresdal	5	3	49	67	0.003	0.043	3.62	0.03
Tokke	13	7	125	138	0.008	0.134	4.69	0.05
Vinje	23	13	216	259	0.004	0.074	5.75	0.05
Aust-Agder	433	3114	2282	3874	0.367	0.269	4.43	0.02
Risør	21	18	156	400	0.101	0.891	3.10	0.02
Grimstad	41	25	308	629	0.093	1.125	2.60	0.02
Arendal	178	1711	699	1188	6.737	2.751	4.73	0.02
Gjerstad	11	6	98	138	0.018	0.310	4.16	0.04
Vegårshei	5	3	43	56	0.009	0.132	2.60	0.02
Tvedestrand	20	11	160	327	0.054	0.783	3.40	0.03
Froland	11	7	103	122	0.012	0.161	2.75	0.03
Lillesand	87	1264	249	430	7.224	1.420	10.79	0.03
Birkenes	21	42	125	156	0.068	0.204	5.15	0.03
Åmli	8	5	77	86	0.004	0.071	4.09	0.04
Iveland	2	1	19	25	0.006	0.076	1.84	0.02
Evje og Hornnes	12	11	93	128	0.022	0.179	3.51	0.03
Bygland	6	4	60	68	0.003	0.051	4.87	0.05
Valle	6	3	53	67	0.003	0.046	4.09	0.04
Bykle	5	2	40	54	0.002	0.031	6.45	0.05

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Vest-Agder	865	2378	3658	5117	0.349	0.537	5.93	0.03
Kristiansand	280	1548	1594	1861	5.954	6.132	4.31	0.02
Mandal	29	21	230	460	0.100	1.106	2.37	0.02
Farsund	181	450	263	284	1.794	1.046	19.61	0.03
Flekkefjord	29	41	239	552	0.086	0.499	3.31	0.03
Vennesla	37	219	274	316	0.599	0.749	3.27	0.02
Songdalen	15	9	125	176	0.044	0.603	2.84	0.02
Søgne	20	11	162	305	0.080	1.141	2.63	0.02
Marnardal	6	4	63	60	0.011	0.165	2.84	0.03
Åseral	2	1	21	21	0.002	0.025	2.74	0.03
Audnedal	5	3	46	48	0.012	0.192	3.04	0.03
Lindesnes	17	10	143	247	0.033	0.481	4.01	0.03
Lyngdal	25	26	184	322	0.070	0.492	3.69	0.03
Hægebostad	5	3	44	65	0.006	0.104	3.14	0.03
Kvinesdal	208	28	202	322	0.030	0.220	37.23	0.04
Sirdal	7	4	70	80	0.003	0.048	4.35	0.04
Rogaland	2372	2936	10277	14225	0.343	1.202	6.94	0.03
Eigersund	90	260	659	515	0.661	1.673	7.29	0.05
Sandnes	135	103	1125	1493	0.364	3.963	3.04	0.03
Stavanger	260	372	2095	3047	5.629	31.744	2.67	0.02
Haugesund	73	271	847	786	3.986	12.463	2.65	0.03
Sokndal	23	57	109	139	0.213	0.411	6.74	0.03
Lund	15	8	149	140	0.023	0.419	4.91	0.05
Bjerkreim	18	13	160	193	0.022	0.273	7.46	0.07
Hå	52	53	382	532	0.214	1.538	4.00	0.03
Klepp	57	58	380	540	0.551	3.588	4.83	0.03
Time	35	20	275	475	0.120	1.627	2.90	0.02
Gjesdal	25	19	204	246	0.034	0.363	3.40	0.03
Sola	289	715	686	2441	10.512	10.091	18.22	0.04
Randaberg	14	8	114	185	0.337	4.765	1.86	0.01
Forsand	5	2	40	67	0.003	0.056	4.53	0.04
Strand	22	14	144	224	0.072	0.746	2.30	0.02
Hjelmeland	13	8	106	143	0.008	0.105	4.68	0.04
Suldal	13	7	117	154	0.004	0.070	3.14	0.03
Sauda	322	46	644	255	0.090	1.271	61.29	0.12
Finnøy	14	14	57	74	0.134	0.541	5.06	0.02
Rennesøy	14	8	104	131	0.126	1.601	5.58	0.04
Kvitsøy	1	0	4	30	0.082	0.745	1.96	0.01
Bokn	5	2	45	72	0.052	1.004	6.93	0.06
Tysvær	399	17	770	1159	0.044	1.959	50.25	0.10
Karmøy	455	846	858	913	3.898	3.953	13.01	0.02
Utsira	1	0	2	28	0.057	0.338	3.03	0.01
Vindafjord	24	13	199	242	0.030	0.466	4.87	0.04

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Hordaland	2859	4124	9697	39543	0.276	0.648	6.90	0.02
Bergen	514	799	4211	5462	1.794	9.463	2.45	0.02
Etne	14	8	120	158	0.012	0.178	3.54	0.03
Ølen	9	5	71	127	0.026	0.389	2.77	0.02
Sveio	13	7	115	167	0.029	0.512	2.86	0.03
Bømlo	14	8	103	209	0.038	0.469	1.49	0.01
Stord	26	14	179	691	0.102	1.297	1.81	0.01
Fitjar	6	5	47	95	0.031	0.309	1.98	0.02
Tysnes	5	3	42	91	0.013	0.171	1.86	0.01
Kvinnherad	182	315	280	392	0.288	0.257	13.99	0.02
Jondal	2	1	13	53	0.005	0.067	1.50	0.01
Odda	417	295	464	279	0.186	0.293	51.31	0.06
Ullensvang	12	7	109	150	0.005	0.083	2.97	0.03
Eidfjord	7	4	70	86	0.003	0.048	6.93	0.07
Ulvik	4	2	32	50	0.004	0.047	3.35	0.03
Granvin	6	3	60	79	0.016	0.293	6.12	0.06
Voss	46	27	384	437	0.015	0.221	3.27	0.03
Kvam	183	812	650	425	1.390	1.114	21.18	0.08
Fusa	9	5	75	179	0.014	0.210	2.46	0.02
Samnanger	9	5	78	114	0.018	0.306	3.77	0.03
Os	28	16	202	364	0.121	1.521	2.20	0.02
Austevoll	7	5	44	100	0.040	0.393	1.61	0.01
Sund	8	5	52	113	0.049	0.549	1.64	0.01
Fjell	36	18	250	408	0.131	1.771	2.40	0.02
Askøy	52	109	319	407	1.167	3.429	2.80	0.02
Vaksdal	17	14	137	182	0.020	0.191	3.92	0.03
Modalen	1	0	3	21	0.001	0.009	1.86	0.01
Osterøy	13	8	96	363	0.032	0.387	1.92	0.01
Meland	8	5	56	163	0.057	0.649	1.78	0.01
Øygarden	75	4	47	22524	0.061	0.737	24.00	0.02
Radøy	10	6	70	142	0.055	0.659	2.19	0.02
Lindås	1111	1602	1211	5273	3.529	2.667	93.15	0.10
Austrheim	6	3	38	91	0.063	0.699	2.20	0.01
Fedje	2	1	3	46	0.114	0.312	2.15	0.00
Masfjorden	7	4	64	103	0.007	0.122	3.76	0.03
Sogn og Fjordane	1064	3240	3582	3544	0.181	0.200	9.96	0.03
Flora	30	56	243	300	0.084	0.363	3.00	0.02
Gulen	8	5	64	72	0.008	0.111	2.97	0.03
Solund	3	2	12	30	0.010	0.054	2.49	0.01
Hyllestad	5	3	43	82	0.011	0.171	2.81	0.03
Høyanger	146	186	177	154	0.216	0.205	30.80	0.04
Vik	7	4	61	88	0.005	0.076	2.81	0.02
Balestrand	9	5	67	81	0.007	0.093	4.82	0.04
Leikanger	7	4	64	81	0.024	0.356	2.53	0.02
Sogndal	20	12	140	187	0.028	0.321	3.31	0.02

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Aurland	9	5	91	101	0.004	0.064	5.12	0.05
Lærdal	10	6	92	95	0.004	0.071	4.58	0.04
Årdal	413	2133	276	109	2.265	0.293	66.65	0.04
Luster	13	8	118	133	0.003	0.045	2.55	0.02
Askvoll	8	5	62	78	0.016	0.197	2.16	0.02
Fjaler	7	6	66	78	0.015	0.169	2.57	0.02
Gaular	12	6	119	124	0.012	0.220	4.14	0.04
Jølster	12	6	114	118	0.010	0.184	3.96	0.04
Førde	28	20	207	304	0.035	0.366	3.25	0.02
Naustdal	8	4	76	83	0.012	0.215	3.00	0.03
Bremanger	204	606	636	180	0.753	0.790	45.50	0.14
Vågsøy	33	114	216	187	0.701	1.336	5.15	0.03
Selje	8	5	66	82	0.022	0.290	2.38	0.02
Eid	18	11	153	218	0.024	0.336	3.32	0.03
Hornindal	4	2	35	94	0.012	0.200	3.14	0.03
Gloppen	19	11	157	214	0.011	0.161	2.98	0.03
Stryn	26	15	227	272	0.011	0.170	3.79	0.03
Møre og Romsdal	943	1342	5657	9047	0.092	0.388	3.95	0.02
Molde	59	121	570	631	0.342	1.605	2.67	0.03
Kristiansund	33	47	253	449	2.145	11.485	1.92	0.01
Ålesund	98	127	816	1139	1.365	8.769	2.76	0.02
Vanylven	17	43	100	132	0.133	0.310	4.30	0.03
Sande	7	4	56	106	0.034	0.425	2.07	0.02
Herøy	30	73	179	205	0.610	1.489	3.71	0.02
Ulstein	12	7	87	294	0.072	0.927	2.07	0.02
Hareid	9	5	67	196	0.068	0.866	1.97	0.01
Volda	15	9	126	218	0.018	0.240	1.94	0.02
Ørsta	35	114	407	483	0.146	0.518	3.48	0.04
Ørskog	9	5	87	109	0.040	0.681	4.66	0.04
Norddal	6	4	57	81	0.004	0.063	3.20	0.03
Stranda	14	9	108	269	0.011	0.128	3.17	0.02
Stordal	4	2	26	254	0.009	0.105	3.68	0.03
Sykkylven	17	10	118	784	0.041	0.495	2.54	0.02
Skodje	16	8	149	221	0.075	1.342	4.91	0.04
Sula	24	55	129	207	0.952	2.216	3.58	0.02
Giske	14	6	92	145	0.162	2.354	2.19	0.01
Haram	22	22	151	325	0.089	0.605	2.56	0.02
Vestnes	22	14	176	285	0.040	0.503	3.54	0.03
Rauma	34	25	299	348	0.017	0.207	4.34	0.04
Nesset	12	7	112	140	0.007	0.113	3.58	0.03
Midsund	5	3	38	75	0.029	0.404	2.31	0.02
Sandøy	2	1	14	35	0.073	0.695	1.42	0.01
Aukra	5	3	39	101	0.056	0.673	1.82	0.01
Fræna	25	16	203	249	0.043	0.565	2.80	0.02
Eide	8	6	68	95	0.040	0.468	2.76	0.02
Averøy	13	9	96	133	0.053	0.556	2.32	0.02
Frei	9	6	71	135	0.087	1.115	1.90	0.01

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Gjemnes	12	6	118	184	0.017	0.318	4.30	0.04
Tingvoll	11	6	101	125	0.020	0.311	3.19	0.03
Sunndal	299	536	351	259	0.325	0.213	40.09	0.05
Surnadal	19	11	160	283	0.008	0.122	3.00	0.03
Rindal	7	7	66	74	0.011	0.106	3.30	0.03
Aure	7	4	59	93	0.008	0.122	2.40	0.02
Halsa	5	3	44	74	0.010	0.149	2.31	0.02
Tustna	2	1	21	39	0.010	0.151	2.11	0.02
Smøla	6	3	46	71	0.013	0.175	2.19	0.02
Sør-Trøndelag	1102	3847	6397	7263	0.216	0.359	4.36	0.03
Trondheim	357	799	1991	2845	2.489	6.203	2.62	0.01
Hemne	179	1027	587	227	1.641	0.938	42.06	0.14
Snillfjord	7	3	66	84	0.007	0.144	5.83	0.06
Hitra	11	7	95	125	0.011	0.147	2.59	0.02
Frøya	10	9	67	90	0.039	0.305	2.33	0.02
Ørland	15	7	89	108	0.104	1.247	2.96	0.02
Agdenes	6	3	54	66	0.011	0.167	2.95	0.03
Rissa	21	12	198	276	0.020	0.337	3.36	0.03
Bjugn	19	36	144	152	0.102	0.406	3.84	0.03
Åfjord	11	7	98	119	0.008	0.109	3.01	0.03
Roan	3	2	32	43	0.006	0.090	2.79	0.03
Osen	3	2	27	43	0.005	0.072	2.35	0.02
Oppdal	30	18	282	304	0.008	0.128	4.90	0.05
Rennebu	20	11	203	191	0.012	0.221	6.82	0.07
Meldal	13	8	106	153	0.013	0.173	3.04	0.02
Orkdal	219	1785	714	425	3.176	1.270	21.63	0.07
Røros	17	11	138	256	0.006	0.079	3.23	0.03
Holtålen	9	5	73	88	0.005	0.063	3.54	0.03
Midtre Gauldal	28	21	284	322	0.011	0.157	4.67	0.05
Melhus	49	29	455	483	0.044	0.695	3.98	0.04
Skaun	20	12	194	223	0.055	0.909	3.67	0.03
Klæbu	7	5	62	85	0.026	0.359	1.73	0.01
Malvik	34	19	302	386	0.118	1.832	3.57	0.03
Selbu	11	7	102	125	0.006	0.089	2.74	0.03
Tydal	3	2	33	41	0.002	0.027	3.37	0.03
Nord-Trøndelag	566	694	4334	4966	0.033	0.206	4.44	0.03
Steinkjer	76	75	650	808	0.053	0.453	3.73	0.03
Namsos	30	33	228	336	0.042	0.291	2.58	0.02
Meråker	78	207	268	140	0.167	0.216	28.71	0.10
Stjørdal	91	84	601	681	0.091	0.648	5.31	0.04
Frosta	7	5	56	71	0.065	0.765	2.70	0.02
Leksvik	9	6	89	125	0.015	0.222	2.65	0.03
Levanger	74	137	701	632	0.222	1.134	4.45	0.04
Verdal	49	47	376	568	0.032	0.256	3.63	0.03

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Mosvik	3	2	27	41	0.009	0.133	2.94	0.03
Verran	8	7	64	117	0.012	0.116	2.69	0.02
Namdalseid	9	5	92	111	0.007	0.123	4.61	0.05
Inderøy	21	17	174	204	0.119	1.192	3.70	0.03
Snåsa	14	9	133	122	0.004	0.061	5.75	0.05
Lierne	7	5	69	73	0.002	0.026	3.98	0.04
Røyrvik	4	2	23	25	0.002	0.017	5.27	0.03
Namsskogan	11	7	100	86	0.005	0.073	9.87	0.09
Grong	19	11	178	178	0.010	0.162	7.59	0.07
Høylandet	8	4	76	83	0.006	0.104	5.50	0.05
Overhalla	15	9	125	146	0.013	0.183	3.89	0.03
Fosnes	3	2	26	35	0.004	0.054	3.14	0.03
Flatanger	3	2	31	45	0.005	0.070	2.27	0.02
Vikna	8	5	67	99	0.017	0.214	2.15	0.02
Nærøy	17	11	163	215	0.010	0.158	3.14	0.03
Leka	2	1	16	25	0.014	0.153	2.08	0.02
Nordland	1745	4763	8468	7288	0.131	0.233	7.27	0.04
Bodø	98	63	595	892	0.072	0.683	2.67	0.02
Narvik	54	72	495	508	0.037	0.255	2.94	0.03
Bindal	6	4	56	67	0.003	0.047	2.82	0.03
Sømna	7	4	55	62	0.021	0.293	3.13	0.03
Brønnøy	18	10	136	169	0.010	0.136	2.70	0.02
Vega	3	2	23	37	0.012	0.150	2.03	0.02
Vevelstad	2	1	13	22	0.002	0.024	2.44	0.02
Herøy	4	2	23	43	0.038	0.369	1.88	0.01
Alstahaug	19	11	131	187	0.027	0.324	2.62	0.02
Leirfjord	8	4	71	83	0.010	0.160	3.33	0.03
Vefsn	285	368	496	383	0.228	0.307	21.42	0.04
Grane	17	10	158	123	0.005	0.083	9.83	0.09
Hattfjelldal	8	9	78	83	0.004	0.032	4.50	0.05
Dønna	4	2	33	44	0.013	0.175	2.31	0.02
Nesna	4	3	35	45	0.013	0.174	2.31	0.02
Hemnes	17	10	145	187	0.007	0.099	3.52	0.03
Rana	418	1942	1430	968	0.452	0.333	17.04	0.06
Lurøy	4	3	34	49	0.011	0.131	1.92	0.01
Træna	1	0	4	15	0.029	0.262	1.21	0.01
Rødøy	4	2	31	46	0.003	0.046	2.06	0.02
Meløy	19	45	360	140	0.054	0.439	2.73	0.05
Gildeskål	9	5	82	99	0.008	0.130	3.62	0.03
Beiarn	4	2	34	39	0.002	0.028	2.51	0.02
Saltdal	22	14	193	204	0.007	0.092	4.44	0.04
Fauske	33	44	321	345	0.039	0.288	3.36	0.03
Skjerstad	4	2	38	51	0.005	0.086	3.26	0.03
Sørfold	272	1909	903	279	1.261	0.597	97.95	0.33
Steigen	10	6	78	93	0.006	0.080	2.99	0.02
Hamarøy	13	7	129	137	0.008	0.138	5.70	0.06
Tysfjord	184	96	810	58	0.071	0.593	72.01	0.32

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Lødingen	8	5	64	79	0.009	0.124	2.92	0.02
Tjeldsund	7	4	61	66	0.013	0.194	4.30	0.04
Evenes	16	6	105	94	0.027	0.452	9.69	0.06
Ballangen	11	6	102	123	0.008	0.120	3.68	0.03
Røst	1	1	9	18	0.097	0.833	2.26	0.01
Værøy	1	1	7	21	0.051	0.363	1.52	0.01
Flakstad	4	3	32	45	0.016	0.185	2.58	0.02
Vestvågøy	28	16	223	278	0.040	0.551	2.72	0.02
Vågan	21	12	158	219	0.027	0.342	2.30	0.02
Hadsel	22	12	159	197	0.022	0.288	2.53	0.02
Bø	9	5	80	101	0.022	0.338	2.54	0.02
Øksnes	11	7	78	102	0.023	0.254	2.36	0.02
Sortland	28	18	226	286	0.032	0.404	3.39	0.03
Andøy	24	11	162	177	0.018	0.259	3.71	0.03
Moskenes	2	1	14	26	0.013	0.125	1.58	0.01
Troms	606	1227	3927	4757	0.049	0.156	4.10	0.03
Harstad	51	49	396	597	0.140	1.133	2.27	0.02
Tromsø	133	160	864	1311	0.063	0.343	2.61	0.02
Kvæfjord	10	6	92	111	0.009	0.144	3.12	0.03
Skånland	12	6	112	139	0.013	0.242	3.59	0.03
Bjarkøy	1	1	9	17	0.011	0.116	1.64	0.01
Ibestad	4	3	30	48	0.012	0.129	2.07	0.01
Gratangen	7	4	63	70	0.012	0.204	4.67	0.04
Lavangen	5	2	45	51	0.008	0.150	4.10	0.04
Bardu	20	11	161	189	0.004	0.063	5.29	0.04
Salangen	7	4	60	93	0.009	0.138	2.70	0.02
Målselv	39	19	289	350	0.006	0.090	5.42	0.04
Sørreisa	13	8	89	114	0.024	0.259	4.00	0.03
Dyrøy	3	2	31	46	0.005	0.082	2.22	0.02
Tranøy	7	4	59	67	0.009	0.118	3.37	0.03
Torsken	3	2	25	30	0.008	0.106	2.37	0.02
Berg	4	3	35	42	0.010	0.130	3.49	0.03
Lenvik	193	893	745	429	1.043	0.869	17.87	0.07
Balsfjord	31	17	282	324	0.011	0.195	5.02	0.04
Karlsøy	6	4	57	74	0.004	0.057	2.35	0.02
Lyngen	9	5	67	89	0.007	0.085	2.43	0.02
Storfjord	11	5	104	128	0.004	0.072	5.72	0.05
Kåfjord	10	5	91	118	0.005	0.090	3.49	0.03
Skjervøy	4	3	28	56	0.006	0.060	1.40	0.01
Nordreisa	16	9	140	189	0.003	0.041	3.43	0.03
Kvænangen	6	3	52	74	0.001	0.025	3.45	0.03
Finnmark	308	1195	2108	2545	0.026	0.046	4.10	0.03
Vardø	8	8	38	56	0.013	0.066	2.66	0.01
Vadsø	27	71	130	187	0.056	0.102	4.56	0.02

Table B6 (cont.). Emissions[1] to air by municipality. 1991. Tonnes unless specified otherwise

	CO_2 1000 tonnes	SO_2	NO_x	NMVOC	SO_2 per km^2	NO_x per km^2	CO_2 per inhabitant	NO_x per inhabitant
Hammerfest	19	32	119	182	0.039	0.145	2.11	0.01
Guovdageaidnu-Kautokeino	13	7	122	168	0.001	0.014	4.46	0.04
Alta	45	28	321	500	0.008	0.088	3.00	0.02
Loppa	2	2	16	36	0.002	0.024	1.42	0.01
Hasvik	3	2	15	25	0.004	0.029	1.89	0.01
Kvalsund	10	4	86	107	0.003	0.049	7.10	0.06
Måsøy	4	4	21	36	0.003	0.019	2.23	0.01
Nordkapp	14	28	66	88	0.032	0.074	3.43	0.02
Porsanger	25	11	171	229	0.002	0.037	5.55	0.04
Kárá johka - Karasjok	10	5	90	129	0.001	0.017	3.80	0.03
Lebesby	5	3	42	58	0.001	0.013	3.02	0.03
Gamvik	4	3	27	40	0.002	0.020	3.19	0.02
Berlevåg	4	2	31	48	0.002	0.029	3.13	0.02
Tana	15	8	131	170	0.002	0.034	4.68	0.04
Unjárga - Nesseby	7	4	70	92	0.003	0.052	7.06	0.07
Båtsfjord	6	4	31	49	0.003	0.022	2.40	0.01
Sør-Varanger	86	969	581	346	0.278	0.167	8.97	0.06
Other regions	12948	35275	159236	77064				
Spitsbergen	96	441	109	68				
Bjørnøya	0	0	1	0				
Hopen	0	0	0	0				
Jan Mayen	0	0	1	0				
Cont. shelf south of 62°N	11421	30364	127939	75827				
Cont. shelf north of 62°N	1432	4470	31186	1169				

[1] Does not include emissions from activities outside Norwegian territories and in air space higher than 1 000 metres

Sources: Statistics Norway and SFT

Table B7. International emissions of SO_x. 1 000 tonnes. Emissions per unit of GDP and per capita

	1970	1975	1980	1985	1990	Per unit GDP (kg/1000 US$)[1] 1990	Per capita (kg/capita) 1990
OECD	64900	58100	53900	42700	40200	3.4	47.9
Norway	171	137	141	91	54	1.0	12.7
Denmark	574	420	449	341	181	2.6	35.2
Finland	515	535	584	382	260	3.8	52.1
Sweden	930	690	489	261	128	1.1	15.0
France	2966	3328	3348	1451	1200	1.5	21.3
Italy	2830	3331	3211	2241	1988	2.6	34.5
Netherlands	807	427	502	259	208	1.0	13.9
Portugal	116	178	266	199	211	3.1	21.4
United Kingdom	6424	5368	4898	3724	3780	5.0	65.8
Switzerland	125	109	126	95	63	0.5	9.3
W. Germany	3743	3334	3194	2396	939	1.0	14.9
Canada	6677	5319	4643	3692	3323	7.9	124.8
USA	28420	25510	23780	21670	21060	4.6	83.7
Japan	4973	2586	1263	..	876	0.5	7.1

[1] GDP expressed in 1985 prices
Sources: OECD 1993a and OECD 1993b

Table B8. International emissions of NO_x. 1 000 tonnes. Emissions per unit GDP and per capita

	1970	1975	1980	1985	1990	Per unit GDP (kg/1000 US$)[1] 1990	Per capita (kg/capita) 1990
OECD	32900	35800	40700	35900	36700	3.1	43.8
Norway	159	179	186	216	230	4.1	54.2
Denmark	..	197	270	296	283	4.0	55.0
Finland	..	160	264	252	290	4.2	58.2
Sweden	302	308	424	434	396	3.3	46.3
France	1322	1608	1646	1400	1487	1.8	26.4
Italy	1410	1507	1585	1630	1996	2.6	34.6
Netherlands	456	481	571	564	552	2.8	36.9
Portugal	72	104	165	96	142	2.1	14.4
United Kingdom	2293	2245	2365	2392	2779	3.7	48.4
Switzerland	149	162	196	214	184	1.5	27.1
W. Germany	2345	2530	2944	2928	2605	2.7	41.2
Canada	1364	1756	1959	1958	1923	4.5	72.2
USA	18960	20330	23560	19390	19380	4.3	77.1
Japan	1651	1782	1400	1176	1301	0.7	10.5

[1] GDP expressed in 1985 prices
Sources: OECD 1993a and OECD 1993b

Table B9. International emissions of CO_2 from energy use. Million tonnes CO_2. Emissions per GDP and per capita

	1970	1975	1980	1985	1990	Per unit GDP (tonnes/1000 US$)[1] 1990	Per capita (tonnes/capita) 1990
Whole world	14640	15744	18792	19580	21562	..	4.1
OECD	8848	9321	10150	9694	10361	0.86	12.1
Norway	28	28	32	30	32	0.55	7.5
Denmark	64	56	64	64	56	0.91	12.7
Finland	41	47	60	53	55	0.89	11.4
Sweden	98	85	75	65	56	0.48	6.5
France	443	462	499	395	385	0.49	7.1
Italy	307	342	382	369	411	0.54	7.2
Netherlands	161	175	184	167	183	0.95	12.8
Portugal	16	22	27	28	43	0.63	4.2
United Kingdom	662	614	601	574	598	0.82	10.6
Switzerland	39	39	42	41	44	0.38	6.6
Germany	1018	994	1092	1039	989	..	12.0
Canada	342	402	439	406	437	1.05	16.1
USA	4267	4444	4913	4732	5038	1.12	19.9
Japan	781	912	937	912	1060	0.57	8.7

[1] GDP expressed in 1985 prices
Sources: OECD 1993a and OECD 1993b

Table B10. Budget for oxidized nitrogen in 1992. Preliminary figures. 1 000 tonnes N

Precipitation in / Emissions from	Nor	Swe	Fin	Den	Neth	UK	Ger	Fra	Bel	Pol	Other	Ocean[1]	Unspecified	Total
Norway	6.4	3.7	1.1	3.1	3.2	23.4	11.6	3.1	1.3	2.3	5.2	2.4	16.0	82.8
Sweden	5.5	13.8	4.1	7.8	4.8	18.5	21.3	4.8	2.4	5.3	9.7	2.6	15.9	116.5
Finland	2.0	7.5	11.2	2.6	1.6	5.8	10.5	1.9	0.7	4.8	21.4	0.9	11.9	82.8
Denmark	0.3	0.4	0.0	1.8	1.2	6.6	4.3	1.3	0.5	0.7	1.4	0.8	1.9	21.2
Netherlands	0.1	0.1	0.0	0.1	6.0	11.3	9.6	4.8	2.9	0.5	1.5	1.4	2.1	40.4
United Kingdom	0.4	0.4	0.0	0.5	3.9	70.6	9.3	8.2	2.2	1.3	6.7	4.9	10.4	118.8
Germany	0.5	0.8	0.2	2.5	22.3	42.5	139.9	51.1	14.7	9.5	40.8	6.0	21.7	352.5
France	0.2	0.3	0.0	0.8	7.3	23.3	38.0	91.1	7.9	2.6	40.1	7.3	25.2	244.1
Belgium	0.0	0.0	0.0	0.1	2.5	6.1	6.8	7.3	3.3	0.3	1.5	1.1	1.8	30.8
Russia	4.0	16.4	23.2	9.1	6.4	18.9	40.1	8.7	3.2	38.1	228.4	2.9	214.8	814.2
Baltic States	0.6	3.8	2.3	2.8	1.7	6.5	11.0	2.2	0.7	8.9	14.2	0.8	8.3	63.8
Poland	0.8	3.1	0.5	4.6	8.4	20.3	65.3	12.3	4.6	45.5	40.0	2.7	17.8	225.9
Czech./Slov.	0.1	0.4	0.1	0.7	3.0	6.4	31.5	7.8	2.1	9.8	34.4	1.0	7.7	105.0
Ocean[1]	16.9	8.4	6.3	9.4	27.9	221.9	76.5	58.4	13.6	11.8	69.3	46.1	248.1	814.6
Other countries	2.0	20.2	9.4	18.2	28.5	80.3	202.2	135.9	18.4	98.9	831.7	18.6	352.6	1816.9
Total	39.8	79.3	58.4	64.1	128.7	562.4	677.9	398.9	78.5	240.3	1546.3	99.5	956.2	4930.3

[1] Atlantic Ocean including North Sea
Source: Sandnes, 1993

Table B11. Budget for oxidized sulphur in 1992. Preliminary figures. 1 000 tonnes S

Precipitation in / Emissions from	Nor	Swe	Fin	Den	UK	Ger	Fra	Bel	Rus	Pol	Other	Ocean[1]	Unspecified	Total
Norway	5.6	2.0	0.7	3.1	24.7	13.9	1.9	1.4	7.6	4.6	12.4	2.3	36.7	116.9
Sweden	2.2	23.1	3.5	11.4	21.3	37.0	3.7	2.9	5.6	13.1	20.8	2.4	39.6	186.6
Finland	0.5	4.2	28.9	1.8	5.4	15.4	1.1	0.7	27.7	9.9	20.9	0.5	32.7	149.7
Denmark	0.1	0.5	0.0	13.8	9.3	10.1	1.2	0.9	0.0	2.6	4.3	1.0	4.2	48.0
Netherlands	0.0	0.0	0.0	0.2	22.8	22.0	7.7	11.6	0.0	1.5	20.5	2.4	4.8	93.5
U. Kingdom	0.1	0.1	0.0	0.5	522.7	18.7	8.7	4.8	0.0	3.7	22.4	7.6	20.5	609.8
Germany	0.2	0.4	0.1	4.6	65.7	924.7	59.3	31.4	0.6	34.3	141.4	7.4	50.5	1320.6
France	0.0	0.1	0.0	0.8	38.0	60.1	234.5	21.2	0.0	8.6	100.8	8.3	61.1	533.5
Belgium	0.0	0.0	0.0	0.1	12.4	12.5	14.0	44.7	0.0	0.9	6.9	1.6	4.0	97.1
Russia	0.8	6.2	18.1	6.4	22.0	71.5	5.9	3.7	1006.9	91.1	450.1	2.2	667.8	2352.7
Baltic States	0.2	1.7	2.5	2.3	7.3	25.0	1.7	0.9	6.1	28.9	73.8	0.7	26.8	177.9
Poland	0.2	1.5	0.3	5.3	25.2	288.6	10.5	6.4	2.9	504.0	147.9	2.4	47.3	1042.5
Czech./Slov.	0.0	0.1	0.0	0.7	8.1	130.9	7.6	3.1	0.3	51.2	343.1	0.9	19.1	565.1
Ocean[1]	5.8	4.8	4.6	15.1	556.4	138.5	82.8	32.0	78.9	32.9	478.4	111.0	491.3	2032.5
Other countr.	1.4	19.0	15.1	35.1	111.4	449.0	134.5	26.8	71.9	354.7	4399.5	19.8	942.3	6580.5
Total	17.1	63.7	73.8	101.2	1452.7	2217.9	575.1	192.5	1208.5	1142.0	6243.2	170.5	2448.7	15906.9

[1] Atlantic Ocean including North Sea
Source: Sandnes, 1993

Table B12. Precipitation of oxidized nitrogen in Norway. 1985, 1987, 1988, 1989, 1990, 1991* and 1992*. 1 000 tonnes as N. Changes in per cent

	1985	1987	1988	1989	1990	1991	1992	Change 1985-1992	Change[1] 1991-1992
Emissions from Norway	5.3	6.2	6.2	6.2	5.9	6.6	6.4	2.7	-3.0
Sweden	5.7	6.4	5.6	3.7	4.1	4.1	3.7	-6.0	-9.8
Finland	1.7	1.7	1.2	1.0	1.4	1.1	1.1	-6.0	-
Denmark	2.9	4.3	4.0	3.2	3.6	3.4	3.1	1.0	-8.8
Netherlands	2.5	2.5	5.0	3.4	4.7	3.6	3.2	3.6	-11.1
United Kingdom	15.0	16.0	21.0	28.3	28.0	22.7	23.4	6.6	3.1
Germany	11.6	11.4	18.9	13.6	13.5	13.5	11.6	0.0	-14.1
France	2.6	2.1	3.9	4.1	6.0	2.7	3.1	2.5	14.8
Belgium	1.1	0.9	2.0	1.6	2.1	1.5	1.3	2.4	-13.3
CIS	2.9	2.6	2.7	1.2	1.9	1.9	1.1	-12.9	-42.1
Poland	3.5	3.5	4.7	2.4	2.3	4.0	2.3	-5.8	-42.5
Czechia and Slovakia	1.4	1.6	2.0	1.3	1.6	2.1	1.6	1.9	-23.8
Ocean[2]	2.1	1.9	2.6	2.8	3.1	2.2	2.4	1.9	9.1
Other countries	2.0	2.3	2.1	2.7	3.1	2.4	2.5	3.2	4.2
Unspecified	17.0	16.2	15.7	19.4	21.4	16.7	16.0	-0.9	-4.2
Total	77.3	79.6	97.6	94.9	102.7	88.5	82.8	1.0	-6.4

[1] For 1991 and 1992 the emissions on which the calculations are based are the same. The changes can therefore be attributed to climatic conditions. [2] Atlantic Ocean including North Sea
Source: Sandnes, 1993

Table B13. Precipitation of oxidized sulphur in Norway. 1985, 1987, 1988, 1989, 1990, 1991* and 1992*. 1 000 tonnes as S. Changes in per cent

	1985	1987	1988	1989	1990	1991	1992	Change 1985-1992	Change[1] 1991-1992
Emissions from Norway	11.3	8.8	7.9	6.7	6.0	5.5	5.6	-9.5	1.8
Sweden	5.4	5.0	3.9	2.2	2.2	2.3	2.0	-13.2	-13.0
Finland	2.5	2.1	1.4	1.0	1.3	0.8	0.7	-16.6	-12.5
Denmark	3.7	4.2	4.2	2.7	2.8	3.4	3.1	-2.5	-8.8
Netherlands	1.2	1.1	2.3	1.3	1.6	1.1	1.0	-2.6	-9.1
United Kingdom	21.2	20.8	27.6	35.3	35.6	26.1	24.7	2.2	-5.4
Germany	20.5	19.6	27.4	17.2	17.1	19.5	13.9	-5.4	-28.7
France	2.3	1.5	2.9	2.7	3.8	1.8	1.9	-2.7	5.6
Belgium	1.7	1.0	2.5	1.8	2.5	1.5	1.4	-2.7	-6.7
CIS	20.3	17.9	14.8	10.7	10.9	11.2	8.6	-11.5	-23.2
Poland	8.5	8.3	12.1	6.6	5.0	8.5	4.6	-8.4	-45.9
Czechia and Slovakia	3.5	3.9	4.9	3.0	3.3	3.9	3.0	-2.2	-23.1
Ocean[2]	2.1	2.0	2.6	2.8	3.0	2.2	2.3	1.3	4.5
Natural emissions[3]	3.5	3.1	3.1	4.3	4.1	3.4	3.6	0.4	5.9
Other countries	4.1	3.8	2.7	4.2	4.7	3.4	3.8	-1.1	11.8
Unspecified	35.5	33.0	33.8	41.4	43.1	35.6	36.7	0.5	3.1
Total	147.3	136.1	154.1	143.9	147.0	130.2	116.9	-3.2	-10.2

[1] For 1991 and 1992 the emissions on which the calculations are based are the same. The changes can therefore be attributed to climatic conditions. [2] Atlantic Ocean including North Sea [3] Emissions from natural sources in marine areas
Source: Sandnes, 1993

Table C1. Stock development. 1976-1993. 1 000 tonnes

Year	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arctic saithe[2]	Barents Sea capelin[2]	Norwegian spring-spawning herring[3]
1976	2540	470	670	6790	150
1977	2180	320	560	5460	660
1978	1820	280	510	5890	1000
1979	1410	290	530	5560	1120
1980	1250	250	580	6970	1210
1981	1100	190	580	4290	1100
1982	950	120	530	3750	1030
1983	770	70	510	4230	1090
1984	930	60	460	2860	1040
1985	1020	150	410	820	1600
1986	1330	270	370	120	380
1987	1160	240	370	100	750
1988	870	150	380	430	2200
1989	970	120	420	870	2630
1990	1130	100	570	5830	2580
1991	1660	130	560	7100	2670
1992	1950	210	590	5150	2400
1993	2340	280	640	800	2360

[1] Fish more than 3 years of age. [2] Fish more than 1 year of age. [3] Spawning stock
Source: ICES Working Group reports

Table C2. Norwegian catch by group of fish species.1986-1993. 1 000 tonnes

	1986	1987	1988	1989	1990	1991	1992*	1993*
Total	1790	1804	1686	1725	1519	1949	2349	2315
Cod	270	305	252	186	125	164	219	271
Haddock	58	75	63	39	23	25	40	44
Saithe	131	152	148	145	112	140	167	186
Tusk	33	30	23	32	28	27	26	27
Ling/blue ling	28	25	24	29	24	23	21	20
Greenland halibut	8	7	9	11	24	33	11	14
Norway haddock (red-fish)	24	18	25	27	41	56	37	28
Others and unspecified	24	34	29	29	30	44	31	32
Capelin	273	142	73	108	92	576	805	530
Mackerel	157	159	162	143	150	179	207	227
Herring	331	347	339	275	208	201	227	349
Sprat	5	10	12	5	6	34	33	48
Other industrial fish species[1]	450	500	526	696	655	447	526	540

[1] Includes lesser silver smelt/greater silver smelt, Norway pout, small sandeel, blue whiting and horse mackerel.
Source: Directorate of Fisheries

Table C3. Use of antibiotics in fish farming. 1981-1993. Kg of active agent

Year	Total	Oxytetra cykline chloride	Nifura- zolidone	Oxolinic acid	Trimetoprim + sulfadiazine (Tribrissen)	Sulfa- merazine	Flume- quine	Flor- fenikol
1981	3640	3000	-	-	540	100	-	-
1982	6650	4390	1600	-	590	70	-	-
1983	10130	6060	3060	-	910	100	-	-
1984	17770	8260	5500	-	4000	10	-	-
1985	18700	12020	4000	-	2600	80	-	-
1986	18030	15410	1610	-	1000	10	-	-
1987	48570	27130	15840	3700	1900	-	-	-
1988	32470	18220	4190	9390	670	-	-	-
1989	19350	5014	1345	12630	32	-	329	-
1990	37432	6257	118	27659	1439	-	1959	-
1991	26798	5751	131	11400	5679	-	3837	-
1992	27485	4113	-	7687	5852	-	9833	-
1993	6144	583	78	2554	696	-	2177	56

Source: Norwegian Medicinal Depot

Table C4. Export of some main groups of fish products. 1981-1993. 1 000 tonnes

Year	Fresh	Frozen	Fillets	Salted or smoked	Dried	Canned	Meal	Oil
1981	24.6	58.7	74.0	13.6	86.2	15.0	266.5	107.3
1982	46.2	100.2	76.3	14.9	68.8	11.2	228.6	101.1
1983	91.5	62.6	91.6	24.9	59.4	22.4	283.9	128.0
1984	72.9	78.7	98.5	24.6	69.5	22.7	248.9	76.9
1985	74.5	79.5	95.9	20.3	64.6	23.4	173.9	114.3
1986	139.4	98.8	95.2	22.7	62.9	24.4	92.6	38.8
1987	189.6	114.2	105.0	38.0	40.6	24.3	88.3	71.3
1988	212.5	126.7	105.1	36.9	47.0	22.9	68.9	45.6
1989	215.1	159.8	95.2	46.2	48.0	23.2	45.4	39.1
1990	238.8	263.4	71.0	34.6	50.6	23.9	45.3	42.7
1991	249.6	366.9	68.7	48.6	50.3	23.0	110.8	58.5
1992	258.8	351.6	103.2	48.0	57.4	23.9	140.1	53.7
1993*	309.1	412.4	141.5	66.4	62.6	23.9	139.6	62.0

Source: Statistics Norway

Table C5. Export of reared salmon. 1981-1993. 1 000 tonnes and million kroner

Year	Total		Fresh or cooled		Frozen	
	Quantity 1000 tonnes	Value Mill. NOK	Quantity 1000 tonnes	Value Mill. NOK	Quantity 1000 tonnes	Value Mill. NOK
1981	7.4	292.9	5.5	211.4	1.9	81.5
1982	9.2	395.3	7.9	330.8	1.3	64.5
1983	15.4	709.1	13.0	582.6	2.4	126.5
1984	19.7	944.9	17.3	819.1	2.4	125.8
1985	24.0	1308.3	21.4	1160.6	2.6	147.8
1986	38.9	1663.7	34.4	1458.6	4.5	205.1
1987	43.2	2174.4	39.2	1967.3	4.0	207.1
1988	66.0	3079.7	56.0	2594.9	10.0	484.8
1989	95.5	3486.1	81.1	2954.6	14.4	531.5
1990	130.7	4834.9	92.8	3423.8	37.9	1411.1
1991	126.6	4449.6	91.3	3149.3	35.4	1300.3
1992	122.1	4399.9	107.1	3881.8	15.0	518.1
1993*	131.0	4555.9	117.9	4089.9	13.1	466.0

Source: Statistics Norway

Table D1. Forest balance 1993. Whole country. 1 000 m^3, not included bark

	Total	Spruce	Pine	Deciduous trees
Volume per 1/1	588092	273721	193447	120924
Total removal	12352	8090	2576	1686
Of which, total roundwood cut	10322	7046	2132	1144
Sold timber, excl. fuel wood	9053	6711	2026	316
Fuel wood for sale and private use	1067	188	58	821
Timber for own use	202	147	48	8
Other removals, sum	2029	1044	444	542
Waste from logging	665	423	128	114
Natural losses	1364	621	316	427
Total increment	19890	10353	5263	4274
Volume per 31/12	595630	275983	196135	123512

Source: Statistics Norway

Table D2. Standing cubic mass and annual increment. Whole country and counties. 1993. 1 000 m^3 bark not included

	Standing cubic mass				Annual increment			
	Total	Spruce	Pine	Deciduous trees	Total	Spruce	Pine	Deciduous trees
1933	322635	170960	90002	61673	10447	5835	2535	2077
1967	435121	226168	133972	74981	13200	7131	3364	2706
1990	560303	263859	185824	110620	18524	9702	4890	3932
1993	595630	275983	196135	123512	19890	10353	5263	4274
County								
Østfold	25444	12794	9278	3373	972	559	260	152
Akershus/Oslo	37381	22838	8660	5883	1615	1037	256	322
Hedmark	110914	56428	43967	10519	4008	2228	1367	413
Oppland	68562	46267	13289	9006	2220	1553	373	293
Buskerud	59433	29658	21587	8188	1927	993	584	349
Vestfold	12884	6497	2250	4137	531	288	53	189
Telemark	52112	22980	19544	9588	1640	784	490	366
Aust-Agder	31531	8985	16071	6475	894	291	408	195
Vest-Agder	22529	3793	11229	7508	712	224	254	234
Rogaland	9076	1402	4206	3469	379	118	128	133
Hordaland	19173	4995	8270	5908	775	363	213	198
Sogn og Fjordane	19065	3850	7248	7967	651	233	178	240
Møre og Romsdal	16908	2952	8304	5652	573	205	191	177
Sør-Trøndelag	32372	16427	10684	5262	867	490	239	137
Nord-Trøndelag	41954	28320	6088	7546	1114	765	110	239
Nordland	18476	7536	1623	9317	501	205	38	258
Troms	15009	262	1773	12974	441	15	63	363
Finnmark	2807	1	2064	741	70	0	55	15

Source: Statistics Norway

Table D3. Crown density distributed between 10% classes for spruce. Whole country. 1988-1993. Per cent

Year	Crown density classes 90	80	70	60	50	40	30	20	10	0	Average	No. trees
1988	51.9	20.5	10.8	6.6	2.9	2.9	2.2	0.9	0.8	0.3	83.6	2007
1989	57.5	18.7	9.7	5.5	2.7	2.4	1.2	1.1	0.8	0.5	85.1	4399
1990	57.1	17.8	9.7	5.1	3.2	2.4	2.0	1.3	0.8	0.8	84.6	4340
1991	52.6	18.2	10.2	6.2	4.2	3.2	2.6	1.5	0.8	0.5	82.5	4228
1992	47.9	19.2	12.4	7.4	4.4	3.8	2.2	1.4	0.8	0.6	81.6	4065
1993	48.2	21.1	12.2	6.6	3.1	2.8	2.3	1.7	1.3	0.7	81.7	4049

Source: NIJOS

Table D4. Crown density distributed between 10% classes for pine. Whole country. 1988-1993. Per cent

Year	Crown density classes 90	80	70	60	50	40	30	20	10	0	Average	No. trees
1988	47.5	25.7	12.4	7.1	1.9	2.2	2.0	0.7	0.3	0.2	83.6	1163
1989	50.7	28.3	12.6	4.6	1.5	0.9	0.5	0.4	0.3	0.2	85.7	3053
1990	51.5	27.7	12.8	4.4	1.2	0.9	0.4	0.4	0.3	0.3	86.0	2998
1991	50.4	29.9	11.6	4.3	1.5	1.1	0.7	0.2	0.1	0.2	86.1	2938
1992	40.3	30.3	16.6	7.4	2.5	1.3	0.8	0.4	0.2	0.2	83.2	2972
1993	39.8	33.8	15.2	5.4	2.3	2.0	0.7	0.4	0.1	0.3	83.5	2908

Source: NIJOS

Table E1. Cultivated agricultural land, by use. Whole country and counties. 1985 and 1993. Decares

	Total cultivated agri-cultural land	Grain and oil seed	Out-door vege-tables	Potatoes, green fodder and silage	Fully cultivated meadow for mow-ing and pasture	Surface cultivated meadow for mow-ing and pasture	Fertilized grazing	Other culti-vated agri-cultural land	Fallow land
Whole country									
1985	8960715	3176930	46791	574576	4074097	288884	657632	101372	40433
1993	9719309	3401043	49789	612688	4344593	259808	940956	81826	28606
County 01-10									
1985	4592700	2711339	32952	249028	1274817	81633	146173	70877	25882
1993	4936716	2884321	36812	289574	1370036	75271	211726	52201	16774
01 Østfold									
1985	719086	606346	3825	25403	57993	4099	10421	9547	1452
1993	749513	637093	4758	24178	60336	5037	12091	4258	1762
02/03 Akershus/Oslo									
1985	731326	602875	2218	21660	77351	5782	12582	5415	3443
1993	788775	664002	2338	18049	77230	3789	17053	3951	2363
04 Hedmark									
1985	948160	550225	4808	70132	271635	8558	23099	12370	7333
1993	1025505	591939	4622	90279	285841	7475	31377	9760	4212
05 Oppland									
1985	865331	261724	3534	65660	459266	20818	47648	3272	3408
1993	948270	267274	4100	83469	488679	21945	78163	2574	2066
06 Buskerud									
1985	445976	258076	6512	17161	119417	11330	19543	10466	3472
1993	483304	278078	6408	18393	133203	10132	27200	8043	1847
07 Vestfold									
1985	401152	316750	7348	21048	26963	2586	4874	20037	1545
1993	419596	325782	10013	26853	34304	2338	5363	13662	1281
08 Telemark									
1985	217468	92904	1275	11081	83125	11993	8164	5604	3322
1993	230376	99217	889	11383	89274	10322	11467	5919	1906
09 Aust-Agder									
1985	99329	14427	2489	7914	63152	3580	3891	2756	1122
1993	108079	13401	2823	6750	74069	2568	5422	2448	598
10 Vest-Agder									
1985	164874	8013	944	8969	115915	12887	15951	1409	786
1993	183298	7535	861	10222	127100	11665	23590	1586	739
11 Rogaland									
1985	745612	36721	4497	75362	373877	15841	235101	3108	1106
1993	881184	30551	4634	102085	404013	15881	319971	3069	980

Table E1 (cont.). Cultivated agricultural land, by use. Whole country and counties. 1985 and 1993. Decares

	Total cultivated agri-cultural land	Grain and oil seed	Out-door vege-tables	Potatoes, green fodder and silage	Fully cultivated meadow for mow-ing and pasture	Surface cultivated meadow for mow-ing and pasture	Fertilized grazing	Other culti vated agri-cultural land	Fallow land
12 Hordaland									
1985	417988	1225	667	10299	253562	58339	80495	12644	756
1993	448612	674	326	7776	261120	54951	111367	11818	581
14 Sogn og Fjordane									
1985	408825	1615	1449	10823	271728	47649	65100	9754	708
1993	452932	1045	1752	6988	291622	40300	101676	8751	798
15 Møre og Romsdal									
1985	545761	19566	1325	22336	435837	21333	41370	1429	2566
1993	582766	20319	540	15687	461112	20141	61250	1641	2076
16 Sør-Trøndelag									
1985	665756	132685	646	47938	445828	12054	23023	919	2663
1993	712177	153427	549	41133	461304	12297	39922	1266	2279
17 Nord-Trøndelag									
1985	774425	269681	3285	90699	374675	10121	20909	1976	3079
1993	841786	307795	3508	83981	403315	10545	28048	1938	2656
18 Nordland									
1985	489187	4012	1285	43895	377502	25067	34667	399	2360
1993	524390	2793	1241	34270	416317	18680	49061	556	1473
19 Troms									
1985	230886	74	590	18050	190465	12435	8507	261	505
1993	247162	83	392	22851	199491	8687	14395	561	702
20 Finnmark									
1985	89575	12	96	6147	75807	4412	2287	8	808
1993	91584	35	35	8343	76263	3055	3540	27	287

Source: Applications for production subsidies, Ministry of Agriculture

Table E2. Area with grain and oil seed by method of soil preparation. Autumn-sown grain. Whole country and selected counties. 1989/90, 1991/92 and 1992/93*. Decares

	Grain and oil seed, total	Of this amount, autumn-sown	Autumn-ploughed land	Autumn-harrowed, no autumn ploughing	All soil preparation in spring	Directly sown grain and oil seed	Unspecified soil preparation[1]
Whole country							
1989/90	3649601	110465	2977341	..	..	9335	662970
1991/92	3737844	150730	2569410	174367	975720	18446	..
1992/93	3686123	367771	2082083	140542	1439823	23687	..
County 01 - 10							
1989/90	3071938	107853	2563424	..	..	8829	499749
1991/92	3163809	147653	2186742	166455	792719	17983	..
1992/93	3127626	363982	1890563	138536	1078664	19885	..
01 Østfold							
1989/90	660337	35139	604733	..	..	3371	52212
1991/92	680960	57353	537145	19295	119445	5105	..
1992/93	692916	135897	501250	19473	168462	3736	..
02/03 Akershus/Oslo							
1989/90	699503	25012	626148	..	..	1203	72168
1991/92	705187	39943	526437	25965	151608	1172	..
1992/93	686689	94947	452480	28176	202139	3893	..
04 Hedmark							
1989/90	657356	7082	496208	..	..	470	160710
1991/92	673762	6728	431890	63817	174025	4052	..
1992/93	665882	16747	369842	36897	256490	2626	..
05 Oppland							
1989/90	287309	7548	214449	..	..	1081	71814
1991/92	294039	2798	192390	19955	77820	3884	..
1992/93	286812	5101	140632	15222	130320	648	..
06 Buskerud							
1989/90	306307	10993	250370	..	..	447	55489
1991/92	318119	10727	200363	20103	95440	2216	..
1992/93	311034	33063	160856	14542	131543	4102	..
07 Vestfold							
1989/90	327163	16923	275099	..	..	2236	49823
1991/92	347776	25996	225915	11911	109084	875	..
1992/93	343422	68824	203993	17764	117514	4161	..
08 Telemark							
1989/90	107438	4456	79454	..	..	20	27966
1991/92	110618	3196	58038	3780	48507	306	..
1992/93	109339	8495	50011	4956	54116	258	..

Table E2 (cont.). Area with grain and oil seed by method of soil preparation. Autumn-sown grain. Whole country and selected counties. 1989/90, 1991/92 and 1992/93*. Decares

	Grain and oil seed, total	Of this amount, autumn-sown	Autumn-ploughed land	Autumn-harrowed, no autumn ploughing	All soil preparation in spring	Directly sown grain and oil seed	Unspecified soil preparation[1]
09 Aust-Agder							
1989/90	16319	700	11812	..	..	-	4511
1991/92	19680	737	9581	841	8910	350	..
1992/93	18510	530	7305	1098	9658	461	..
11 Rogaland							
1989/90	50788	32	4881	..	..	344	45553
1991/92	49130	554	3896	907	44071	263	..
1992/93	39237	132	3165	-	35730	345	..
15 Møre og Romsdal							
1989/90	27006	1098	15105	..	..	-	11899
1991/92	23889	43	13282	720	9847	40	..
1992/93	19082	-	3891	179	14532	476	..
16 Sør-Trøndelag							
1989/90	165710	111	123439	..	..	105	42183
1991/92	166110	1130	115765	3701	46603	33	..
1992/93	170014	330	55765	2768	110994	480	..
17 Nord-Trøndelag							
1989/90	327353	1371	268567	..	..	57	58706
1991/92	328947	1350	248544	2443	77838	127	..
1992/93	325375	1490	126358	1002	197094	923	..

[1] Area with grain and oil seed, where not possible with annual comparison of method of soil preparation.
Source: Statistics Norway

Table E3. Percentage of animal farms with less than 4 decares fully cultivated spreading area per animal manure unit (amu). Surplus amu as per cent of all amu. Whole country and counties. 1985 and 1993

	Farms with less than 4 decares fully cultivated land per amu								Surplus amu
	Total farms		Farms with 1-9 amu		Farms with 10-20 amu		Farms with more than 20 amu		
	No. farms	Per cent of all animal farms	No. farms	Per cent of all farms with 1-9 amu	No. farms	Per cent of all farms with 10-20 amu	No. farms	Per cent of all farms with more than 20 amu	as per cent of all amu
Whole country									
1985	12662	18	4274	11	3353	19	5035	35	11
1993	9971	18	3131	13	2574	16	4266	26	7,8
County 01 - 10									
1985	1959	8	723	5	550	9	686	16	6
1993	1457	8	460	6	373	7	624	13	4,5
01 Østfold									
1985	123	7	25	3	21	5	77	14	10
1993	102	7	13	2	26	8	63	11	8,3
02/03 Akershus/Oslo									
1985	81	5	25	3	18	5	38	8	6
1993	69	5	21	4	10	4	38	8	5,6
04 Hedmark									
1985	252	6	94	4	56	5	102	10	4
1993	167	5	43	4	35	4	89	8	3,0
05 Oppland									
1985	574	9	165	5	206	9	203	16	3
1993	363	7	95	5	119	6	149	10	2,6
06 Buskerud									
1985	205	8	107	7	60	9	38	15	4
1993	153	8	73	7	37	6	43	14	3,4
07 Vestfold									
1985	83	8	13	2	16	8	54	20	7
1993	79	10	7	2	11	7	61	18	7,3
08 Telemark									
1985	237	12	131	9	52	15	54	39	8
1993	161	11	67	7	37	11	57	32	6,5
09 Aust-Agder									
1985	125	10	53	6	38	15	34	31	7
1993	105	11	31	5	29	10	45	31	6,4
10 Vest-Agder									
1985	279	12	110	7	83	18	86	36	12
1993	258	14	110	11	69	14	79	26	6,9

Table E3 (cont.) Percentage of animal farms with less than 4 decares fully cultivated spreading area per animal manure unit (amu). Surplus amu as per cent of all amu. Whole country and counties. 1985 and 1993

	Farms with less than 4 decares fully cultivated land per amu								Surplus amu
	Total farms		Farms with 1-9 amu		Farms with 10-20 amu		Farms with more than 20 amu		
	No. farms	Per cent of all animal farms	No. farms	Per cent of all farms with 1-9 amu	No. farms	Per cent of all farms with 10-20 amu	No. farms	Per cent of all farms with more than 20 amu	as per cent of all amu
11 Rogaland									
1985	4451	64	671	31	970	70	2810	84	30
1993	3720	59	534	34	794	59	2392	70	21,9
12 Hordaland									
1985	2018	30	970	20	555	43	493	70	16
1993	1760	32	888	27	459	33	413	51	12,7
14 Sogn og Fjordane									
1985	2204	33	1049	25	777	43	378	60	13
1993	1683	31	745	27	620	33	318	41	9,7
15 Møre og Romsdal									
1985	743	11	273	7	220	13	250	21	5
1993	559	11	219	9	165	11	175	13	2,9
16 Sør-Trøndelag									
1985	293	6	77	4	92	5	124	9	3
1993	175	4	41	3	45	3	89	6	1,8
17 Nord-Trøndelag									
1985	256	6	43	3	61	4	152	9	3
1993	186	5	22	2	48	4	116	6	2,3
18 Nordland									
1985	398	8	248	8	72	5	78	9	3
1993	231	6	107	6	39	3	85	9	2,3
19 Troms									
1985	255	8	157	8	48	6	50	18	4
1993	145	7	72	7	28	4	45	12	3,3
20 Finnmark									
1985	85	10	63	11	8	5	14	9	5
1993	55	9	43	15	3	2	9	5	3,7

Source: Applications for production subsidies, Ministry of Agriculture

Table F1. Waste water treatment plants. Capacity (p.u.) by purification principle. County. 1992

County	Total	Main principle of purification					
		Mechanical	Chemical	Biological	Chem./ Biol.	Uncon- ventional	Other/ unknown
Whole country	4624951	1194482	2516323	65065	729099	51773	68209
Østfold	294705	3100	271450	3030	17125	-	-
Akershus	1035000	-	1018790	450	13325	1810	625
Oslo	351105	-	-	75	350080	950	-
Hedmark	193315	-	77970	2555	99090	3700	10000
Oppland	235850	-	122930	150	107120	5650	-
Buskerud	295194	5833	240933	4375	30560	6979	6514
Vestfold	202125	50430	136790	280	14270	355	-
Telemark	230430	17000	183500	15950	8180	5800	-
Aust-Agder	100430	62100	31250	900	5850	330	-
Vest-Agder	169170	29780	77750	1710	7760	1170	51000
Rogaland	411292	158297	250410	1500	650	435	-
Hordaland	345557	248293	66150	4095	24930	2089	-
Sogn og Fjordane	63476	52554	-	6300	1350	3202	70
Møre og Romsdal	65802	41437	20000	580	2740	1045	-
Sør-Trøndelag	387345	353393	7400	2740	19555	4257	-
Nord-Trøndelag	119945	94955	4100	9960	8610	2320	-
Nordland	33636	25911	350	6200	850	325	-
Troms	55624	23130	4550	890	17054	10000	-
Finnmark	34950	28269	2000	3325	-	1356	-

Source: Statistics Norway

Table F2. Waste water treatment plants. Capacity (p.u.) by size category. County. 1992

County	Total	Size category (p.u.)					
		50-99	100-499	500- 1999	2000- 9999	10000- 49999	50000-
Whole country	4624951	21023	160966	298342	767880	1217140	2159600
Østfold	294705	280	2725	8000	31700	72000	180000
Akershus	1035000	180	4345	10275	86000	134200	800000
Oslo	351105	215	890	-	-	-	350000
Hedmark	193315	490	5630	20395	54800	37000	75000
Oppland	235850	1275	9705	31870	93200	99800	-
Buskerud	295194	3460	11011	28223	66500	123500	62500
Vestfold	202125	180	2455	12750	33740	93000	60000
Telemark	230430	-	3130	25000	39200	107000	56100
Aust-Agder	100430	100	1980	8800	13550	76000	-
Vest-Agder	169170	525	6595	16600	31450	114000	-
Rogaland	411292	1682	14980	17180	76450	61000	240000
Hordaland	345557	3153	31864	31900	52400	160240	66000
Sogn og Fjordane	63476	3856	15450	14970	17200	12000	-
Møre og Romsdal	65802	1948	10864	5950	27040	20000	-
Sør-Trøndelag	387345	987	10645	19163	49750	36800	270000
Nord-Trøndelag	119945	1047	13888	22610	36800	45600	-
Nordland	33636	259	3015	11362	9000	10000	-
Troms	55624	310	6244	9890	24180	15000	-
Finnmark	34950	1076	5550	3404	24920	-	-

Source: Statistics Norway

Table F3. Waste water treatment plants. Number and capacity by size category and purification principle. 1992

Purification principle	Total	No. in size categories (p.u.) 50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total	1680	317	757	330	200	63	13
Mechanical	810	162	430	113	80	23	2
Chemical	199	9	23	51	72	35	9
Biological	134	15	74	40	5	-	-
Chemical/biological	291	19	115	117	35	3	2
Unconventional	235	111	113	8	3	-	-
Other/unknown	11	1	2	1	5	2	-

Purification principle	Total	Capacity in size categories (p.u.) 50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total	4624951	21023	160966	298342	767880	1217140	2159600
Mechanical	1194482	10552	88747	99943	295100	430140	270000
Chemical	2516323	630	6003	51650	296440	697000	1464600
Biological	65065	1030	16240	36395	11400	-	-
Chemical/biological	729099	1230	29239	102890	125740	45000	425000
Unconventional	51773	7511	20112	6950	17200	-	-
Other/unknown	68209	70	625	514	22000	45000	-

Source: Statistics Norway

Table G1. Quantity of municipal waste by type of waste and county. 1992. Tonnes

	Total	House-hold waste	Industrial waste: Waste from manufac-turing	Waste from building/ construc-tion, demolition	Offices, businesses, institutions, restaurants and hotels	Other special industrial waste	Mixed industrial waste	Un-known/ mixed waste
Total	2222779	1041591	188131	94913	174110	111292	519169	93573
Østfold	142671	61764	389	2177	6389	5907	45109	20936
Akershus	174886	101289	2220	3589	6135	5207	55559	887
Oslo	293509	110844	566	-	36948	-	145151	-
Hedmark	80911	45647	5611	2760	6264	1405	13777	5447
Oppland	97428	38334	10003	5818	5302	8049	8703	21219
Buskerud	118670	53939	22223	7345	11531	12459	7518	3655
Vestfold	114408	51751	27006	7836	14160	6685	1104	5866
Telemark	76230	42974	1849	1725	2148	224	26330	980
Aust-Agder	45549	23306	6605	6140	4529	152	4817	-
Vest-Agder	94290	40756	22187	9878	7978	10830	2616	45
Rogaland	194859	90167	4181	13593	9182	12182	59888	5666
Hordaland	237517	105651	57702	2887	5759	20152	39205	6161
Sogn og Fjordane	54955	25089	6481	3609	6269	4101	8827	580
Møre og Romsdal	107437	56946	3194	2100	1404	2669	37368	3756
Sør-Trøndelag	122683	57129	2306	5075	9641	860	42336	5336
Nord-Trøndelag	47400	25801	4759	2376	7558	2110	4502	294
Nordland	114234	56347	5054	6784	17359	9963	8622	10105
Troms	70090	36748	4271	6858	9800	6046	3944	2423
Finnmark	35052	17109	1524	4363	5755	2291	3793	217

Source: Statistics Norway

Table G2. Average quantity of waste, by type of waste. Households linked to municipal waste collection system. County. 1992. Kg per inhabitant

	Municipal waste per inhabitant				Municipal waste to recycling per inhabitant			Degree of linkage
	Total	House-hold waste	Indus-trial waste	Un-known/ mixed	Total	House-hold waste	Indus-trial waste	
				Kg				Per cent
Whole country	517	242	253	22	43	22	22	97
County								
Østfold	598	259	251	88	35	25	9	94
Akershus	412	238	171	2	40	36	5	98
Oslo	620	234	386	-	37	26	12	100
Hedmark	432	244	159	29	25	11	15	95
Oppland	534	207	207	119	50	23	27	98
Buskerud	524	238	270	16	50	33	17	93
Vestfold	569	258	283	29	125	62	63	98
Telemark	467	263	198	6	26	22	4	94
Aust-Agder	463	237	226	-	53	38	14	96
Vest-Agder	641	277	364	0	121	31	91	98
Rogaland.	562	260	286	16	36	27	9	97
Hordaland	570	254	302	15	62	10	52	98
Sogn og Fjordane	513	234	273	5	15	8	7	87
Møre og Romsdal	449	238	195	16	57	13	44	97
Sør-Trøndelag	484	225	237	21	13	8	5	96
Nord-Trøndelag	372	202	167	2	46	12	34	94
Nordland	475	234	199	42	5	3	2	94
Troms	471	247	208	16	10	0	9	99
Finnmark	461	225	233	3	0	0	-	94

Source: Statistics Norway

Table G3. Household waste to recycling by material. County. 1992. Per cent

	Total	Paper and card-board	Glass	Plastic	Rubber and tyres	Iron and other metals	Food, slaughter and fish wastes	Wood wastes	Tex-tiles	Other
Total	100.0	65.5	12.6	0.2	0.1	7.7	1.3	0.6	1.3	10.7
Østfold	100.0	67.3	13.7	-	0.0	4.3	10.9	3.4	0.4	-
Akershus	100.0	77.7	11.3	-	-	8.7	-	..	2.3	-
Oslo	100.0	87.4	11.1	-	-	1.5	-	0.0	..	-
Hedmark	100.0	48.7	21.0	-	-	5.0	-	-	-	25.3
Oppland	100.0	66.5	12.7	-	0.6	9.0	0.2	0.8	-	10.1
Buskerud	100.0	65.0	10.7	1.1	0.0	8.7	4.0	0.9	1.6	7.8
Vestfold	100.0	28.5	4.7	..	0.3	5.4	-	0.8	0.2	60.1
Telemark	100.0	71.2	15.7	-	..	13.1	-	-	..	0.1
Aust-Agder	100.0	73.4	17.2	-	-	7.8	-	0.5	1.1	-
Vest-Agder	100.0	86.1	5.6	-	..	7.2	-	-	-	1.1
Rogaland	100.0	79.8	7.8	0.1	0.0	0.4	0.6	0.4	2.1	8.9
Hordaland	100.0	47.6	21.8	0.4	-	28.1	-	-	2.1	-
Sogn og Fjordane	100.0	42.3	23.6	-	2.5	15.8	15.7	-	0.1	-
Møre og Romsdal	100.0	63.1	26.7	-	0.5	9.0	-	0.6	-	-
Sør-Trøndelag	100.0	29.4	22.3	2.6	0.1	26.3	..	1.2	18.0	-
Nord-Trøndelag	100.0	36.4	29.7	-	0.2	24.3	-	5.7	1.0	2.8
Nordland	100.0	35.7	62.4	-	-	2.0	-	-	-	-
Troms	100.0	-	95.5	-	-	-	-	-	4.5	-
Finnmark	100.0	-	100.0	-	-	-	-	-	-	-

Source: Statistics Norway

Table G4. Industrial waste to recycling by material. County. 1992. Per cent

	Total	Paper and card-board	Glass	Plastic	Rubber and tyres	Iron and other metals	Food, slaughter and fish wastes	Wood wastes	Tex-tiles	Other
Total	100.0	32.2	3.2	1.0	1.9	31.9	8.8	5.1	0.0	16.0
Østfold	100.0	31.4	-	0.5	-	37.4	-	29.2	-	1.5
Akershus	100.0	22.3	-	-	-	40.6	-	30.6	-	6.5
Oslo	100.0	1.8	-	-	-	98.0	-	0.1	-	-
Hedmark	100.0	20.7	1.6	3.2	0.5	61.4	12.6	-	..	-
Oppland	100.0	69.2	5.2	4.1	0.8	4.3	7.6	0.4	-	8.4
Buskerud	100.0	23.9	1.7	1.8	5.5	11.3	32.6	7.8	..	15.3
Vestfold	100.0	24.2	0.0	0.1	1.0	1.7	30.4	10.2	..	32.3
Telemark	100.0	92.9	0.9	-	-	6.3	-	-	-	-
Aust-Agder	100.0	58.2	-	-	2.9	38.4	-	0.6	-	-
Vest-Agder	100.0	22.2	-	0.0	..	71.2	6.6	-	-	-
Rogaland	100.0	55.0	15.1	0.8	0.1	1.9	27.1	-	-	-
Hordaland	100.0	34.0	4.6	0.1	0.2	17.7	1.6	0.2	-	41.6
Sogn og Fjordane	100.0	11.0	4.8	3.2	0.6	80.4	-	0.0	-	-
Møre og Romsdal	100.0	43.4	4.3	1.0	0.2	38.8	-	12.3	0.1	-
Sør-Trøndelag	100.0	44.6	19.4	14.7	0.3	18.4	2.0	0.6	-	-
Nord-Trøndelag	100.0	23.1	-	3.2	16.6	26.2	5.1	13.3	-	12.5
Nordland	100.0	81.4	14.4	2.6	1.7	-	-	-	-	-
Troms	100.0	43.1	19.2	-	37.7	-	-	-	-	-
Finnmark	-	-	-	-	-	-	-	-	-	-

Source: Statistics Norway

Publications from the Division for Resource Accounts and Environmental Statistics and the Natural Resources Division 1993 and 1994

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No. 78 Vennemo, H.: Tax reforms when utility is composed of additive functions.

81 Birkelund, H., E. Gjelsvik and M. Aaserud: Carbon/energy taxes and the energy market in Western Europe.

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104 Alfsen, K. H., H. Birkelund and M. Aaserud: Secondary benefits of the EC carbon/energy tax.

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94/1 Austbø, T.: Miljøvernkostnader - nytt statistikkområde? (Environment protection costs - a new area of statistics?) In Norwegian.

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94/4 Resultatkontroll jordbruk 1993. (Outcome assessment agriculture 1993.) In Norwegian.

Statistics of the week*:
* All in Norwegian

No. 3/93 Ny statistikk over kommunalt avfall (New statistics on municipal waste).
6/93 Mindre pløying om høsten (Less ploughing in the autumn).
9/93 Vekst i flere viktige fiskebestander (Growth in several important fish stocks).
16/93 Utslipp til luft reduseres (Reduced emissions to air).
16/93 God bestand av vågehval (Good stock of minke whale).
21/93 Kraftig skogøkning - viktig bidrag til bedre miljø (Strong increase in forest - important contribution to a better environment).
25/93 Mer spesialavfall blir levert inn (More hazardous waste is being delivered).
34/93 Kommunalt avfall, 1992. Bare 7 prosent til gjenvinning (Municipal waste, 1992. Only 7 per cent recycled).
37/93 Hordaland og Rogaland med størst utslipp til luft (Hordaland and Rogaland with largest emissions to air).
39/93 Energivarebalanse og energiregnskap 1991, 1992: Elektrisitet erstatter olje (Energy carrier balance and energy accounts 1991, 1992: Electricity replaces oil).
42/93 Få nye renseanlegg satt i drift (Few new waste water treatment plants put into operation).
44/93 Mest gjenvinning av avfall i Vestfold og Vest-Agder (Most recycling of wastes in Vestfold and Vest-Agder).
47/93 Ny undersøkelse om næringsavfall (New survey on industrial wastes).
7/94 Vet vi hva miljøvernet koster? (Do we know what protection of the environment costs?).
11/94 Utslipp pr. innbygger: Osloborgere forurenser minst. (Emissions per capita: Inhabitants of Oslo pollute least).
11/94 Skogen binder mye av CO_2-utslippet. (The forest assimilate a large part of the emitted CO_2).

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