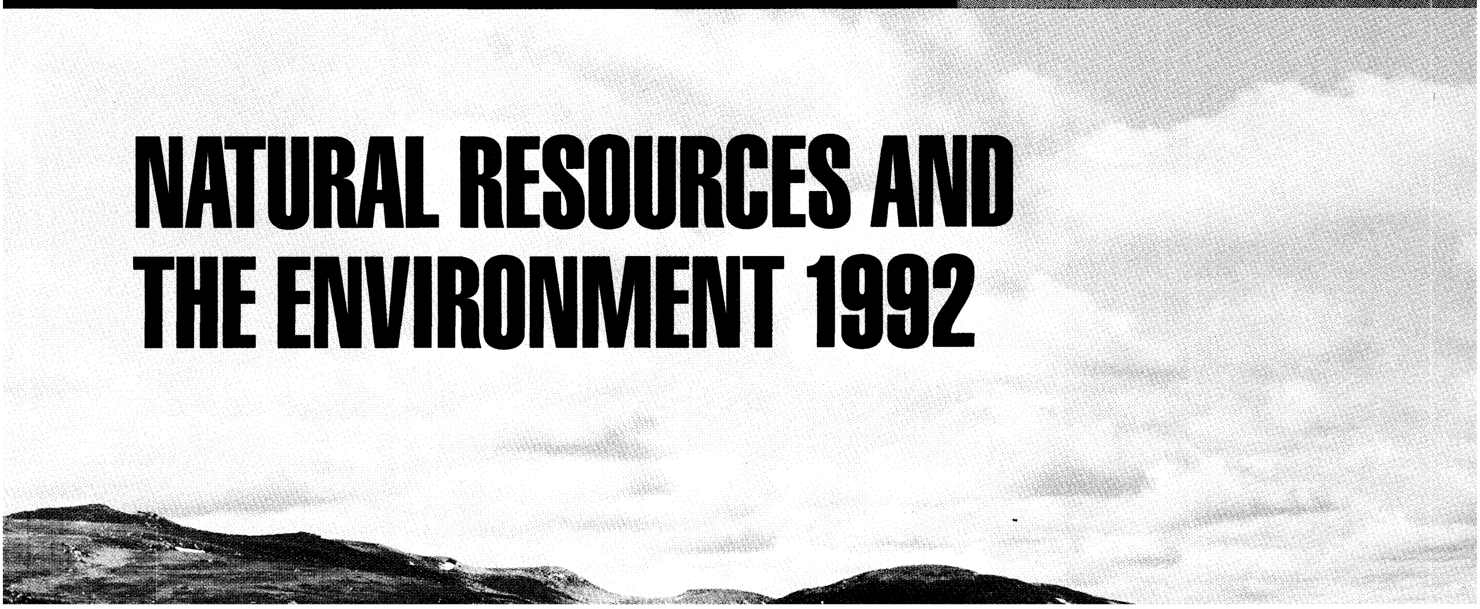
RAPPORTER

93/1A

NATURAL RESOURCES AND THE ENVIRONMENT 1992



Til salgs hos:

Akademika
- avdeling for offentlige publikasjoner
Møllergt. 17
Postboks 8134 Dep
0033 Oslo

Tlf.: 22 11 67 70
Telefax: 22 42 05 51

RAPPORTER FRA STATISTISK SENTRALBYRÅ 93/1A
REPORTS FROM THE CENTRAL BUREAU OF STATISTICS

NATURAL RESOURCES AND THE ENVIRONMENT 1992

THE NATIONAL WEALTH, ENERGY, AIR, FISHING, SEALING AND WHALING, FORESTS, AGRICULTURE, WASTE WATER TREATMENT PLANTS, WASTE

RESOURCE ACCOUNTS AND ANALYSES

STATISTISK SENTRALBYRÅ
CENTRAL BUREAU OF STATISTICS OF NORWAY
OSLO-KONGSVINGER 1993

ISBN 82-537-3855-2
ISSN 0332-8422

EMNEGRUPPE
10 Ressurs- og miljøregnskap og andre generelle ressurs- og miljøemner

EMNEORD
Forurensning
Naturmiljø
Miljøøkonomi
Utslipp

Photo: Front cover and back cover: Frode Brunvoll

The publication is printed in: Grytting AS, Orkanger

PREFACE

The Central Bureau of Statistics (CBS) elaborates statistics on the state of the environment as well as accounts for a number of important resources. CBS 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* presents an annual survey of this work.

Natural Resources and the Environment 1992 presents updated resource accounts for energy and accounts for emissions to air, as well as the results of analyses based on these accounts. The report also contains inventories for fishing, sealing and whaling, and analyses of agricultural pollution, forest damage, municipal waste water treatment plants and waste. The report starts with a chapter on the national wealth.

The Central Bureau of Statistics wishes to thank all the institutions that have supplied data for *Natural Resources and the Environment 1992*.

The publication, prepared jointly by the Division for Resource Accounts and Environmental Statistics, Department of Economic Statistics, and the Natural Resources Division, Research Department, has been edited by Senior Executive Officer Per Schøning. Mary Bjærum has translated the Norwegian version into English.

Central Bureau of Statistics, Oslo 4 June 1993

Svein Longva

CONTENTS

Explanation of symbols in tables:

.	Category not applicable
..	Data not available
-	Nil
0	Less than 0.5 of unit employed
0.0	Less than 0.05 of unit employed
*	Provisional or preliminary figure

INDEX OF FIGURES

Page

Page

Page

INDEX OF TABLES

Page

1. INTRODUCTION

It was pointed out at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 that consumption and production in the industrialized countries place too much strain on the environment. Sustainable development is threatened, for example, by emissions of gases that increase risk of climate change and deplete the ozone layer, by pollution of the sea and by local pollution of air and water. Rational management of natural resources is also a necessity for sustainable development at global level. *Natural Resources and the Environment 1992* provides a basis for evaluating Norway's management of natural resources and the environment. It provides information on important natural resources and the environment in the form of statistics and the results of analyses. Most of the statistics have been elaborated by the Central Bureau of Statistics, but data have also been obtained from other sources. In the areas dealt with in the report, an attempt has been made to shed light on interesting features of development and the reasons for any changes. In some cases the effects of future measures are also analyzed.

Natural resources are part of the total *national wealth,* which comprises, as well as other things, human capital (in the form of technology, know-how and health status), production capital (infrastructure, machinery and buildings), financial claims abroad, and the status of the natural environment. The chapter on the national wealth contains an assessment of the size of some of these components.

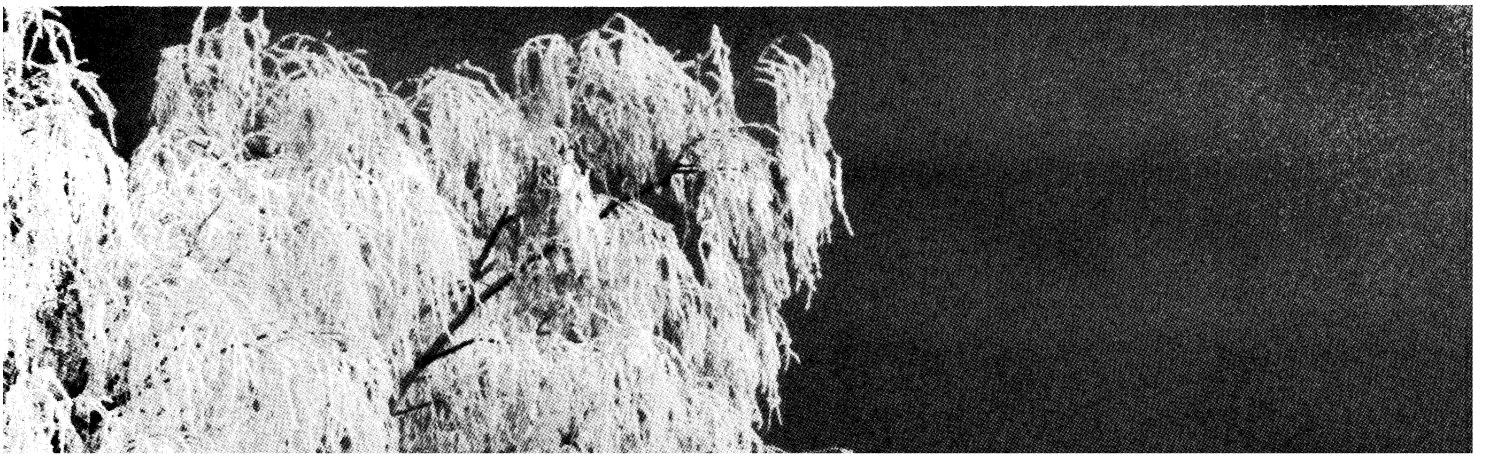
In early 1993, the public debate on environmental issues is focused in particular on air pollution and changes in the global climate. A fundamental question is whether Norway will be able to realize the defined goals for emissions of CO_2, SO_2 and NO_x, and to what degree the measures used to achieve these goals will affect other goals for economic activity and employment. The chapter on air, includes the most recent data on emissions, and an evaluation of the costs of reducing CO_2-emissions in Norway.

Emissions to air are strongly linked to use of fossil fuels. A comprehensive chapter on energy contains updated statistics on extraction and use of energy in Norway, as well as the main results of analyses of both Norwegian and European energy markets.

Norway has signed the North Sea Declaration, and has thus undertaken to halve discharges of nitrogen and phosphorus to the North Sea by 1995, with 1985 as base year. The report contains new statistics and analysis results of relevance for monitoring developments in this area. This applies to statistics on agriculture and associated pollution, and new figures for discharges from municipal waste water treatment plants.

A chapter on fish presents figures on Norwegian fish stocks and catches, and some key figures on fish farming, and a chapter on forests contains the most recent information on forestry and forest damage both in Norway and in the rest of Europe. The report also includes a chapter on waste, and waste management. In 1993, CBS will collect new statistics in this field and will be able to provide comprehensive data from next year onwards.

One way of focusing the main characteristics of the state of the environment is to present a set of *environmental indicators.* An environmental indicator is a figure that gives a simple indication of the state and development of a specific condition in the environment. Work is currently being done on environmental indicators in a number of countries and in international organizations such as OECD. In Norway, a reference group has been appointed to develop a set of environmental indicators. The group is headed by the Ministry of Environment. The Central Bureau of Statistics is both represented in this group and is also doing independent work on environmental indicators. The following summary contains some key figures, or *indicators,* from each of the main chapters of the report: The National Wealth; Energy; Air; Fishing, Sealing and Whaling; Forests; Agriculture; Waste Water Treatment Plants; and Waste.



2. SUMMARY AND SOME KEY FIGURES

THE NATIONAL WEALTH

the connection between the components of the national wealth

****

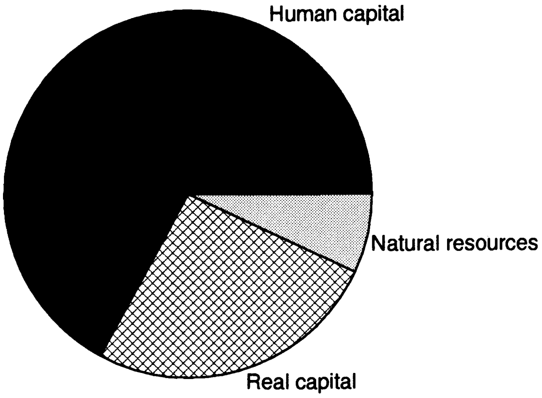
The national wealth, as defined and calculated in this publication, is estimated to just under NOK 10 000 billion in terms of 1991-NOK, and includes only the value of saleable goods, not taking into account the state of the natural environment.

Human capital is by far the largest component of the national wealth. Natural resources, where the petroleum wealth constitutes just over 80 per cent, account for a relatively small share of the wealth.

MORE ABOUT THE NATIONAL WEALTH on pages 21 to 26

The figure shows the national wealth, restricted to ***the value of real capital, natural resources and human capital.***

Figure 1. The national wealth in 1991



ENERGY

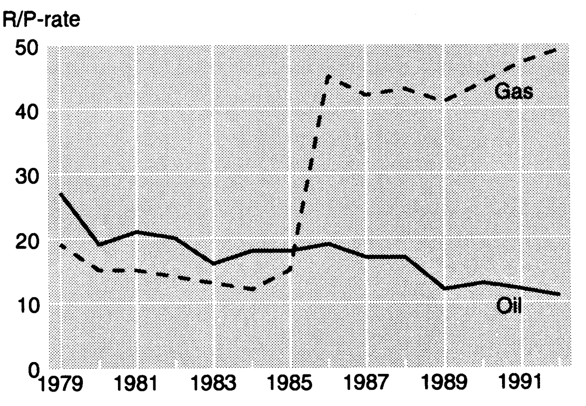
reserves - extraction - consumption

****

Oil and gas reserves

At today's level of production and with known extraction technology, the oil reserves in fields that have been developed or are to be developed will last 11 years. The gas reserves will last 49 years. If the reserves in fields that are not yet licensed are added, this period is extended to 20 years for oil and 115 years for gas. Figure 1 shows the trend in the relationship between reserves and production.

Figure 1. Relationship between reserves and production of oil and gas (R/P rate). Developed fields and fields to be developed. 1979-1992



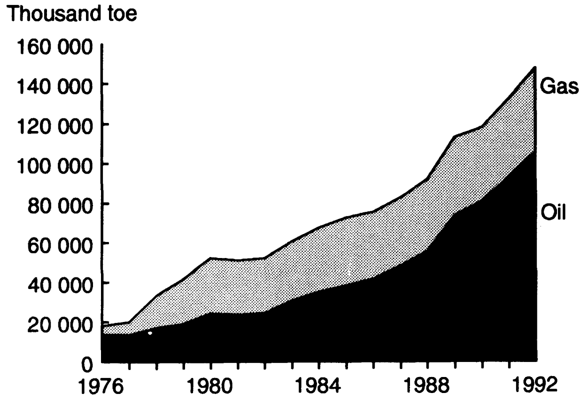
Continues on next page.

Production

Oil and gas

During the past year, the petroleum industry consolidated its position as Norway's most important sector of industry, with a growth in volume of 11 per cent compared with 1991. In 1992, Norway was the world's largest exporter of oil outside OPEC. Owing to the fall in oil prices, however, the gross value of production did not increase correspondingly and the return, measured in terms of the oil rent, remained almost unchanged. Total investments continued to increase to almost NOK 50 billion, or 54 per cent of the total investments on the Norwegian mainland. Figure 2 shows the trends in oil and gas production respectively.

Figure 2. Production of oil and gas. 1976-1992. 1000 toe



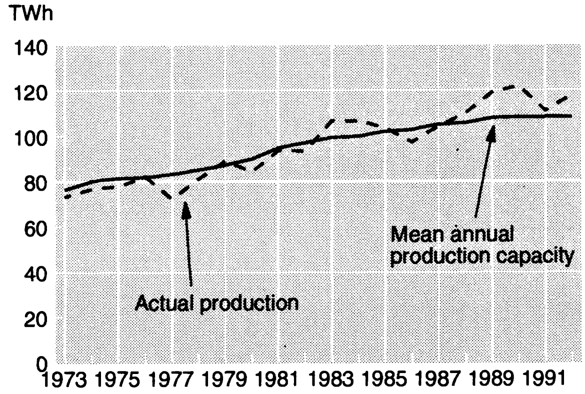
Source: Petroleum Directorate

Hydropower

Figure 3 shows changes in actual production and production capacity in the Norwegian hydropower system during the period 1973-1992.

The production capacity is stated in terms of the mean annual production potential of the hydropower system. In 1992 the actual production was higher than the calculated capacity, as has been the case for the last 10 years. The actual production is determined by the flow of water to reservoirs and power stations, and by demand. A large flow of water, a low level of demand and market-based sales have led to relatively low prices for surplus power.

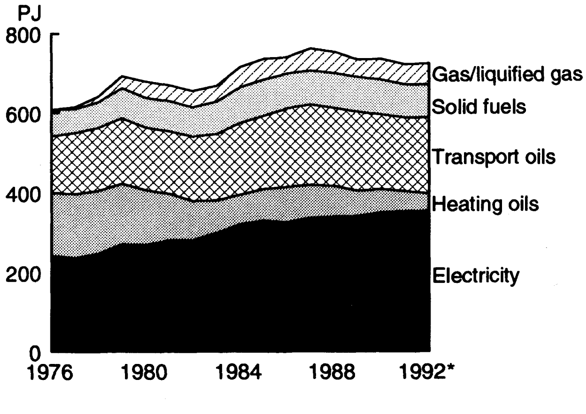
Figure 3. Mean annual production capacity and actual production in the Norwegian hydropower system. 1973-1992. TWh



Consumption

Total energy consumption in Norway, the energy sectors and ocean transportation excluded, increased from 1976 to 1987, and then declined. Consumption of transport oils followed the same trend as for the total consumption. Consumption of electricity increased throughout the period, but the growth has declined in recent years, mainly owing to milder winters and lower consumption in industry. Consumption of heating oils decreased throughout the period. Changes in domestic energy consumption are shown in Figure 4.

Figure 4. Use of energy sources outside the energy sectors and ocean transportation. 1976-1992. Petajoule



MORE ABOUT ENERGY on pages 27 to 66

AIR

emissions to air - type, source and effects

****

Emissions of SO_2 and lead have been reduced substantially since 1973. The approximately 70 per cent reduction in SO_2-emissions from 1980 to 1992 implies that Norway has fulfilled her commitment to reduce emissions by 30 per cent during this period. The reasons for the marked reduction are a lower content of sulphur in oil products, a change to products with a lower sulphur content, reduced consumption and better cleaning technology.

Emissions of CO_2 increased during the period 1973-1989. From 1989 to 1992, however, these emissions decreased by about 5 per cent. The national goal is to stabilize emissions at 1989 level by the year 2000. Recent year's developments can be explained by the fact that the reduction in emissions due to lower consumption of oil products has been almost outweighed by increased emissions caused by a higher level of activity in the North Sea.

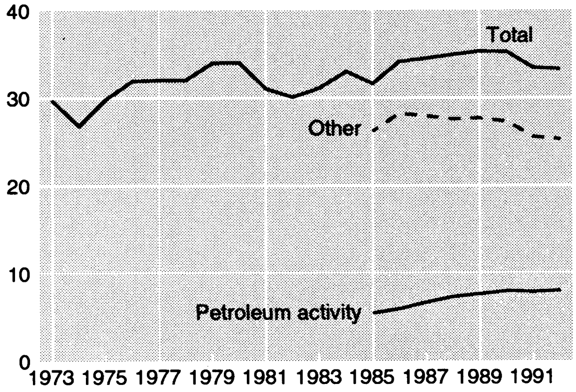
The increase in emissions of CO from 1973 to the mid-1980s has since been followed by a clear reduction. The main reasons for the decrease are lower consumption of gasoline and smaller emissions from gasoline-run cars per kilometer driven.

Emissions of NO_x increased up to 1989. There was a marked decrease from 1990 to 1991, which can be explained by lower consumption of oil products, a larger percentage of cars with a catalyzer, and less flaring in the North Sea. Norway has undertaken to stabilize the emissions to 1987 level by 1994. Preliminary figures indicate that, from 1987 to 1992, the decrease was more than 7 per cent.

Emissions of NMVOC are increasing, owing to a higher level of activity in the North Sea. The most important source is loading of crude oil from buoys. During the period 1989-1992 the increase was 3 per cent. The goal is a reduction of 30 per cent by 1999.

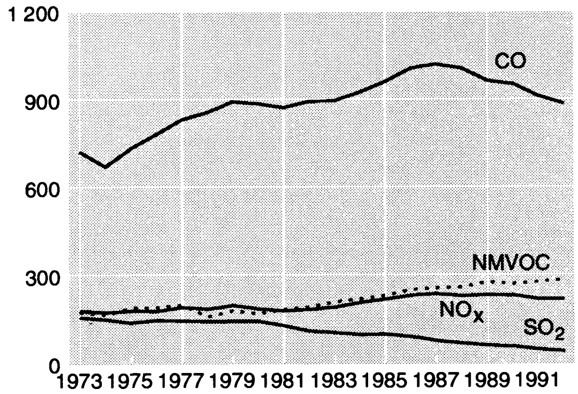
MORE ABOUT AIR on pages 67 to 95

Figure 1. Total emissions of CO_2, by source. 1973-1992. Million tonnes



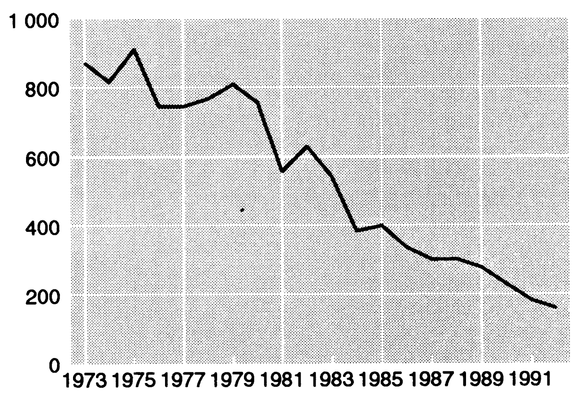
Source: CBS, SFT

Figure 2. Total emissions of CO, NMVOC, NO_x and SO_2. 1973-1992. 1000 tonnes



Source: CBS, SFT

Figure 3. Total emissions of lead (Pb).1973-1992. Tonnes



Source: CBS, SFT

FISHING, SEALING AND WHALING

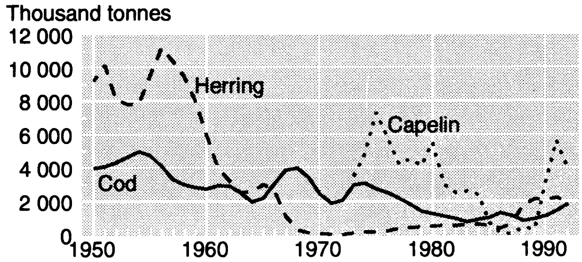
development of stocks - catches - aquaculture - exports

****

Norwegian spring-spawning herring, capelin and North-East Arctic cod are three of the most important fish stocks in Norwegian waters. Historically low levels have been recorded for all three stocks ever since the end of the 1960s. The stock of spring-spawning herring was fished right down at the end of the 1960s. The stock of Barents Sea capelin has decreased since 1980 onwards, and broke down completely in 1986/87, partly as a result of taxation, but partly from natural causes. The cod stock remained at a low level throughout the 1980s. In recent years, however, a positive trend has been observed for all three stocks.

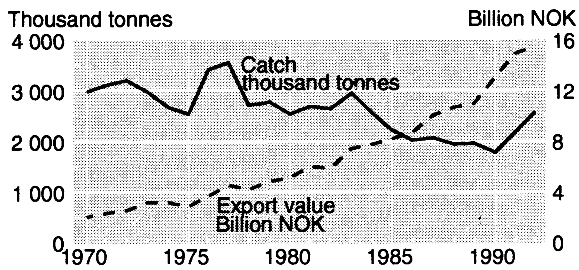
The total ***catch*** in Norwegian fisheries increased in 1992 to 2.6 million tonnes, with a first-hand value of NOK 5.8 billion. ***Exports*** of fish and fish products increased in 1992 to about 1.2 million tonnes, with an export value of NOK 15.4 billion. This amounts to about 14 per cent of the total traditional export of commodities.

Figure 1. Development of the stock of North-East Arctic cod[1], Norwegian spring-spawning herring[2] and Barents Sea capelin[3]. 1950-1992. 1000 tonnes



[1] Fish that are 3 years old or more. [2] Spawning stock.
[3] Fish that are 2 years old or more.

Figure 2. Catch and export value. 1970-1992



MORE ABOUT FISHING, SEALING AND WHALING on pages 97 to 109

FORESTS

forest resources - forest health status - forests in Europe

****

Caculations show that the volume of standing forest in Norway is increasing. Figure 1 shows ***gross increase*** and ***total depletion*** of cubic mass in m^3, excluding bark, for the years 1987 to 1992. The figure also shows the ***annual degree of exploitation***, calculated as total annual depletion of cubic mass as a percentage of total increase in volume.

The forest health status, measured in terms of crown density, has shown a tendency to deteriorate in Norway in recent years. Figure 2 shows nationally representative figures for changes in ***crown density*** of spruce and pine during the period from 1988 to 1992.

Most countries in Europe report a decline in forest health status in 1991.

Figure 1. Gross increase, total depletion and degree of exploitation. Whole country. 1987-1992

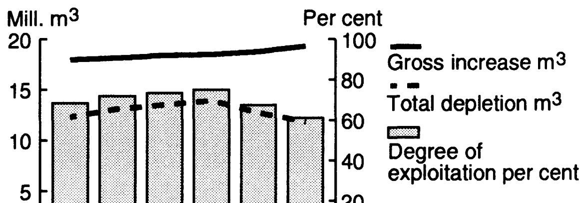
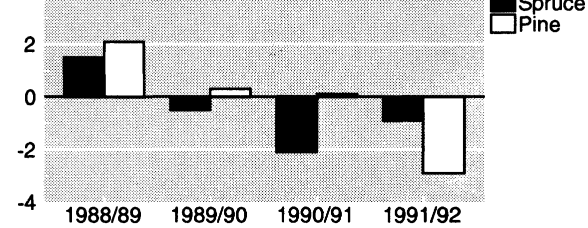


Figure 2. Changes in crown density of spruce and pine. Whole country. 1988-1992



Source: NIJOS

MORE ABOUT FORESTS on pages 111 to 117

AGRICULTURE

land use - soil preparation - fertilization - pollution

****

A large share of the pollution from agricultural land can be put down to autumn ploughing, implying that the fields have no protective cover of vegetation during the autumn, winter and spring.

Figure 1 shows a decrease in the ***grain area ploughed in autumn*** in the counties draining into the Skagerrak, from 83 per cent in 1989/90 to 69 per cent in 1991/92. The reduction was greatest in Buskerud, Telemark and Vestfold, with a decrease of about 20 per cent.

Figure 2 shows that the total ***sold quantity of commercial nitrogen (N) fertilizer*** remained stable from 1978 to 1991, while, during the same period, the ***quantity of phosphorus (P) fertilizer*** sold was halved. There are signs of more optimal fertilization - the area of grain land where split nitrogen fertilization is practised increased from 8 per cent in 1989 to 12 per cent in 1991.

Figure 1. Grain area in the counties draining into the Skagerrak, distributed between land ploughed in autumn and land not ploughed in autumn. 1989/90 - 1991/92

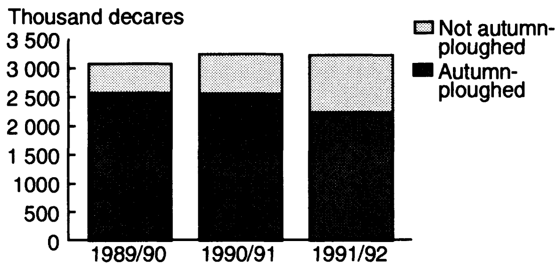
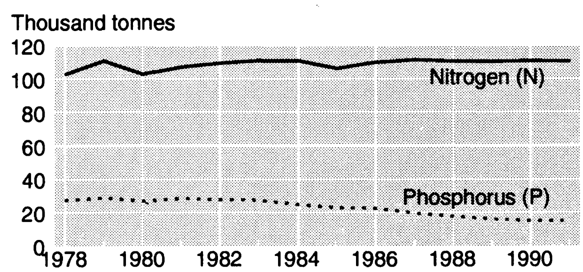


Figure 2. Sold quantity of commercial nitrogen (N) fertilizer and phosphorus (P) fertilizer



MORE ABOUT AGRICULTURE on pages 119 to 128

WASTE WATER TREATMENT PLANTS

plants - capacity - load - treatment principles

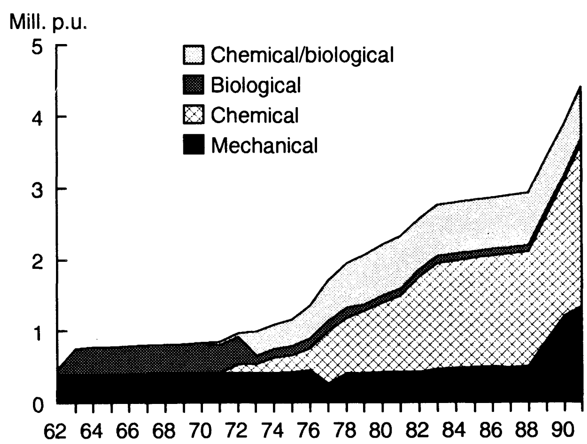
****

Most of Norway's waste water treatment plants have been built during the last 30 years. To start with, the ***method of treatment*** was based on either mechanical or biological principles. Since the beginning of the 1970s, it has become more common to build treatment plants with a chemical stage, and from the end of the 1970s, chemical or biological/chemical plants have been in the majority.

The figure shows the development of ***treatment capacity*** for the different methods of treatment from 1962 to 1991. The main reason for the increase in capacity of mechanical plant at the end of the 1980s is a change in the definition of the term mechanical plant.

In the early 1960s the waste water treatment plants had a total capacity of about 0.5 million population units (p.u.). The capacity has now increased to about 4.5 million p.u.

Figure 1. Treatment capacity by treatment principle. 1962-1991. Million population units



MORE ABOUT WASTE WATER TREATMENT PLANTS on pages 129 to 136

WASTE

municipal waste - hazardous waste

****

2.2 million tonnes of ***municipal waste*** was generated in 1991. This is 0.2 million tonnes more than in 1985 (figure 1).

The Norwegian system for management of "special" waste receives increasing quantities of ***hazardous waste*** (figure 2). The explanation lies in the larger quantities of oil-contaminated drill cuttings delivered to recipient facilities in Western Norway. The quantity of waste oil has remained fairly constant.

MORE ABOUT WASTE on pages 137 to 145

Figure 1. Total municipal waste. 1980, 1985 and 1991. Million tonnes

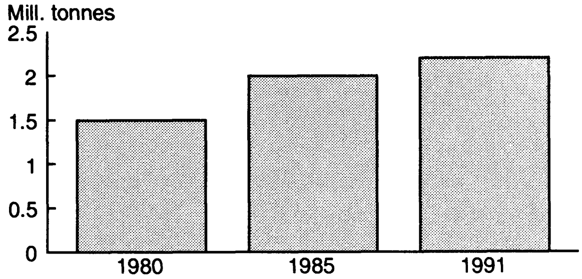
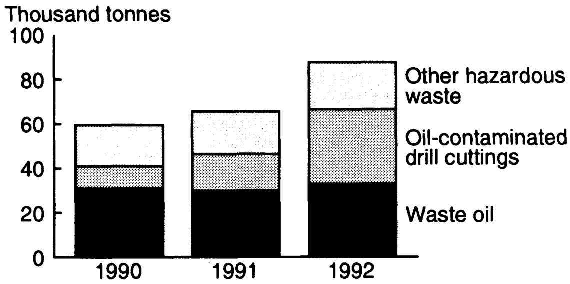
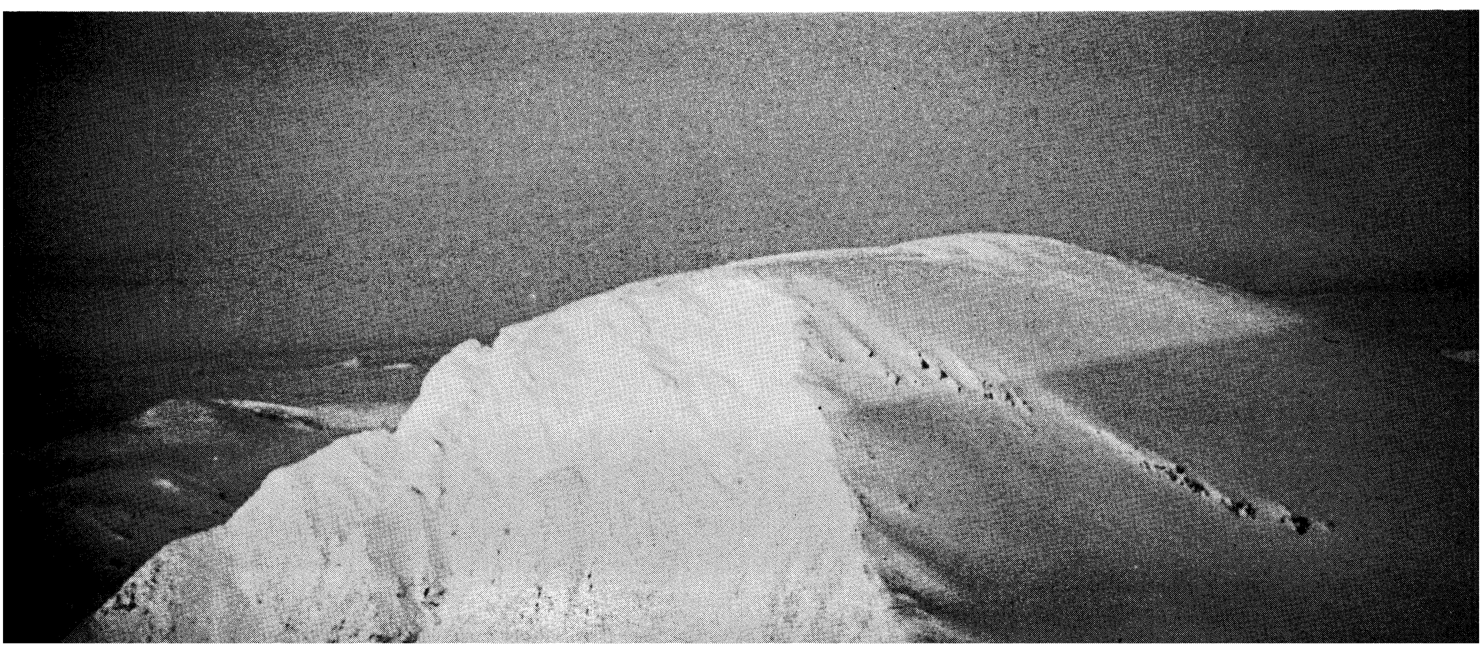


Figure 2. Delivered hazardous waste. 1990-1992. 1000 tonnes



Source: NORSAS



3. NORWAY'S NATIONAL WEALTH

3.1. Introduction

It is reasonable to interpret the concept of *sustainable development* as a wish to give future generations an opportunity to experience at least the same level of welfare as we experience today. To make sure that we do show concern for future generations it is necessary in a planning context to apply concepts, which ensure that such long-term considerations are born in mind. *Wealth* is such a concept, which gives some indication of the present value of potential consumption in the future. If we draw on our wealth, this reduces future welfare. However, our welfare does not depend on our material consumption alone. Therefore the *national wealth,* in the broadest sense of the term includes not only *production capital* (i.e. infrastructure, machinery and buildings), *consumption capital* in the form of permanent consumer goods and *claims abroad,* but also *human capital* in the form of technology, know-how and health status, and *natural resources* such as fish, oil and gas, as well as the *natural environment in the broadest sense.*

In this chapter, the *national wealth* is given a more *restricted* interpretation, and does not include the status of the natural environment. This aspect is dealt with, however, in other chapters of this report.

It is far from easy to express the national wealth in quantitative terms, even with a restricted interpretation. This makes the estimates very uncertain. For example, they are often based on assumptions about future levels of prices, economic growth etc. However, it is still of interest to estimate the size of the wealth because, if nothing else, this will give some indication of the relative importance of the different components of the wealth under given assumptions. In this chapter we shall roughly estimate the components of the wealth connected to real capital, certain natural resources, and human capital. As we shall see, the estimates of the national wealth and its decomposition are very sensitive to changes in the assumptions. Furthermore, the uncertainty about future revenues is an important problem, as we shall show later. This chapter is not intended to present concrete recommendations.

3.2. Calculation of the national wealth

Aside from real capital, calculations of wealth have been restricted mainly to *petroleum resources.* In the case of these resources, an obvious problem is how to allocate the revenues over time. Oil and gas are non-renewable resources. According to present prognoses the oil and gas revenues will come to an end in the middle of the next century. Nevertheless, by calculating the petroleum wealth as the present value of future revenues, and comparing the return on this wealth with the use of the revenues, we can give some indication of what is reasonable use of the revenues in the light of our concern for future generations if we ignore the elements of uncertainty.

Today, the petroleum wealth, including the real capital on the continental shelf, is estimated to NOK 810 billion. Of this amount, the real capital on the continental shelf accounts for NOK 250 billion (Ministry of Finance, 1993). Let us simplify the approach and assume that the oil age lasted for only one year and that the petroleum revenues that year were NOK 810 billion. We could then invest the whole of this sum in foreign bonds. We assume that we can find bonds with a fixed annual interest rate of 7 per cent, which is the interest rate used by the Ministry of Finance when calculating the wealth. The total return on these financial investments is then NOK 57 billion per year. If we use more of the oil revenues than this, the wealth will decrease. This will affect the return on the wealth for future generations.

In reality, the petroleum revenues will be spread over many years. However, if the present value is NOK 810 billion, and we can save and borrow at an interest rate of 7 per cent, this will not affect the calculations. We save in the years when the petroleum revenues exceed NOK 57 billion per year, and borrow in years when they are less. If we do not use more than NOK 57 billion per year, we shall, as before, still have the sum of NOK 810 billion remaining in the form of claims abroad when the revenues from oil have stopped. There are some important differences, however. Firstly, there is the question of *when* to extract the oil and gas. The petroleum wealth will depend on the chosen path of extraction. For example, a postponement of production will mean that the revenues will become of less value as a consequence of discounting. On the other hand, changes in prices and costs over time might pull in the opposite direction. The most serious problem that arises when the revenues are distributed over several years is how to deal with the uncertainty of future revenues.

By calculating the wealth of other revenues as well as the revenues from oil it is possible to establish how much of the nation's welfare can be ascribed to petroleum resources, human resources or claims abroad. Table 3.1 gives a rough estimate of the national wealth and how it is distributed.

Note that the natural resource wealth only includes the present value of *income* generated by extraction and use of natural resources. The value of untouched nature, biological diversity, aesthetic experience of nature as such, etc. are not included. This means that the table gives a far from complete picture of the importance of natural resources and the environment for the welfare and quality of life of the Norwegian population.

The total national wealth is calculated as the present value of the future net national product. In order to avoid double accounting of the income now used for investments, we ignore the

Table 3.1. Estimate of the national wealth, decomposed according to source. Billions NOK 1991

	Bill. NOK	Per cent
Real capital	2 450[2]	26
Total natural resources	680	7
Oil and gas	560[3]	
Hydropower	90[3]	
Fish	0	
Forest	30	
Financial wealth	-70	
Human capital	6 340	67
The national wealth	**9 400**	**100**

[1]All figures are rounded off

[2]The estimate of real capital applies to 1990. Source: National Accounts (CBS).

[3]Source: Ministry of Finance (1993)

growth caused by an increase in capital stock, and only include the wealth that can be ascribed to technological progress. To illustrate this we have chosen to define technological progress as 1 per cent per year. This means that without net investments, with a constant labour force and constant prices for raw materials on the world market, production would increase by 1 per cent per year. We have also assumed a discounting rate of 7 per cent.

The net national product was NOK 590 million in 1991. Since the oil revenues will sooner or later cease, they cannot be expected to follow the same path as other revenues. We shall therefore consider the oil revenues separately. The net product in the petroleum sector amounted to NOK 61 billion. For the rest of the economy it was NOK 529 billion. With an annual growth of 1 per cent and a discounting rate of 7 per cent, this gives an estimated national wealth of NOK 8 910 billion for mainland Norway. To this must be added the petroleum wealth, excluding the real capital on the continental shelf, amounting to NOK 560 billion. After deducting financial debts, the total national wealth will then be NOK 9 400 billion.

It is important to note the significance of interest rates and growth rates in calculations of the national wealth. If the growth rate is reduced to 0 per cent, the wealth from the mainland economy will fall to NOK 7 560 billion, while by reducing the interest rate to 5 per cent the mainland wealth becomes NOK 13 350 billion.

The national wealth is next decomposed as the items real capital, natural resources, financial wealth and human capital. The estimates of real capital and financial wealth are taken from the National Accounts. The estimate of the wealth represented by natural resources will be considered below, and the remainder will then be ascribed to human capital. Alternatively, human capital can be estimated as the present value of future income from labour. Today, wages cost NOK 303 billion. If human capital is defined as the present value of the future cost of wages, and we assume that the labour force remains constant, a human capital of NOK 6 340 billion will represent an annual real increase in wages of 2.1 per cent. Note, however, that the total cost of wages is a low estimate of the share of the production that can be ascribed to labour; this applies in particular in the case of self-owned enterprises. With a more correct estimate of the total income from labour, the growth in income corresponding to a human capital of NOK 6 340 billion would be slightly lower.

It is interesting to note the extent to which human capital dominates the estimate of the national wealth. The calculations indicate that a highly skilled labour force is Norway's most important *economic* resource.

This conclusion requires that it makes sense to decompose the national wealth. It is clear that all the components of the national wealth are necessary for production. Oil produces no revenues without the labour needed to extract it, and this labour would be less productive without machinery. All the components are needed simultaneously to produce what we produce today.

The reason why it is nevertheless useful to examine the contribution from the different components is that Norway is able to trade with other countries. This is most obvious if we assume that Norway can carry on unlimited trade on the world market, at fixed prices. If we lack the labour to extract oil, we purchase it from abroad. If we had not had any oil we would have bought it from abroad. To push it to the extreme: If we woke up one morning with no real capital, we would start the day by buying it back from abroad. The productivity of the labour force would then be unaffected by the loss of real capital, but we would have to take up a loan of NOK 2 450 billion in order to buy back the real capital. This would mean a reduction of NOK 2 450 billion in the national wealth. Therefore, given perfect international markets for credit and goods, it becomes meaningful to decompose the national wealth in this way.

The necessity of perfect goods and credit markets also demonstrates one of the problems that would arise if we included environmental quality into our calculations of the wealth. Obviously, we cannot buy fresh air from abroad to compensate for a deterioration of our own air quality. Therefore it is impossible to separate the contribution made by the environment to the national wealth from the contribution made by other components. However, poor quality air could also affect the national wealth in the more restricted context of our calculations. A higher level of pollution can cause injuries to health which reduce the productivity of the labour force, and therefore also lead to reduced human capital. Since human capital is the dominating component of the wealth, these effects could well be considerable.

3.3. The wealth of resources and the resource rent

As in the case of the other components of the wealth, the *wealth represented by natural resources* is equal to the present value of the income they generate. The principles for calculating the income that can be ascribed to a particular resource are the same for all natural resources, but we choose to illustrate this by calculating the income that can be ascribed to oil. When calculating the oil rent, we must deduct the part of the income obtained from invested capital. It is natural to deduct the return that the same amount of capital would have produced in another sector, that is to say, normal return. The oil rent is the part of the oil revenues that remains after normal return on capital is deducted.

In general, *the resource rent* is defined as:

Factor income
+ Indirect special taxes
- Subsidies
- Normal return on capital
- Labour cost
= **Resource rent**

The factor income is the total income in the sector after all costs except costs for wages and capital have been deducted.

The estimates of the resource wealth for oil and gas and hydropower have been obtained from the Ministry of Finance (1993). The estimate of the forest wealth has been obtained from the National Accounts. This leaves fish, where the wealth is estimated to NOK 0. With subsidies, the earning ability in the fisheries sector today is in the order of NOK 120 000 per man year. Even before the subsidies are deducted there is still no resource rent remaining. This has been the situation in the fisheries for a long time, but it cannot be excluded that better management of resources might lead to a positive resource rent sometime in the future.

One of the reasons why calculations of the wealth can be useful is that they provide a basis for discussing how to use the revenues. From the aspect of sustainable development, it is useful to know, for example, whether a nation should save more in order to compensate for extraction of natural resources. In our introductory calculation we saw that a petroleum wealth of NOK 810 billion with a return of 7 per cent is equivalent to a steady annual flow of income of NOK 57 billion. Given this rate of interest, and a national wealth of NOK 9 400 billion, this line of reasoning indicates that we can use NOK 614 billion per year without reducing the wealth. This is NOK 24 billion more than the national product of NOK 590 billion. *Given the assumptions outlined above,* the deficit can be paid back later without reducing the standard of living of future generations in relation to our own, provided that we accept the assumptions.

The most important assumption is that we ignore *uncertainty* when defining both the growth rate and the discounting rate. We also face the possibility of unexpected changes in the wealth from year to year.

The change in the wealth from year to year can be divided into three components:

+ return on the wealth
+/- revaluations during the year
- use
= **Change in the wealth**

If the use of the revenues is equal to the return, we would expect the wealth to remain unchanged from one year to the next. Owing to the uncertainty concerning future revenues, however, it may be necessary to make substantial revaluations. Let us assume that during the first year there are grounds to assume that a reasonable estimate of annual growth in the net national product was 1 per cent, but that in the following year there are grounds to believe that the most reasonable estimate is 0 per cent. As shown above, such a change in the estimation of future prospects would imply a reduction of NOK 1 350 billion in the national wealth, and this has nothing to do with whether we have *used* a lot or a little of the wealth. In the case of the petroleum wealth, the revaluation from 1985 to 1986 was estimated to NOK -731 billion. Therefore, there are grounds to believe that it is a very risky policy to use NOK 614 billion per year, which our above calculations indicated could be used without reducing the wealth. For a more thorough discussion of the importance of uncertainty, see Brekke et al. (1989) and Brekke (1991).

A policy involving a deficit of NOK 24 billion per year is risky, but Norway's total savings in 1991 amounted to NOK 70 billion. This could be a reassuring safety margin if we accept the assumption of 1 per cent growth. Although 1 per cent growth is not particularly high in a historical perspective, both the desirability and the potential for continued economic growth are a matter of controversy. The calculations in this chapter only show the consequences of an *assumed* growth of 1 per cent.

If we assume that the growth is -1 per cent, given a constant labour force and constant capital, the wealth will be only NOK 7 050 billion. A calculation similar to the one described at the beginning of the chapter shows that we could then use only NOK 460 billion and still maintain the same standard of living. When the total national product is NOK 590 billion, this means saving NOK 130 billion per year. Compare this with the fact that Norway's total savings amounted to just under NOK 70 billion in 1991.

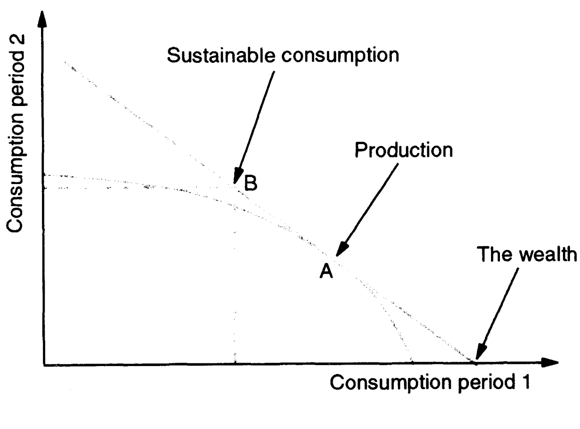
A final point is that the rate of interest of 7 per cent, which is normally used in such calculations, is somewhat arbitrary. The effect of a lower rate of interest is ambiguous, however. Given a rate of interest of 5 per cent the estimated wealth will increase by about NOK 14 000 billion. With a 5 per cent rate of interest the return will be almost NOK 50 billion *higher* than with a rate of interest of 7 per cent.

In order to explain the concept of wealth we assume that only two periods exist. The first period is our own generation, and the second is the coming generation. We wish to choose between production (net for real investments) in period 1 and in period 2. Production in the second period is higher if, during the first period, we decide not to extract natural resources now, or to invest in real capital. Without foreign trade our consumption would have to equal our production. Lower production/consumption today could then imply a higher standard of living for future generations. The choice between consumption in period 1 and period 2 is represented by the curved line.

Given foreign trade and the possibility of borrowing or saving, one is not bound to consume the same as one produces during each period. For example, if we choose production in the two periods as shown in A, we are able, by saving or borrowing, to finance all combinations of consumption for the two periods shown by the straight line through point A (the slope depends on the rate of interest). For all these possible levels of consumption the present value of consumption in the two periods, that is to say, our generalized concept of wealth, is the same. The wealth expressed in terms of units of the consumption during period 1 is defined at the intersection with the axis for consumption in period 1. If we also assume that interests rates and prices are determined on the world market, then the slope of the curve is also determined by the world market. Then we should choose production so that the position of the straight line is such as to give the greatest possible wealth. The figure shows that, when thinking in terms of wealth, the choice of consumption can take place in two stages. First we must find production point A, which is tangential to the line representing the possibilities of borrowing. The figure shows that, with the given slope of the line, it is impossible to achieve the same wealth by adjusting at any other point. With poor management of natural resources, the production may take place at quite a different point. The costs of such poor adjustment can then be represented by a loss of wealth.

The other choice concerns the use of the wealth. Given A, and therefore the wealth, it is also necessary to choose a point of consumption on the straight line. Point B represents the choice where the standard of living is the same in both periods, and can therefore said to give sustainable development. If we choose a point closer to A, future generations will have a lower standard of living than we experience today. These conditions can now be discussed independently of the actual calculation of the wealth.

Wealth in a model containing two periods



Box 3.1. Calculation and use of the national wealth.

3.5. Summary

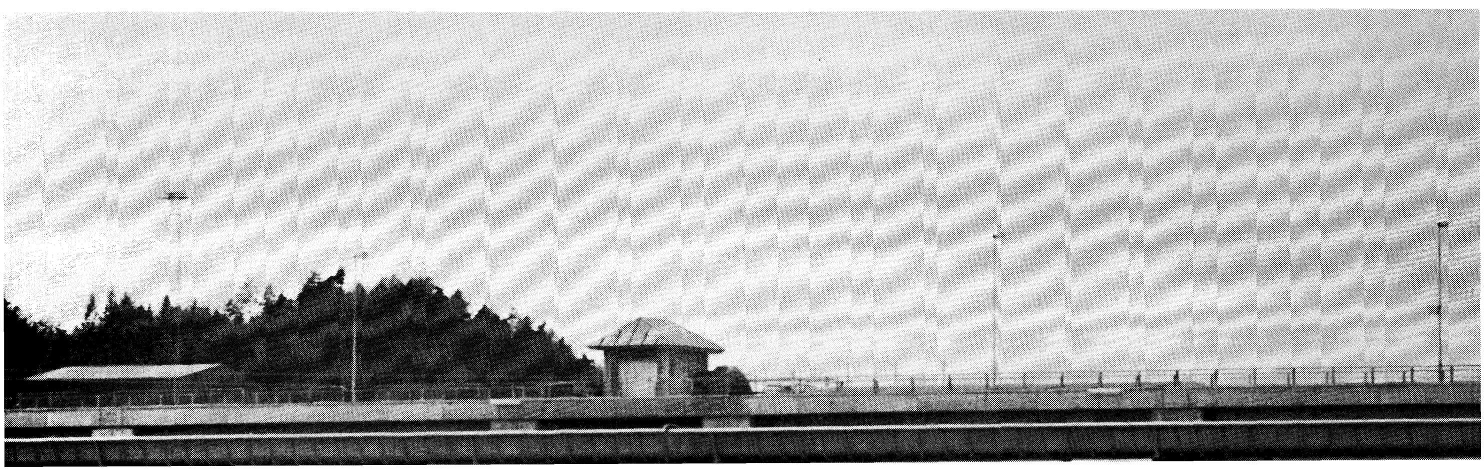
Calculations of wealth are one way of summing up the prospects for the future. Our understanding of the future is based on models constructed on the basis of historical data. Therefore the calculations of the wealth cannot be more reasonable than the models themselves. In this chapter, in order to focus on the actual concept of wealth, we have used very simple models, with a fixed rate of interest, no uncertainty and fixed rates of growth. However, in reality, the concept of wealth does not depend on such simple models. There is therefore a possibility to modify and supplement many of the analyses with more realistic models. But regardless of what models are used, it is useful to have concepts which can sum up the prospects for the future in a simple way. The chapter must therefore be interpreted as illustrating a mode of thinking and as a tool in planning; it is not intended to present concrete recommendations.

References:

Brekke, K.A., T.A. Johnsen and A. Aaheim (1989): Petroleumsformuen - Prinsipper og beregninger (The petroleum wealth - Principles and calculations). Economic Analyses no. 5. In Norwegian.

Brekke, K.A., (1991): Bruken av oljeinntektene. Formuesberegninger som hjelpemiddel i makroøkonomisk styring. (Use of the oil revenues. Calculations of wealth as an instrument of macroeconomic management). Economic Analyses no. 7. In Norwegian.

Ministry of Finance (1993): Report no. 4 to the Storting (1992-93). Long-term programme 1994-1997. (Extracts in English).



4. ENERGY

At the turn of the year, Norway's reserves of oil and gas in developed fields and in fields to be developed constituted 2605 Mtoe. This is an increase compared with the previous turn of the year owing to revaluation of existing fields and the granting of new licenses. With today's level of extraction and with known technology the oil reserves will last for 20 years. The gas reserves will last for 115 years. These estimates of the reserves include fields that are not yet licensed. On 1 January 1993 the total economically exploitable hydropower reserves amounted to 176.4 TWh and the average power potential for water resources developed for hydropower was 109.5 TWh. The reason for the increase in power potential since 1 January 1992 is the development of Svartisen.

Production of crude oil and natural gas increased by 14 per cent and 2 per cent, respectively from 1991 to 1992. In 1992, Norway was the world's largest exporter of oil outside OPEC. Export of natural gas is expected to increase considerably towards the middle of the 1990s. Electricity production increased by about 6 per cent, 6.7 TWh, from 1991 to 1992. The reason was more precipitation and greater flow of water to the reservoirs. Norway exports electricity, mainly on a short-term basis, to Sweden, Denmark, Finland and Russia.

Use of energy in Norway outside the energy sectors and ocean transportation has decreased slightly in recent years. The main reason for the decrease is lower consumption of petroleum products, especially heating oil and gasoline. Since the mid-1970s there has been a steady, though declining, increase in temperature-adjusted electricity consumption. There has been a change from use of oil to use of electricity, in spite of the fact that oil for heating has been cheaper than electricity at times. The reason may be the large cost of installing and maintaining oil heating plants.

4.1. Reserves and production potential

Oil, gas, hydropower and bio-energy are the most important energy resources used in Norway. In the case of non-renewable resources, e.g. oil, gas, coal and uranium, we use the term reserves. In the case of renewable resources, e.g. hydropower, we also use the term production capacity, in addition to reserves.

Oil and gas

The petroleum resources can be divided into four main categories:

* Fields in operation
* Fields that are under development or have been licensed for development
* Fields being evaluated
* Potential resurces in unexplored parts of the Norwegian continental shelf.

The term reserves refers to the share of total proven resources that can be extracted profitably at today's prices and by known technology. If product prices rise, or production technologies improve, the estimated reserves will increase. Tables 4.1 and 4.2 show changes over time in the accounts of reserves of crude oil and natural gas, respectively.

On 1 January 1993 the reserves in developed fields and in fields to be developed amounted to 1112 million tonnes crude oil and 1274 billion Sm^3 natural gas, which is equivalent to 2386 Mtoe. In the course of 1992 the preliminary estimates of the reserves increased to 1224 million tonnes crude oil and 1381 billion Sm^3 natural gas, in spite of extraction of 107 million

Table 4.1. Reserve accounts for crude oil. Developed fields and fields to be developed[1]. 1987-1992. Million tonnes

	1987	1988	1989	1990	1991	1992*
Reserves per 1/1	796	855	1000	982	1111	1112
New fields	54	143	-	103	93	86
Re-evaluation	54	58	56	108	2	133
Extraction	-49	-56	-74	-82	-93	-107
Reserves per 31/12 ...	855	1000	982	1111	1112	1224
R/P-rate	17	18	13	14	12	11

[1] The figures are not the same as in earlier editions of Natural Resources and the Environment.
Source: Petroleum Directorate (OD), CBS

Table 4.2. Reserve accounts for natural gas. Developed fields and fields to be developed[1]. 1987-1992. Billion Sm^3

	1987	1988	1989	1990	1991	1992*
Reserves per 1/1	1259	1247	1265	1261	1233	1274
New fields	6	10	-	15	54	138
Re-evaluation	12	38	27	-15	14	-3
Extraction	-30	-30	-31	-28	-27	-28
Reserves per 31/12 ...	1247	1265	1261	1233	1274	1381
R/P-rate	42	42	41	44	47	49

[1] The figures are not the same as in earlier editions of Natural Resources and the Environment.
Source: OD, CBS

Table 4.3. World reserves[1] of oil and gas

	Reserves 1/1 1992		Reserves 1/1 1993		Changes in reserves from 1992 to 1993	
	Oil	Gas	Oil	Gas	Oil	Gas
	Bill. toe		Bill. toe		Per cent	
Asia-Pacific	5.9	8.2	6.0	9.4	1.1	13.9
Western Europe	2.0	4.9	2.1	5.3	9.1	7.4
Eastern Europe and CIS[2] ..	7.9	48.5	8.0	53.9	0.7	11.1
Middle East	89.3	36.2	89.3	41.8	0.0	15.2
Africa	8.2	8.5	8.4	9.5	2.3	11.8
America	20.5	13.9	20.8	14.3	1.4	3.5
The world	133.8	120.3	134.6	134.2	0.6	11.6
OPEC	103.9	47.6	104.2	54.0	0.4	13.4
Norway	1.0	1.7	1.2	1.9	15.7	16.4

[1] The term "reserves" as used in this table is not the same as used in the account figures in tables 4.1 and 4.2. For most of the countries the figures refer to proven reserves that are exploitable with today's technology and given today's prices. [2] Commonwealth of Independent States
Source: Oil and Gas Journal, 1992

tonnes of crude oil and 28 billion Sm^3 of natural gas. This is partly due to revaluation of several existing fields, and partly to new licenses; Frøy, Mime, Sleipner West and Troll West Oil. If the reserves in fields that are not yet licensed are added, and assuming an improvement in production technology, the Petroleum Directorate's estimate of the reserves of oil and gas on the Norwegian continental shelf per 31 December 1992 increases to 4985 Mtoe. To the proven reserves must be added the potential in the unexplored parts of the continental shelf. The Petroleum Directorate estimates this quantity to 3670 Mtoe.

The ratio between reserves and production, the R/P ratio, tells how long today's reserves will last given today's level of extraction and known technology. The oil reserves in fields that have been developed or are to be developed will last 11 years, while the gas reserves will last 49 years. If the reserves in fields that are not yet licensed are added, the R/P ratio is 20 years for oil and 115 years for gas. These estimates will be changed in the years to come, depending on rate of extraction, new discoveries and new production technologies.

Table 4.3 gives an estimate of the world's reserves of oil and gas by region.

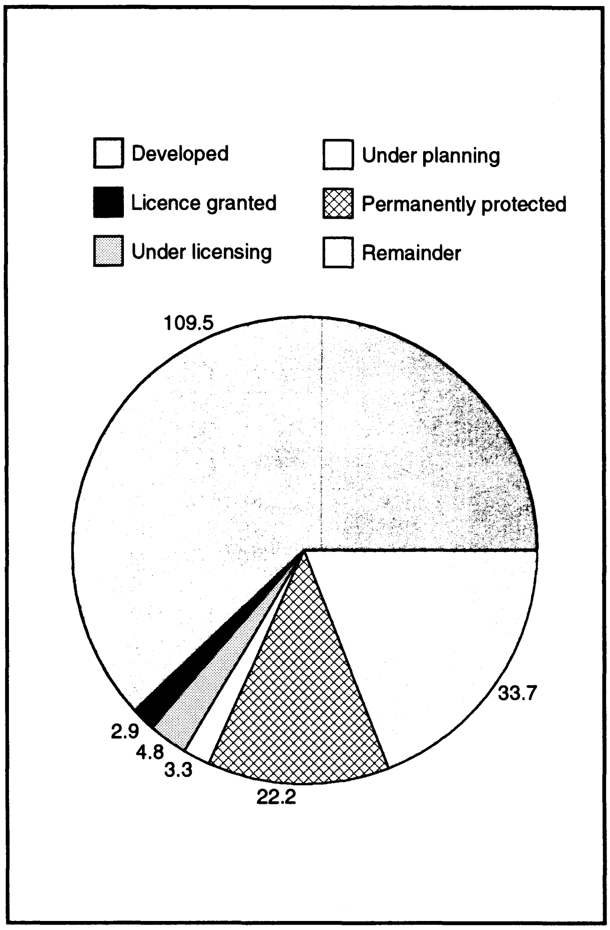
On 1 January 1993, Norway had the second largest proven reserves of both oil and gas in Europe (including CIS). The largest reserves are in the Commonwealth of Independent States (CIS). In Western Europe, 56 per cent of the oil reserves and 37 per cent of the gas reserves are located on the Norwegian continental shelf. Norway possesses 0.9 and 1.4 per cent of the world's proven reserves of oil and gas, respectively.

Hydropower

The hydropower reserves can be placed into four categories:

* Watercourses that have been developed for hydropower
* Watercourses that are under construction or are under licensing
* Protected watercourses
* Remaining watercourses in the "Master Plan for Water Resources".

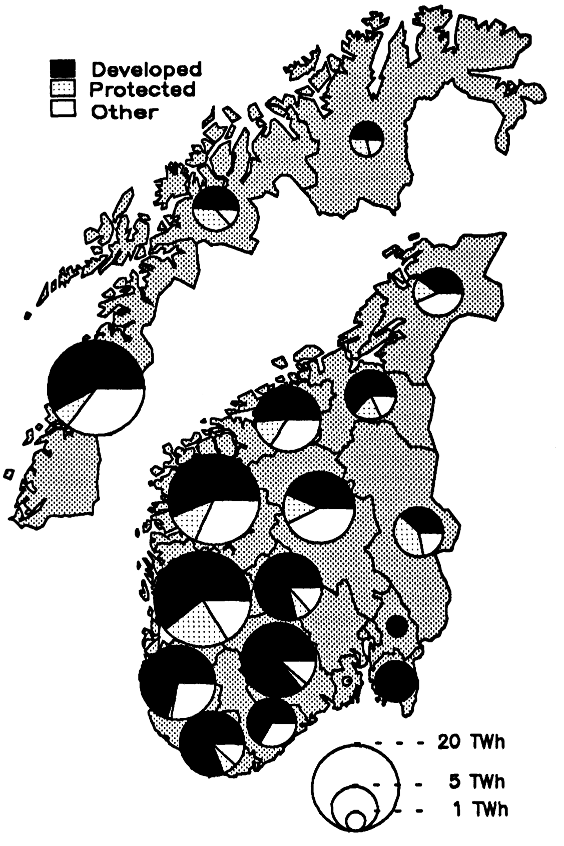
Figure 4.1. Exploitable hydropower. 1 January 1993. TWh



Source: NVE

The distribution of Norwegian hydropower reserves between the different categories is shown in figure 4.1. The distribution by county is shown in figure 4.2. Per 1 January 1993, Norway's total exploitable water resources amounted to 176.4 TWh. The average power potential can be defined as the production capacity of the power stations in a year with normal precipitation. At the turn of the year 1992/93, the average power potential for developed watercourses was 109.5 TWh. This is an increase of 1.4 TWh compared with the previous year. The main reason for the increase in potential is the completion of the development of Svartisen I. Undeveloped hydropower resources, excluding permanently protected watercourses, amounted to 44.7 TWh on 1 January 1993. Of this amount, about 11 TWh was under construction, under licensing or under planning.

Figure 4.2. Exploitable hydropower. 1 January 1993. By county



Source: NVE

The mean power potential of the Norwegian hydropower system is calculated by the Norwegian Water Resources and Energy Administration (NVE). The calculations are based on precipitation and flow to the reservoirs, as observed during the period 1930-1980. There is some uncertainty associated with the system of calculation and the period chosen for calculating normal flow to the reservoirs. Based on flow during the period 1930-1990, Samkjøringen (The Norwegian Power Pool, now incorporated into Statkraft SF, or Norwegian Grid Company) has estimated the power potential to 111 TWh. If the calculations are based on the period 1980-1990, the capacity is estimated to be 122 TWh. Table 4.4 shows different electricity balances for Norway based on flow data for different periods.

Table 4.4. Electricity balance. Actual balance in 1992 and theoretical balance given 3 different periods as a basis for calculating a year with normal flow. TWh

	Actual 1992	Inflow data 1930-1980	1930-1990	1980-1990
Overflow	2.4*			
Production	117.7	108.1	111.0	122.0
Export	10.1	0.0	2.7	13.0
Import	1.4			
Domestic consumption	108.9	108.1	108.3	109.0
Loss + power to pumping stations**	10.7	8.4	8.6	9.3
Surplus power ...	7.1	4.1	4.1	4.1
Energy-intensive indystry.	27.6	30.0	30.0	30.0
Regular consumption	63.5	65.6	65.6	65.6

* For the first three quarters
** Loss only in normal years, power to pumping stations is included in the average power potential
Source: CBS

The world's hydropower resources

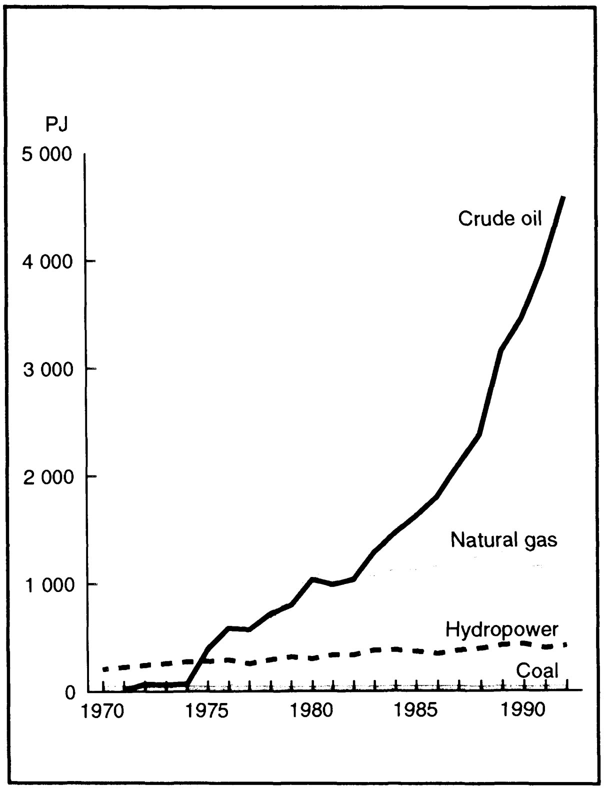
In 1987, the world's developed hydropower resources amounted to about 2632 TWh. Norway's share of this amount was 4.3 per cent. In Europe (CIS not included) the developed resources amounted to about 727 TWh, of which Norway's share was 15.7 per cent.

Other sources of energy

In 1988, the world's proven reserves of *coal* amounted to 22.4 million PJ. 72 per cent of this amount is regarded as hard coal. With the present rate of extraction the world's coal reserves will last about 200 years. The largest reserves are located in North America, CIS and China.

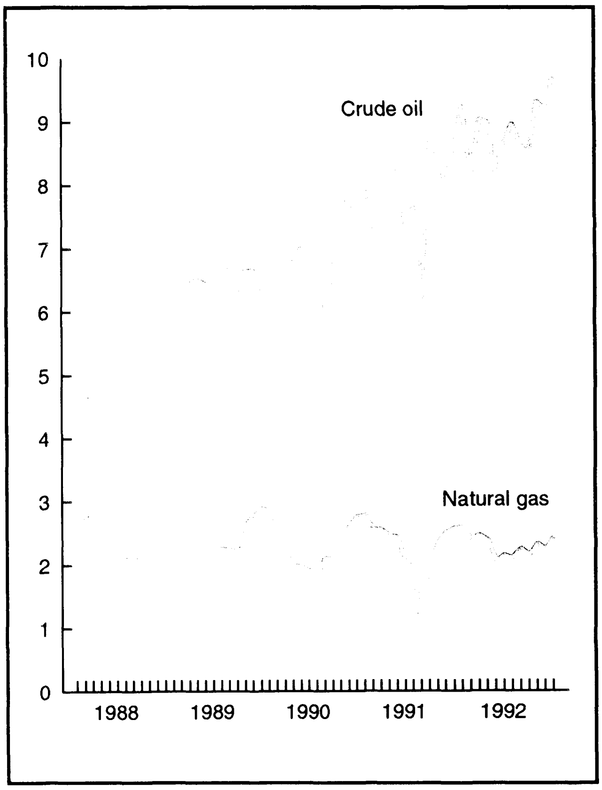
The world's reserves of *uranium* correspond to an energy content of 0.6-0.9 million PJ, if the costs do not exceed 80 dollars per kg. With costs between 80 and 130 dollars per kg, a further 0.3-0.4 million PJ must be added to the above estimate. In 1991 the spot price of uranium was 24 dollars per kg. The price of uranium is falling steadily because of over-production.

Figure 4.3. Extraction of energy sources. 1970-1992. PJ



Source: CBS

Figure 4.4. Production of oil and gas. 1988-1992. Crude oil in million tonnes. Natural gas in billion Sm^3



Source: CBS

The largest reserves are located in South Africa, Niger, Australia, CIS, Canada, USA and Brazil.

4.2. Production

Changes in the extraction of the energy sources hydropower, crude oil, natural gas and coal in Norway are illustrated in figure 4.3. Coal extraction has varied between 6-14 PJ per year from 1930 until today. There has been an even increase in hydropower production, but a marked increased in extraction of natural gas and of crude oil in particular from the mid-1970s until today.

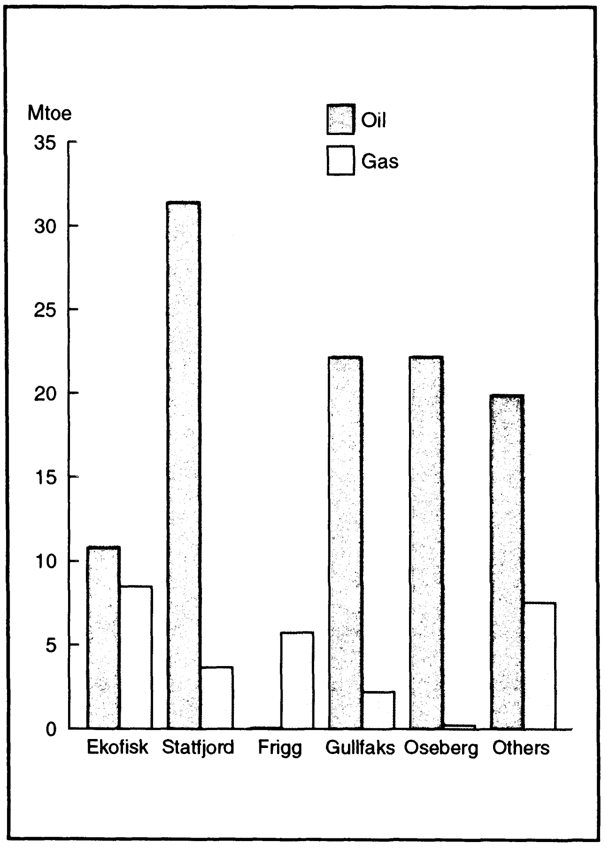
Oil and gas

According to CBS's production statistics, the total Norwegian production of *crude oil and natural gas* amounted to 134 million tonnes oil equivalents (Mtoe) in 1992, an increase of 11 per cent compared with 1991. The growth in production was particularly strong towards the end of 1992. The increase refers mainly to oil production (including natural gas liquid (NGL)), which increased by as much as 14 per cent to 107 Mtoe. Annual gas production also increased, owing to an increase in production throughout the second half of last year.

In 1992, production of Norwegian *crude oil,* including NGL, averaged 2.18 million barrels per day. In December, production reached the highest level to date, about 2.3 million barrels per day. The largest contributors to the increased production were the Gullfaks and Oseberg fields, which now account for 42 per cent of the oil produced on the Norwegian continental shelf. The Statfjord, Veslefrikk, Ula and Gyda fields also contributed to increased production, as did the Snorre field, which became operative in August 1992.

In 1993, oil production is expected to increase by about 5 per cent compared with 1992.

Figure 4.5. Oil and gas production from the 6 largest fields. 1992. Mtoe



Source: CBS

Table 4.5. World production of crude oil. 1990-1992

	Production, Mtoe			Growth, per cent	
	1990	1991	1992	1991	1992
Asia-Pacific	312	321	323	3.0	0.6
Western Europe	200	212	223	6.1	5.1
Eastern Europe and CIS	583	527	457	-9.6	-13.2
Middle East	836	811	868	-3.0	7.0
Africa	301	314	315	4.3	0.3
America	786	809	804	2.9	-0.7
The world	3018	2994	2989	-0.8	-0.2
OPEC	1165	1165	1215	0.0	4.3
Norway	81	93	104	15.8	11.7

Source: Oil and Gas Journal, 1992

Production from the Statfjord, Gullfaks and Oseberg fields will probably remain at about the same level as in 1992, while production from the Snorre field will increase. In addition, the Embla, Brage and Draugen fields will come on stream. The Draugen and Brage fields have large oil reserves, which will ensure a high level of oil production on the Norwegian continental shelf during the next few years.

Since production started in 1989, the reserves in the Oseberg field have been adjusted upwards by as much as 450 million barrels. The estimated reserves for the Statfjord field have also been adjusted upwards, but production in this field is expected to fall from plateau level in the course of the next few years.

CBS's production statistics show that production of *Norwegian natural gas* increased by 2 per cent from 1991 to 1992. The most remarkable feature of the Norwegian gas production in 1992 was the strong reduction (14 per cent) in production from the Frigg area. The share of the gas produced in the Frigg field decreased from 25 per cent in 1991 to 20 per cent in 1992. Production from Odin will probably be halved this year, implying a further reduction of the production from the Frigg area. The satellite field, Lille-Frigg, will become operative towards the end of 1993, but will not compensate for the decrease in production from the existing installations. The increase in gas production in 1992 refers mainly to the Gullfaks, Ekofisk and Tommeliten fields. Export of Norwegian natural gas will increase considerably towards the middle of the 1990s, when the large gas fields Sleipner Øst, Sleipner Vest and Troll Øst become fully developed.

According to estimates in Oil and Gas Journal, there was only a marginal decrease in *world oil production* in 1992, see table 4.5. Production in the Commonwealth of Independent States (CIS) decreased by as much as 13 per cent, but the domestic consumption sank correspondingly, implying that net export remained unchanged. Increased demand in the rest of the world was met by increased production in the Middle East and Western Europe. Production increased in Kuwait in particular, as production capacity was gradually restored after the oil fires during the Gulf war. In Europe, Norway was the main contributor to the growth

Table 4.6. World production of natural gas. 1980-1991

	Production, Mtoe						Growth rate, per cent p.a.		
	1980	1987	1988	1989	1990	1991	1990-1991	1980-1987	1987-1991
America	646	585	608	636	650	667	2.7	-1.4	1.9
Middle East	34	74	82	93	106	105	-0.8	11.8	5.1
Western Europe	173	174	163	161	170	189	11.4	0.1	1.2
Africa	18	51	55	59	56	58	3.9	16.2	1.7
Asia	39	79	84	95	108	98	-9.5	10.5	3.0
Total, excluding transitional economies	920	982	1011	1064	1112	1141	2.6	0.9	2.2
Transitional economies	450	674	709	727	735	761	3.6	5.9	1.8
World as a whole	1370	1655	1720	1791	1847	1902	3.0	2.7	2.0

Source: Oil and Energy Trends, Blackwell Publisher (1992), CBS

in production, with an increase of 12 per cent. In 1992, Norway was the largest exporter of oil in the world outside OPEC. Saudi Arabia is the world's largest exporter, and is on way to achieving equally high total production as in CIS, which is the country producing the largest amount of oil to date. It is uncertain, however, whether the decline in production in the CIS will continue.

There are no statistics available for world production of *natural gas* in 1992. CIS is the world's largest producer of natural gas, and increased production by almost 3 per cent to 704 Mtoe in 1991. Production of natural gas also increased by 3 per cent in the world as a whole, see table 4.6. The growth in production was greatest in Western Europe, with a strong increase in production in the United Kingdom, The Netherlands and Germany. There was a marginal decrease in gas production in the Middle East as a result of the Gulf War, when Saudi Arabia compensated for the loss of production in Iraq and Kuwait. A substantial fall in production in Indonesia also led to a decrease in production in Asia as a whole.

The average annual growth in *world gas production* was 2.7 per cent from 1980 to 1987, and 2 per cent from 1987 to 1991. The growth was strongest in the Middle East, Asia and Africa, where most of the gas is sold on the domestic market. Production costs are low in the Middle-East in particular, and here the gas is used mainly in energy-intensive and petrochemical industry.

From January to August 1992, gas production increased by 6.7 per cent in Canada, 2.5 per cent in USA, 0.3 per cent in Western Europe and 1.5 per cent in CIS, compared with the year before.

Hydropower

117.7 TWh of electricity was produced in Norway in 1992. About 0.5 per cent of this amount is thermal power. Electricity production increased by 6.7 TWh from 1991. The reasons were more precipitation and better flow to the reservoirs than in 1991. Water equivalent to 2.4 TWh passed outside the production system during the first three quarters of the year.

Table 4.4 shows the electricity balance for 1992. The table also shows theoretical balances for three different estimates of the production capacity in the hydropower system. Given the most conservative estimate of the power potential, domestic demand will be large enough to absorb the production at today's prices. Domestic demand is calculated for normal temperatures and assuming complete utilization of the production capacity by energy-intensive industry. If the calculations are based on the most optimistic flow conditions, 13.0 TWh of electricity can potentially be exported. Even with a lower estimate of normal hydropower production, there is still a potential to export electricity.

Table 4.7. Average electricity prices in different user groups, electricity tax included, (VAT excluded). 1991 and 1992. Øre/kWh

	1991	1992
Export	10.6	6.8
Import	10.7	10.8
Domestic consumption (excl. loss)	29.6	29.2
Surplus power	11.6	5.0
Energy-intensive industry	12.2	12.7
Regular consumption ...	39.4	39.1

Source: CBS

Other sources of energy

According to the preliminary figures, coal production in Svalbard was 11 PJ in 1992, compared with 10 PJ in 1991. Wood, wood waste and paper waste are the most important biological fuels in Norway. Production of these fuels, including production for own consumption, amounts to about 38 PJ per year. This figure is very uncertain. In 1991, about 4 PJ was produced for district heating from incineration of waste. About 90 per cent of this amount can be regarded as bio-energy. Large amounts of methane gas are generated from landfills. Methane has a high energy content, but most of the gas passes directly into the air (see chapter 5, Air). It is estimated that methane gas equivalent to about 7.6 PJ is produced every year. Most of this methane is biogas. Since 1988, some of this gas has been utilized as energy. In 1992, about 6 per cent of the generated gas, equivalent to 0.5 PJ, was utilized.

Import and export

In 1992, Norway was net importer of coal and coke, and net exporter of crude oil, natural gas, LPG/NGL and petroleum products. In 1992, Norway exported 592 million tonnes net of crude oil and 26 million toe natural gas (provisional figures). The most important buyers of Norwegian natural gas are Germany, France and the United Kingdom.

In the course of 1992, Norway exported 10.1 TWh electricity, i.e. 9 per cent of the gross production. The net export was 8.7 TWh in 1992 compared with 2.8 TWh in 1991. About 6.8 TWh of the gross export went to Sweden, 3.1 TWh to Denmark and the rest to Finland and Russia. These figures refer mainly to short-term exports. In 1992, the average price of exported electricity was 6.8 øre per kWh, cf. table 4.7. In 1991 the average price of exported electricity was 10.6 øre per kWh. The price of imported power was 10.8 øre per kWh in 1992. This is about the same price as in 1991.

Up to and including week 40, the export price to Denmark was between 6 and 8 øre per kWh. The price to Sweden during the same period was between 3 and 7 øre per kWh. In week 41 there was a drastic increase in the spot market price in Norway. This implied that, after this date, the export price to Sweden was between 12 and 15 øre per kWh. The strong rise in prices in week 41 led to a lower Swedish demand for Norwegian electricity and lower short-term sales of electricity in Norway. On average, Norwegian sales of electricity to Sweden were reduced by about 500 MW or about 60 GWh per week. Sweden chose to cover its increased domestic demand by importing electricity from Denmark instead. Owing to the low price of coal and surplus production capacity, Denmark could offer electricity at prices ranging from 12 to 18 øre per kWh. It has been maintained that Sweden chose to import electricity from Denmark for strategic reasons. The reason for the large demand for electricity by Sweden was that several of the Swedish nuclear power plants did not become operative in the autumn as planned after maintenance work in the summer.

In Norway there were strong reactions following the marked increase in the spot price of electricity on the domestic market in week 41. The media suggested that several producers had cooperated to force up the price. According to economic theory, this kind of cooperation between producers can increase the return to the producers even if the higher prices lead to lower consumption. The Directorate of Prices investigated whether the rise in prices was due to cooperation between Norwegian producers, but found no signs of such behaviour.

Table 4.8. Extraction, conversion and use[1] of energy sources. 1991*

	Coal	Coke	Fuel wood, wood waste, paper waste, other waste	Crude oil	Natural gas	Petroleum products[2]	Electricity	District heating
	1000 t	1000 t	1000 toe	1000 t	Mill.Sm[3]	1000 t	GWh	GWh
Extraction of energy sources	340	-	-	92263	27279	1087[3]	110523	-
Energy use in extraction sectors	-	-	-	-	-2085[4]	-224	-1767	-
Imports and Norwegian purchases abroad	601	829	0	1621	-	10754	3219	-
Exports and foreign purchases in Norway	-271	-93	0	-82196	-25209	-7681	-6039	-
Stocks (+ Decrease, - Increase)	21	-2	.	235	.	84	.	-
Primary supply	691	733	0	11923	-15	4019	105936	-
Petroleum refineries	-	143	-	-12062	-	11249	-424	-
Other energy sectors, other supply	-27	-	900	-	-	143	62	1545
Registered losses, statistical errors	-4	-32	-	139	15	-953	-7774	-529
Registered use outside energy sectors	660	844	900	-	-	14459	97800	1016
Domestic use	660	844	900	-	-	6591	97800	1016
Agriculture and fishery	5	-	-	-	-	617	681	7
Energy intensive manufacturing	423	713	4	-	-	1224	29710	107
Other manufacturing and mining	226	129	414	-	-	521	15578	113
Other industries	-	-	-	-	-	2441	21160	453
Private households	7	2	482	-	-	1788	30672	336
Ocean transport	-	-	-	-	-	7869	-	-

[1] Includes energy goods used as raw materials [2] Includes liquified 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 terminals

Source: CBS

4.3. Use of energy sources

The Energy Accounts follow the different sources of energy from extraction via conversion to use within the different production sectors and in private households. In the Energy Accounts, use of energy sources covers consumption for all Norwegian economic activity. Energy Accounts have been prepared for the years 1976 to 1991. Tables 4.8 and 4.9 show the preliminary accounts for 1991. The Central Bureau of Statistics also prepares an energy sources balance covering consumption of the different forms of energy in Norway. It is these figures from the energy sources balance that are used when reporting Norway's energy consumption to international institutions.

In the Energy Accounts, the energy sectors consist of extraction sectors (coal mining, hydropower plants and extraction of oil and gas)

Table 4.9. Extraction, conversion and use[1] of energy sources, 1991*. PJ. Change in per cent

	Coal and Coke	Fuel wood, wood waste, paper waste, other waste	Crude oil	Natural gas	Petroleum-products2	Electricity	District heating	Total	Average annual change in per cent 1976-1990	Average annual change in per cent 1990-1991
Extraction of energy sources	10	-	3903	1122	50[3]	398	-	5482		
Energy use in extraction sectors	-	-	-	-86[4]	-9	-6	-	-102		
Imports and Norwegian purchases abroad	43	0	69	-	457	12	-	580		
Exports and foreign purchases in Norway	-11	0	-3477	-1037	-332	-22	-	-4878		
Stocks (+Decrease, -Increase)	1	.	10	.	4	.	-	14		
Primary supply	42	0	504	-1	169	381	-	1096		
Petroleum refineries	5	-	-510	-	482	-2	-	-25		
Other energy sectors, other supply	-1	38	-	-	6	0	6	49		
Registered losses, statistical errors	-1	-	6	1	-41	-28	-2	-66		
Registered use outside energy sectors	45	38	-	-	616	352	4	1055	0.9	1.0
Domestic use	45	38	-	-	285	352	4	724	1.4	-1.6
Agriculture and fishery	0	-	-	-	26	2	0	29	0.2	-6.5
Energy intensive manufacturing	34	0	-	-	55	107	0	197	1.6	-3.0
Other manufacturing and mining	11	18	-	-	22	56	0	107	-0.9	-1.8
Other industries	-	-	-	-	104	76	2	182	1.9	1.1
Private households	0	20	-	-	78	110	1	210	2.4	-0.9
Ocean transport	-	-	-	-	330	-	-	330	-0.3	6.8

See footnotes for table 4.8.
Source: CBS

and conversion sectors (oil refineries, thermal power plants, combined power and heating plants and district heating plants). These sectors consume energy sources themselves. Most of this consumption refers to consumption of natural gas on offshore oil platforms, which accounts for more than 20 per cent of Norway's consumption of fossil fuels. The trend in the consumption of natural gas in the North Sea during the period 1976-1992 is shown in figure 4.6. The figure shows the amount of gas utilized, for example for production of electricity, and the amount burned in flares.

In 1991, energy consumption outside the energy sectors and ocean transportation was 724 PJ. This is a decrease of 1.6 per cent compared with 1990. The main reason for the decrease is reduced consumption of petroleum products, but another reason was less use of coal and coke in industry. Electricity consumption increased by 1 per cent. There was an increase in consumption of firm power, but a slight decrease in consumption of surplus

Table 4.10. Use of energy sources outside the energy sector and ocean transportation. 1976-1992. PJ. Change in per cent

Energy source	1976	1980	1985	1986	1987	1988	1989	1990	1991*	1992*	Average annual change in per cent 1976-1991	1991-1992
Total	607	679	737	741	764	753	735	736	724	726	1.2	0.3
Electricity	241	269	329	324	335	339	340	349	352	353	2.6	0.3
Firm power	232	265	312	315	321	323	320	324	330	327	2.4	-0.9
Surplus power	9	4	17	10	15	16	20	24	23	26	6.5	13.0
Oil total	300	294	263	287	284	271	262	245	235	233	-1.6	-0.9
Oil other than for transportation	159	138	80	90	84	77	64	58	51	43	-7.3	-15.7
Gasoline	9	3	0	0	-	0	0	-	-	-	.	-
Kerosene	17	16	9	10	11	10	8	7	6	6	-6.7	-
Medium distillates	66	63	43	43	45	42	38	36	32	28	-4.7	-12.5
Heavy oil	66	56	28	37	29	25	18	16	12	9	-10.7	-25.0
Oil for transportation	141	156	183	197	200	195	198	186	184	190	1.8	3.3
Gasoline, gasoline type jet fuel, kerosene type jet fuel	74	81	92	100	102	103	103	100	97	97	1.8	-
Medium distillates	64	70	83	89	90	85	89	83	84	90	1.8	7.1
Heavy oil	3	5	7	8	8	6	6	4	3	3	-	-
Gas[1]	1	41	52	40	56	52	43	52	51	53	30.0	3.9
District heating	.	.	2	2	3	3	3	3	4	4	.	-
Solid fuel	65	74	91	88	86	88	87	88	83	83	1.6	-
Coal, coke	47	48	57	53	50	53	51	50	45	45	-0.3	-
Wood, wood waste, paper waste, other waste	18	26	34	34	35	34	36	38	38	38	5.1	-

[1] Includes liquified gas. From 1990 also excess gas from petrochemical industry.
Source: CBS

power. The total consumption of energy decreased in most of the main industrial sectors. Consumption of energy in energy-intensive industry decreased by 3 per cent from 1990 to 1991. This included a decrease in consumption of electricity, petroleum products and coal/coke. The decrease in consumption in the sector "agriculture and fisheries" was mainly due to reduced consumption of marine diesel in the fishery sector.

Preliminary figures for 1992 show that the total consumption of petroleum products remained almost unchanged when compared with 1991, see table 4.10. There has been a reduction in consumption of heating oils and gasoline, but an increase in consumption of auto diesel and marine gas oil.

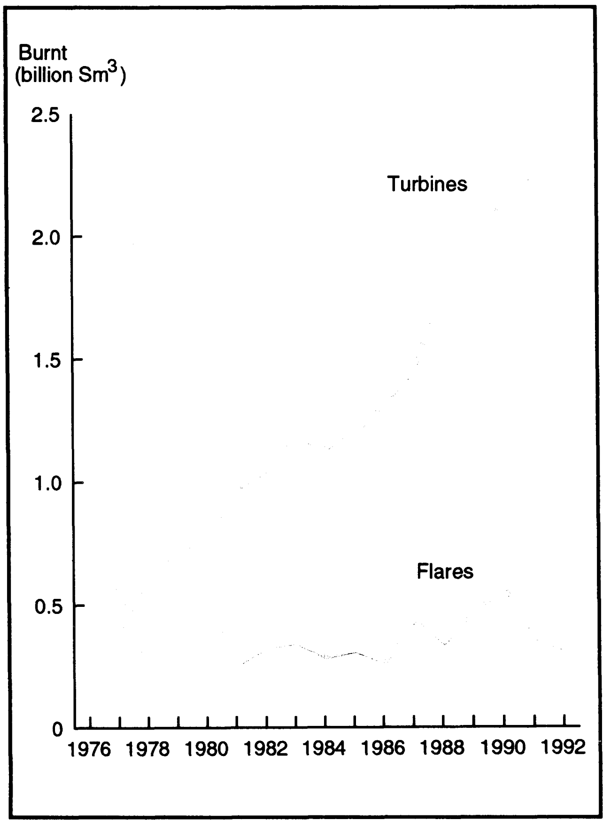
Table 4.11. shows the electricity balance for the years 1975-1992. According to the preliminary figures, gross domestic consumption of electricity was 108.9 TWh in 1992. This is about the same as in 1991. The figures show a decrease of about 1 per cent in consumption of firm power, and a corresponding increase in consumption of surplus power. Net firm power consumption was 91.1 TWh, of which 30 per cent was used in energy-intensive industry and 70 per cent in regular consumption. Table 4.11

Table 4.11. The Electricity Balance[1]. 1975 - 1992. TWh. Change in per cent

	1975	1980	1985	1986	1987	1988	1989	1990	1991*	1992*	Average annual change in per cent 1975-1985	Average annual change in per cent 1985-1992
Production	77.5	84.1	103.3	97.3	104.3	110.0	119.2	121.8	111.0	117.7	2.9	1.9
+Import	0.1	1.8	4.1	4.2	3.0	1.7	0.3	0.3	3.2	1.4	45.0	-14.2
-Export	5.7	2.3	4.6	2.2	3.3	7.4	15.2	16.2	6.0	10.1	-2.1	11.9
=Gross domestic consumption	71.9	83.6	102.7	99.3	103.9	104.4	104.3	105.9	108.1	108.9	3.6	0.8
-Consumption in pumping plants	0.1	0.5	0.8	0.9	0.7	1.0	0.4	0.3	0.7	0.7	23.1	-1.9
-Surplus power	3.2	1.2	4.8	2.7	4.1	4.5	5.6	6.7	6.3	7.1	4.1	5.8
-Losses in exports and surplus power	0.8	0.3	1.0	0.3	0.5	0.8	1.5	1.6	0.9	1.2	2.3	2.6
=Gross firm power consumption	67.7	81.6	96.2	95.4	98.6	98.1	96.9	97.3	100.3	99.9	3.6	0.5
Energy intensive industries	27.0	28.7	30.9	29.2	29.8	30.5	30.5	30.5	29.5	28.4	1.4	-1.2
Regular consumption[2]	40.7	52.9	65.3	66.2	68.8	67.6	66.4	66.9	70.8	71.5	4.8	1.3
-Losses in the transmission lines, consumption in the power stations, statistical differences[3]	6.3	7.7	8.7	9.1	9.2	9.2	8.8	8.6	8.7	8.8	3.3	0.2
=Net firm power consumption[3]	61.4	73.9	87.5	86.4	89.3	88.9	88.1	88.7	91.6	91.1	3.6	0.6
Energy intensive industries	26.2	27.9	30.0	28.4	28.9	29.6	29.6	29.6	28.7	27.6	1.4	-1.2
Regular consumption[2]	35.2	46.0	57.5	58.0	60.4	59.3	58.5	59.2	62.9	63.5	5.0	1.4
Regular consumption[2] temperature adjusted	36.3	45.1	55.0	57.1	58.6	60.2	61.7	63.1	64.3	65.8	4.2	2.6
Average annual change, per cent		4.4	4.0	3.8	2.6	2.7	2.5	2.4	1.9	2.3	.	.

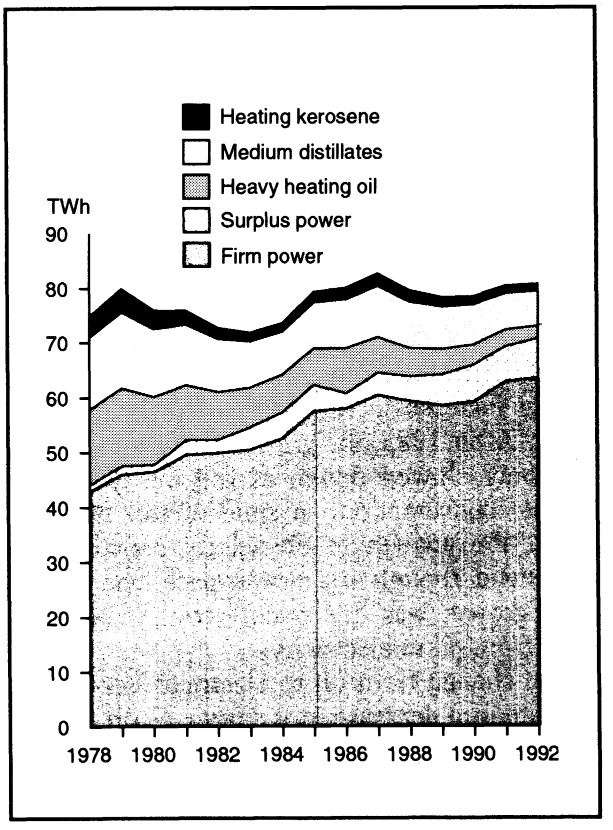
1 The definitions in the table correspond to the definitions in the Electricity Statistics.
2 Firm power consumption outside energy-intensive industries.
3 The Electricity Statistics register the sum of losses and statistical difference. From 1983, losses are estimated as the difference between gross and net electricity consumption in energy-intensive industries plus an estimated loss in regular consumption of 14 per cent (in 1989 13.5 per cent, in 1990 13.0 per cent and from 1991 12.5 per cent). Net consumption appears as the difference between gross consumption and estimated losses. This estimation procedure implies a slight deviation between these figures for regular consumption and those of the Electricity Statistics.
Source: CBS, NVE

Figure 4.6. Consumption of natural gas in the North Sea, for power production and burned in flares. 1976-1992. Billion Sm^3



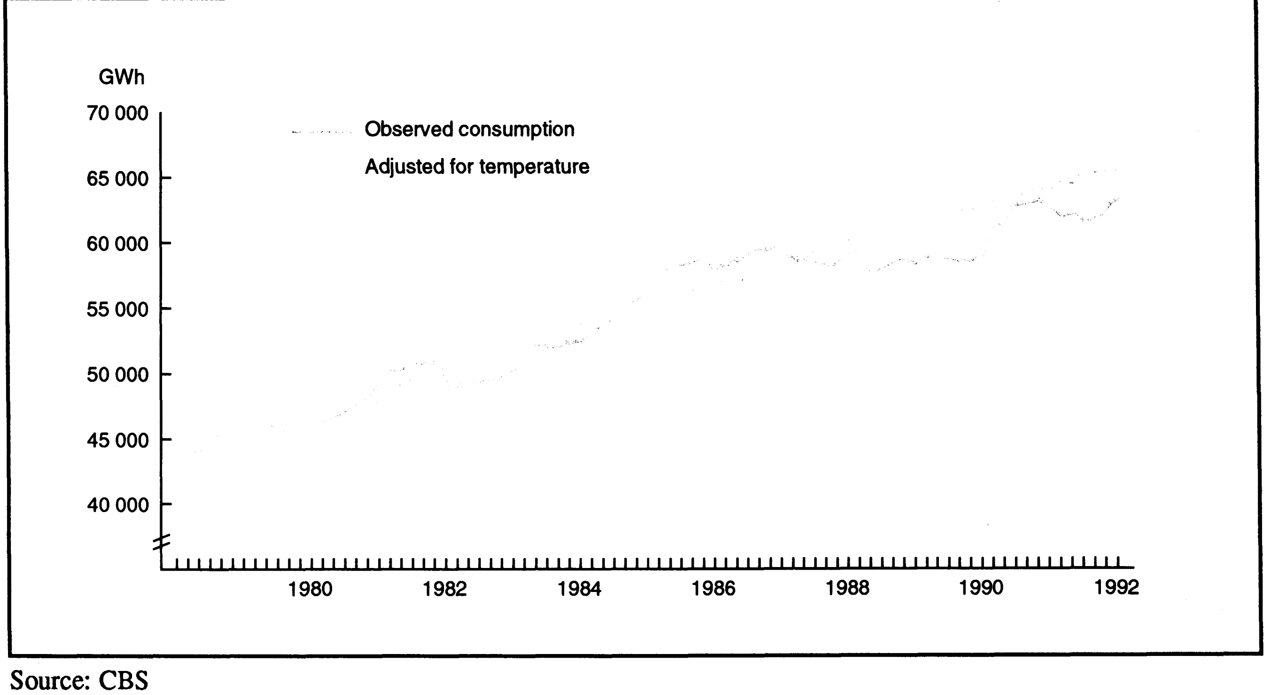
Source: OD

Figure 4.8. Regular electricity consumption and sales of heating oil and kerosene. Utilized energy. 1978-1992. TWh



Source: CBS

Figure 4.7. Net regular firm power consumption. 12 monthly gliding sum. 1978-1992. GWh



Source: CBS

also shows changes in regular firm power consumption, adjusted for variations in temperature. These changes are illustrated in figure 4.7. The increase in the temperature-adjusted consumption has remained relatively stable, but the rate of growth has slowed down during the period, from about 4 per cent per year during the first half of the 1980s to about 2 per cent per year in recent years.

The strong growth in consumption at the beginning of the 1980s was connected partly to the relatively strong growth in the Norwegian economy. Another reason was the shift from use of oil to use of electricity following the strong increase in oil prices after OPEC II in 1979. After 1985, the growth in the Norwegian economy slowed down, as did the growth in private consumption. In spite of this development, the growth in electricity consumption continued, though at a slower pace than before. This growth was due mainly to the continued shift from oil to electricity.

The change from oil to electricity took place in spite of a decrease in the price of oil relative to the price of electricity throughout large parts of the 1980s. The fact that there still occurred a change from oil to electricity may be connected to the high investment cost of new oil-based installations, as well as high maintenance costs of existing installations. Figure 4.8 shows a dramatic decrease in total sales of oil for stationary combustion in Norway from 1978 to 1992. In 1978, these oil sales, calculated in terms of TWh utilized energy, amounted to about 30 TWh, while the corresponding figure for 1992 is about 10 TWh.

Since 1987, there has been a slight decline in total Norwegian energy consumption outside the energy sectors and ocean transportation. Consumption of transport oils has followed the same trend as the total energy consumption.

Energy prices

Table 4.12 shows the prices of different sources of energy in 1992. The price trend for energy sources for stationary purposes is shown in figure 4.9. The price of both electricity and oil products decreased from 1991 to 1992. All taxes included, the average price of electricity to private households was 46.9 øre per kWh in 1992. NVE has estimated the variable part of the price (the energy part) to 41.6 øre per kWh. This is 1.4 per cent lower than in 1991. The price of heating kerosene decreased by 6.7 per cent from 1991 to 1992, to 37.4 øre per kWh (delivered energy). The price of heating oil no. 1 decreased by more than 11 per cent to 28.3 øre per kWh (delivered energy) in 1992. Normally an energy efficiency of 0.75 is calculated for kerosene and 0.70 for heating oil. Converted to price per kWh utilized energy, the price becomes 49.9 øre per kWh for kerosene and 40.4 øre per kWh for heating oil. Considered in isolation, this shows that heating oil no. 1 can compete with electricity, but that heating kerosene is clearly more expensive than electricity compared with the national average for electricity prices. A complete analysis of the choice between oil and electricity for heating purposes must also take into account other operating and maintenance costs connected to the heating equipment. When deciding whether to invest in new heating equipment it is important to take into account investment costs, return on invested capital, and the expected lifetime of the equipment.

Figure 4.10 shows changes in the price of gasoline and auto diesel. Gasoline prices were higher in 1992 than in 1991. The CO_2-tax on gasoline was increased by 20 øre in 1992 to 80 øre per litre, which is maintained in 1993. The price of auto diesel decreased from 1991 to 1992. The CO_2-tax on auto diesel was 30 øre both in 1991 and 1992. From 1 January 1993 the CO_2-tax on auto diesel has been fixed at 40 øre per litre. At the same time, the tax on mineral oil, which was 30 øre per litre at the beginning of 1992, has been removed.

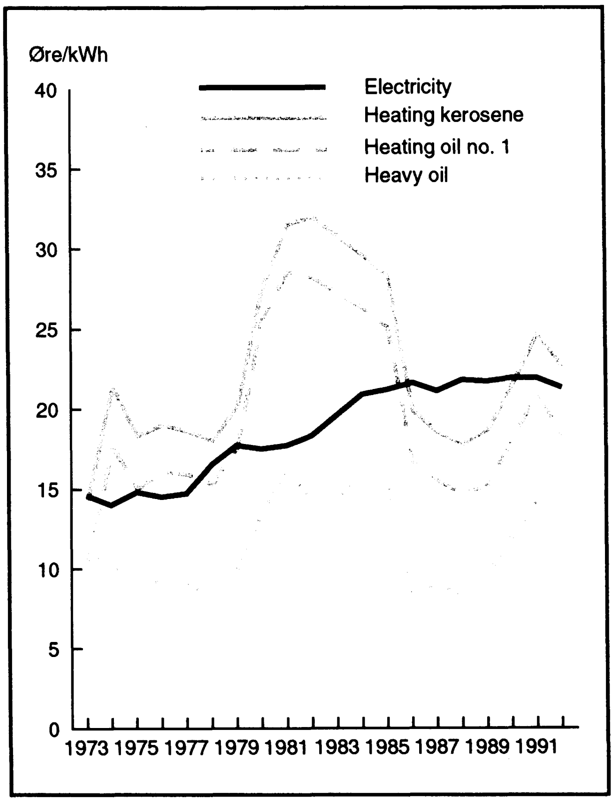
NVE has estimated the average price of electricity for regular consumption to 39.1 øre per kWh, excluding VAT, in 1992, see table 4.7. In 1991 the corresponding price was 39.4 øre per kWh. The prices calculated for 1992 are preliminary estimates based on the tariffs that applied at the beginning of 1992. When the official statistics are available, these will probably show that the decrease in the price of electricity was stronger than indicated by the preliminary estimates. The price decrease is a result of greater competition in the electricity market. The price of surplus power, the observed price

Table 4.12. Average prices[1] of electricity[2] and selected petroleum products. Delivered energy. 1982-1992

Energy source	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991*	1992*
Heating products:											
Price øre/kWh											
Electricity[3]	23.2	26.9	30.5	32.7	35.6	37.9	41.7	43.5	45.7	47.3	46.9
	(20.2)	(23.4)	(26.5)	(28.5)	(31.6)	(34.3)	(37.2)	(38.6)	(41.4)	(42.2)	(41.6)
Heating kerosene .	30.5	31.8	32.5	32.8	24.8	25.0	25.7	28.3	33.9	40.1	37.4
Fuel oil no. 1	25.1	26.2	26.9	27.2	19.4	19.6	19.7	21.6	26.6	31.9	28.3
Fuel oil no. 2	23.8	25.0	25.7	25.7	18.1	18.3	18.8	20.7	25.7	30.8	27.2
Heavy fuel oil ...	13.7	14.8	17.7	17.8	10.4	12.4	11.7	14.7	19.1	23.3	23.6
Transportation products:											
Price øre/litre											
Super gasoline ...	460.5	492.5	520.9	512.8	476.0	510.0	536.0	578.5	642.8	741.0	795.0
Regular gasoline .	451.7	480.2	505.3	501.8	.	.	.	.	.	.	.
Unleaded gasoline .	.	.	.	521.2	457.0	489.0	503.0	540.5	596.9	681.2	722.5
Auto diesel	262.7	272.3	280.3	282.0	207.6	210.0	214.0	233.0	285.9	341.0	326.0

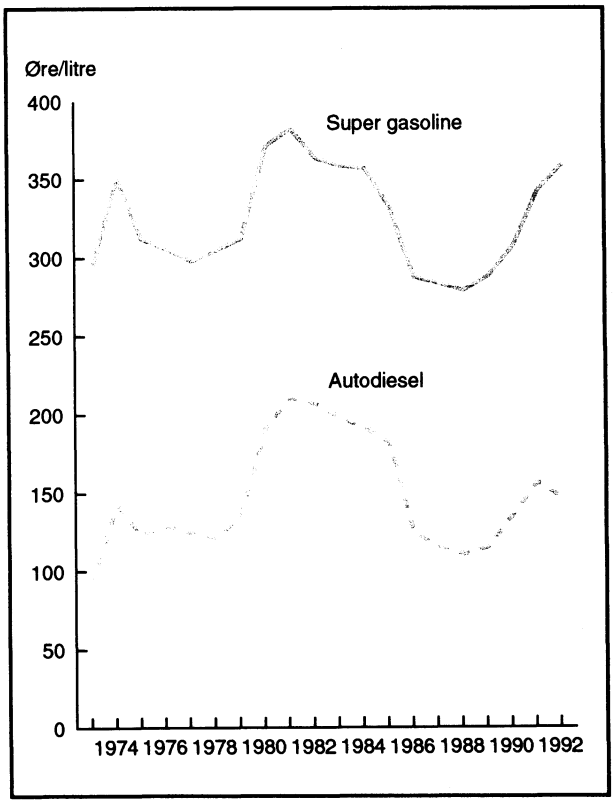
1 All taxes included.
2 Households and agriculture.
3 The figures in parentheses comprise the variable part of the price (the energy part of the H4-tariff).
Source: CBS, NVE, Norwegian Petroleum Institute

Figure 4.9. Calculated prices of utilized energy. 1973-1992. Fixed 1980-prices. Øre/kWh. All taxes included



Source: CBS, Norwegian Petroleum Institute

Figure 4.10. Prices of fuel oils. 1973-1992. Fixed 1980-prices. Øre/litre



Source: CBS, Norwegian Petroleum Institute of power sold on the Norwegian Power Pool's exchange, was more than halved from 1991 to 1992, from 11.6 øre per kWh to 5.0 øre per kWh. The low price in 1992 was a result of higher sales in 1992 than in 1991. As a whole, the average price of electricity sold on the domestic market decreased from 29.6 øre per kWh in 1991 to 29.2 øre per kWh in 1992.

World consumption of energy sources

A summary of energy consumption in selected countries, OECD and the world as a whole is presented in appendix 1. In 1989, Norway accounted for 0.3 per cent of the world's total energy consumption. The OECD countries account for about half of the world's total energy consumption. In Norway, energy consumption per inhabitant is 4.23 toe, which is higher than the average of 3.37 toe for the OECD countries and 1.05 toe for the world as a whole (1989). Only in Canada and the United States, with a consumption of respectively 6.25 and 5.60 toe, is consumption per inhabitant higher than in Norway. However, the energy intensity in Norway, measured in terms of consumption of energy per unit GDP, is about the same as the average for the OECD countries.

4.4. Energy markets

The petroleum market

Immediately before the turn of the year 1991/92, there was a marked fall in the spot price of Brent Blend to 18 dollars per barrel. Low demand and large stocks persisted throughout the first quarter of 1992. However, from a bottom price of 17 dollars a barrel in March, the price of crude oil rose to 21 dollars a barrel at the end of June, the highest price registered during the whole of last year. Expectations of a rather tight oil market in the fourth quarter helped to keep the price of crude oil fairly high throughout the third quarter. Weak growth in demand in the OECD countries, and high production in the OPEC countries triggered a fall in prices towards the end of the year. This led to an accumulation of stocks, and the prospect of a further drop in prices in January this year.

According to preliminary estimates from IEA, the world's total demand for crude oil increased by 0.4 million barrels per day in 1992 to 67 million barrels per day.

For the OECD area, the estimates indicate that the average demand for crude oil increased by about 1.3 per cent in 1992 compared with the year before, to 35.5 million barrels a day. The growth in consumption is somewhat stronger in North America than in the rest of the OECD.

In countries outside the OECD in Asia, the IEA estimates that consumption of oil increased by as much as 8.5 per cent from 1991 to 1992. However, the growth in consumption was compensated by a decrease in consumption of crude oil in countries belonging to the earlier "East block". The decline was particularly marked in the Commonwealth of Independent States, CIS. Therefore, for the non-OECD countries as a whole, consumption of crude oil decreased only slightly by 0.1 million barrels per day in 1992, compared with 1991.

During the first three months of 1992, OPEC's production of crude oil dropped from a level of almost 24.5 million barrels a day to 23.5 million barrels a day. This drop was followed by a strong growth of production in the Middle East, in Iran and Kuwait especially. This contributed to a steady growth in OPEC's production of crude oil during the second half of the year, and in December 1992 the organization produced 25.4 million barrels per day. Thus the average production for 1992 is estimated to 24.4 million barrels per day, the highest level for 12 years. (The figures include Ecuador, which withdrew from OPEC in autumn 1992. However, Ecuador's production amounts to only 0.3 million barrels per day). During the second half of the year, OPEC exceeded its own production ceiling, the most recent being 24.6 million barrels per day, set at the OPEC meeting on 26 November last year. At the same time, there was a decrease in the price of crude oil to below the goal of 21 dollars per barrel. Production and exports from Kuwait increased from 0.4 million barrels per day at the start of 1992 to 1.3 million barrels per day in December. Production and exports

Table 4.13. Demand for and supply of oil[1]. Million barrels per day

													Prognoses			
	90.1	90.2	90.3	90.4	91.1	91.2	91.3	91.4	92.1	92.2	92.3	92.4	93.1	93.2	93.3	93.4
Demand	67.4	64.6	65.7	65.6	67.5	65.0	65.2	68.3	68.6	65.4	65.7	68.2	68.7	66.0	66.3	69.4
OECD	38.7	36.8	38.1	37.7	38.5	36.9	37.2	39.2	39.4	37.1	38.1	39.5	40.0	37.5	38.3	40.2
Europe	13.2	12.6	13.0	12.9	13.6	13.1	12.8	14.1	14.0	12.9	13.5	13.7	14.0	13.0	13.4	13.9
North America	19.0	18.7	19.1	18.6	18.2	18.1	18.8	18.9	18.7	18.5	18.8	19.3	19.2	18.7	19.0	19.7
Pacific	6.5	5.5	6.0	6.2	6.7	5.7	5.6	6.3	6.7	5.7	5.8	6.5	6.8	5.8	5.9	6.6
Rest of the world	28.7	27.8	27.6	27.9	29.0	28.1	28.0	29.1	29.2	28.3	27.6	28.7	28.7	28.5	28.0	29.2
Supply	68.3	67.5	65.1	67.0	67.1	65.9	66.6	67.4	67.3	66.1	66.9	67.7	..	..	..	..
OPEC[2]	25.8	25.6	23.9	25.1	25.1	24.6	25.6	26.1	26.2	25.7	26.7	27.4	..	..	..	..
OECD	16.2	15.8	15.4	16.3	16.5	15.8	16.1	16.7	16.8	16.2	16.3	16.8	16.8	16.3	16.3	16.8
Rest of the world	26.3	26.1	25.8	25.6	25.5	25.5	24.9	24.6	24.4	24.1	23.8	23.5	23.4	23.4	23.3	23.2
Changes in stocks	0.5	2.4	-1.1	1.1	-0.1	0.6	1.0	-0.7	-1.3	0.7	1.2	-0.5	..	..	..	..

1 Including NGL.
2 Including Ecuador.
Source: Oil Market Report (IEA) November 1991
Discrepancies in the table are caused by rounding off figures, and statistical deviations

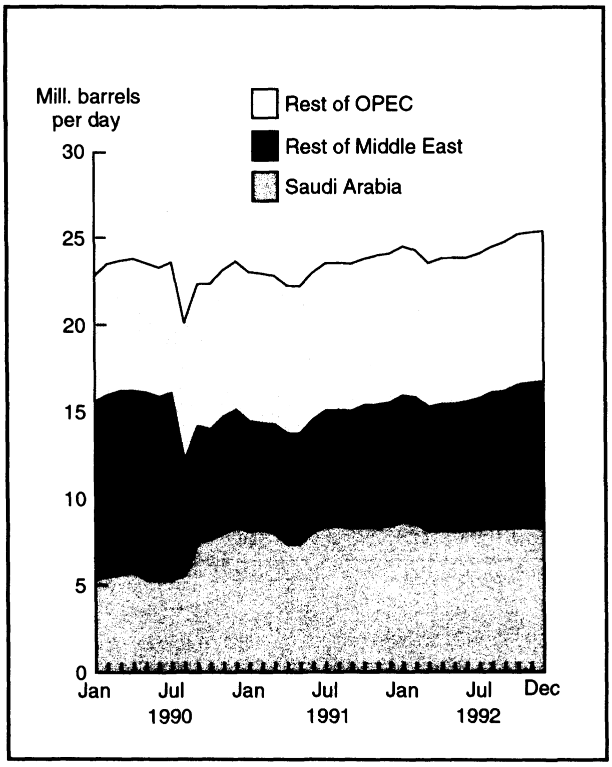
from Kuwait are expected to grow further this year, and could reach the levels recorded before the invasion by Iraq, i.e. about 1.7 million barrels per day, during the first half of 1993.

The embargo against Iraq is still effective, so that Iraq's production - about 0.4 million barrels a day - is limited by domestic refining capacity and export to Jordan. The development of production in Iraq in the future is still uncertain. In October 1991, the UN sanctioned sale of a limited amount of Iraqi oil under the strict control and administration of the UN. The possibility that Iraq might accept the conditions for the implementation of such sales has affected market developments throughout 1992. However, the effect of these rumours declined in the autumn. In the light of the warlike events in January this year, there are few who expect a quick solution to this conflict.

Within the OECD, production of crude oil increased only very slightly during 1992. The strongest increase was in Norway. With a production of 2.25 million barrels per day in November last year, Norway consolidated her position as the second largest producer among the OECD countries, i.e. after USA. In the Commonwealth of Independent States, production of oil and NGL decreased for the fourth year running. While the annual decrease in production was 6 per cent in 1990 and 10 per cent in 1991, the estimates for 1992 indicate that production of oil and NGL decreased by as much as 13.5 per cent compared with the year before. Almost the entire decrease of 1.4 million barrels per day occurred in Russia, which in 1992 accounted for just over 90 per cent of the total production of 9 million barrels per day in CIS. According to IEA, the average export of oil and NGL from CIS increased by 13 per cent to 1.3 million barrels per day from 1991 to 1992, During the last quarter of 1992, however, the net export was around 1.9 million barrels per day. Uncertainty about developments in the new independent republics makes it difficult to predict the development of exports from this area.

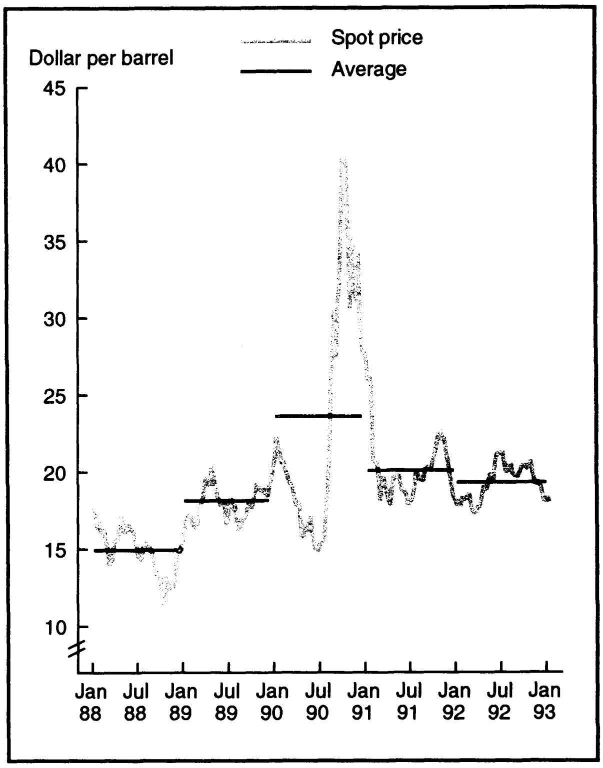
IEA's prognoses of the demand and supply of crude oil during the first half of this year are based on an economic growth of just over 2 per cent for the OECD area and a price for crude oil of 18.5 dollars per barrel. For North America - where the greatest growth is expected - the increase in demand during the first quarter of this year is estimated to 2 per cent compared

Figure 4.11. Oil production in OPEC.1990-1992*
Million barrels per day



* Including Ecuador
Source: Petroleum Intelligence Weekly

Figure 4.12. Spot price of Brent Blend. 1988-1993.
US dollars per barrel



Source: Petroleum Intelligence Weekly

with the same period last year. The underlying increase in demand is somewhat lower, however, since the 1st quarter of 1992 was extremely mild. For the OECD countries in the Pacific, IEA expects a demand growth of 1.6 per cent, whereas no change in demand is expected for OECD countries in Europe. Thus, for the OECD area as a whole, the demand is expected to increase by 1.3 per cent during the first six months of 1993 compared with the same period last year. For the area outside the OECD, the decrease in oil consumption in the CIS is expected to be stronger than the growth in Asia and South America. The decrease in oil consumption outside the OECD balances the increase within the OECD. For the world as a whole, consumption of crude oil is expected to remain unchanged during the first six months of 1993, compared with the same period last year.

If OPEC's level of production of just over 25 million barrels per day, recorded in December last year, is maintained, there will be a considerable surplus supply of crude oil on the market during the first half of 1993. Unless the quotas of the other countries are reduced, this surplus will be further increased by an expected increase of production in Kuwait, and by the possibility of increased export from Iraq. The OPEC meeting on 13 February this year agreed on a production quota of 23.6 million barrels per day, a decrease of 1.5 million barrels per day compared with the level of production in January. This seems to be insufficient to balance the market in the 2nd quarter of 1993. However, the quota is to apply from 1 March to the end of June. The first reactions on the spot market indicated that the results of the meeting did not meet expectations.

The European gas market

Norway's entire saleable gas production is transported by pipeline to Europe, with an increasing share to the Continent and less to the United Kingdom. Owing to the high transport costs, the world markets for natural gas are separated into regions, and developments on the European gas market are of greatest interest to Norway.

During recent years, the gas markets in Western Europe have expanded steadily. From 1987 to 1991, gas consumption increased by 14 per cent, or about 3.5 per cent per year. Natural gas accounted for almost 18 per cent of total energy consumption in 1991. Just over 50 per cent of the consumption was covered by indigenous production. CIS is the most important exporter, with a market share that increased from 16 per cent in 1987 to 20 per cent in 1991. Part of the increase can be explained by the integration of the earlier DDR into Germany, where CIS is the dominating supplier. Exports have also increased from Algeria and the Netherlands in recent years. Norway's decreasing share of the market is explained by the decrease in production on the Frigg field. None of the exporters (except for the Netherlands) can increase deliveries to the Continent without investing in more transport capacity.

The import prices of natural gas are regulated by long-term contracts where the price level is closely linked to (previous) prices of oil products. There was a marked decrease in the real price of gas imports to Europe in 1986, connected to the drop in the price of oil. This decrease was followed by a rising trend from 1989 to 1991. At the turn of the year 1991-92, the average import price was 2.57 dollars per million btu. At the last turn of the year, the price was 2.76 dollars per million btu (World Gas Intelligence, WGI). The average price of imports from Norway was respectively 2.76 and 2.78 dollars per million btu. According to CBS's statistics on foreign trade, the average export value of Norwegian gas was 65 øre per Sm^3 in 1991, but dropped to 61 øre per Sm^3 during the first six months of 1992. Figures from WGI indicate that the price of Norwegian gas measured in dollars decreased slightly, or remained more or less unchanged, from 1991 to 1992.

The International Energy Agency (IEA) now forecasts that the demand for gas in Western Europe may reach 450-480 bcm (billion standard cubic metres) in the year 2010. This implies an increase of up to 75 per cent, or about 3 per cent per year. In Eastern Europe, gas consumption is expected to double. For Europe as a whole, the demand will reach 570 - 650 bcm by the year 2010. Although the forecast for Western Europe represents no more than an extrapolation of the growth rate in recent years, it reflects a drastic adjustment of the forecast from the end of the 1980s, which indicated a moderate growth in demand on the gas markets in Europe. The greatest increase in the demand for gas is expected on the market for production of electricity.

It has been clear for some time that, within a price interval of up to twice the price of coal, natural gas has a cost advantage over other alternative sources of energy in the power generation sector. Given the present level of prices, this implies the development of gas-fired electricity production in most countries of Europe. However, a condition for such a development is the removal of the barriers that currently prevent gas from penetrating this segment of the market. Another prerequisite is the development of a more integrated gas market in Europe, where both the final consumers and the producers have the best possible access to the transmission and distribution network. Since these intermediate links are regional natural monopolies, it will also be necessary to regulate them, to make them costefficient by exploiting economies of scale. This implies a re-organization of the present national regimes, which often tend to safeguard other conflicting national interests.

Developments in this field have not been rapid. The EC Commission's proposed Gas Directive, the directive on third-party access (TPA) to the gas network, was postponed indefinitely at the meeting of Ministers in December last year. The Commissioner for Competition in the EC, Lord Brittan, responded by bringing an action against the gas monopolies before the EC Court, with reference to the Treaty of Rome. Nevertheless, it is most likely that national control, and the associated trade barriers, will still continue, regulated only by the not very comprehensive directive on transparent markets and a weak right of transit for imports via the transport network of a third party. An analysis of this development, and the possible consequences for changes in supplies of gas in Europe, including Norwegian gas exports, is presented in Nilstad and Gjelsvik (1993).

Investments in petroleum activities

According to CBS's survey of investments for the 4th quarter of 1992, accrued investments in the oil and gas extraction sector were estimated to NOK 44.6 billion for 1992. Investments in the extraction sector increased by 18.3 per cent (nominal increase) from 1991 to 1992. The increase in costs in 1992 was connected to field development in particular, while exploration costs decreased from the high level experienced in 1991. Accrued investments in the pipeline sector are estimated to NOK 5.0 billion in 1992, compared with NOK 5.4 billion in 1991. Thus the total investments in petroleum activities in 1992 amounted to NOK 49.6 billion. By comparison, according to the Quarterly National Accounts, investments on the Norwegian mainland amounted to NOK 92 billion in 1992.

The strong growth in investments for field development from 1991 to 1992, all of 27 per cent, is explained by the extensive investments in the Sleipner East, Brage, Draugen, Heidrun and Snorre fields.

The quarterly survey shows that, for fields in operation, the accrued investments amounted to NOK 5.3 billion in 1992, about the same as in 1991. However, the share of the costs related to production drilling increased from 65 per cent in 1991 to 73 per cent in 1992. Costs for production drilling are the costs of maintaining and increasing production of oil and gas. In 1992, extensive production drilling took place in the Statfjord and Oseberg fields in particular, but part of the increased costs was connected to the smaller fields, Ula and Gyda.

According to the investments survey for the 4th quarter, exploration costs are estimated to NOK 7.5 billion in 1992, compared with NOK 8.1 billion in 1991, which is the highest observed level of exploration costs. The downward adjustment of the exploration estimate for 1992 during the last two investment surveys breaks with the tendency observed in previous years for the estimate of exploration costs to increase throughout the year of investment.

Investments in onshore activities are estimated to NOK 3.5 billion for 1992, a current value increase of as much as 67 per cent compared with 1991. The increase is due to the high cost of extensions to the compressor plant at Kårstø, and investments for the terminal for landing oil and gas from the Troll field.

Table 4.14. Executed and assumed accrued investments in oil extraction and pipeline transport. 1991-1993. Billion NOK, current prices

	1991	1992*	1993*
Extraction of oil and gas	37.7	44.6	53.9
Exploration	8.1	7.5	7.7
Field development	22.3	28.3	35.6
Goods	12.1	14.8	21.5
Services	9.0	11.6	11.6
Production drilling	1.2	1.8	2.6
Fields in operation	5.2	5.3	6.5
Goods	0.7	0.7	0.6
Services	1.1	0.8	1.0
Production drilling	3.4	3.8	4.9
Onshore activity[1]	2.1	3.5	4.1
Pipeline transport	5.4	5.0	7.0
Oil sector as a whole	43.1	49.6	60.9

*Estimates according to CBS's quarterly investments survey in the 4th quarter 1992
[1] Including office buildings, bases and terminal buildings on land.
Source: CBS

Investments in pipelines are estimated to NOK 5 billion, a current value decrease of 7 per cent compared with 1991. The greater part of the investments in 1992 was connected to the construction of Zeepipe, Europipe and Sleipner condensate pipes.

Petroleum revenues

The oil and gas activities are a source of excess return or rent, compared with the return from other industrial activities. This excess return is called the oil rent, and is calculated as the total income from production of oil and gas after subtracting production costs and a normal return on invested productive capital (a rate of 7 per cent in our calculations). The method of calculation ignores the fact that several of the input factors used in the extraction of oil and gas probably receive a higher return than in other industry. Therefore, to some degree, they can be said to receive part of the oil rent, not included in the calculations. Nor do the calculations take into account possible costs of clean-up operations, which must now be expected, as the fields become closed down.

CBS has calculated the oil rent on the basis of the definition of capital in the National Accounts, which does not include investment in capital stock until this is ready for production, i.e. when the platforms are installed at the field. The value of platforms under construction are entered as inventory. Since the loss of return on this inventory is a cost component, it is natural to take this into account when calculating the oil rent. We have therefore adjusted the calculations and now include platforms under construction in the capital stock that is expected to yield a normal return. To illustrate the effects of this adjustment, we also present estimates for the oil rent in accordance with earlier practice. The adjustment causes a somewhat lower oil rent (see figure 4.13), but except for the last few years the differences have been slight. Owing to the high rate of investment, there is now an accumulation of platforms under construction.

The high capital intensity makes the estimates of the oil rent sensitive to the method of calculating the capital stock. In the National Accounts, stereotyped methods are used to estimate capital depreciation, independent of field. Real depreciations will depend on the reserves and the rate of extraction, and these are field-specific data. A research project has been started to undertake a closer study of the data series for capital depreciation and capital stock. When the results of this work are available, they will be used in the system for calculating the oil rent. This may lead to changes in historical series over and above those resulting from normal revisions of the National Accounts. As a result of such revisions, the estimates for 1990 and 1991 have been adjusted downwards in relation to last year's estimates of the oil rent.

Norway's net cash flow (NNCF) from the petroleum activity is calculated as the operating result plus capital depreciation and royalties minus accrued investments. The sum of Norway's net cash flow over the whole production period is the total net income from the petroleum activity. With the new method of calculation, the present value of the cash flow is equal to the present value of the oil rent plus the value of the capital stock on the continental shelf. The national wealth of the oil reserves can be defined as the present value of the oil rent. Figure 4.13 shows the course of development for oil rent and net cash flow. In years with large investments and low income, the net cash flow can be negative, as in the years before 1978. The oil rent is not influenced to the same extent by fluctuations in investments.

A third term used in connection with the oil revenues is the Government net cash flow (GNCF) from the petroleum activity. Up to 1985, the Government net cash flow consisted mainly of income from taxes. Since then, however, the Government has been directly involved as shareowner, so that the Government net cash flow is calculated as the sum of income from taxes, income from the Government's direct involvement and dividends from Statoil, minus the Government's share of investments in the licenses. Income from taxes consists of post-paid tax on income, a special petroleum tax and a carbon tax, as well as royalties and some smaller items. Post-payment of tax means that the Government net cash flow lags behind Norway's net cash flow and the oil rent.

The gross product of extracted oil and gas also increased in 1992, to almost NOK 90 billion. Oil production increased by almost 14 per cent, but the average price decreased from 131 to NOK 120 per barrel. The decline in gas production has stopped, and annual production increased by 2 per cent. The oil rent is provisionally estimated to just under NOK 35 billion, or just over NOK 8000 per inhabitant. This amounts to just under 5 per cent of the GDP, and the nominal value is the same as the year before. A larger volume has compensated for falling prices and higher costs. With the earlier method of calculation, the oil rent is estimated to just over NOK 37 billion, or 2.8 billion more than the present estimate.

Norway's net cash flow decreased for the second year in a row, and is estimated to NOK 36 billion in 1992. The reason for the decrease is that accrued investments continued to rise last year.

In the National Budget, Government net cash flow is estimated to NOK 26.4 billion for 1992, and the estimate is the same for 1993. Over time, the Government net cash flow in per cent of Norway's net cash flow can be interpreted as the total fiscal effect of the Government's tax and participation policies. In terms of present value, the Government has so far collected 80 per cent of the present value of the cash flow.

Table 4.15. Oil income and oil rent (Billion NOK) and the oil rent as a share of Gross Domestic Product (per cent). 1976-1992

Year	Gross product in the extraction sector	Previous practice		New practice	
		Oil rent	Oil rent as per cent of GDP	Oil rent	Oil rent as per cent of GDP
1976	6.1	3.3	1.9	3.1	1.8
1977	7.4	2.8	1.5	2.6	1.4
1978	12.8	7.0	3.3	6.9	3.2
1979	20.8	13.7	5.7	13.3	5.6
1980	41.0	31.8	11.2	31.2	10.9
1981	50.0	36.5	11.1	36.2	11.0
1982	55.3	37.8	10.4	37.3	10.3
1983	66.9	48.0	11.9	47.2	11.7
1984	83.4	59.5	13.1	58.8	13.0
1985	89.7	62.3	12.4	60.9	12.2
1986	51.0	18.3	3.6	17.1	3.3
1987	51.8	14.1	2.5	12.8	2.3
1988	44.4	1.9	0.3	0.8	0.1
1989	69.8	22.2	3.6	21.6	3.5
1990	87.2	38.6	5.8	37.0	5.6
1991	87.8	37.3	5.4	34.9	5.1
1992	89.5	37.4	5.3	34.6	4.9

Source: CBS

Ricardian rent and return on capital in hydropower production

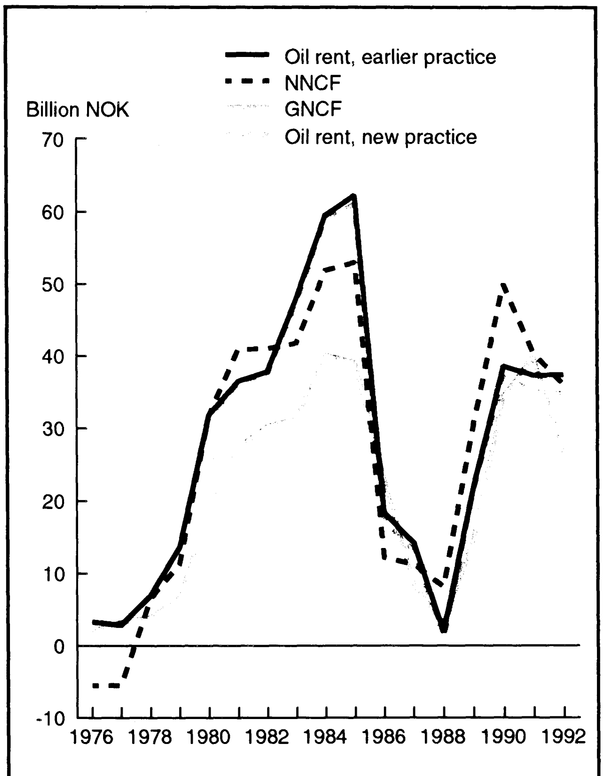
The Ricardian rent in hydropower production (the hydropower rent) can be calculated as the return over and above the normal return on capital (7 per cent). Such a surplus return is achieved with increasing development costs for extending the capacity of the system. The long-term potential for the hydropower rent will only be realized if the market price of electricity is equal to the long-term marginal cost of new development. In the Norwegian electricity market, the average price of electricity is lower than the long-term marginal cost, owing to some surplus capacity and low prices to large industrial groups in some regions. This implies that the hydropower rent is lower than the long-term potential for this rent. The hydropower rent is described in more detail in Natural Resources and the Environment, 1990 (CBS, 1991).

NVE has estimated that, in 1992, the long-term marginal cost of new hydropower development was about 41 øre per kWh for regular consumption (delivered to consumer, VAT not included), and about 29 øre per kWh for energy-intensive industry. With electricity prices equal to long-term marginal cost, and sales of firm power equal to mean production capacity in 1992, cf. table 4.4, the operating surplus in the electricity sector, including the tax on electricity, could be NOK 21.0 billion. With an assumed normal rate of return of 7 per cent on a capital of NOK 189 billion (preliminary estimate from the National Accounts), the hydropower rent can thus be estimated to NOK 7.8 billion. This represents the annual potential rent in the electricity sector at present capacity, assuming a high enough demand to keep the market in equilibrium.

Preliminary estimates for 1992 show an operating surplus of about NOK 13.4 billion in the electricity sector, including the tax on electricity. This gives a return on capital of about 7.1 per cent in this sector. Thus the electricity sector gave a surplus return of NOK 0.6 billion in 1992. The return on capital in the electricity sector is composed of the Ricardian rent and the monopoly rent. The monopoly rent is collected by price-discrimination between different users on the Norwegian electricity market, where private households pay higher prices than paid by energy-intensive industry. Figure 4.14 shows the realized return on capital in the electricity sector for the years 1980-1992. The return on capital is calculated on the basis of the operating surplus plus the tax on electricity as a percentage of the real capital in the electricity sector.

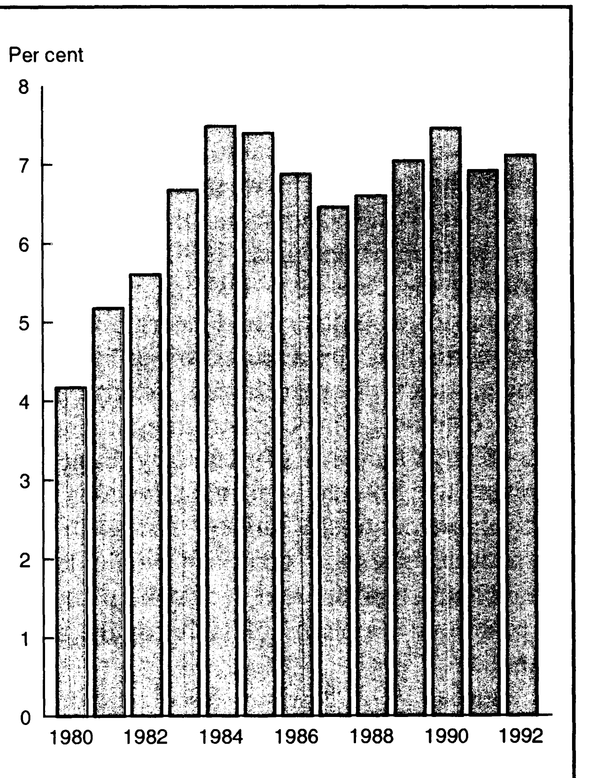
Owing to variations in flow of water to the reservoirs, the rate of return will also vary. The rate of return shows an increasing trend for the

Figure 4.13. Oil rent and cash flow from extraction of oil and gas. 1976-1992. Billion NOK



Source: CBS

Figure 4.14. Return on capital in the electricity sector 1980-1992. Per cent



Source: CBS

period as a whole. This is due to a strong rise in the price of electricity delivered for regular consumption and little development during the period. The return on capital is not higher because energy-intensive industry and pulp and paper manufacturing have long-term contracts for purchase of electricity at low prices.

4.5. Energy policy

Effects of the Energy Act

In 1992 the power market has been strongly influenced by the Energy Act. This has affected the prices of both the producers and the purchasers of electricity. Electricity brokers and the more active power companies have ensured harder competition for customers in the power market. In particular, in 1992 many large companies or groups of companies obtained agreements for delivery of cheap electricity. The Confederation of Norwegian Business and Industry (Næringslivets Hovedorganisasjon - NHO) estimates that many enterprises have reduced their electricity costs by 30-40 per cent as a result of the increased competition in the electricity market. Owing to the harder competition and lower prices, several power companies experienced a marked decrease in income in 1992. This applies both to distribution companies with long-term purchasing contracts that lost customers, and to production companies with large costs.

Towards the end of the year, pressure was put on the Government to improve the economy of the power plants with the greatest economic problems. In October/November the Government proposed various restrictions to the Energy Act. It was proposed that only purchasers of large quantities of electricity (purchases exceeding 2 MW or 5 GWh per year) should be allowed to enter into contracts lasting less than 5 years. However, this proposal, which would have obstructed competition on the electricity market and lead to higher electricity prices, was rejected by the Storting (Norwegian National Assembly).

The Storting has fixed a ceiling of 5 TWh for exports of electricity over contracts lasting less than 5 years. Statnett SF (The Norwegian Transmission Grid Company) is responsible for dividing this quantity between relevant Norwegian sellers. Power companies that have undertaken developments since 1980 shall receive priority in the case of 1 TWh of this 5 TWh. The Minister of Industry and Energy has stated in the media that applications to export additional quantities will be evaluated. Several producers of electricity are currently negotiating exports of large amounts of electricity. In general, however, the branch is positive towards long-term export contracts. Greater access to enter into long-term export contracts would lead to better contract prices and would help to solve the economic problems of some of the power plants.

In autumn 1992, Statkraft SF (The Norwegian Energy Corporation) decided to stop the development of Svartisen II. Further development was considered unprofitable. After this decision was published, the Government submitted a proposal to the Storting suggesting that funds should be allocated so that Statkraft would find it profitable to complete the development. The Storting decided to allocate about NOK 400 million to the project in the form of direct grants and favourable loans. Statkraft then regarded the development of this 250 GWh as profitable. One of the intentions of the Energy Act and the re-organization of Statkraft into a state-owned production company was to allow the participants in the market to decide themselves whether new developments should be undertaken or not. In this case the Storting chose to set aside the market participants' assessments of profitability. Compared with other development projects, Svartisen II is extremely expensive.

Master Plan for Water Resources

In Report No. 60 (1991-92) to the Storting, the Government submitted an updated Master Plan for Water Resources. This is the second updating of the Master Plan since the original plan was submitted in 1984. The Government proposed simplifying the Master Plan by defining only two categories of hydropower projects. Category I would include "projects which can be considered for a licence immediately in order to cover the demand for energy in the years to come". Category II would cover "projects which can be exploited for power production or other purposes, but which cannot be considered for a license at the present time". Watercourses which, according to Protection Plan IV, should be protected, are no longer included in the Master Plan. Given the Government's proposed Protection Plan IV, the Master Plan now covers a total of 678 projects with a total production potential of 26.3 TWh. It is proposed that 16.6 TWh of the amount be placed in Category I, and the remaining 9.7 TWh in Category II. In addition to the projects placed in Category I in the Master Plan, a further 4.2 TWh that are either not included in the Master Plan or only require a licence in accordance with the Energy Act can also be considered for a licence, bringing the total amount that can be considered up to 20.8 TWh. This is an increase of 6.1 TWh compared with the figure before the Master Plan was updated.

The electricity tax

The electricity tax was re-organized at the turn of the year 1992/93. The Storting has decided to remove the electricity tax on sales of electricity to the ferrous alloys, aluminium and pulp and paper industries, and for greenhouses. For other sectors within mining and manufacturing industry the electricity tax is 2.3 øre per kWh. For other commercial activities and private households the electricity tax is fixed at 4.6 øre per kWh in 1993. In addition, a production tax has been imposed of 1.2 øre per kWh, covering all power production. The Storting has thus chosen to ease the situation of industry, and increase the tax for other commercial activities and private households (from 4.15 øre per kWh in 1992). This differentiation will imply that different purchasers will pay a different price for the same commodity. The value of an additional unit of the commodity will be different in different connections. This leads to efficiency loss. This tax discrimination is in addition to all the other existing price discriminations practised on the electricity market, where energy-intensive industry is able to buy power through long-term contracts at low prices, cf. Bye and Johnsen (1991).

The Power Plant Taxation Committee

In autumn 1992, a committee headed by Professor Asbjørn Rødseth submitted a proposal for new taxation rules for power plants. The proposal was distributed for comment to the parties concerned early in 1993, and the Government intends to present a Proposition to the Storting in spring 1994. The proposed changes in the taxation of power plants will not apply until 1995.

In the case of power plants, the total system of taxes and duties currently consists of an electricity tax, a property tax to the municipality and a tax on income and wealth. To these must be added services in the form of deliveries of electricity at cost price to the local municipality.

For private companies, the tax on income and wealth is calculated according to the ordinary rules for taxation of companies. This implies that limited share companies do not pay tax on wealth. This tax is instead paid by the shareholders along with the tax they pay on other shares. Publicly owned companies pay a percentage tax on income and wealth based on an assessment of the value of the power plant. The company pays the tax on wealth to the local municipality, regardless of how the undertaking is organized. Municipal and intermunicipal plants owned by a municipality or several municipalities may be exempted from tax to the municipality. About 84 per cent of the power companies pay a percentage tax after assessment.

Taxes and duties in the electricity sector represent a very large source of revenue. In 1991, the electricity tax supplied about NOK 3.4 billion, tax on income and wealth (from assessed plants) NOK 1.4 billion and property tax NOK 813 million. If the tax paid by private companies on income and wealth is excluded, the total revenue from taxes and duties was about NOK 5.6 billion in 1991. Licensing fees accounted for about NOK 333 million, cf. Norwegian Official Report (NOU) 1992:34. One of the premisses of the committee's report was that the re-organization of the system should not lead to a reduction of the total revenue obtained from taxes and duties in the electricity sector.

The existing system of taxes for power plants has a number of weaknesses. The amount of tax depends on type of ownership, and in many cases, when decided by assessment, the tax burden does not harmonize particularly well with the profitability of the specific power plant. The system is therefore not very well adapted to market-based sales of electricity, with greater freedom in fixing prices, and more competition in the market. Moreover, the tax system does not adequately take into account the hydropower (Ricardian) rent in electricity production. The rules for assessing the value of the plant as a basis for the percentage tax on income and wealth also have unfortunate effects on profitability from modernization. According to the present rules, the tax will be highest when the plant is new and will gradually decrease as the plant becomes older. Large rehabilitations imply that, in a tax context, the plant is regarded as new, which means a higher tax for the power company, regardless of whether or not the rehabilitations raise the plant's production capacity. In this way, the rule for taxation can imply that modernizations that may be profitable to society can be unprofitable for the owner of the power plant.

The committee proposes that the tax on income be re-organized, and that the tax on wealth for publicly owned power plants be reduced by about 70 per cent from today's level. The committee also proposes that a tax be imposed on the hydropower rent. It is proposed to replace the percentage tax on the value of transmission lines by a tax per kilo-metre of transmission line.

Tax on income

The committee proposes a two-part system of income tax which will apply to both privately and publicly owned plants. In the proposed system, all plants will pay a tax decided on the basis of the accounts, according to the ordinary rules for companies. At the same time, all production companies shall pay an assessed tax to the municipality, the so-called "hydropower tax". This is an ascribed tax, based on specific norms for prices, depreciation etc. The hydropower tax will be directed to a greater extent at profitability, but in spite of this, will not be affected much by variations in the hydropower rent.

According to the committee's proposal, the tax on hydropower income and wealth will be assessed independent of the age of the power plant and of rehabilitations, unless the latter increase production capacity. For a new, marginal plant, the present value of the tax will remain almost unchanged in relation to the present rules, but the time profile of the tax is changed. This implies a somewhat lower tax in early years and a higher tax when the plant is more than 30 years old. The assessment of wealth in publicly owned plants shall take place according to the same principles as for assessed income. The tax on wealth will then also be independent of the age of the plant. The value of the wealth of the plant is fixed as the present value of sales income minus operating costs, licensing fees, property tax and any tax on the hydropower rent. The present value of expected costs of modernization of different parts of the plant can also be deducted from the present value of the income from sales.

Coordination of the taxes on income

An element of tax by assessment has been maintained out of consideration for the municipalities' wish for a stable income from taxes. The assessed income tax will still not conform particularly well with the current profits of the power plant, and will be less neutral than a tax based on the accounts. In order to protect the taxpayers from the unfortunate sides of this assessed tax, the two forms of tax will be coordinated through the Tax Distribution Fund. The Fund functions as a mechanism for levelling out taxes, and implies that taxpayers in most cases will be faced with the same tax burden as if they paid a tax based on accounts, while the municipalities will receive a stable income from the taxes. This two-part system will cost money to administer, but tries to give due consideration to conflicting interests; purely tax-economic criteria on the one hand and, on the other, the interests of the municipality where the power plant is located.

Tax on the hydropower rent

It is proposed that the tax on the hydropower rent be designed as tax on gross income from sales, minus capital costs and operating costs defined according to specific norms. The deduction for capital costs shall be the present value of the investment costs. The committee has not considered alternative designs for the tax on consumption of electricity, but regards the tax on the hydropower rent as a relevant alternative to a possible tax on production.

Transmission tariffs

From 1 January 1993, Samkjøringen (Norwegian Power Pool) has been incorporated into Statnett SF. Short-term sales of electricity are now administered by Statnett SF (Norwegian Power Corporation). The extent of short-term sales has increased since the Energy Act came into force. This market is developing continuously. From 1 May 1993 a system will be introduced whereby sales of weekly contracts can be made up to six months before the delivery is to take place. In addition, Statnett SF is responsible for transmission of power in the central network (300 and 420 kV transmission lines and transformers), and for export and import of electricity from or to Norway.

Since May 1992 the transmission tariffs in the central network have consisted of so-called point tariffs. This means that the seller of the electricity pays a price to feed electricity into the network and the purchaser pays a price to take electricity out of the central network. In principle, these point tariffs are intended to cover transformation up and down, as well as transport costs in the central network. About half of the total sales of electricity in Norway are transported via the central network.

On 1 January 1993, the point tariff system was also introduced in the regional distribution networks. This makes it much easier to calculate the cost of transporting electricity in Norway. This reform will imply that all purchasers of electricity should be able to obtain information from their regional distribution company on the total costs connected to transmitting electricity in Norway. The Norwegian Watercourses and Energy Administration (NVE) will deal with any disputes in this field.

4.6. Energy consumption and CO_2-emissions in Western Europe

The EC is currently preparing a "package" of measures to stabilize CO_2-emissions in the EC area to 1990 level by the year 2000, see European Commission (1991). An important element of this package is a tax on carbon/energy which, according to plan, will be introduced sometime in 1993. The introduction of such a tax would affect several Norwegian energy policy and environmental policy goals. Norway has been a driving force behind the international efforts to stabilize CO_2-emissions. A carbon/energy tax imposed in the EC countries, and possibly in the EFTA countries as an adjustment to the EC, will be an important means of achieving stabilization of these emissions in Western Europe. Moreover, the tax will influence oil and gas consumption in Norway's most important market. It has been widely conceived that the introduction of a tax on carbon will increase the demand for gas, through gas capturing shares of the market from coal, which would mean a double gain for Norway: Stabilization of CO_2-emissions and greater potential sales of natural gas.

The possibilities of this double gain are discussed below. It has been pointed out (Birkelund et al., 1992) that the effect of a carbon tax on gas consumption and CO_2-emissions will depend on the prices and tax structure for energy sources in the different countries and on adjustment in the important electricity sector. These conditions are considered below by means of alternative simulations using the energy demand model SEEM. The supply and the price of electricity are determined in the model, while the supply aspects in the markets for coal, oil and natural gas and income and production in the economy are exogenous variables. The model covers 9 West-European countries, which combined account for 80-90 per cent of the market for Norwegian oil and gas: the "big four" (Germany (West), United Kingdom, France and Italy), the gas country, The Netherlands, and four Nordic countries (Sweden, Finland, Denmark and Norway). The model includes in addition to the electricity sector five final consumption sectors; manufacturing industry, services, private households, transportation and others (agriculture, fisheries etc.). The model is described in more detail in Birkelund et al. (1992).

Assumptions

We have studied how a carbon tax based on the EC Commission's proposals would affect CO_2-emissions and the demand for gas under three different sets of assumptions, hereafter called regimes. For each regime we have carried out a simulation *without* carbon tax - the reference scenario - and a simulation *with* carbon tax - the impact scenario - for the period 1988-2000. This gives six simulations in all. These are summarized in table 4.16.

The analysis is based on **BAU**, Business As Usual, which is identical with the model presented in Birkelund et al. (1992). Among the assumptions made in the BAU-simulations, the following are important for the further discussion:

a) The carbon/energy tax proposed by the EC Commission will be imposed *in addition to existing taxes on energy*. It will include a component based on the carbon content of the fuel and a component based on the content of energy. In the following analysis we assume that the variant where the whole of the tax is carbon-related is implemented in the impact scenario. There are plans to introduce the EC tax in 1993, with a level of 3 dollars per barrel of oil. It is assumed that the tax will be increased by one dollar per year until it reaches 10 dollars (1993 prices) per barrel of oil at the turn of the century. The income from the carbon tax is intended to finance lower rates of taxation in other parts of the economy. This implies that the tax is expected to have only a slight effect on GDP, see European Commission (1991). We

Table 4.16. Simulation alternatives

Regime:	BAU	NIL TAX	GAS-BASED POWER
Scenarios:	1) Reference	2) Reference	3) Reference
	4) EC's carbon tax	5) EC's carbon tax	6) EC's carbon tax

have therefore chosen to use the same extrapolations of the goals for production, income and consumption in all scenarios.

b) *Electricity production* is based mainly on the official plans of the different countries, as reported to the International Energy Agency, see IEA (1988). The electricity markets are characterized to a large degree by national regulation. This means that the choice of what type of electricity production to use is *not* necessarily based on cost-efficiency considerations.

The regime **NIL TAX** is different from BAU, owing to a modification of a). The existing energy taxes in stationary combustion are reduced to nil from 1989 onwards. In the impact scenario, the carbon tax replaces existing taxes. This has been done to find out whether the existing taxes are so high that the input from the carbon/energy tax on end user prices would be too small i) to achieve adequate reduction in energy consumption and emissions and ii) to achieve a large enough change in the relative prices of the different forms of energy to obtain any significant transition from coal and oil to the less carboniferous natural gas. The tax on fuel in the transport sector is maintained in this regime because, with the known technology, the size of the tax probably has little effect on the substitution between energy sources in this sector.

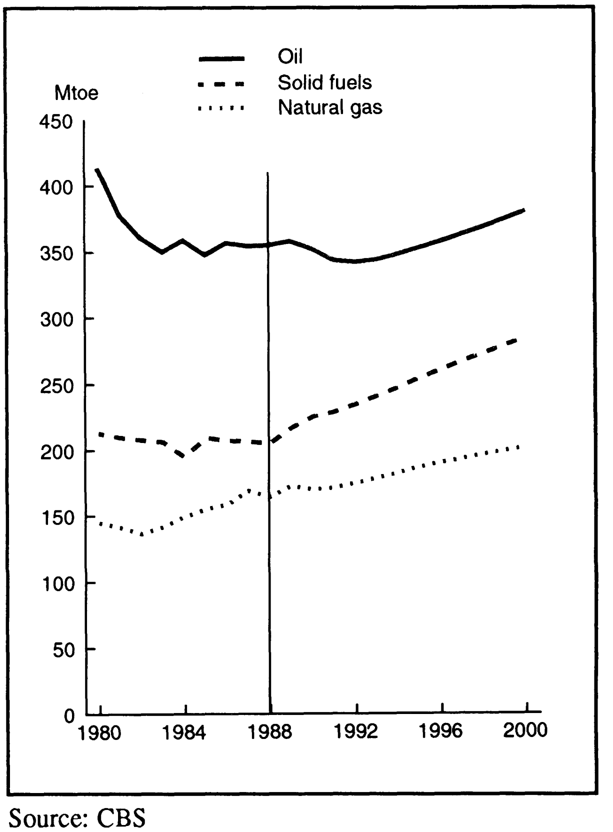
The regime **GAS-BASED POWER** is the same as NIL TAX except for a modification of assumption b). In GAS-BASED POWER we investigate the effect of greater cost-efficiency in the electricity sector. That is to say, the choice between gas and coal in the development of thermal power is decided by costs and not by plans that favour coal. We exclude the development of oil-based power, since this is much less profitable than the development of thermal power based on coal or gas. We also assume that the development employs the most advanced technology. We have therefore compared the best coal-based power technology (condensation plants) with the best gas-based power technology (gas combined cycle).

Other assumptions in the reference and impact scenarios respectively are the same for all three regimes, and are described in more detail in Birkelund et al. (1992).

Use of fossil fuel in the reference scenarios

Figure 4.15 shows total consumption of fossil fuel in the BAU regime's reference path. Driven by economic growth, the demand for all types of fuel increases during the simulation period. From 1988 to the year 2000, use of solid fuels increases by as much as 34 per cent, while the growth in consumption of gas is 20 per cent and of oil 15 per cent. Most of the increase in consumption of solid fuels is related to thermal power plants. This is connected to a strong increase in the demand for electricity. For the nine countries combined, IEA's plans involve limited development of hydropower and nuclear power, so that the need for thermal power increases even more rapidly than the demand for power does. The plans to develop thermal power capacity also involve a transition from oil-fired plants to gas or coal-fired plants.

Figure 4.15. Total consumption of fossil fuels in the model area. BAU's reference path. 1980-2000. Mtoe



Source: CBS

Table 4.17 shows total consumption of fossil fuels in the reference paths in the regimes NIL TAX and GAS-BASED POWER, compared with the reference path for BAU. The figures show percentage deviations in the year 2000. The NIL TAX column indicates that a *theoretical* removal of the special taxes in the stationary sectors from 1989 onwards leads to higher oil consumption, while use of solid fuel and natural gas is slightly reduced. This is because the special tax is imposed mainly on oil, and to some degree on gas. Therefore the change of regime implies a change from coal and electricity to oil and gas in the final consumption sectors. However, the reduced demand for electricity leads to a marked decrease in consumption of gas for thermal power production, which implies a reduction in the total consumption of gas.

With the present energy prices minus special taxes, a change from expansion of the thermal power capacity based on the official plans to cost-effective expansion would probably cause a strong shift over to gas-based power. This is indicated in the right-hand column in table 4.17. The total gas consumption in GAS-BASED POWER is as much as 40 per cent higher than in BAU in the year 2000, while consumption of solid fuels is 35 per cent lower.

Effects of EC's carbon tax on use of fuel

Table 4.18 shows the calculated effect of carbon tax on consumption of fossil fuels in the different regimes. The figures show the percentage change from the respective reference paths in the year 2000.

Table 4.17. Total consumption of fossil fuels in NIL TAX and GAS-BASED POWER, compared with BAU. Year 2000. Percentage deviation between the reference paths

	NIL TAX	GAS-BASED POWER
Olje	6.5	6.5
Gass	-1.7	40.1
Kull	-2.7	-35.1

Table 4.18. Effect on total consumption of fossil fuels in BAU, NIL TAX and GAS-BASED POWER. Year 2000. Percentage deviation from the reference paths

	BAU	NIL TAX	GAS-BASED POWER
Oil	-6.0	-7.0	-6.6
Gas	-6.0	-7.0	-9.2
Coal	-17.1	-17.0	-18.2

In the BAU regime, the largest percentage decrease, about 17 per cent, is found for solid fuel. The decrease refers in particular to use of coal in manufacturing industry and in the thermal power sector. The reduction in manufacturing industry is caused by a strong increase in the price of coal as a result of the EC tax, which is heaviest for coal. The reduced use of coal in the thermal power sector, which is the dominating consumer of coal, is due to the fact that the carbon tax leads to increased costs for the energy inpuy in the sector. This in turn increases the price of electricity, implying that the demand for electricity is 6 per cent lower in the year 2000 than in the reference path. It is assumed in the model that the entire reduction in electricity production takes place at thermal power plants. This leads to a reduction of as much as 13 per cent in thermal power production in the year 2000. About the same reduction is found for use of respectively solid fuels, oil and gas for thermal power. Considered alone, the EC tax will turn the relative energy prices and the composition of the energy consumption in favour of gas-based power. This effect is small, however, compared with the direct, negative effect on gas-based power of reduced total power production.

The BAU column in table 4.18 also indicates that a carbon tax works to reduce gas consumption as a whole, since the consumption of this fuel also decreases in the other sectors. Although the tax turns the demand for energy towards the more environmentally friendly natural gas, the gas consumption decreases owing to a reduction in energy consumption as such. The percentage reduction in the total demand for oil is the same as for gas, in spite of the fact that a higher tax is imposed on oil consumption than on consumption of gas. This is because a large part of the oil consumption occurs in the transportation sector. In this sector the fuel costs are so high to start with that a price increase as a result of a carbon tax is relatively small. The percentage reduction in use of energy is therefore moderate.

The results in table 4.18 indicate that the size and structure of the special energy tax are not of much importance for the *impact* of EC's carbon-related tax. The effect is about the same in NIL TAX as in the BAU regime. There is a slightly greater reduction in oil and gas consumption in NIL TAX, but the effect on the consumption of solid fuels is almost unchanged. This is because the special tax is imposed mainly on oil and gas consumption. Therefore, a removal of the special tax means a lower price for oil and gas, but not for coal. This means that the carbon tax has a stronger effect on oil and gas prices in NIL TAX than in BAU, while the relative increase in the price of coal is the same.

In the GAS-BASED POWER regime the effect of the carbon tax on gas consumption is, in fact, even greater than under the other two regimes. This is because: The percentage decrease in gas consumption in thermal power production because of the carbon tax is about the same in all regimes, and is greater than the percentage reduction of gas consumption in the final consumption sectors. This means that the total percentage decrease in consumption of gas is highest in GAS-BASED POWER, since, in this regime, a larger share of the consumption occurs in the thermal power sector. It should be noted, however, that the reduction in gas consumption takes place from a higher level than in the other two regimes, so that gas consumption *after* the imposition of a carbon tax is highest in GAS-BASED POWER. In GAS-BASED POWER coal-based thermal power production is not affected by the carbon tax. Therefore the reduction in consumption of coal is connected entirely to the reduction in the final consumption sectors. The reason why the carbon tax has a relatively stronger effect on coal consumption in this regime than in the others is that the large percentage reduction of coal consumption in the manufacturing sectors weighs more in this regime. The absolute reduction in coal consumption, however, is far less than in BAU.

Emissions of CO_2 in the three regimes

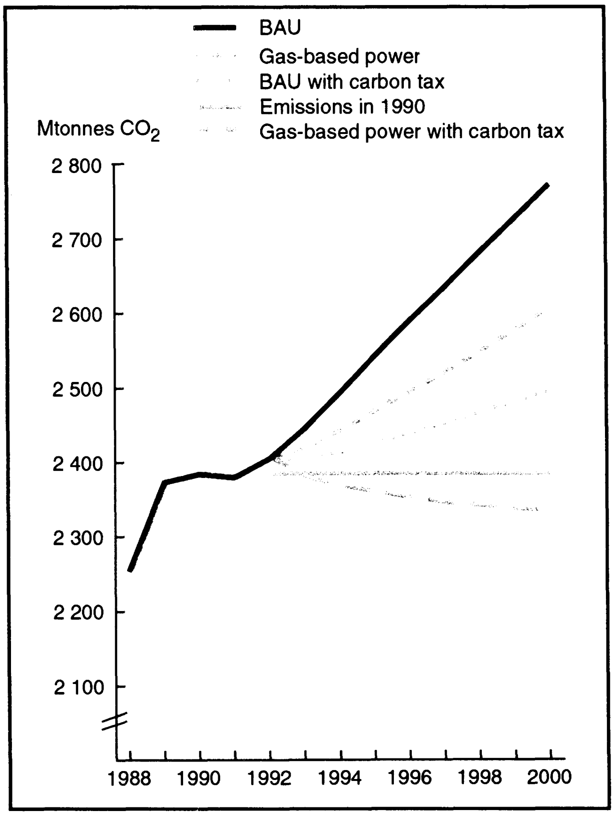
Figure 4.16 shows total emissions of CO_2 in the reference path and the carbon tax scenario in the regimes BAU and GAS-BASED POWER. Since the curves for NIL TAX are very like the corresponding curves for BAU they are excluded for the sake of simplicity. The figure shows that a change from plans favouring coal to cost-effective production of thermal power using gas will have a marked effect on emissions of CO_2 in Western Europe. The reference path for GAS-BASED POWER is much lower than the reference path for BAU. In the GAS-BASED POWER regime, introduction of a carbon tax equivalent to that proposed by EC, would mean that the requirement to stabilize CO_2-emissions at 1990 level would be more than realized.

Conclusion

The simulations indicate that a tax on carbon would have a clear negative effect on the demand for gas in Western Europe. Considered alone, such a tax would definitely lead to loss of markets for Norwegian exports of gas. On the other hand, the present protection of coal-based power that is implicit in the plans submitted to IEA (1988), leads both to greater emissions of CO_2, lower consumption of gas and higher-priced electricity than what would be obtained through a more cost-effective power production policy. It is thus in Norway's interest to encourage cost-effective strategies in the energy policy.

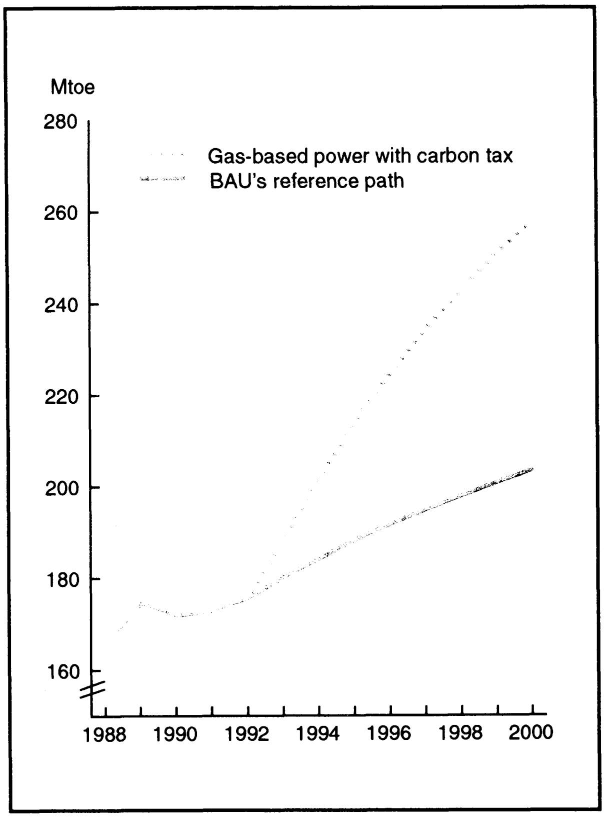
However, the introduction of a carbon tax will make it more expensive for the different countries to implement the planned expansion of coal-fired power production reflected in the BAU regime. It is possible that the higher costs to the different countries as a result of the tax on carbon will be enough to launch a more cost-effective development of the power sector in Western Europe. In such a scenario, the potential effect of the carbon tax is thus represented by the difference between the reference

Figure 4.16. CO_2-emissions in the different regimes. 1988-2000. Mtonnes



Source: CBS

Figure 4.17. Total consumption of natural gas in BAU's reference path and in GAS-BASED POWER's scenario with a tax on carbon. 1988-2000. Mtoe



Source: CBS

path in BAU and the simulation of effect in GAS-BASED POWER. Figure 4.17 shows the total consumption of natural gas in the two simulations. If the carbon tax promotes cost-effective development in the thermal power sector, the result could be a large increase in the demand for gas in Western Europe - and, at the same time, the goal to stabilize CO_2-emissions by the year 2000 will be achieved by a good margin.

Finally, it must be pointed out that we cannot expect such a complete breakthrough for gas-based power as indicated by the GAS-BASED POWER regime. A cost-effective thermal power sector would mean adjusting the policy of coal subsidies in important countries like Germany and the United Kingdom. This could in turn lead to other prices for competing fuels such as natural gas and oil. What types of power plant would then be chosen - with or without a tax on carbon - is impossible to say.

4.7. Stationary consumption of energy in private households

In 1990, private households' share of total domestic energy consumption, not including the energy sectors, was 28 per cent, see Central Bureau of Statistics (1992). According to the Energy Accounts, about 70 per cent of this is used for stationary purposes (heating, lighting and electrical appliances). The strong connection between use of energy and environmental problems makes it important to find out what factors influence this stationary energy consumption in households.

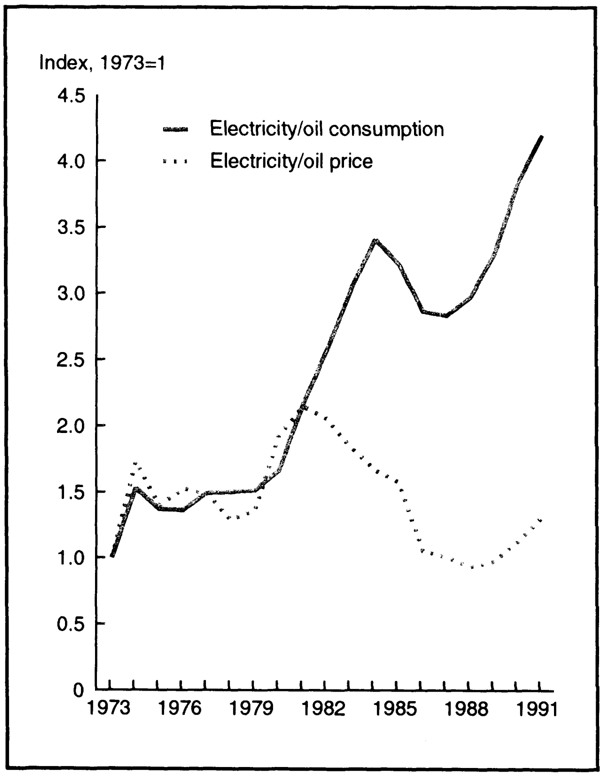
Historical trends in energy consumption, prices and income

Changes in relative prices and income are traditionally used to try to explain trends in the consumption of energy in households in CBS's macroeconomic models. Up to the beginning of the 1980s, models using these variables as explanatory factors gave satisfactory results, to the extent that an increase in the price of oil relative to the price of electricity implied reduced use of oil in relation to use of electricity. Figure 4.18 shows relative consumption of electricity and oil and the relation between the price of electricity and the price of oil. Use of wood is not included, since the consumption of wood varies very little over time, and the estimates are uncertain.

There was a strong increase in consumption of electricity relative to consumption of oil during the first half of the 1980s. This occurred in spite of the fact that electricity became relatively more expensive during the same period. A possible explanation is that many of the households had procured new types of equipment using electricity, such as dishwashers, microwave ovens, water beds, etc. Moreover, electricity was still cheaper than oil. Only after the drop in oil prices in 1986 did the relation between the price of oil and the price of electricity return to the level experienced in the latter half of the 1970s. In 1985 and 1986, electricity consumption decreased considerably relative to consumption of oil, as a reaction to the fall in oil prices and relatively more expensive electricity, but after 1988, there was again a marked rise in electricity consumption relative to consumption of oil. The trend since 1988 may be connected to the relatively strong increase in the price of oil.

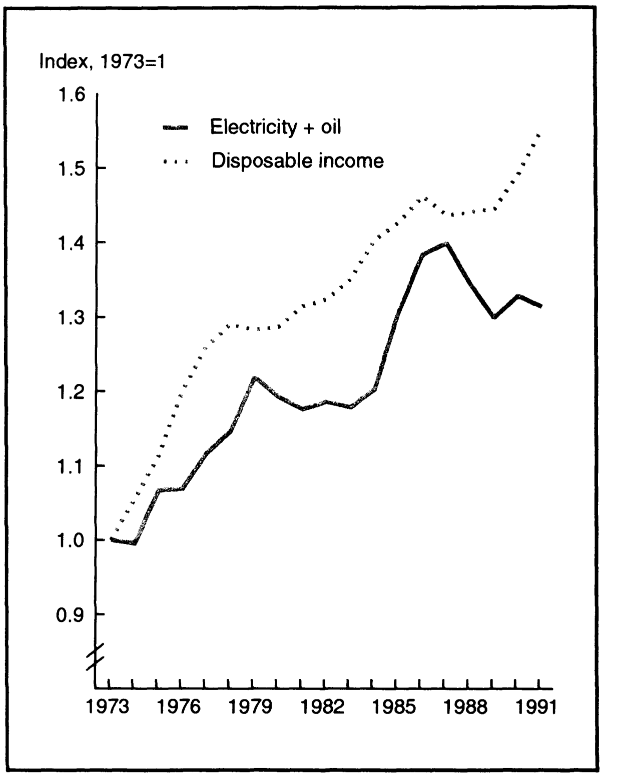
Figure 4.19 shows the trend in consumption of energy in private households (gross energy input, not adjusted for temperature) and disposable income in fixed prices. The disposable in-come of the households rose fairly steadily throughout the period from 1973 to 1991. Total consumption of electricity and oil shows an increasing trend, but with some fluctuations, partly due to fluctuations in temperature. According to the Central Bureau of Statistics (1992), it is calculated that, from 1980 to 1990,

Figure 4.18. Consumption of electricity relative to consumption of oil and price of oil relative to price of electricity for private households, 1973-1991. Index, 1973=1



Source: CBS

Figure 4.19. Consumption of electricity and oil, and disposable income in private households. 1973-1991. Index 1973=1



Source: CBS

the total temperature-adjusted energy consumption in private households increased by average 1.7 per cent per year. Although the total energy consumption and disposable income show more or less the same trend over time, the relative prices and income are not sufficient to explain the annual variations in energy consumption in the households.

Explanation of energy consumption on the basis of microdata

Partly in order to investigate in more detail whether variables other than prices and income are required to explain energy consumption, an Energy Survey was carried out in 1990 (Ljones et al., 1992). Data from this survey were used in an analysis of stationary energy consumption for space heating. The analysis is based on the theory of *discrete/continuous choice,* see for example McFadden (1973) and Dubin and McFadden (1984). The theory assumes that households or individuals first choose one of several possible systems of heating. Next, the household decides to what extent the heating equipment is to be used. The parameters in the model are calculated in two stages. In the first stage the discrete choice of heating equipment is estimated. The choice of heating equipment is of major importance for the composition of the energy consumption, and there is also an association between choice of equipment and the total energy consumption of the household. In the second stage, this association is taken into account when estimating the coefficients that decide the energy consumption given the choice of equipment.

Choice of heating equipment

The Population and Housing Census 1990 (FoB90) shows the distribution of different types of heating equipment in private households, see table 4.19.

The table shows that slightly less than 26 per cent of the households heated their dwelling with electricity alone. 44 per cent had a combination of equipment, with the possibility of using both electricity and wood. This indicates that electricity is used to a large extent as a basic source of heating, but that many also heat with wood.

Table 4.19. Share of private households with the different alternative forms of heating in 1990. Per cent

Total	100.0
Electricity	25.7
Electricity and wood	33.2
Electricity, oil and wood	10.8
Electricity and oil	7.1
Wood	6.0
Central heating and other alternatives not included in the estimations	17.2

Source: CBS

The table shows what type of heating equipment the households have chosen, and we wanted to find out what factors determined these choices. The analysis covered only dwellings built after 1970, because we had no information on the cost of procuring the heating equipment in the older dwellings. We excluded central heating, since we lacked information on the cost of procuring equipment for a central heating plant, and because households with common central heating probably behave differently from other households when it comes to energy consumption. The choice of heating equipment presents the following 5 alternatives:

- electricity
- wood
- electricity and oil
- electricity and wood
- electricity, oil and wood

The results of the analysis show that the capital cost of installing the equipment is of major importance for choice of equipment. The more the heating equipment costs, the less likely it is to be chosen. In this analysis we consider only fixed costs, and not variable costs of energy. The capital cost depends on the price and the energy capacity of the equipment and the household's demand for capacity (kW). The capital cost also depends on the effective rate of interest on loans and the lifetime of the equipment. The effective rate of interest is lower the higher the income. The main reason for this is the system of taxation, with income tax deductions for interest and a marginal tax that increases with income. The second reason is that credit worthiness increases with income, implying lower interest before taxation.

The results also show an association between the household's income and the type of heating equipment chosen. The higher the income, the greater is the likelihood of the household choosing electricity alone, while the likelihood of choosing a combination of electricity and wood increases slightly less with higher income. A combination of electricity, oil and wood is the least likely choice in households with a high income. It is possible that high-income households choose electricity because it is easy and not very time-consuming to use. Because the alternative cost connected to use of time is high, the choice falls on a system that requires little time. Many households with a high income may choose wood in addition to electricity because many like to have a fireplace as a status symbol and source of pleasure. Therefore this choice of equipment need not necessarily lead to high consumption of wood.

If the household lives in a housing cooperative or owner-tenant flat the choice is more likely to be electricity alone than electricity and oil, or electricity, oil and wood. The widespread use of electricity in these types of dwellings is probably because these dwellings are often small. Electricity is then the most appropriate form of heating, and there is little need of additional heating. Previously, central heating was widely used in such dwellings, but electricity is now the most usual form of heating in new housing cooperatives and owner-tenant accommodation.

The type of house also helps to determine the choice of heating equipment. Households living in detached houses or farm dwellings are more likely to choose combinations of equipment involving use of wood than to choose other types of equipment. The most likely choice is wood combined with electricity.

The analysis also shows a connection between the size of the household and the age of the dwelling on the one hand, and the type of equipment chosen on the other. The larger the household, the greater the likelihood that the household chooses electricity and wood rather than electricity alone. This is because larger households often live in larger dwellings such as detached houses or farm dwellings, where this combination is most likely. As regards the association between the age of the dwelling and type of equipment chosen, the results show that the chance of choosing alternatives other than electricity alone is greater the newer the dwelling. During the latter half of the 1970s, the uncertainty about oil prices may have led to more households choosing heating based on electricity. At the end of the 1980s, the households were more interested in being able to alternate between several forms of heating, and many households chose wood rather than oil as supplementary heating. This may have been due to the high capital costs connected to oil-based equipment, and uncertainty about trends in oil prices. Moreover, in the mid-1980s, there was a tendency to choose far larger dwellings than in the 1970s.

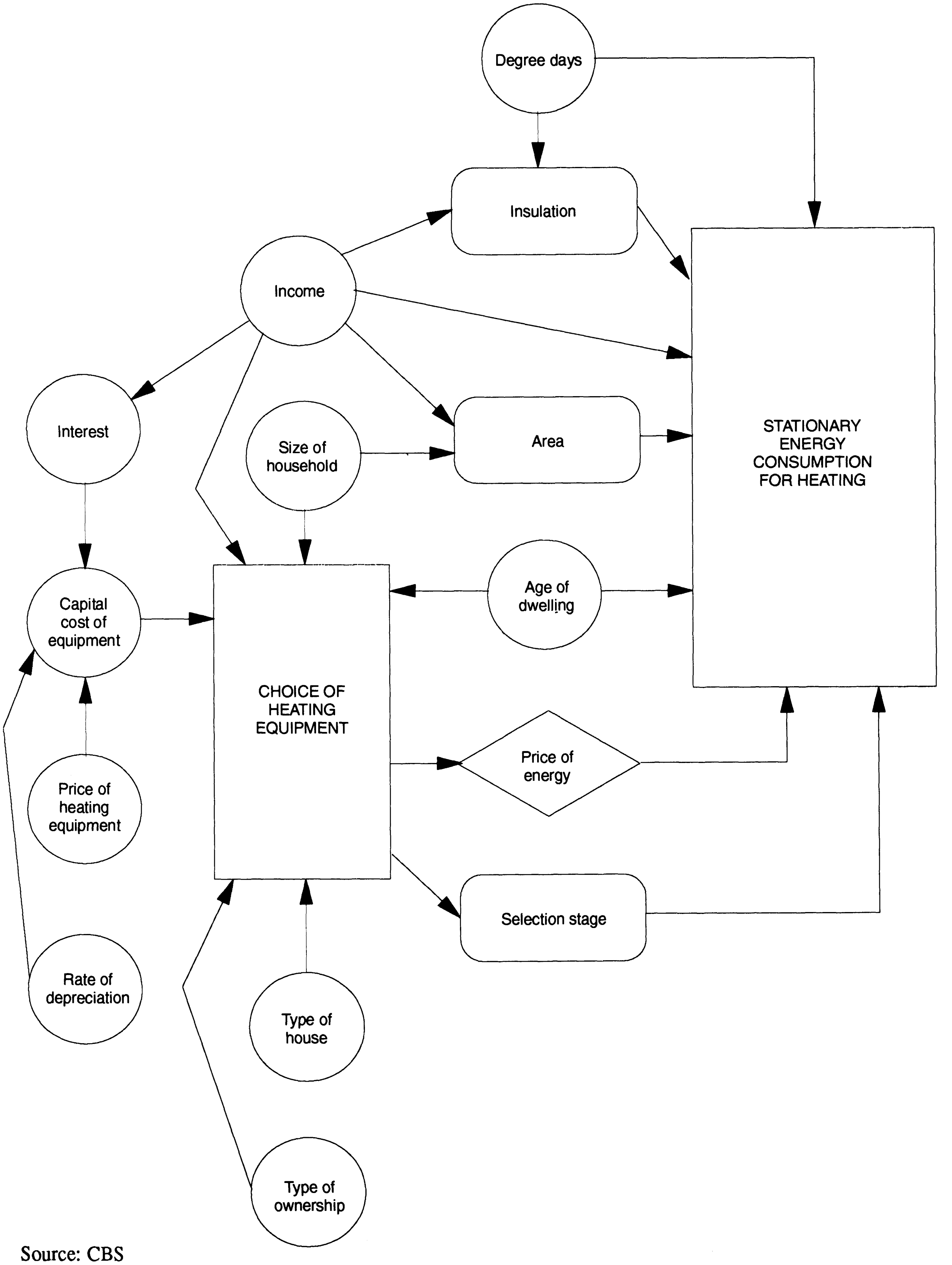
Energy consumption

The households' day-to-day energy consumption depends on the type of heating equipment chosen. Figure 4.20 shows which factors explain the choice of heating equipment and energy consumption in the model used.

The price of the different sources of energy is connected to the chosen heating equipment. If the household has chosen electrical heating alone, the price of energy is the same as the price of electricity, while the energy price for a household with a combination of several types of equipment is the average price of the sources of energy used. On the basis of estimated coefficients and average values for the price of energy and energy consumption, the long-term price elasticity of energy is calculated to -0.46. This means that if the price of energy increases by 10 per cent, energy consumption is reduced by 4.6 per cent.

There is reason to believe that energy consumption depends on the area of the dwelling. It is also reasonable to assume that the area of the dwelling depends on the size and income of the household. An estimation of this last-mentioned association shows that the area increases with the size and income of the household. Area, size of household and income all affect energy consumption. Since these variables are interdependent, this must be taken into account

Figure 4.20. Flow diagram for the variables included in the model



Source: CBS

in the estimations. Figure 4.20 shows that income and size of household determine the area, which in turn determines energy consumption. The results of the estimations confirm our assumption that energy consumption increases if the (estimated) area increases.

We have similarly estimated the relationship between insulation of the walls of the dwelling and income and degree days. Degree days express how cold it was during the preceding year. The results show a greater probability of the walls being insulated the colder it is in the area and the higher the income of the household. If one ignores the correlation between insulation on the one hand and outside cold and high income on the other, the striking result is that energy consumption is higher in insulated than in uninsulated dwellings. The explanation often suggested for this association is that the households "take out" the effect of better insulation in terms of higher indoor temperature and greater comfort. According to our results, this explanation is probably wrong, since it is based on an incorrect specification of the model. By using the estimated association for insulation, we find that energy consumption is *lower* in an insulated than in an uninsulated dwelling, provided that all other variables are the same.

We found that the colder the climate, the better the dwelling is insulated, and the lower the energy consumption becomes. According to our calculations, with a given standard of insulation, and if all other conditions remain unchanged, energy consumption will be higher if the dwelling is located in a cold part of the country than if located in a place with a milder climate. These effects of a cold climate work in opposite directions. Our results show that the colder the climate, the higher is the energy consumption.

The calculations show that energy consumption increases with the age of the dwelling. This may be due to other elements of the construction that are not included when studying the insulation of walls. An example is the standard of windows. Although both new and old dwellings are insulated, new dwellings may be even more tightly sealed. Another reason for the high energy consumption in the oldest dwellings could be that the heating equipment is less effective than in newer dwellings.

Income is a variable with a direct effect on energy, and energy consumption increases with income. However, income also has an indirect effect on energy consumption, since it influences the choice of heating equipment, which in turn affects energy consumption. Moreover, income has an indirect effect on energy consumption by affecting the area of the dwelling. The higher the income, the larger is the area, and thus also the energy consumption. Income is also associated with energy consumption through insulation of walls. The higher the income, the greater is the probability that the walls are insulated, and the lower is the energy consumption. The total effect of income on energy consumption can be expressed by the long-term income elasticity, which for an average household is estimated to 0.1. According to our results, a 10 per cent increase in income would increase energy consumption by about 1 per cent.

Possible future trends in energy consumption

In order to forecast trends in energy consumption on the basis of our model it is necessary to evaluate trends in all the relevant variables explaining choice of equipment and energy consumption.

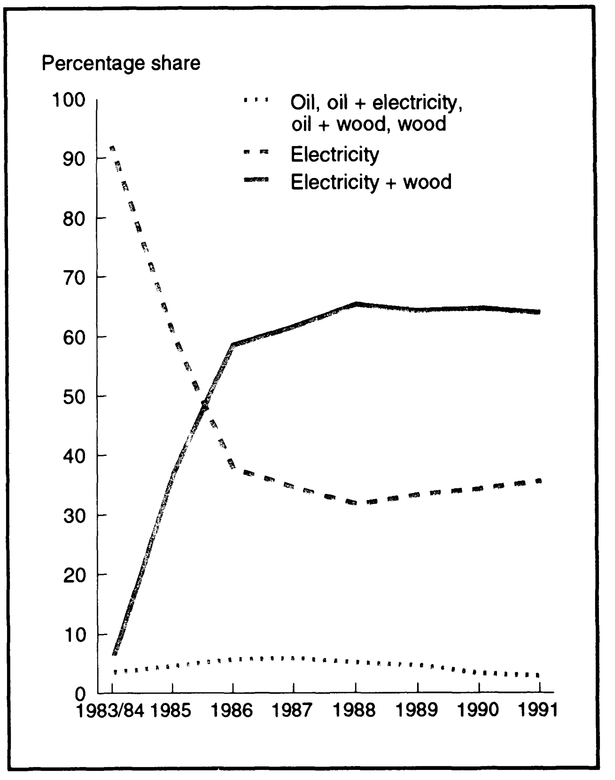
Changes in the price of heating equipment will help to decide the choice of equipment in new dwellings and in old dwellings where equipment is to be replaced. There is no reason to expect large changes in the costs of the traditional equipment covered by this analysis. In future, however, the choice of equipment will be affected by the introduction of new technology, and the costs of this technology. Heat pumps are becoming more common, and may gradually influence the choice of equipment. Investment costs are relatively high for some kinds of heat pumps but, taking into account the long lifetime of the equipment and the lower costs of energy, the total costs per year means that heat pumps can already compete with other types of equipment.

According to the Population and Housing Censuses in 1980 (FoB80) and 1990 (FoB90), the size of private households changed quite considerably from 1980 to 1990. The number of single person households increased from 28 to 34 per cent, and there was a corresponding decrease in the number of households consisting of four or more persons. There is no reason to assume that this trend will continue to the same degree in the years to come, because the number of small households in the country is limited by demographic and economic conditions.

In 1991, only 33 per cent of new dwellings were detached houses; the corresponding figure in 1987 was 62 per cent. On the other hand, the total percentage of blocks of flats, terrace houses/row houses and other small dwellings increased from 19 to 43 per cent during the same period. This increase in small types of dwellings is connected to the increase in small households. Given the levelling out of the size of the households and the composition of small and large types of dwellings, there is no reason to expect any marked change in the composition of heating equipment. The reduction in the average size of private households could lead to an increase in dwellings with electric heating only. For a given size of population, the reduced size of private households leads to more households and a need for new dwellings. The results of the estimations show that a choice other than electricity alone is most relevant in newer dwellings. Figure 4.21 shows the composition of heating equipment in new dwellings.

In line with the results of the estimations, the figure shows an increase in the number of new dwellings with electrical heating combined with wood, compared with dwellings with electrical heating only. The reason for the strong increase in this percentage may be that in 1979, a new rule was introduced into the Building Regulations, requiring all detached houses and semi-detached or row houses to have a chimney. The reason is that these types of dwellings would have an alternative form of heating in the event of a power cut. At the same time, many more of the households bought a wood-burning stove or a fireplace as a supplement to electrical heating. The analysis does not take into account the cost of the time spent on heating with wood or other types of heating. Such costs are important in a society

Figure 4.21. Heating equipment in new dwellings. 1983-1991. Per cent



Source: Building area statistics 1991, CBS

where time is scarce, and there may be grounds to assume that heating with wood will be used mainly as a supplement to other forms of heating.

We have studied some of the changes in the conditions affecting choice of heating equipment, and will comment upon changes in the energy consumption of the households. An increase in the price of the sources of energy associated with the chosen system of heating leads to a reduction of energy consumption in households with this form of heating. The question therefore arises whether it is possible to say anything about changes in energy prices.

The trend in oil prices is uncertain. The price of wood will probably change very little. The price of electricity is currently low, especially for consumers of large amounts of electricity. There has also been a drop in the real price of electricity for private households. There are grounds to expect higher prices for electricity towards the turn of the century.

About 90 per cent of the dwellings have insulated walls, and this indicates a relatively small potential for reduced energy consumption by improving the standard of insulation. However, our analysis only considers insulation of walls, but floor and roof can be poorly insulated even if the walls are well insulated. In addition, better insulation technology in new dwellings may produce more tightly sealed dwellings and lower energy consumption.

Energy consumption is lower in new than in older dwellings. Although relatively few dwellings are being built at present, considered alone this will lead to a slight reduction in average consumption per dwelling, provided that the size of the dwelling is not increased to any extent. The building area statistics show an average increase in the size of dwellings during the decade up to 1987. However, the average size of new dwellings decreased by about 8 per cent per year from 1987 to 1991. As mentioned above, this is explained by the change in the composition of house types among new dwellings. This development will lead to a smaller average area per dwelling for the entire stock of dwellings, which, taken alone, will lead to lower energy consumption per dwelling. According to FoB80 and FoB90, the number of dwellings increased by 15 per cent from 1980 to 1990, and the number will probably increase slightly in the years to come. Although fewer dwellings are being built per year than before, these still more than balance the number that are demolished or turned into offices etc. 21 511 dwellings were built in 1991. Based on the number of new dwellings according to the building area statistics and the net increase in the number of dwellings according to FoB80 and FoB90, it is estimated that the average number of dwellings that "disappeared" during the 1980s was about 7000 per year. The increase in the number of dwellings indicates a continued increase in energy consumption.

Private households have experienced a real increase in disposable income in recent years. This trend may turn as a result of the poor economy of the country. The income elasticity of about 0.1 per cent implies that a change in income does not have much effect on energy consumption.

As regards choice of heating equipment and energy consumption, the development will be affected by many factors. There is reason to believe that electric heating equipment will still be important. A combination of electrical equipment with other equipment will be usual in larger dwellings. Wood will continue to be a widespread source of supplementary heating, and will become more common than before in small dwellings. Uncertainty concerning the price of the different sources of energy makes it difficult to predict the trend in total energy consumption. Both expected higher prices for electricity towards the turn of the century, and the fact that new dwellings are relatively small and energy-efficient, point in the direction of lower energy consumption per dwelling. However, since the number of dwellings is increasing, a slight increase in the energy consumption for heating purposes in private households is nevertheless likely in the years to come.

Units and conversion factors

Average energy content, degree of efficiency and density, by source of energy

Energy source	Theoretical energy content	Unit	Fuel efficiency: Manuf. Mining	Fuel efficiency: Trans-port	Fuel efficiency: Other use	Density
Coal	28.1	TJ/ktonnes	0.80	0.10	0.60	..
Coal coke	28.5	TJ/ktonnes	0.80	-	0.60	..
Petrol coke	35.0	TJ/ktonnes	0.80	-	-	..
Wood	8.4	TJ/kfm^3	0.65	-	0.65	0.5 tonnes/fm^3
Paper waste (dry matter)	12.6-15.5	TJ/ktonnes	..	..	..	..
Wood waste (dry)	15.0-18.5	TJ/ktonnes	..	..	..	..
Crude oil	43.0	TJ/ktonnes	..	..	..	0.85 tonnes/m^3
Refinery gas	48.6	TJ/ktonnes	..	..	..	..
Natural gas (1990)	40.5	TJ/MSm^3	..	..	..	0.85* kg/Sm^3
Liquid propose and butane (LPG)	46.1	TJ/ktonnes	0.95	-	0.95	0.53 tonnes/m^3
Gasoline	43.9	TJ/ktonnes	0.20	0.20	0.20	0.74 tonnes/m^3
Kerosene	43.1	TJ/ktonnes	0.80	0.30	0.75	0.80 tonnes/m^3
Diesel-, gas-, heating oil 1 and 2	43.1	TJ/ktonnes	0.80	0.30	0.70	0.84 tonnes/m^3
Heavy oil	40.6	TJ/ktonnes	0.90	0.30	0.75	0.97 tonnes/m^3
Electricity	3.6	TJ/GWh	1.00	0.95	1.00	..

* Upper heat value

Energy units[1, 2]

	PJ	TWh	quad (oil)	Mtoe (oil)	Mbarrel (oil)	GSm^3 (bcm) (gas)	GScuft (gas)
1 PJ	1	0.278	9.50×10^{-4}	0.024	0.175	0.025	0.83
1 TWh	3.60	1	3.42×10^{-3}	0.085	0.629	0.088	3.00
1 quad (oil)	1053	292.5	1	24.9	184.1	25.6	877.5
1 Mtoe (oil)	42.3	11.8	0.04	1	7.4	1.03	35.3
1 Mbarrel (oil)	5.72	1.59	5.4×10^{-3}	0.135	1	0.141	4.8
1 GSm^3 (bcm) (gas)	40.5	11.3	3.9×10^{-2}	0.97	7.1	1	33.7
1 GScuft (gas)	1.20	0.33	1.1×10^{-3}	0.028	0.21	0.03	1

[1] 1 quad = 10^{15} Btu (British thermal units).
1 Mtoe = 1 mill. tonnes of (crude)oil equivalents.
1 Mbarrel = 1 million barrels crude oil (1 barrel = 0.159 m^3).
1 GSm^3 = 1 billion standard cubic meters natural gas.
1 GScuft = 1 billion standard cubic feet natural gas. (1 Scuft = 0.0283 Sm^3).
[2] Norwegian average natural gas 1990 is reference for natural gas.

Prefixes

Name	Symbol	Factor
Kilo	k	10^3
Mega	M	10^6
Giga	G	10^9
Tera	T	10^{12}
Peta	P	10^{15}
Exa	E	10^{18}

References:

Birkelund, H., E. Gjelsvik and M. Aaserud (1992:) *EFs karbon-/energiskatt og det vest-europeiske energimarkedet* (EC's tax on carbon and energy and the West European energy market). Economic analyses no. 7. Central Bureau of Statistics, Oslo. (In Norwegian).

Bye, T. and T.A. Johnsen (1991): *Effektivisering av kraftmarkedet* (A more effective power market). Report 91/13, Central Bureau of Statistics, Oslo. (In Norwegian).

Dubin, J.A. and D. McFadden (1984): *"An Econometric Analysis of Residential Electric Appliance Holdings and Consumption"*, Econometrica, Vol 52, no.2.

European Commission (1991): *A community strategy to limit carbon dioxide emissions and to improve energy efficiency.* Communication from the Commission to the Council. European Commission, Brussels.

IEA (1988): *Energy Policies and Programs of IEA Countries, International Energy Agency, Paris*

Ljones, A., R. Nesbakken, S. Sandbakken and A. Aaheim (1992): *"Energibruk i husholdningene. Energiundersøkelsen 1990".* (Energy consumption in private households. Energy Survey 1990). Report 92/2, Central Bureau of Statistics, Oslo. (In Norwegian).

McFadden, D. (1973): *"Conditional Logic Analysis of Qualitative Choice Behaviour"*, in "Frontiers in Econometrics", ed. by P. Zarembka, New York, Academic Press.

Nilstad, M. and E. Gjelsvik (1993): *EF-kommisjonens utkast til gassdirektiv (TPA-direktivet). Konsekvenser for norsk gasseksport.* (The EC Commission's Gas Directive (TPA Directive). Consequences for Norwegian exports of gas). To be published in the report series from the Central Bureau of Statistics. (In Norwegian).

NOU 1992:34: *Skatt på kraftselskap* (Tax on power companies). Norwegian Official Report No. 1992/34. (In Norwegian).

Central Bureau of Statistics (1991): *"Natural Resources and the Environment 1990".* Report 91/1A. Central Bureau of Statistics, Oslo-Kongsvinger.

Central Bureau of Statistics (1992): *"Natural Resources and the Environment 1991".* Report 92/1A. Central Bureau of Statistics, Oslo-Kongsvinger.

Report no. 60 (1991-92): Om samlet plan for vassdrag. (Report no. 60 (1991-92) to the Storting concerning the Master Plan for Water Resources.) Ministry of Environment. (In Norwegian).

Each year CBS, in cooperation with the State Pollution Control Authority (Statens Forurensningstilsyn - SFT) prepares inventories of Norwegian emissions of several polluting components. The emission figures for recent years reflect a gradual reduction in the use of petroleum products in Norway but, at the same time, a higher level of activity in the North Sea. The emission figures have also been influenced by cleaning measures, improved combustion technology and quality criteria for oil products. For emissions of some components (SO_2, lead and CO) the figures show a clearly decreasing tendency, while emissions of CO_2 and NO_x have tended to decrease only slightly during the last couple of years. There has been a moderate increase in emissions of NMVOCs. Special attention is awarded to the reasons for changes in emissions to air from road traffic. Changes in emissions help, in their turn, to explain changes in the concentrations of air pollutants. The inventories are part of the general monitoring of the environment, and also provide a basis for forecasts of future emissions to air and the effects of various pollution control measures. These measures usually represent a cost to society, but can also lead to gains in the form of reduced harm to human health and damage to nature and various materials. The costs of reducing CO_2-emissions in Norway are discussed.

5.1. Air pollution - some sources and effects

There are three main sources of emissions to air in Norway: Stationary combustion, mobile combustion and so-called process emissions. In stationary combustion, coal, coke and oil products are burned in large or small stoves, furnaces, turbines or flares. The purpose is usually to provide heat or power for industrial processes and other forms of heating. Emissions from mobile combustion are characterized by use of fossil fuels to drive an engine. Examples are motor vehicles, boats, aircraft and motorized tools. Process emissions are characterized as originating from processes other than combustion. A large part of these emissions originate from industrial processes, but emissions from other activities such as domestic animal husbandry/manuring and deposition of waste are also categorized as emissions from processes. Use of coal or coke as reducing agent in the production of metals is also regarded as a process. Use of solvents and distribution of oil products create emissions by evaporation. It is important to classify the emissions by source so as to be able to evaluate countermeasures. The measures can be directed both at combustion conditions (furnaces and engines) and at the sources of energy (energy carriers). Examples of measures are catalytic converters (catalyzers) in cars, more stringent quality criteria for oil products and/or taxes to reduce use of particularly polluting products. The emissions can also be reduced by cleaning or by modifying production and/or distribution routines.

Air pollution in Norway is caused partly by Norwegian emissions from industry, transport and heating systems, and by long-range transported pollution from other countries (transboundary pollution). *Norwegian emissions* are the main source of local pollution, which impairs health and damages materials, while *transboundary pollution* is the main source of acidification of the environment. The harmful effects may be difficult to predict. They depend on the concentration of the different polluting components and on the duration of exposure of humans and the environment. The concentration is determined by the intensity and location of the emissions, the weather, and other conditions which can affect dispersal and transformation of the emissions. In the case of certain components the damage does not occur until the concentration exceeds a certain critical level. For other components, even low concentrations involve risk of damage. This applies in particular to emissions with carcinogenic properties.

In recent years, global environmental problems caused by increased emissions to air have attracted considerable attention. The global thermal balance is dependent, for instance, on the chemical composition of the atmosphere. Without the atmosphere the global mean temperature would have been about 32 degrees centigrade lower than it is today. The atmosphere absorbs some of the heat radiated from the earth, but lets through almost all the radiation from the sun. It is this that is called *the greenhouse effect*. It is feared that increased emissions of certain gases during the last century are destroying the natural thermal balance, and are thus causing a change in the earth's climate. The most important greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), freons, ozone (O_3) and water vapour. Emissions of other components can influence the thermal balance of the globe indirectly through chemical reactions in the atmosphere.

Human beings and the natural environment are protected from the harmful effects of ultraviolet radiation by ozone, which functions as a filter in the atmosphere (the layer of the atmosphere roughly 15-50 km above the earth). Several measurements indicate that this ozone layer has become thinner in recent years. The reason may be increased emissions of pollutants. Emissions of chlorofluorocarbons (CFCs) and halons are regarded as particularly harmful, because these classes of chemical compounds have a very long lifetime, 100-200 years, in the troposphere (roughly the lower 0-15 km of the atmosphere). When they reach the stratosphere, however, they decompose, and may start chain reactions where each molecule can contribute to the destruction of thousands of ozone molecules.

The effects of air pollution are sometimes due to secondary pollutants. These are substances generated, for instance, during oxidation of the original emissions. For example, emissions of the alkali ammonia (NH_3) will have a net acidifying effect on the earth by oxidation.

$$NH_3 + \text{oxidizing agent} \Rightarrow NO_3^- + H^+$$

Ozone is formed in the troposphere through reactions between nitrogen oxides (NO_x) and hydrocarbons under the influence of solar radiation. Higher concentrations of ozone in the troposphere are damaging to human beings and the natural environment. Sulphate (SO_4^{2-}) is formed by oxidation of sulphur dioxide (SO_2) or other sulphur compounds.

Table 5.1 summarizes some sources, effects and recommended air quality criteria for the most important air pollution problems. The limit for injury to health ("air quality criterium") means the level of pollution to which a population can be exposed without risk of injury to health. In 1992, new air quality criteria have been recommended by a working group including representatives of SFT, the Norwegian Institute for Air Research (Norsk institutt for luftforskning - NILU), the Norwegian Institute for Forest Research (Norsk institutt for skogforskning - NISK), and the National Institute of Public Health (Statens institutt for folkehelse - SIFF).

Table 5.1. Sources, harmful effects and recommended air quality criteria for certain pollutants

Components	Sources	Harmful effects	Recommended air quality criteria[1]
Sulphur dioxide	Combustion of oil Transportation Process emissions: - Refineries - Metals manufacturing - Silicon carbide - Pulp and paper processing	*Health:* SO_2 combined with suspended particulates increases risk of respiratory diseases *Nature:* Damage to vegetation Contributes to acidification of soil and water Corrosion of materials Influences global thermal balance	*Health:* 400 µg/m^3 (15 min) 90 µg/m^3 (day) when combined with PM_{10} 40 µg/m^3 (6 mth) when combined with PM_{10} *Vegetation:* 150 µg/m^3 (hour) 50 µg/m^3 (day) 20 µg/m^3 (year)
Nitrogen oxides	Transportation Combustion of oil Process emissions: - Manuf. fertilizers - Manuf. basic metals	*Health:* Increases risk of respiratory diseases. NO_2 is more harmful than NO *Nature:* Contributes to acidification of soil and water NO_2: Reacts with NMVOCs to produce ozone in presence of solar radiation. NO_2: Corrosion of materials in presence of SO_2. Influences the oxidation capacity of the atmosphere	*Health* (NO_2): 500 µg/m^3 (15 min) 100 µg/m^3 (hour) 75 µg/m^3 (day) 50 µg/m^3 (6 mths) *Vegetation* (NO_2): 30 µg/m^3 (year)
Carbon monoxide	Transportation Combustion of oil Wood burning Process emissions: - Silicon carbide - Manuf. basic metals	*Health:* CO adheres to red blood cells and reduces uptake of oxygen. - Increased risk of cardiac spasm - Reduced activity in healthy persons - Lower birth-weight in newborn	*Health:* 80 mg/m^3 (15 min) 25 mg/m^3 (hour) 10 mg/m^3 (8 hrs)
Volatile organic compounds (VOCs)	Transportation Wood burning Two-stroke engines Combustion of oil Gasoline distribution Solvents Loading of oil Extraction: oil and gas Refineries	*Health:* May contain carcinogenic substances like PAH and benzene *Nature:* Reacts with NO_2 to produce ozone in presence of solar radiation. Influences oxidation capacity of the atmosphere	
Polycyclic aromatic hydrocarbons (PAH)	Wood burning Aluminium plants Motor vehicles	*Health:* PAH when inhaled can induce cancer in the respiratory system	
Ammonia	Use of commercial fertilizer and manure Ammonia production	*Nature:* Contributes indirectly to acidification of soil and water Direct damage to vegetation near source of emission	
Suspended particulates (PM_{10})	Coal burning Wood burning Transportation	*Health:* Suspended particulates together with SO_2 can cause respiratory diseases. Suspended particulates are often carriers of carcinogenic substances and micropollutants[2]	*Health:* 70 µg/m^3 (day) 30-40 µg/m^3 (6 mths)
Dust	Coal burning Dust from roads (studded tyres)	*Well-being:* Dust cover on vegetation and materials near source of emission	
Lead	Gasoline-driven cars	*Health:* Increased risk of coronary diseases and spontaneous abortion. Altered behavioural pattern and reduced intelligence and fertility. Anaemia	

Table 5.1. (cont.).

Components	Sources	Harmful effects	Recommended air quality criteria[1]
Photo-chemical oxidants (Ozone, PAN)	Produced in the atmosphere through reaction between NO_2, CO and hydrocarbons under the influence of solar radiation	*Health:* Can cause respiratory diseases. *Nature:* Damage to forests and other vegetation. *Materials:* Damage to e.g. rubber and plastics	Health: 100 $\mu g/m^3$ (hour) 80 $\mu g/m^3$ (8 hrs) Vegetation: 150 $\mu g/m^3$ (hour) 60 $\mu g/m^3$ (8 hrs) 50 $\mu g/m^3$ (6 mths)
Carbon dioxide	Fossil fuels Deforestation/changed land use Cement production Basic metals production	Contributes to greenhouse effect	
Methane	Domestic animals/manure Deposition of waste Extraction: oil, gas, coal Loading of oil Wood burning Fossil fuels	Direct contribution to greenhouse effect, causes formation of O_3 in the troposphere and changes in the properties and composition of the atmosphere (also affects the ozone in the stratosphere)	
Nitrous oxide	Microbiological processes, burning of fossil fuels, burning of biomass, manure and commercial fertilizers, fertilizer production	Contributes to the greenhouse effect. Reduces ozone in the stratosphere.	
Chlorofluoro-carbons (freons)	Refrigeration plants, chemical dry cleaning, foam plastic production	Reduces the ozone layer in the stratosphere. Contributes to greenhouse effect.	
Halons	Fire-extinguishing installations	Reduces the ozone layer in the stratosphere	

1 New values as from 1992
2 "Micropollutants" means persistent organic substances and heavy metals

Sulphur dioxide	SO_2
Sulphate	SO_4^{2-}
Nitrogen oxides	NO_x(NO and NO_2)
Carbon monoxide	CO
Carbon dioxide	CO_2
Lead	Pb
Ozone	O_3
Methane	CH_4
Nitrous oxide	N_2O
Chlorofluorocarbons	CFC
Halons	$Br_xCl_yF_zC$
Ammonia	NH_3
Volatile organic compounds (not including methane)	NMVOC

Box 5.1. Some chemical formulas and abbreviations

[illegible]

Inventories of emissions to air have been compiled for sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), non-methane volatile organic compounds (NMVOC), particulates and lead (Pb) for the years 1973-1991. Inventories have been compiled for methane (CH_4) and nitrous oxide (N_2O) for the years 1987-1991. Emissions of ammonia (NH_3) have been calculated for the years 1988-1991. The figures for 1991 are based on preliminary calculations. For 1992, preliminary figures have been calculated only for the total emissions of the different components. Cruder estimates also exist for some of the components for the period 1960-1972. In general, the emission inventories for earlier years are less detailed and more uncertain than those for more recent years. The emission inventories have been calculated on the basis of surveys of energy consumption (Resource Accounts for Energy, and Manufacturing Statistics from the Central Bureau of Statistics). Consumption of the different forms of energy is distributed between the different assumed purposes within each economic sector (MODIS IV). The consumption is multiplied by emission coefficients connected to source of combustion, form of energy and type of industry. The calculations also take into account information on companies with a discharge permit from SFT, in which case the estimated figures are replaced by reported and/or measured values. Process emissions and emissions from evaporation are estimated on the basis of information on the different activities. This includes data reported to SFT, conclusions in relevant reports and specific emission coefficients connected, for example, to volume of production. The figures for fuel consumption, the emission coefficients, distribution by source and other parameters are all somewhat uncertain. Least uncertainty is connected to the emission coefficients for CO_2, Pb and SO_2. In these cases the emission coefficients are determined respectively by the carbon, lead and sulphur content of the fuel. Emissions of other components from fuel consumption are determined to a large extent by the combustion conditions. Greatest uncertainty is connected to the emission coefficients for NMVOC, N_2O and CH_4. Process emission figures that are not connected to industrial enterprises are generally uncertain. Emissions from road traffic are estimated on the basis of fuel consumption, number of motor vehicles in the different age classes, technological and weight categories, average distance driven and assumed pattern of driving. The figures are corrected for the age of the motor vehicle park. These data are then linked to specific fuel consumption and emission factors for type of emission per kilometre driven or emission per kilogram fuel. Emissions caused by starting a car with a cold engine (cold starts) and emissions of volatile hydrocarbons (NMVOC) from evaporation of gasoline from the cars have also been calculated.

Table 5.2. Selected emission coefficients for NOx, NMVOC, CO and particulates. 1990

	NO_x	NM-VOC	CO	Particulates
	kg/tonne			
Stationary combustion				
Natural gas				
Industry	7.4	0.3	2.0	0.0
Heating kerosene				
Households	2.5	0.6	6.5	0.3
Industry	3.0	0.4	2.0	0.25
Heating oil				
Households	2.5	0.6	6.5	0.3
Industry	3.0	0.4	2.0	0.3
Heavy oil				
Households	4.2	0.3	0.4	1.3
Industry	5.0	0.3	0.2	1.3
Coal				
Households	1.4	10.0	100.0	8.5
Industry	4.5	0.8	3.0	1.4
Wood				
Households	0.7	20.0	100.0	10.0
Industry	0.9	1.3	15.0	2.4
Mobile combustion				
Marine fuels				
Ocean transport ...	70.0	2.5	5.0	1.2
Road traffic *(averages)*	kg/tonne			
Passenger cars				
Gasoline	31.7	45.4	399.5	0.46
Diesel	11.7	4.0	14.5	6.18
Vans				
Gasoline	36.3	45.4	372.5	0.45
Diesel	12.3	4.4	13.9	6.3
Heavy vehicles				
Gasoline	36.0	44.0	463.0	0.1
Diesel	40.3	5.0	20.4	3.3

Source: CBS, SFT, Institute of Technology (TI)

The emission coefficients are adjusted slightly from year to year, depending on changes in the chemical composition of the fuels, changes in combustion technology and new knowledge. The historic figures for emissions from combustion in the North Sea and emissions from road traffic have been adjusted because of new knowledge about emission coefficients. The changes are greatest for NO_x. New sources or new methods of calculation are also taken into account, mainly in the category process emissions/evaporation. Here too the historic emission figures have been updated. This applies to process emissions of lead, emissions of CH_4 and NMVOC from extraction and loading of oil, methane from manure, ammonia from agriculture, as well as several industrial sources of emissions (SO_2 and NO_x). The energy data for a number of sources have also been updated from 1989 to 1990. The estimates of emissions from use of solvents are very uncertain. These emissions are estimated to range from 30 000 to 50 000 tonnes per year. Emission figures for air traffic include emissions from Norwegian aircraft in Norway during all phases of the flight. The summary of emissions does not include emissions from foreign ships in Norwegian waters. Carbon released as NMVOC, CH_4 and CO is oxidized in the atmosphere to CO_2. Therefore all these emissions are also regarded as (indirect) emissions of CO_2.

Table 5.3. Emission coefficients for SO_2 and CO_2. 1990-1991

	kg SO_2/tonne energy source		Tonnes CO_2/tonne of energy source[1]
	1990	1991	
Natural gas	0.0	0.0	2.75
LPG (propane)	0.0	0.0	3.00
Kerosene	0.3	0.4	3.15
Gasoline	0.6	0.6	3.13
Heating oils	3.2	2.8	3.17
Diesel	3.2	2.8	3.17
Marine fuel	3.2	2.8	3.17
Special distillate	6.0	4.6	3.17
Heavy oil LS	17.0	16.8	3.20
Heavy oil NS	39.4	43.6	3.20
Coal, industry	16.0	16.0	2.42
Coal, households	20.0	20.0	2.42
Wood	0.4	0.4	-[2]

[1] The emission coefficients for CO_2 are based on total carbon content of the fuels; i.e. the carbon in other emitted substances containing carbon are included in the coefficients for CO_2.

[2] Renewable source of energy, emissions included in the natural carbon cycle.

Source: NP, SFT, CBS.

Tables 5.2 and 5.3 show some of the emission coefficients used to calculate emissions from fuel consumption.

The emission inventories give some indication of the pollution load. They provide a basis for assessing where to introduce pollution control measures and show the effects of any measures introduced. They also provide the necessary data to make forecasts of emissions to air, and thereby find out whether Norway is fulfilling national objectives and international agreements on reductions of emissions to air.

Emissions to air by sector and source of emissions

Table 5.4 shows emissions of SO_2, NO_x, NMVOC, CO, CO_2, particulates, Pb, CH_4, N_2O and NH_3 in 1990 distributed by economic sector. Table 5.5 shows the same emissions distributed by source of emission. In table 5.6 the emission figures for some of the main economic sectors are distributed between stationary and mobile sources and emissions from industrial processes/evaporation. Table 5.7 shows provisional emission figures for 1991, distributed by source of emission. Emissions from evaporation and solvents are distributed only roughly between the economic sectors.

Table 5.4. Emissions to air by sector. 1990. 1 000 tonnes unless otherwise specified

Sector	SO_2	NO_x	CO	CO_2	NM-VOC	Par-ticu-lates	Pb	CH_4	N_2O	NH_3
				Mill. tonnes			Tonnes			
Total	53.5	230.3	951.0	35.2	269.9	21.4	230.3	281.8	15.6	38.2
Energy sectors	6.3	45.0	8.2	9.9	113.5	0.5	1.7	16.4	0.2	-
Extraction of oil and gas[1]	1.3	40.5	6.1	7.9	104.6	0.3	0.0	10.7	0.1	-
Extraction of coal	0.0	0.0	0.2	0.0	0.0	0.0	0.0	5.5	0.0	-
Oil refineries	4.3	3.2	0.0	1.7	8.4	0.1	0.0	0.1	0.1	-
Electricity and water supply[2]	0.7	1.3	1.9	0.2	0.5	0.1	1.5	0.1	0.0	-
Manufacturing and mining	34.2	22.2	73.2	9.6	21.5	1.8	9.9	1.4	7.5	0.5
Pulp and paper industry	3.3	1.2	1.9	0.2	0.2	0.4	0.0	0.2	0.3	-
Manufacture of industrial chemicals	6.8	3.6	40.2	1.5	1.6	0.1	0.0	1.0	6.7	0.5
Manufacture of mineral products .	3.1	4.9	1.0	1.5	0.2	0.2	0.1	0.0	0.0	-
Manufacture of iron, steel and ferroalloys	12.3	6.6	0.0	3.1	1.9	0.0	8.0	0.0	0.0	-
Manufacture of other metals	5.0	1.7	20.3	2.0	0.1	0.1	0.0	0.0	0.0	-
Manufacture of metal products, boats, ships and platforms	0.3	0.9	1.6	0.2	7.2	0.0	0.4	0.0	0.0	-
Manufacture of wood, plastic, rubber, graphic and chemical products	1.4	1.3	5.8	0.3	8.5	0.7	0.5	0.1	0.1	-
Manufacture of consumer goods .	2.0	2.2	2.3	0.7	1.7	0.2	0.6	0.0	0.1	-
Other	13.0	163.1	869.6	15.7	134.9	19.1	218.6	264.0	7.9	37.7
Building and construction	0.5	6.2	5.3	0.5	4.4	0.5	1.0	0.1	0.0	-
Agriculture and forestry	0.8	7.7	13.6	0.8	3.1	1.1	1.6	91.0	6.5	37.4
Fishing and hunting	2.0	33.1	2.9	1.5	1.2	0.6	0.4	0.4	0.1	-
Land transport, domestic	1.9	20.7	23.4	2.0	4.4	2.3	3.9	0.1	0.2	0.0
Sea transport, domestic	3.3	26.0	2.5	1.2	1.0	0.4	0.3	0.3	0.1	-
Air transport, domestic	0.1	3.0	2.5	1.0	0.5	0.1	2.1	0.0	0.1	-
Other private services	1.2	15.7	130.5	1.9	26.7	0.6	39.2	0.4	0.2	0.0
Public activities (municipal)[2]	0.3	0.3	0.7	0.3	0.1	0.0	0.2	159.2	0.0	-
Public activities (state)	0.3	3.9	2.6	0.5	0.4	0.1	0.6	0.1	0.0	-
Private households	2.6	46.5	685.6	5.9	93.2	13.3	168.9	12.5	0.6	0.2

[1] Includes gas terminal, oil drilling operations, and transport and supply boats. [2] Includes emissions from waste incineration plants.

Source: CBS, SFT

Table 5.5. Emissions to air by source. 1990. 1 000 tonnes unless otherwise specified

Sources	SO_2	NO_x	CO	CO_2	NM-VOC	Par-ticu-lates	Pb	CH_4	N_2O	NH_3
				Mill. tonnes			Tonnes			
Total	53.5	230.3	951.0	35.2	269.9	21.4	230.3	281.8	15.6	38.2
Stationary combustion	11.5	40.6	137.7	13.9	11.4	14.2	1.7	13.9	1.5	-
Boilers and direct-fired industrial furnaces	7.7	13.2	6.7	4.3	1.0	1.6	0.3	0.4	0.8	-
Gas turbines	0.1	14.1	3.9	5.3	0.5	0.0	-	2.1	0.0	-
Flares	0.0	9.4	0.8	1.6	0.8	0.0	-	0.3	0.0	-
Non-industrial boilers and small stoves	3.4	3.0	126.1	2.6	8.9	12.5	0.1	11.0	0.6	-
Incineration of waste	0.4	1.0	0.3	0.1	0.3	-	1.3	0.1	-	-
Mobile combustion	11.4	180.3	753.3	13.9	103.3	7.2	220.5	3.1	0.9	0.2
Road traffic	3.6	83.7	706.4	8.0	83.0	4.0	211.2	1.8	0.6	0.2
Passenger cars	1.2	51.8	641.8	5.3	73.2	1.2	195.3	1.6	0.3	0.2
Gasoline	1.0	50.9	640.7	5.0	72.9	0.7	195.3	1.6	0.2	0.2
Diesel	0.2	0.9	1.1	0.2	0.3	0.5	0.0	0.0	0.0	0.0
Vans	0.4	5.3	44.0	0.7	5.6	0.6	13.9	0.1	0.0	0.0
Gasoline	0.1	4.2	42.7	0.4	5.2	0.1	13.9	0.1	0.0	0.0
Diesel	0.3	1.1	1.3	0.3	0.4	0.6	0.0	0.0	0.0	0.0
Heavy vehicles	2.1	26.6	20.7	2.1	4.2	2.1	1.9	0.1	0.3	0.0
Gasoline	0.0	0.6	7.5	0.1	0.7	0.0	1.9	0.0	0.0	0.0
Diesel	2.1	26.1	13.2	2.0	3.5	2.1	0.0	0.0	0.3	0.0
Motorcycles, two-stroke engines, tractors and motorized tools	0.7	11.3	37.2	0.9	16.5	1.6	6.3	0.2	0.0	0.0
Railways	0.1	0.6	0.2	0.1	0.1	0.1	0.0	0.0	0.0	-
Air traffic	0.1	3.8	3.2	1.3	0.6	0.2	2.2	0.0	0.1	-
Ships and boats	6.8	80.9	6.3	3.7	3.1	1.4	0.6	1.0	0.2	-
Processes and evaporation	30.6	9.3	60.0	7.3	155.2	-	8.0	264.8	13.2	37.9
Domestic animals and manuring	-	-	-	-	-	-	-	91.0	6.5	37.4
Liming	-	-	-	0.2	-	-	-	-	-	-
Biological degradation of waste	-	-	-	0.1	-	-	-	159.2	-	-
Evaporation, solvents	-	-	-	0.1	31.6	-	-	-	-	-
Gasoline distribution	-	-	-	0.0	9.4	-	-	-	-	-
Oil loading	-	-	-	0.3	97.8	-	-	2.5	-	-
Refining, crude oil and natural gas	3.9	-	-	0.0	9.2	-	-	0.4	-	-
Extraction: crude oil, natural gas and coal	-	-	-	0.0	3.7	-	-	10.7	-	-
Transformation of nitrogen to fertilizers	-	2.4	-	0.6	-	-	-	-	6.7	0.5
Reduction of ore to metals and alloys	16.6	6.9	20.0	4.7	1.4	-	-	-	-	-
Use of coke and coal for production of carbides	4.4	-	40.0	0.4	-	-	-	1.0	-	-
Transformation of gas to basic plastic	-	-	-	0.0	0.9	-	-	-	-	-
Use of sulphurous solutions, manufacture of cellulose	1.9	-	-	-	-	-	-	-	-	-
Transformation to mineral products	1.0	-	-	0.7	-	-	-	-	-	-
Other industrial processes[1]	2.8	0.0	-	-	1.1	-	8.0	-	-	-

[1] Production of sulphuric acid (SO_2), anode mass (SO_2), titanium dioxide (SO_2) and explosives (NO_x), as well as fermentation processes (NMVOC), processing of sulphurous ore (SO_2) and recycling of scrap iron (Pb).

Source: CBS, SFT

Table 5.6. Emissions to air in 1990 by main source of emission and main sector. 1 000 tonnes unless otherwise specified

Sources and sectors	SO_2	NO_x	CO	CO_2	NM-VOC	Par-ticu-lates	Pb	CH_4	N_2O	NH_3
				Mill. tonnes			Tonnes			
Stationary combustion	11.5	40.6	137.7	13.9	11.4	14.2	1.7	13.9	1.5	-
Energy sectors	1.3	30.3	5.4	8.8	1.9	0.2	1.2	2.6	0.2	-
Primary industries	0.3	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	-
Manufacturing and mining	7.1	7.4	6.4	2.6	0.7	1.5	0.3	0.3	0.7	-
Supply of services	1.2	0.8	0.7	1.0	0.1	0.1	0.1	0.0	0.2	-
Private households	1.6	2.0	125.1	1.4	8.7	12.3	0.0	11.0	0.4	-
Mobile combustion	11.4	180.3	753.3	13.9	103.3	7.2	220.5	3.1	0.9	0.2
Energy sectors	1.1	14.7	2.7	0.7	0.9	0.3	0.5	0.2	0.0	-
Primary industries	2.5	40.7	16.4	2.0	4.3	1.6	2.1	0.5	0.1	0.0
Manufacturing and mining	0.4	5.5	6.8	0.4	1.1	0.3	1.5	0.1	0.0	0.0
Supply of services	6.5	74.9	166.8	6.4	22.6	4.0	47.4	0.9	0.5	0.1
Private households	1.0	44.6	560.5	4.5	74.4	1.0	168.9	1.5	0.2	0.2
Processes/evaporation	30.6	9.3	60.0	7.3	155.2	-	8.0	264.8	13.2	37.9
Energy sectors	3.9	-	-	0.4	110.8	-	-	13.6	-	-
Primary industries	-	-	-	0.2	-	-	-	91.0	6.5	37.4
Manufacturing and mining	26.7	9.3	60.0	6.6	19.7	-	8.0	1.0	6.7	0.5
Supply of services	-	-		0.1	14.7	-	-	159.2	-	-
Private households	-	-	-	0.0	10.0	-	-	-	-	-

Source: SFT, CBS

Emissions in Norway 1973-1992

The historical trend in emissions to air can be explained mainly by changes in economic activities, use of energy, technology and measures to reduce emissions. Changes in the use of the different forms of energy are described in more detail in chapter 4 of this report. This section describes the most important changes in emissions of SO_2, NO_x, CO, NMVOC, particulates, lead and CO_2 during the period 1973-1992. Inventories are available for methane and nitrous oxide for the last five years only. Ammonia emissions have been estimated for the years 1988-1991 only. The figures for 1991 are preliminary figures based on the provisional Energy Accounts. These preliminary figures will be fairly good for process emissions and emissions from mobile sources of combustion. The estimated emissions from stationary combustion, excluding activities in the North Sea, are more uncertain. The figures for 1992 are preliminary estimates, and are not distributed by economic sector or source.

There was a marked reduction in **emissions of SO_2** during the period 1973-1992, see figure 5.1. Emissions from stationary combustion decreased from 73 000 tonnes in 1973 to 10 000 tonnes in 1991. Process emissions decreased from 67 000 tonnes to 26 000 tonnes during the same period. The reduction in SO_2-emissions can be explained by several factors:

– The sulphur content of various oil products has been reduced. Regulations concerning the sulphur content of heavy oil came into force in 1977 in the coastal counties of Southern Norway, and were made more stringent in the 13 southernmost counties in 1986.

– A ten-year programme to clean up older polluting industry was started in 1974. The programme involved granting permits for emissions and issuing instructions to install cleaning equipment in a number of undertakings.

– There was a good supply of surplus electricity in the 1980s. This reduced the use of oil, particularly in the pulp and paper processing industry.

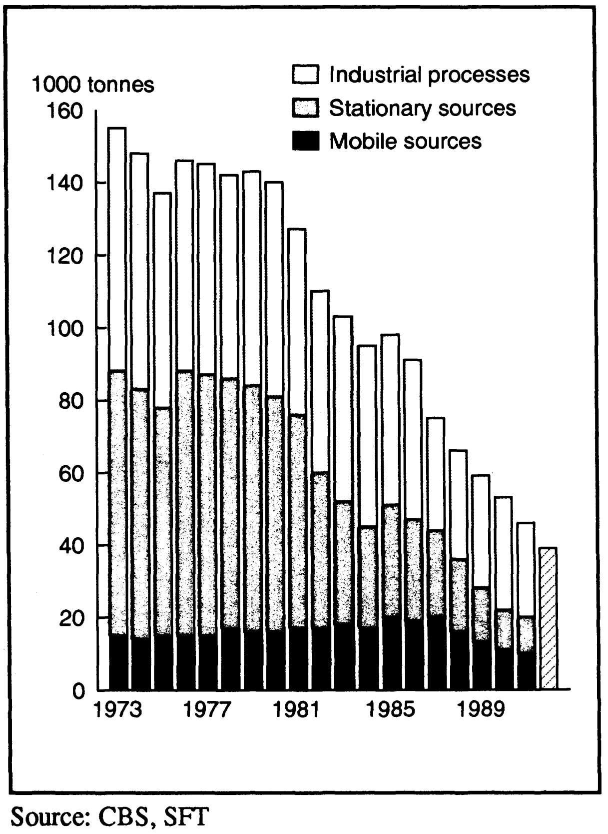
Table 5.7. Emissions to air by source. 1991. Preliminary figures. 1 000 tonnes unless otherwise specified

Sources	SO_2	NO_x	CO	CO_2	NM-VOC	Particulates	Pb	CH_4	N_2O	NH_3
				Mill. tonnes			Tonnes			
Total	46.0	218.4	909.1	33.4	276.3	21.3	182.0	278.6	14.9	38.1
Stationary combustion	10.4	37.6	137.5	13.3	11.4	14.1	1.7	14.0	1.4	-
Gas turbines	0.0	14.9	4.1	5.7	0.6	0.0	-	2.2	0.0	-
Flares	0.0	5.8	0.5	1.1	0.7	0.0	-	0.3	0.0	-
Incineration of waste	0.3	1.0	0.3	0.1	0.3	-	1.3	0.1	-	-
Other combustion	10.0	15.9	132.6	6.4	9.9	14.1	0.3	11.5	1.4	-
Mobile combustion	10.0	173.4	723.0	13.6	99.7	7.2	178.3	3.0	0.9	0.3
Road traffic	3.3	80.1	676.7	7.9	79.7	4.0	170.6	1.7	0.6	0.3
Passenger cars	1.2	48.0	613.4	5.1	69.9	1.2	157.9	1.5	0.3	0.3
Gasoline	0.9	47.1	612.3	4.9	69.6	0.7	157.9	1.5	0.3	0.3
Diesel	0.2	0.9	1.1	0.2	0.3	0.5	0.0	0.0	0.0	0.0
Vans	0.3	5.2	43.1	0.7	5.5	0.7	11.2	0.1	0.0	0.0
Gasoline	0.1	4.0	41.8	0.3	5.1	0.0	11.2	0.1	0.0	0.0
Diesel	0.3	1.2	1.4	0.3	0.4	0.6	0.0	0.0	0.0	0.0
Heavy vehicles	1.8	26.9	20.1	2.1	4.2	2.2	1.4	0.1	0.3	0.0
Gasoline	0.0	0.5	6.8	0.0	0.6	0.0	1.4	0.0	0.0	0.0
Diesel	1.8	26.3	13.4	2.1	3.6	2.2	0.0	0.0	0.3	0.0
Motorcycles, two-stroke engines, tractors and motorized tools	0.6	11.0	37.0	0.8	16.4	1.5	5.2	0.2	0.0	0.0
Railways	0.1	0.7	0.2	0.1	0.1	0.1	0.0	0.0	0.0	-
Air traffic	0.1	3.6	3.0	1.2	0.5	0.2	1.9	0.0	0.1	-
Ships and boats	5.8	78.1	6.1	3.5	3.0	1.3	0.5	1.0	0.2	-
Processes and evaporation	25.6	7.5	48.6	6.5	165.2	-	2.0	261.6	12.6	37.8
Domestic animals and manuring	-	-	-	-	-	-	-	91.0	6.5	37.4
Liming	-	-	-	0.2	-	-	-	-	-	-
Biological degradation of waste	-	-	-	0.1	-	-	-	155.1	-	-
Evaporation, solvents	-	-	-	0.1	31.6	-	-	-	-	-
Gasoline distribution	-	-	-	0.0	9.2	-	-	-	-	-
Oil loading	-	-	-	0.3	108.7	-	-	3.1	-	-
Refining, crude oil and natural gas	2.4	-	-	0.0	8.7	-	-	0.3	-	-
Extraction: crude oil, natural gas and coal	-	-	-	0.0	3.7	-	-	11.4	-	-
Transformation of nitrogen to artificial fertilizers	-	1.6	-	0.6	-	-	-	-	6.1	0.3
Reduction of ore to metals and alloys	14.4	5.8	18.0	4.2	1.3	-	-	-	-	-
Use of coke and coal for production of carbides	3.7	-	30.6	0.4	-	-	-	0.8	-	-
Transformation of gas to basic plastic	-	-	-	0.0	0.9	-	-	-	-	-
Use of sulphurous solutions, manufacture of cellulose	1.6	-	-	-	-	-	-	-	-	-
Transformation to mineral products	0.8	-	-	0.6	-	-	-	-	-	-
Other industrial processes[1]	2.8	0.0	-	-	1.1	-	2.0	-	-	-

[1] Production of sulphuric acid (SO_2), anode mass (SO_2), titanium dioxide (SO_2) and explosives (NO_x), as well as fermentation processes (NMVOC), processing of sulphurous ore (SO_2) and recycling of scrap iron (Pb).

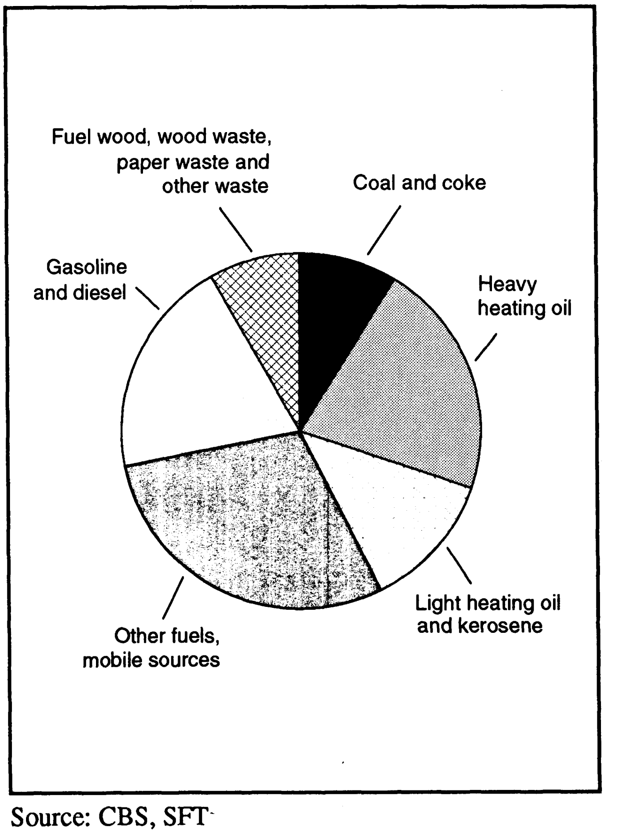
Source: CBS, SFT

Figure 5.1. Emissions of SO_2 by source. 1973-1992*. 1 000 tonnes SO_2



Source: CBS, SFT

Figure 5.2. Emissions of SO_2 from combustion by source of energy. 1991



Source: CBS, SFT

– There were several mild winters at the end of the period, which led to less use of energy for heating.

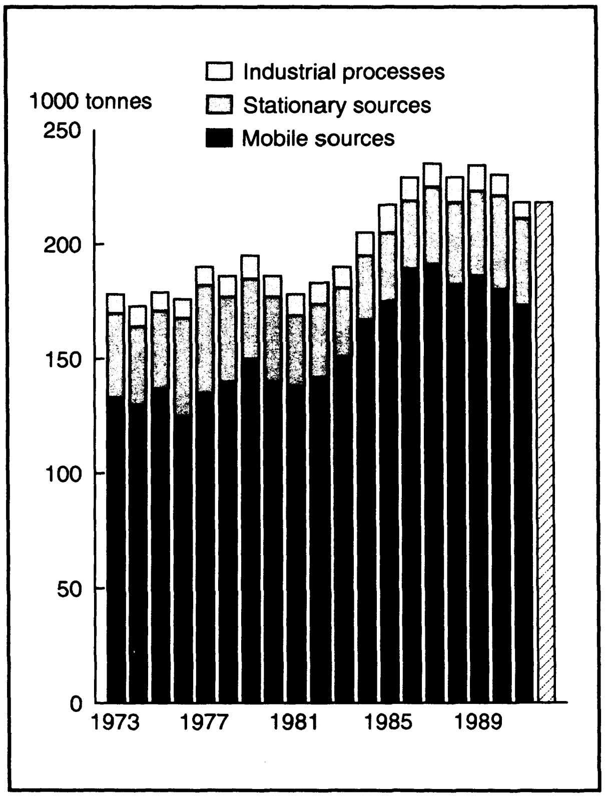
Due to the factors listed above, total emissions were reduced by about 75 per cent during the period 1973-1992. Norway has undertaken to reduce the emissions by 30 per cent by 1993, compared with 1980. The preliminary figures indicate a reduction of about 70 per cent from 1980 to 1992. The reduction in total SO_2-emissions from 1990 to 1991 was 14 per cent. A decrease of about 15 per cent is expected from 1991 to 1992. The largest reductions in emissions have occurred in the pulp and paper processing industry, from 33 000 tonnes in 1976 to 2 900 tonnes in 1991. This sector is the largest consumer of surplus electricity. The smelting works at A/S Sulitjelma were closed down in 1987, implying a reduction in emissions of SO_2 from industrial processes. The emissions from industrial processes were reduced by 16 per cent from 1990 to 1991 after having remained stable at 1987 level up to 1990. Emissions from stationary sources were halved from 1988 to 1991; the same applies to emissions from mobile sources in relation to emissions in 1987.

More than half the SO_2-emissions in Norway originate from industrial processes. The rest are equally distributed between stationary and mobile sources. Figure 5.2 shows emissions from fuel consumption in 1991 distributed between the different sources of energy.

Industrial activities were the cause of 64 per cent of the total emissions of SO_2 in 1990. About half this amount originated from manufacture of metals. In this case, SO_2-emissions are normally dependent on both the sulphur content in the coal or coke and sulphur in the ore. Other industries causing substantial emissions are manufacture of industrial chemicals, oil refining, pulp and paper processing and domestic sea transport.

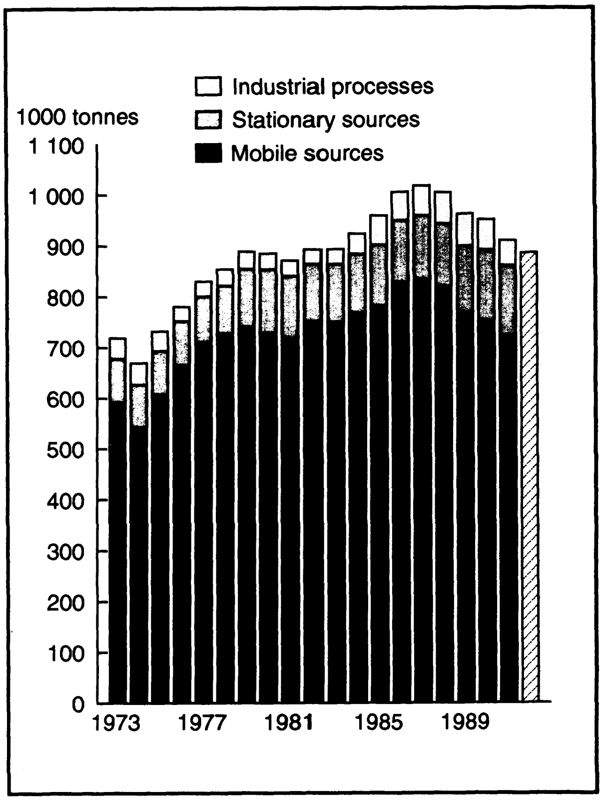
There was a marked increase in **emissions of NO_x** during the first half of the 1980s; after having remained almost stable from 1986 to 1990 these emissions decreased by almost 5 per cent from 1990 to 1991, see figure 5.3. According to the provisional figures, the emissions

Figure 5.3. Emissions of NOx by source. 1973-1992*. 1 000 tonnes NOx



Source: CBS, SFT

Figure 5.4. Emissions of CO by source. 1973-1992*. 1 000 tonnes CO



Source: CBS, SFT

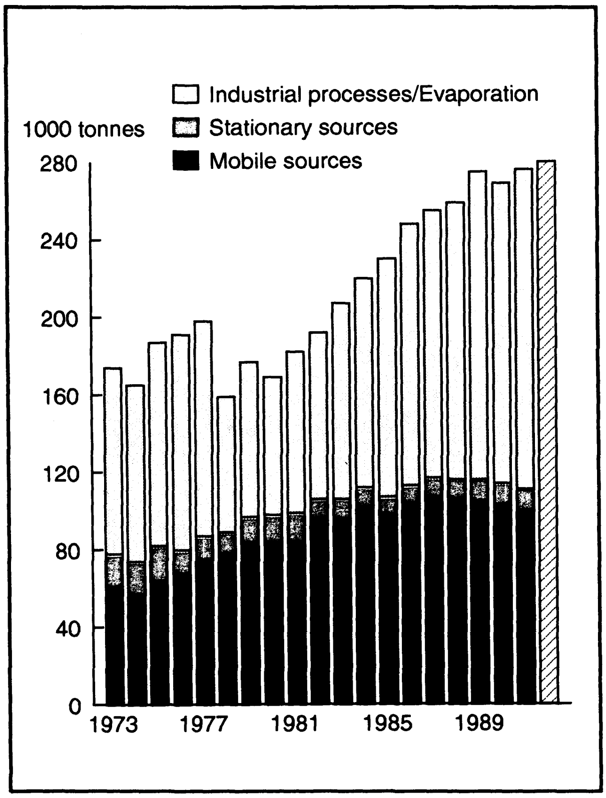
remained unchanged from 1991 to 1992. The main reason for the strong increase in the 1980s was increased use of passenger cars. Mobile combustion was the cause of 78 per cent of the emissions in 1990, the dominating sources being ships and road traffic. In 1989, catalyzers were made mandatory in new cars run on gasoline. About 18 per cent of the total emissions in 1990 originated from stationary combustion. The main reasons for the reduction from 1990 to 1991 are less burning in flares, reduced gasoline consumption, more cars with catalyzers, reduced fuel consumption within the fisheries and sea transport, and smaller emissions from industrial processes. The largest emissions of NO_x are connected to extraction of oil and gas, fishing, transportation and private households.

Norway has undertaken to stabilize emissions of NO_x at 1987 level by 1994. Preliminary figures indicate that the emissions have been reduced by more than 7 per cent from 1987 to 1992.

Emissions of CO remained relatively stable during the 1980s up to 1985, increased slightly up to 1987, and then decreased, see figure 5.4. The increase from 1985 to 1987 was due to larger consumption of gasoline. 76 per cent of the total CO-emissions in 1990 originate from combustion of gasoline; most important are "cold starts" and old cars. The increase in the use of passenger cars in the 1980s had a stronger impact than improvements in combustion technology. During the last couple of years, consumption of transport oils (including gasoline) have decreased slightly. In recent years the reduction in emissions has been particularly marked for mobile sources. Passenger cars are responsible for about 70 per cent of the emissions from mobile sources.

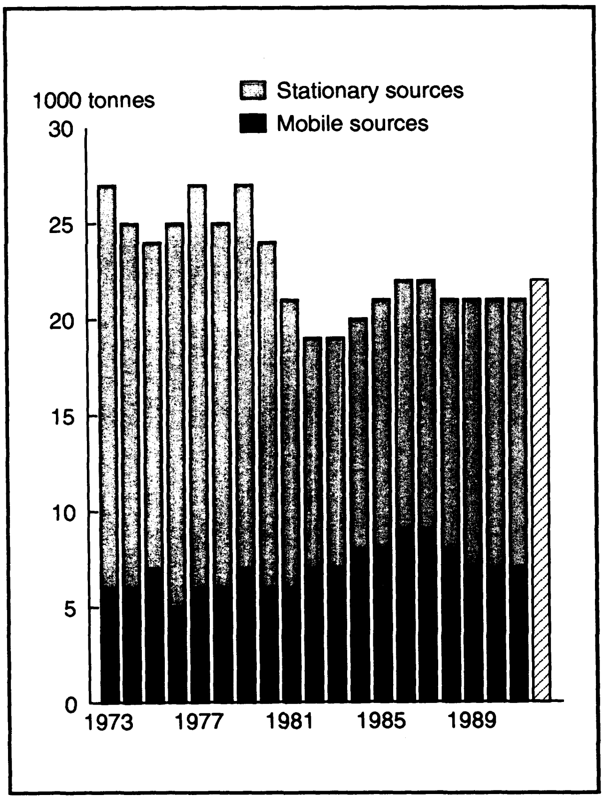
Emissions of CO from industrial processes decreased considerably in 1991 after having remained stable during the preceding few years. In 1990, about 6 per cent of the total emissions came from industrial processes. The most important sources are manufacturing of magnesium, and especially carbides. Stationary com-

Figure 5.5. Emissions of NMVOC by source. 1973-1992*. 1 000 tonnes NMVOC



Source: CBS, SFT

Figure 5.6. Emissions of particulates by source. 1973-1992*. 1 000 tonnes particulates



Source: CBS, SFT

bustion was the cause of 14 per cent of the total emissions. 93 per cent of this 14 per cent came from combustion of wood, and most of this, 95 per cent, originates from the burning of wood in small stoves in private households. Emissions from stationary sources increased slightly during the 1980s, owing to more use of wood. The estimates of wood consumption are based, however, on rather uncertain data.

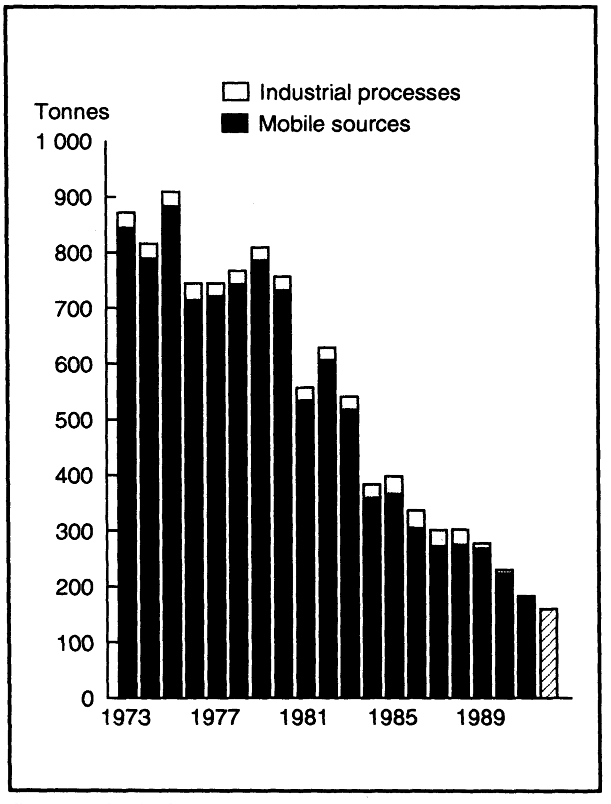
Emissions of volatile organic compounds (NMVOC) increased around the mid-1970s due to a higher level of activity in the oil sector. Emissions from this sector decreased again with the change to other methods of landing the oil. The increase in total emissions up to 1987 can be partly explained by the landing of crude oil from new fields, and partly by increased emissions from mobile sources, see figure 5.5. The figures for NMVOC emissions in general are very uncertain.

The main sources of emissions of NMVOC are evaporation, distribution of oil products, gasoline-driven cars and processes connected to extraction of oil and gas. About 54 per cent of the NMVOC emissions in 1991 were connected to processes or evaporation. Emissions from oil activities (including transport of crude oil and gas terminal) accounted for about 42 per cent of the total emissions in 1991. The decidedly largest source was shipping of crude oil. Emissions from use of solvents accounted for about 11 per cent of the total NMVOC-emissions, but this figure is very uncertain.

Incomplete combustion in mobile sources, as well as evaporation, accounted for about 36 per cent of the total emissions in 1991. Use of passenger cars in particular, but also two-stroke engines, were important in this connection. Only 4 per cent of the NMVOC emissions originated from stationary combustion, the most important source being burning of wood in private households.

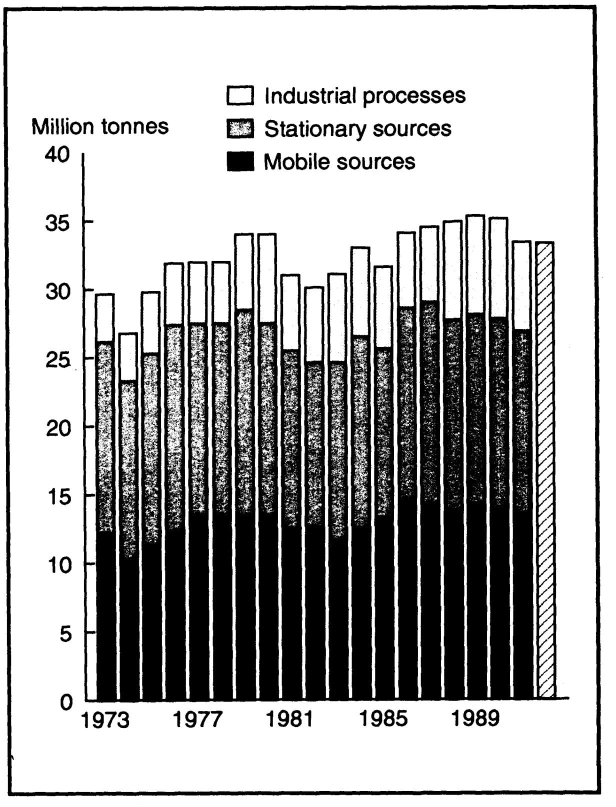
Norway has undertaken to reduce emissions of NMVOC by 30 per cent by 1999, compared with 1989; preliminary figures show that the emissions *increased* by about 3 per cent from 1989 to 1992.

Figure 5.7. Emissions of lead by source. 1973-1992*
Tonnes Pb



Source: CBS, SFT

Figure 5.8. Emissions of CO_2 by source. 1973-1992*
Million tonnes CO_2



Source: CBS, SFT

Emissions of particulates decreased from 1973 up to 1983, see figure 5.6. The main reason was less stationary combustion of heavy oil. The decrease was followed by an increase up to 1987, owing to higher consumption of wood in private households in addition to increased use of passenger cars. No marked changes have occurred in emissions of particulates since 1988.

34 per cent of the total emissions in 1990 originated from mobile sources, with 64 per cent of this amount coming from diesel-driven engines.

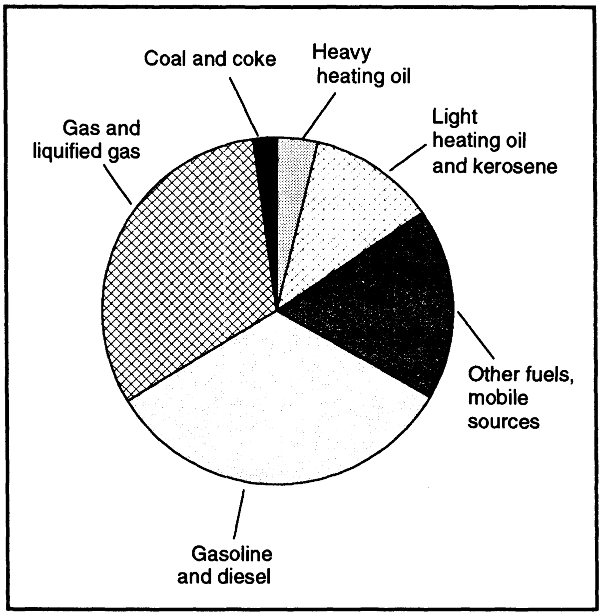
Private households accounted for 62 per cent of the total emissions of particulates in 1990. The main reason was heating with wood. Domestic transportation accounted for 13 per cent of the emissions in 1990.

Emissions of lead have decreased in recent years, see figure 5.7. The reason was reduced content of lead in gasoline (regulations came into force in 1980 and 1983), in addition to the introduction of non-leaded gasoline in 1986. In 1991, sales of non-leaded gasoline accounted for 47 per cent of total sales. A/S Christiania Spigerverk was closed down in 1989. This is the most important reason for the decrease in emissions of lead from industrial processes from 1988 to 1989. Industrial processes and stationary sources (incineration of waste and combustion of oil) together accounted for only 2 per cent of the total emissions in 1991.

In 1991, 98 per cent of the emissions of lead originated from mobile sources and were almost entirely due to the addition of lead to gasoline. Private households and provision of services are the most important sectors as regards emissions of lead.

Emissions of CO_2 have varied somewhat during the period. Figure 5.8. shows a marked decrease in emissions from 1973 to 1974, followed by an increase up to 1979/1980. Emissions decreased again up to 1982. This trend was followed by a slight rise up to 1990, which was again followed by a slight reduction of emissions in 1991. The reason for the clear reductions was reduced consumption of oil products owing to higher prices in 1973-74, 1979-80,

Figure 5.9. Emissions of CO_2 from combustion of different forms of energy. 1991



Source: CBS, SFT

and 1990-91. There has been a general decline in consumption of oil products since 1987, but combustion connected to extraction and processing of oil and gas has increased. Figure 5.9 shows the connection between emissions of CO_2 from combustion and the different sources of energy in 1991.

Mobile and stationary sources each contributed to about 40 per cent of the carbon dioxide emissions in 1991. The remainder, 20 per cent, originated from industrial processes, where the main source of the emissions was manufacturing of metals. Extraction of oil and gas accounts for the largest share of the total emissions, 23 per cent, followed by private households, 17 per cent, metals manufacturing, 14 per cent, and transportation, 13 per cent.

The Storting (Norwegian National Assembly) has made it a provisional national goal to stabilize CO_2-emissions at 1989 level by the year 2000; preliminary figures show that the emissions decreased by 5.5 per cent from 1989 to 1992.

Emissions of methane remained at about the same level throughout the period 1987-1991; in 1991 they amounted to 279 000 tonnes. The two most important sources of methane emissions are domestic animal husbandry/manuring and deposition of waste, which accounted respectively for 33 per cent and 56 per cent of the total emissions in 1991. Emissions of methane from activities connected to extraction of oil and gas (including shipping of crude oil, and the gas terminal at Kårstø) accounted for 4 per cent. Stationary combustion accounted for 5 per cent and mobile combustion 1 per cent of the total emissions, with the largest contribution again originating from heating with wood in private households.

There are two main sources of **emissions of N_2O**. These are use of manure and commercial fertilizer in agriculture, and production of nitric acid. The former accounted for 44 and the latter for 41 per cent of the total emissions of nitrous oxide in 1991. 9 per cent of the emissions came from stationary sources and 6 per cent from mobile sources. Emissions of nitrous oxide in Norway have been reduced during the period 1987-1991.

Emissions of NH_3 amounted to 38 000 tonnes in 1990. These emissions depend to a large extent on number of domestic animals and spreading of manure, 85 per cent, as well as the use and composition of commercial fertilizers, 14 per cent. A very small share of the emissions comes from production of ammonia. The emission figures for ammonia are very uncertain.

Emissions of CFCs and halons

The State Pollution Control Authority has collected figures on imports of CFCs and halons as raw materials in 1986, 1989, 1990, 1991 and 1992. The time series is shown in table 5.8. There are no good figures for annual emissions of these compounds but, averaged over time, the import statistics also indicate the level of emissions. Imports of CFC-compounds decreased by 77 per cent from 1986 to 1992.

It has been found difficult to replace halon in various fire-extinguishing installations but, in spite of this, imports have decreased by 71 per cent since 1986. New regulations banning the use of halon in Norway came into force on 1 July 1991. However, dispensation from the ban has been granted in some cases. Today, it is possible to use hydro-chlorofluorocarbons, so-called HCFCs, as a substitute for CFCs. Most of these will also have an ozone-depleting effect, but not as great as that of CFCs. Consumption of HCFCs is now also regulated by the Montreal Protocol. Hydrofluorocarbons not containing chlorine are now used in refrigeration plants. These compounds have no known harmful effects on stratospheric ozone, but are more expensive. However, all these substitutes for CFCs are regarded as greenhouse gases.

Long-range transported air pollution

Through EMEP (European Monitoring and Evaluation Programme), a co-operative programme for monitoring and evaluation of long-range transported air pollution in Europe, Norway's own contributions of oxidized sulphur and nitrogen, and the amounts of these components received from other countries, have been calculated for the years 1985 and 1987-1991. The calculations include only contributions from European countries. They are based on reported and estimated emission figures coupled with meteorological, physical and chemical data in order to model horizontal transport in the atmosphere. The calculated concentrations are compared with the observed values. Oxidized nitrogen occurs mainly in the form of NO_2 and NO_3^-, and oxidized sulphur as SO_2 and SO_4^{2-}. The results of the calculations for 1991 are shown in figures 5.10 and 5.11. The overview includes only countries that affect Norway to a significant degree, The item "other countries" represents the sum of small contributions from Hungary, Italy, Rumania, Spain and Yugoslavia. Marine areas where emissions both occur and are received are the Baltic Sea, the Norwegian Sea and the Atlantic Ocean. Some of the sulphur emissions originate from natural sources, mainly marine biological processes.

Norway is the recipient of 135 000 tonnes of oxidized sulphur (measured as S) and 85 000 tonnes of oxidized nitrogen (measured as N) (provisional figures 1991). Only 5 per cent of the sulphur and 7 per cent of the nitrogen originate in Norway. The main contributors are Great Britain, Germany, Poland and the earlier Soviet Union. The calculations also show large differences within Norway itself. The southernmost counties are exposed to the greatest load of pollution. The Norwegian emissions are deposited mainly in immediate marine areas. Sweden and the earlier Soviet Union are also important recipients.

Table 5.8. Raw materials import of CFCs and halons to Norway in 1986-1992[1]. Tonnes

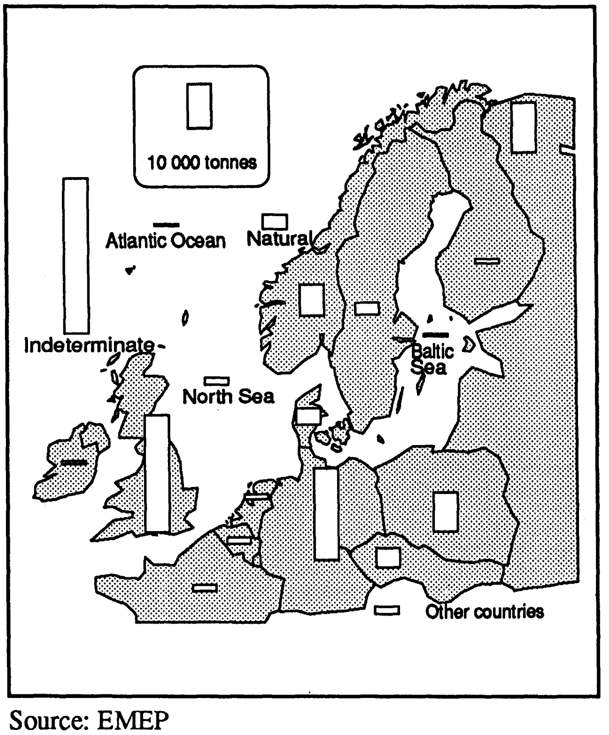
	1986	1989	1990	1991	1992
Total import of CFCs	1 411	990	773	478	331
KFK-11 ($CFCl_3$)	680	418	314	97	13
KFK-12 (CF_2Cl_2)	311	234	200	169	162
KFK-113 ($C_2F_3Cl_3$)	350	262	194	122	97
KFK-114 ($C_2F_4Cl_2$)	-	1	1	1	1
KFK-115 (C_2F_5Cl)	70	75	64	89	59
Total import of halons	151	90	136	90	44
Halon 1211(CF_2BrCl)	13	4	4	3	-
Halon 1301 (CF_3Br)	136	86	132	87	44
Halon 2402 (C_2F_4Br)	2	-	-	-	-

[1] Import in products not included.
Source: SFT

Agreements

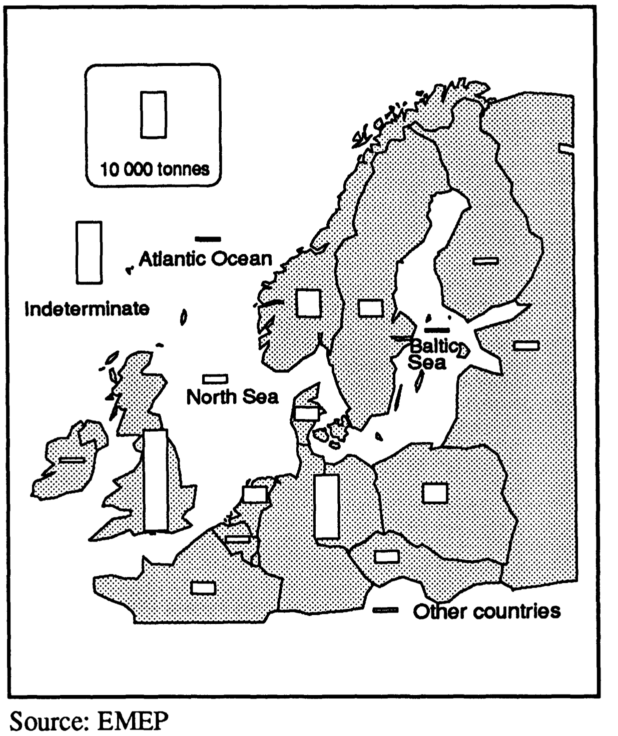
Norway has undertaken to reduce emissions of certain components. Box 5.2 summarizes these agreements and national goals. The most recent agreement (1991) refers to reductions of emissions of non-methane volatile organic compounds (NMVOCs).

Figure 5.10. Supply of oxidized sulphur (measured as S) to Norway from European countries and marine areas. 1991



Source: EMEP

Figure 5.11. Supply of oxidized nitrogen (measured as N) to Norway from European countries and marine areas. 1991



Source: EMEP

International environmental agreements can take many forms and are committing to a greater or lesser degree. The most important categories of agreements are:

Declarations, most of which are political statements of willingness, often somewhat vaguely formulated.

Conventions, which specify general commitments and objectives in relation to a group of environmental problems for the different partners to the agreement.

Protocols which usually contain specific commitments for the different countries.

In principle, Conventions and Protocols are legally binding, but as yet no sanction mechanisms have been established to ensure that the commitments are met. As an appendix to international agreements, or preceding negotiations on such agreements, it is not unusual for the different countries to publicly announce national targets for stabilizing or reducing various kinds of environmentally harmful emissions.

The following is a short list of some international agreements which Norway is party to. The brackets show the year the agreement was signed. The agreements may include other provisions and requirements than those stated below.

Declarations	*Problems*	*Goals*
North Sea Declaration (1990)	Micropollutants	50 per cent reduction by 1995 with 1985 as base year. 70 per cent for cadmium, mercury, lead and dioxins
	Nutrients	50 per cent reduction by 1995 with 1985 as base year
	PCB	Cease all use by 1995
Conventions		
ECE (1979)		Limits on long-range transboundary air pollution
Vienna (1987)		Protect the stratospheric ozone shield
Protocols		
Helsinki (1985)	SO_2	30 per cent reduction by 1993 with 1980 as base year
Sophia (1988)	NO_x	Stabilization at the 1987 level by 1994.
Montreal (1987)	CFCs	Reduce use of CFCs by 75 per cent by 1994 with 1986 as base year. Phasing out by 1996.
	Halons	Phasing out by 1994.
London (1990)	CFCs	With 1986 as base year: 20 per cent reduction by 1993, 85 per cent reduction by 1997 and complete phasing out by the year 2000.
	Halons	50 per cent reduction by 1995 and complete phasing out by the year 2000.
	Carbon-tetrachloride	85 per cent reduction by 1995 with 1989 as base year, and phasing out by 1996.
	Metyl-chloroform	50 per cent reduction by 1994 with 1989 as base year, complete phasing out by 1996.
Genèva (1991)	NMVOC	30 per cent reduction by 1999 with 1989 as base year. Applies to all mainland Norway and Norway's economic zone south of latitude 62° North.
National goals		
	SO_2	50 per cent reduction by 1993 with 1980 as base year.
	NO_x	30 per cent reduction by 1998 with 1986 as base year.
	CO_2	Stabilization at the 1989 level by the year 2000.
	CFCs	Prohibited by 1995.
	Halons	Prohibited by 1995.

Box 5.2. International agreements signed by Norway.

5.3. Emissions to air from road traffic

Emissions from road traffic are influenced by many different factors. The most important are type of vehicle, technology, distance driven, age of the vehicle and "cold starts". Values for gasoline and autodiesel consumption are important for calculating total emissions of the different components in Norway.

Exhaust emission criteria have now been laid down, or are planned, for all gasoline-driven and diesel-driven vehicles in Norway, except for mopeds, motorcycles and heavy vehicles run on gasoline. The exhaust emission criteria imply that all new vehicles shall emit less than the specified limit, also after having been run for some time. Exhaust emissions from gasoline-driven passenger cars have had to meet certain requirements since 1974. During the 1970 and the 1980s, steadily more stringent exhaust emission criteria were imposed for passenger cars (ECE 15-00 - 15-04). New criteria were laid down for passenger cars in 1989 (US-83). To satisfy these requirements, the car is required to have a three-way catalytic convertor. The criteria for heavier diesel-driven vehicles are the same as in the EC countries, and will be made effective on 1 October 1993 both in Norway and the EC. Today, there are no exhaust emission criteria applying to these vehicles.

When the vehicle is in use, it will normally generate more exhaust emissions, though in some cases less, than it did when it was new. The effect of aging is particularly important for cars with a catalyzer, since this device is very effective in reducing the emissions to start with, but becomes less effective as time goes on. For example, if the car has driven 140 000 km, the emissions of NO_x will be more than three times as great as when the car was new. However, it will still emit only 19 per cent compared with a similar car without a catalyzer. In the case of gasoline-driven cars without a catalyzer, emissions of hydrocarbons (VOC) and CO increase for each kilometre driven as the car gets older, while emissions of NO_x decrease. In the case of heavy diesel-driven vehicles, emissions of CO and particulates increase but emissions of VOC and NO_x decrease. Fuel consumption per kilometre increases as the car gets older. The results of the calculations for 1991, for different classes of vehicles and ways of driving, are shown in table 5.9 and 5.10. The emissions from gasoline-driven passenger cars, distributed by technological classes, are shown in table 5.11.

Table 5.9. Emissions and fuel consumption from road traffic. Classes of vehicles. 1991. 1000 tonnes unless otherwise specified

Class	Fuel cons.	CO_2	SO_2	Lead	CO	NO_x	Particulates	NMVOC	CH_4	N_2O	NH_3
		Mill. tonnes		Tonnes							
Total	.	7.9	3.3	172	687.6	80.1	4.0	83.7	1.8	0.6	0.3
Total gasoline	1697	5.3	1.0	172	671.7	51.7	0.7	79.4	1.7	0.3	0.3
Passenger cars	1556	4.9	0.9	158	612.2	47.1	0.7	69.6	1.5	0.3	0.3
Vans	111	0.3	0.1	11	41.8	4.0	0.0	5.1	0.1	0.0	0.0
Goods vehicles etc.	12	0.0	0.0	1	5.6	0.4	0.0	0.5	0.0	0.0	0.0
Buses	2	0.0	0.0	0	1.1	0.1	0.0	0.1	0.0	0.0	0.0
Mopeds	8	0.0	0.0	1	5.7	0.0	0.0	3.0	0.0	0.0	0.0
Motorcycles	7	0.0	0.0	1	5.2	0.0	0.0	1.0	0.0	0.0	0.0
Total diesel	830	2.6	2.3	0	15.8	28.4	3.3	4.3	0.1	0.3	0.0
Passenger cars	78	0.2	0.2	0	1.1	0.9	0.5	0.3	0.0	0.0	0.0
Vans	97	0.3	0.3	0	1.4	1.2	0.6	0.4	0.0	0.0	0.0
Goods vehicles etc.	490	1.6	1.4	0	10.9	19.8	1.7	2.9	0.0	0.2	0.0
Buses	164	0.5	0.5	0	2.5	6.5	0.5	0.7	0.0	0.1	0.0

Source: Institute of Technology (TI), Norwegian Institute for Air Research (NILU) and CBS

Different classes of vehicles influence the different pollution components. In general, gasoline-driven vehicles are of particular importance for emissions of lead, CO and NMVOC. Diesel-driven vehicles are of particular importance for emissions of SO_2 and particulates. Both types of vehicles are important for emissions of CO_2, NO_x and N_2O. Emissions of methane and ammonia from road traffic are small in relation to the total emissions from this source. The trend in gasoline and autodiesel consumption 1973-1991 is shown in figure 5.12. Road traffic's share of total emissions of the different components in 1991, as well as trends in the emissions of certain selected components, 1973-1991, are shown in figure 5.13.

Table 5.10. Emissions and fuel consumption from road traffic, by way of driving. 1991. 1000 tonnes unless otherwise specified

Way of driving	Consumption	CO_2	SO_2	Lead	CO	NO_x	Particulates	NMVOC	CH_4	N_2O	NH_3
		Mill. tonnes		Tonnes							
Total	.	7.9	3.3	172	687.6	80.1	4.0	83.7	1.8	0.6	0.3
Warm engine driving, total	2363	7.4	3.2	157	405.8	79.9	3.8	46.6	1.4	0.6	0.3
Urban driving	732	2.3	0.9	53	161.1	15.8	0.9	17.3	0.5	0.1	0.1
Rural 50-70[1]	474	1.5	0.7	30	76.7	17.7	0.8	9.3	0.3	0.1	0.1
Rural 80[1]	937	2.9	1.3	59	131.4	38.1	1.6	13.6	0.4	0.3	0.2
Motorways	205	0.6	0.3	13	25.6	8.3	0.3	2.7	0.1	0.1	0.0
Moped/motorcycle ...	15	0.0	0.0	2	11.0	0.1	0.0	3.7	0.1	0.0	0.0
Cold starts	163	0.5	0.1	16	281.8	-0.2	0.3	13.8	0.4	0.0	0.0
Evaporation	.	.	.	.	.	.	.	23.3	.	.	.

[1] Speed limits on roads
Source: TI, Norwegian Institute of Air Research (NILU) and CBS

Table 5.11. Emissions and fuel consumption from road traffic. Gasoline-driven passenger cars, by technology. 1991. 1000 tonnes unless otherwise specified

Class	Technology	Year reg.	Fuel cons.	CO_2	SO_2	Lead	CO	NO_x	Particulates	NMVOC	CH_4	N_2O	NH_3
				Mill. tonnes		Tonnes							
Passenger cars	No crit./ ECE 15-00	Before 1978	247	0.8	0.1	25	174.4	6.4	0.1	14.5	0.3	0.0	0.0
	ECE 15-02	1978	112	0.4	0.1	11	57.0	3.2	0.1	6.2	0.1	0.0	0.0
	ECE 15-03	1980	504	1.6	0.3	51	205.8	16.5	0.3	24.4	0.5	0.1	0.0
	ECE 15-03/04	1985	519	1.6	0.3	53	165.7	20.0	0.2	23.7	0.5	0.1	0.0
	US-83	1989	174	0.5	0.1	18	9.2	1.0	0.0	0.9	0.1	0.1	0.3

Source: TI, NILU and CBS

Figure 5.12. Consumption of automobile gasoline and autodiesel in Norway. 1973-1991

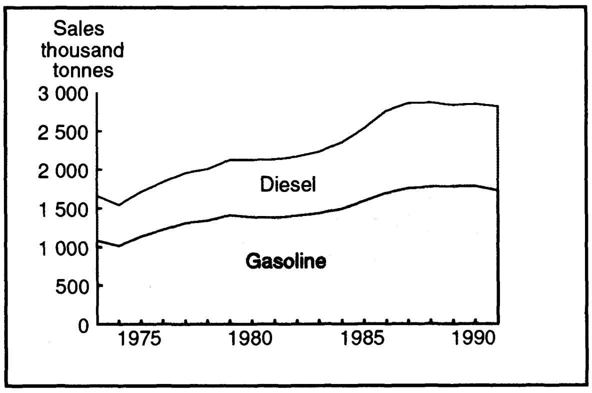
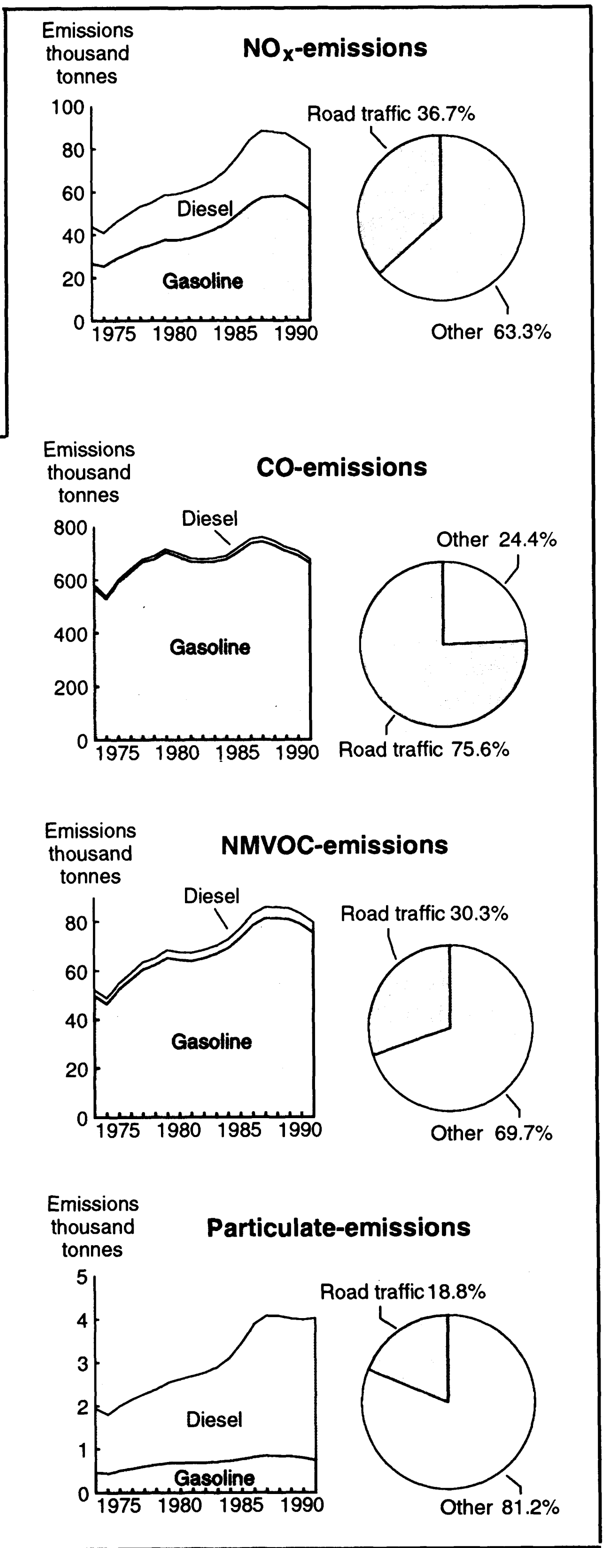
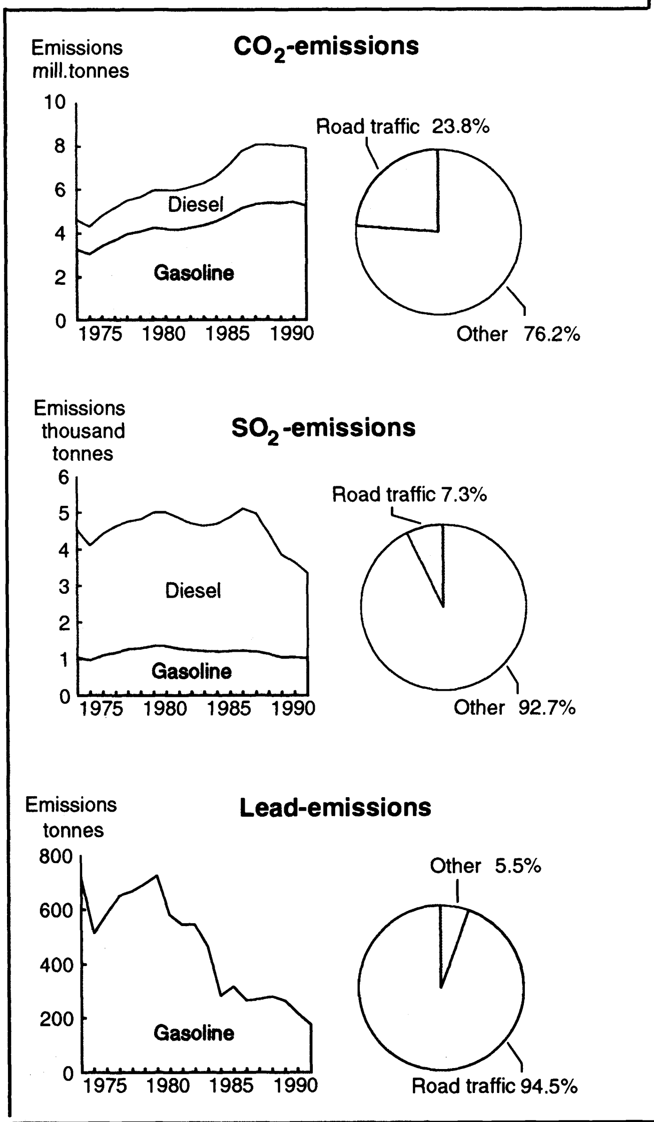


Figure 5.13. Emissions from road traffic 1973-1991 and road traffic's share of total emissions in 1991

Source: CBS, TI, NILU

SO_2, CO_2 and lead: The emissions are respectively affected only by the sulphur, carbon and lead content of the gasoline, and not by the combustion conditions. SO_2-emissions decreased by 26 per cent from 1973 to 1991, in spite of an increase in consumption of gasoline and diesel, owing to reductions in the sulphur content of the fuel. The CO_2-emissions depend only on the consumption of gasoline and diesel. Emissions from road traffic increased by 70 per cent from 1973 to 1991. The emissions of lead depend both on the content of lead in the gasoline and the gasoline consumption. Total emissions decreased by 75 per cent from 1973 to 1991 despite a 62 per cent increase in consumption of gasoline. The decrease in emissions is explained by a lower content of lead in the gasoline and increasing use of non-leaded gasoline.

CO: The emissions are especially large from gasoline-driven cars without a catalyzer. Older cars will normally emit more than newer cars. This is because newer cars, particularly cars with a catalyzer, emit less than cars with older technologies, but also because the specific emission will increase with the age of the car. Although the specific emission (emission per km) decreased during the period, the total emissions increased by 16.5 per cent from 1973 to 1991. This can be explained by the higher consumption of gasoline. The decrease in recent years can be put down to constant or lower consumption of gasoline, and an increase in the share of cars with a catalyzer. "Cold starts" account for 41 per cent of the total emissions from road traffic. This emission can also be linked to gasoline-driven cars in particular.

NO_X: Both gasoline-driven and diesel-driven cars are major sources of emissions. For gasoline-driven cars, the emissions are usually lower from cars with a catalyzer than from other types. Exhaust emission criteria will be imposed for heavy diesel vehicles as from 1 October 1993. There was a strong increase in emissions of this component, 82 per cent, from 1973 to 1991, but a slight reduction has been observed in recent years. There are two reasons for this reduction; stagnation in sales of gasoline and diesel, and a larger share of cars with a catalyzer.

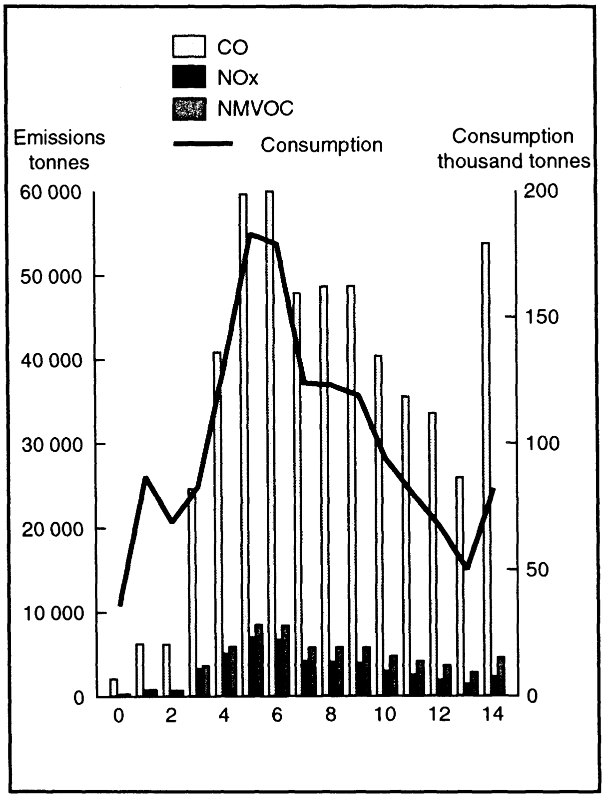
Particulates (exhaust particulates): Diesel-driven vehicles are the most important source of emissions and accounted for 82 per cent of the total emissions from road traffic in 1991. The emissions have increased throughout the period, with an increase of as much as 107 per cent from 1973 to 1991.

NMVOC: Gasoline-driven vehicles are decidedly the most important source of emissions from road traffic, with as high a share as 95 per cent. 56 per cent of this amount originates from cars driven with a warm engine, 17 per cent from "cold starts", and 28 per cent from evaporation from the engine. The total emissions have increased by as much as 47 per cent during the period. The reasons for the decrease in the last couple of years are stagnation in consumption of gasoline and a larger share of cars with a catalyzer.

N_2O: Both gasoline- and diesel-driven cars are sources of emissions. The total emissions increased by as much as 110 per cent from 1973 to 1991. There was also an increase in the total emission from 1990 to 1991. This increase occurred because the specific emissions are higher for gasoline-driven cars with a catalyzer.

Figure 5.14 shows emissions of certain components from gasoline-driven cars as a function of the age of the car. The figure also shows gasoline consumption. There is no direct connection between gasoline consumption and emissions. This is because the different cars meet different exhaust emission criteria, and because the emissions change as the car becomes older. The figure also shows that a relatively large share of the gasoline consumption refers to 5-6 year-old cars (compared with 1991). The age-distribution of gasoline-driven passenger cars is shown in figure 5.15. In 1991, there were 170 285 light passenger cars registered in 1986, and only 61 750 registered in 1990. However, the annual average distance driven is higher for new cars than for older cars. The emissions from gasoline-driven cars per vehicle-kilometre is shown in figure 5.16. The figure shows that the emissions of NO_X, NMVOC and CO per vehicle/kilometre increase considerably with the age of the vehicle. Most vehicles between 0 and 3 years of age have a catalyzer, and emissions are very small compared with those from older cars. CO_2-

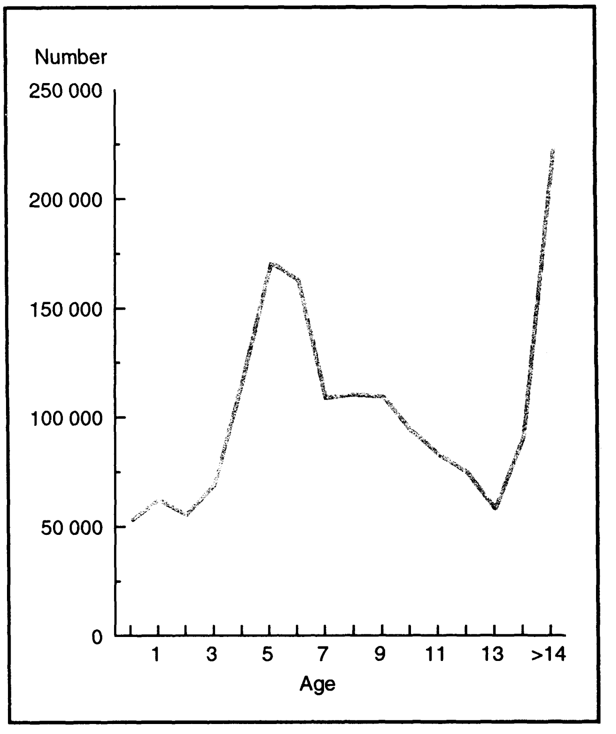
Figure 5.14. Fuel consumption and emissions of NO_x, CO and NMVOC for different age classes. Gasoline-driven cars. 1991



Source: CBS, TI, NILU

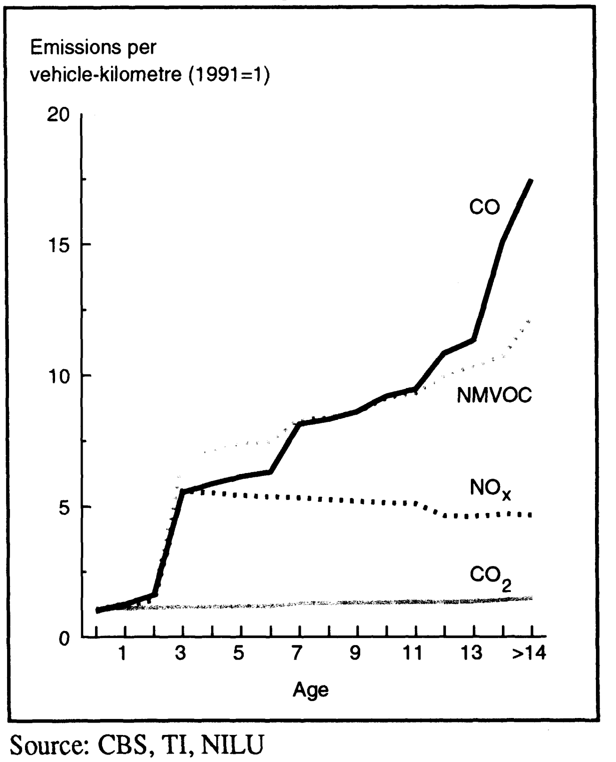
emissions per vehicle-kilometre are also dependent on the age of the car. This is because new cars use less gasoline per kilometre.

Figure 5.15. Age distribution of the stock of gasoline-driven passenger cars. 1991



Source: Directorate of Roads

Figure 5.16. Emissions of CO_2, NO_x, CO and NMVOC from gasoline-driven vehicles, by vehicle-kilometres, for different age classes. Index: 1991=1



Source: CBS, TI, NILU

There has been a strong increase in the number of passenger cars, gasoline consumption and number of kilometres driven from the time when passenger cars became generally available up to today. Figure 1 shows the trend in gasoline consumption in private households and the real price of gasoline, taxes included, from 1973 to 1991 (source: CBS). Gasoline consumption has doubled during this period, from 920 million litres in 1973 to about 1820 million litres in 1991. Except in the years 1973-74 and 1990-91, consumption of gasoline in private households has increased steadily. For the period as a whole, the growth in consumption has averaged about 3.9 per cent per year. The average yearly increase in prices was 0.8 per cent. Changes in prices have been much more uneven than changes in consumption, with long periods of decreasing real prices. The figure indicates a relatively clear, negative relation between real price and consumption. Growth in consumption is greatest in periods when real prices are decreasing, and weakest in periods when prices are increasing. The relation is most obvious for the period from 1973 to 1974, where the real price of gasoline increased by about 20 per cent owing to a strong increase in the world market price of crude oil. The price increase was reflected in a corresponding percentage decrease in gasoline consumption.

Figure 2 (source: Institute of Transport Economics (Transportøkonomisk institutt - TØI) and CBS) shows growth in the number of registered cars, total distances driven by passenger cars, and the real disposable income of private households. From 1973 to 1991 the stock of private cars increased by an average of 3.2 per cent per year. In 1973 there were about 0.9 million private cars, and in 1991 rather more than 1.6 million, an increase of 77 per cent. The number of persons per car has dropped from 4.3 persons in 1973 to 2.6 persons in 1991. The growth in the number of kilometres driven is much higher than the growth in the number of private cars. The number of driven kilometres was more than doubled during the period, with an average annual increase of 4.1 per cent. In addition, there was a marked improvement in energy efficiency, since an average car (in terms of age and type), at average speed, used about 0.95 litres of gasoline per 10 kilometres in 1973 and 0.81 litres per 10 kilometres in 1991 (source: TØI). Thus every car covered a longer distance in the course of a year in 1991 than in 1973, but used less gasoline per kilometre. In order to explain the growth in the stock of cars and in the number of kilometres driven it is natural to consider the periods before and after 1986 separately, since this was the year when an obvious change occurred in the growth rate. Up to 1986 the growth in the stock of private cars was 4.4 per cent per year, and growth in the number of kilometres driven was 5.2 per cent per year. This can be only partly explained by the increase in the real disposable income of private households, which was 2.5 per cent. Other contributory factors were increased participation if women in the labour force, and more leisure time per employee. There has been a slight decrease in the number of private cars since 1986. This corresponds with very weak growth in household income. Lack of growth in the stock of cars is due to impacts from preceding years, when the growth was very strong and the market, to some extent, was saturated. The weak growth in income implied that cars were not replaced at the same rate as they otherwise would have been. The average age of private cars increased during the period from 6.3 years in 1975 to 8.7 years in 1989 (source: TØI). Since the growth in the stock of private cars has stopped, there is reason to believe that the average age has further increased since 1989. The higher average age corresponds with a slight decrease in distance driven during the last two years, since new cars are driven more than older ones are.

Developments in the future will depend on trends in employment, household income, and relative prices. No immediate increase in sales of new cars is expected, since only a moderate increase is expected for both income and employment in the short term. The free float of the Norwegian krone at the end of last year led to some depreciation of the krone in relation to other currencies, which is expected to cause an increase in car prices. Further, without new growth in car sales in particular, and in income and employment in general, neither the distance driven nor consumption of gasoline is expected to increase in the immediate future. In the longer term, however, there is reason to expect an improvement in economic growth. With no substantial changes in relative prices, or new restrictions on the use of passenger cars, the growth in the number and use of passenger cars will continue.

Figure 1. Real price and gasoline consumption by the households. 1973-1991. Indices, 1973=1

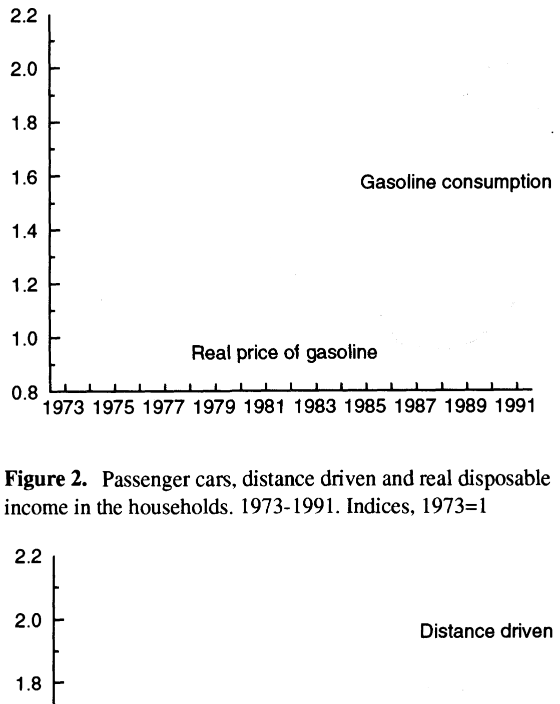
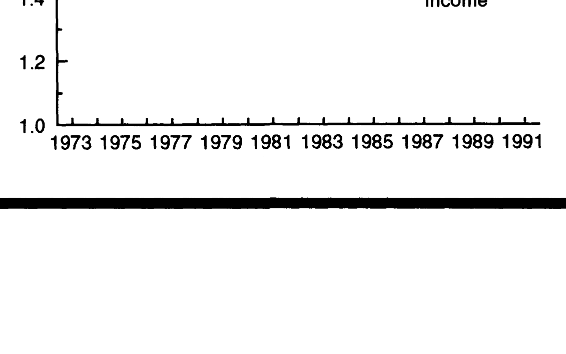


Figure 2. Passenger cars, distance driven and real disposable income in the households. 1973-1991. Indices, 1973=1



Box 5.3. Car transport and economy in private households

5.4. Trends in regional concentrations of pollutants

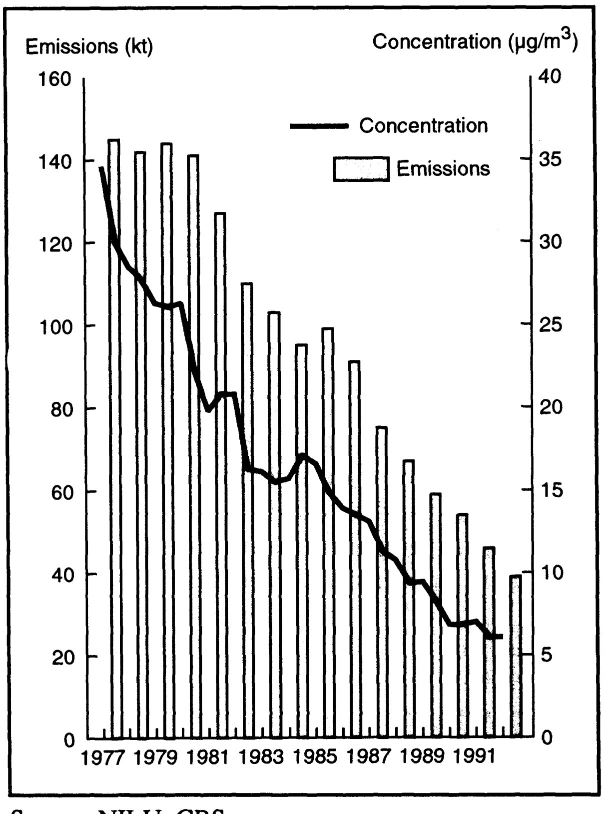
At the request of the State Pollution Control Authority, the Norwegian Institute for Air Research (NILU) has made regular measurements of sulphur dioxide, soot and lead in air at different places in Norway since 1977 (National Programme for Pollution Monitoring). Concentrations of NO_2 have been measured since 1986. From April 1991 to March 1992, 24-hour average concentrations of these pollutants have been registered at 33 stations in 25 towns and urban districts. In addition to the national programme, measurements are taken at five stations in Sør-Varanger in order to register the SO_2-load in the area. The concentrations of the different components are measured at different times of the year.

The measurements show that the concentrations of all the components vary significantly over the year, with relatively high levels in the winter months and lower concentrations in summer. This is explained by higher consumption of fuels (oil, kerosene and wood) for heating in winter, and thus greater emissions, and by the fact that the pollution is not dispersed as easily in winter as in summer. Figures 5.17, 5.18 and 5.19 show seasonal variations and changes in average concentrations of sulphur dioxide, soot and lead in 8 larger Norwegian towns (Fredrikstad, Oslo, Drammen, Kristiansand, Stavanger, Bergen, Trondheim and Tromsø). The figures also show national emissions of the same components. In general, variations in the average air quality for these towns correlates with emissions of the corresponding component.

In 1992, new air quality criteria have been recommended for most of these components, but these have not been taken into account in this report. The new air quality criteria are generally more stringent than the old ones (they set a lower limit for the concentrations). These new air quality criteria are shown in figure 5.1. The number of times the recommended limit is exceeded may therefore be higher than indicated in the following summary. The deviations are greatest for NO_2.

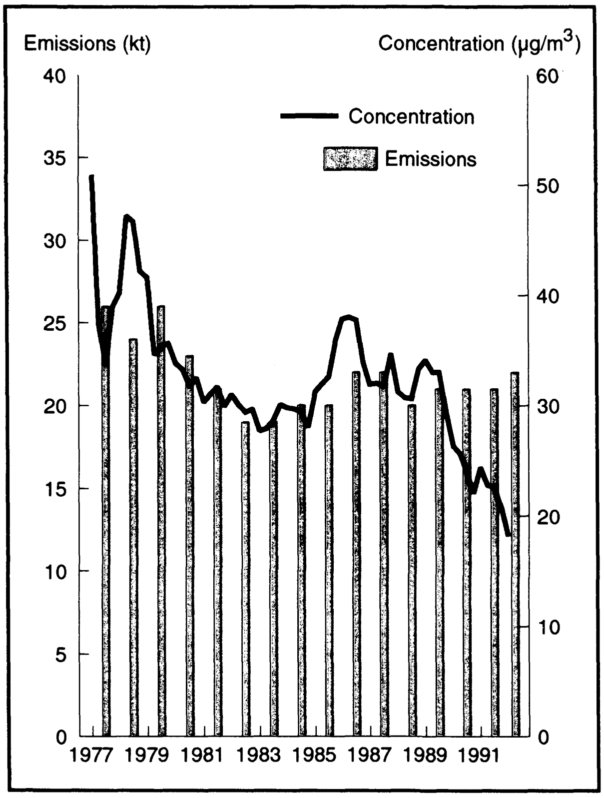
Figure 5.17 shows a clear decline in average concentrations of *sulphur dioxide* during the series of measurements. The average concentration in the season 1991/92 was the lowest since the measurements started. The reasons are reduced emissions and favourable dispersion conditions. However, the average values may hide sporadic periods of poor air quality. In the case of some components, such as SO_2 and NO_2, greatest harm occurs during these periods with high concentrations. The measurements show only few such episodes for SO_2 during the period concerned. Values exceeding the lower 24-hour average critical level (100 $\mu g/m^3$) were registered at four stations, and values exceeding the upper 24-hour critical level (150 $\mu g/m^3$) at two stations. Episodes with high values for sulphur dioxide concentrations occur most often at places with large emissions from local industry. The highest values for SO_2 are now measured at stations in Sarpsborg, Halden, Årdalstangen and Øvre Årdal. No excess values

Figure 5.17. Average SO_2-concentrations in air in some larger Norwegian towns. $\mu g\ SO_2/m^3$ air. National emissions of SO_2. 1 000 tonnes. 1977-1992



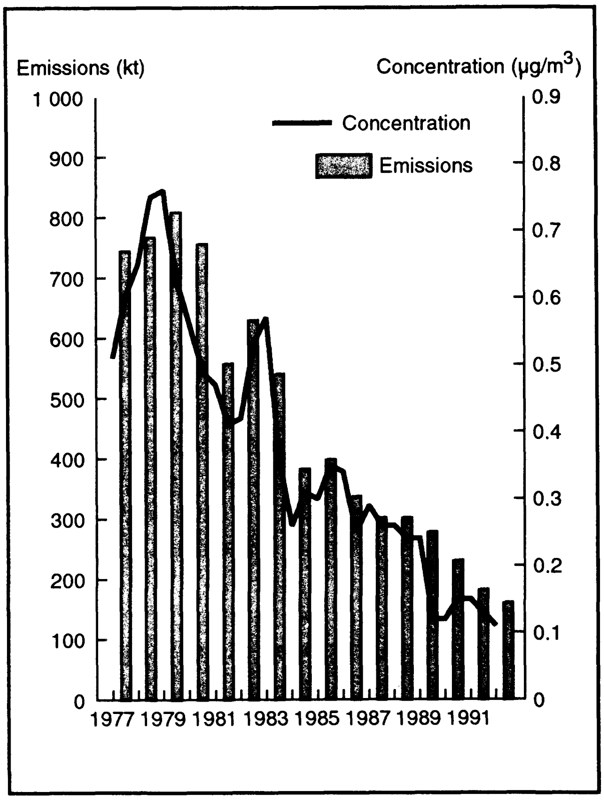
Source: NILU, CBS

Figure 5.18. Average concentrations of soot in air in some larger Norwegian towns. µg soot/m³ air. National emissions of particulates. 1 000 tonnes. 1977-1992



Source: NILU, CBS

Figure 5.19. Average concentrations of lead in air in some larger Norwegian towns. µg lead/m³ air. National emissions of lead. Tonnes. 1977-1992



Source: NILU, CBS

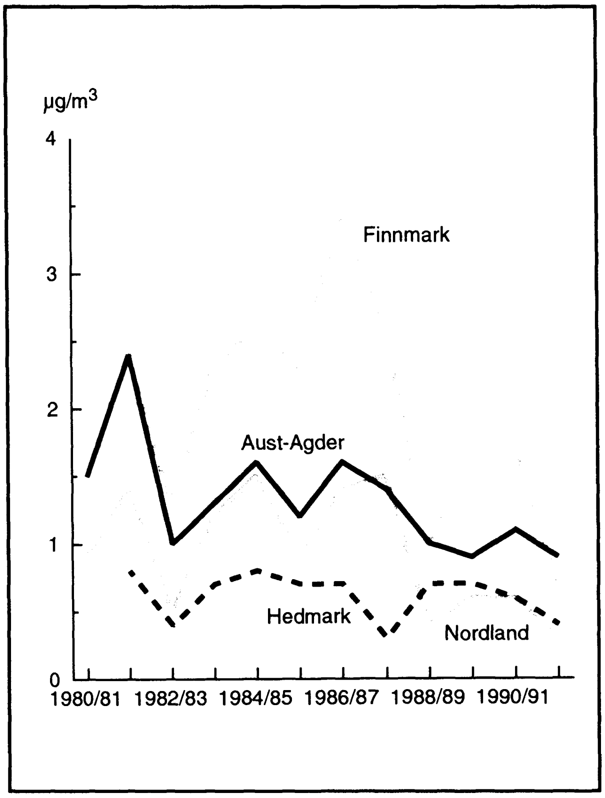
were registered in the largest towns during the period in question. The lowest six-monthly critical level, 40 µg/m³ was never exceeded. Outside the national monitoring programme, excess values were also measured at four stations in Sør-Varanger. These can be explained by SO_2-emissions from Russian nickel works in Nikel and Zapoljarnij.

Soot concentrations showed a tendency to decline at the beginning of the period, increased during the mid-1980s and have declined in recent years, see figure 5.18. In 1991/92, the critical level for the 24-hour average concentration (100 µg/m³) was exceeded at stations in Drammen, Fredrikstad, Oslo (Bryn School) and Skien. Except for Bryn School in Oslo, all the stations are located near to streets with much road traffic. Generally lower concentrations were measured in February 1992 than in the same month in 1991. The reasons may be milder weather and better dispersal conditions combined with lower emissions from road traffic. Today, road traffic is probably the most important source of soot in the larger towns, but at the start of the measuring period the greater part of the soot originated from oil used for heating.

A distinct decline has been observed in the concentration of *lead* after the gradual changeover to non-leaded gasoline. A period of marked reductions in lead concentrations in urban air in the early 1980s has been followed by smaller reductions in recent years, see figure 5.19. The measurements in February showed the lowest concentration of lead measured to date. No concentration exceeding WHO's critical level for lead concentrations in air (0.5-1 µg/m³) were recorded at any station during the winter of 1991/92.

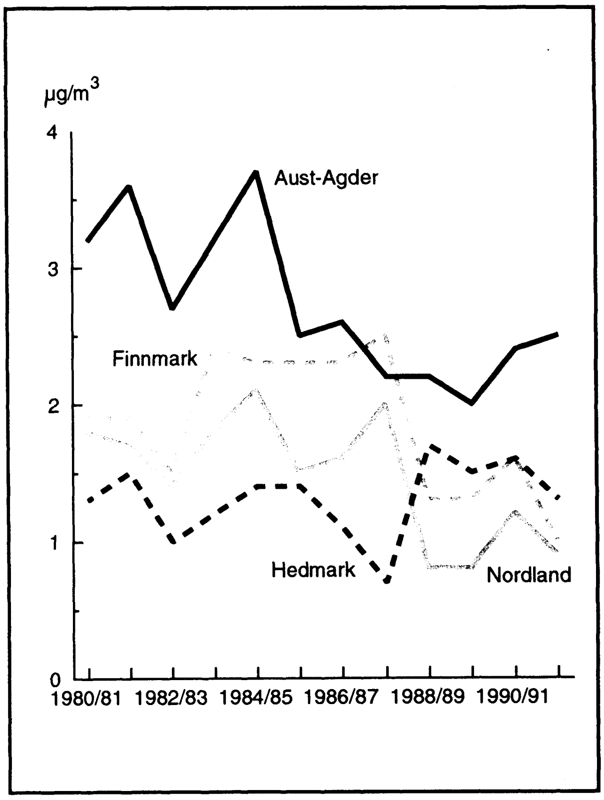
Measurements of *NO_2-concentrations* did not start until autumn 1986. Values exceeding the 24-hour average critical level were measured at 5 out of 12 stations in winter 1991/92. The highest values were recorded in Drammen and

Figure 5.20. Annual average concentrations of SO_2 at some background stations. $\mu g/m^3$ air. 1980-1992



Source: NILU, SFT

Figure 5.21. Annual average concentrations of particulate sulphate at some background stations. $\mu g /m^3$. 1980-1992



Source: NILU, SFT

Oslo (St. Olavs plass). The critical level for the six-monthly average concentration (75 $\mu g/m^3$) was not exceeded at any station. Most of the stations showed a lower NO_2-concentration than in winter 1990/91, about the same level as in winter 1989/90. The variation can be explained by the general weather conditions during these winters. Road traffic is considered to be the most important source of high concentrations of NO_2 in air.

Air quality at Norwegian background stations

Transboundary pollution is measured in air and precipitation at 7 background stations. These stations are influenced only slightly by local sources of emissions. Much of the pollution comes from other countries, see figures 5.10 and 5.11. Figures 5.20 and 5.21 show changes in the annual average concentrations of sulphur dioxide and particulate sulphur respectively at some stations. As a whole, the measurements show a declining trend, but have varied only slightly in recent years. The figures also show that the sulphur load at the background stations also varies between regions. The highest average concentrations were recorded at Jergul in Finnmark, Skreådalen in Vest-Agder and Birkenes in Aust-Agder.

5.5. Cost of measures to reduce CO_2-emissions in Norway

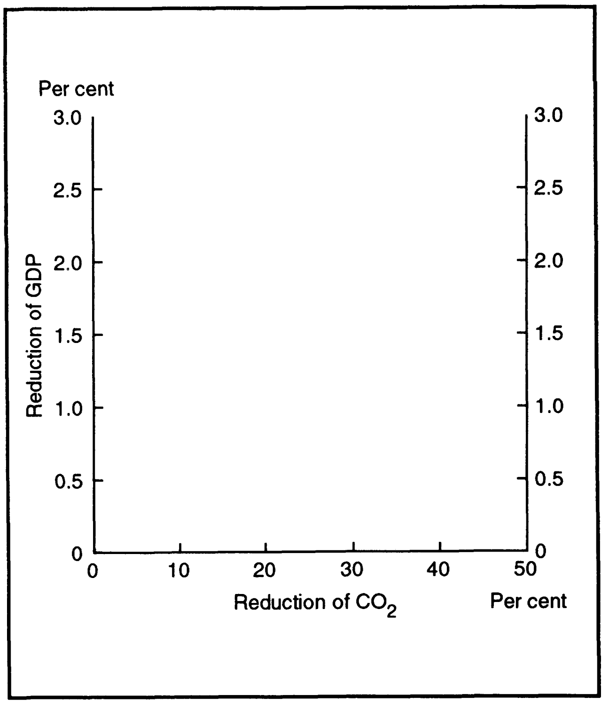
In recent years, considerable attention has been given to the cost of reducing emissions of CO_2 in Norway. Several analyses have focused on the costs in terms of reduced Gross Domestic Product connected to realizing the goals for reductions of emissions. These analyses show that the marginal costs in the form of a reduction in the Gross Domestic Product become greater the greater the reductions in emissions. Such a trend appears to be reasonable, given that the emissions that are cheapest to reduce are the ones that are reduced first.

In this analysis we have studied the costs of reducing emissions of CO_2 in Norway. The model used for this purpose is a revised version of CBS's long-term equilibrium model (MSG). The main revision consists of a new way of modelling the demand for energy for stationary purposes. Secondly, greater emphasis has been placed on transportation. Further, a new model has been developed for the electricity sector and has been implemented into the main model.[1]

By preparing different scenarios or paths of development (up to the year 2020) and varying the CO_2 tax imposed on consumption of fossil fuels, we can arrive at a relation between reduction in CO_2-emissions and corresponding reduction in Gross Domestic Product. This relation can be called a climate-cost function. Taking into account all reservations about the uncertainty of the results in the model, and given the basic assumptions for the development path, the climate-cost function shows the costs in terms of Gross Domestic Product associated with realizing specific goals for reductions of emissions.

An important assumption for the results is that the taxes are completely returned to the economy in the form of reduced payroll tax. Another important assumption in our analysis is that we take into account only Norwegian measures. Multilateral measures will change assumptions such as reduced oil prices and improved competitive conditions for some sectors of Norwegian export industry (energy-intensive industry). Further, access to trade emission quotas will significantly change the conditions for Norway.

Figure 5.22. Reduction in Gross Domestic Product (GDP) as a function of a reduction in CO_2-emissions in the year 2020. Percentage deviations from a scenario with no special measures to reduce CO_2-emissions



Source: CBS

Figure 5.22 shows the relation between the reduction in CO_2-emissions and the reduction in Gross Domestic Product. The reductions are measured in relation to a reference scenario with no measures to reduce CO_2-emissions. The figure shows, not surprisingly, that also in Norway the reduction in Gross Domestic Product caused by reducing emissions of CO_2 by one extra unit becomes greater the greater the reductions already achieved.

A tax of about NOK 350 per tonne CO_2 will be required in order to stabilize the emissions at 1992 level by the year 2020. This is equivalent to a tax of about 95 øre per litre oil. By comparison, today's (1993) CO_2-tax is 40 øre per litre oil. The associated reduction in Gross Domestic Product is about 0.5 per cent. Scena-

[1] After the Norwegian version of the report was sent to the printers, the results of the analyses have been revised. The English version contains these revised results.

rios with the highest taxes (NOK 14 per litre oil in the year 2020) give an approximately 50 per cent reduction in emissions and a 2.9 per cent reduction in GDP in relation to the reference scenario. In relation to the 1992 level, this represents a reduction in emissions of about 35 per cent.

An analysis of the cost of reducing CO_2-emissions in the USA, carried out by Jorgenson and Wilcoxen (1990) shows that stabilizing the emissions at 1990 level in the year 2020 will require a tax of about 5 dollars per tonne CO_2. In Norway's case, similar stabilization would require a tax of about 45 dollars per tonne CO_2. There may be many reasons for this large difference between the countries. One is stronger economic growth in the Norwegian reference scenario than in the American. This means that, in the Norwegian analysis, we have to reduce from a higher level. Another reason may be differences in the prognoses for technical change. It is probably also important that, in Norway, much of the changeover from forms of energy with a high carbon content will have already been achieved, so that further reductions will be more expensive.

In the light of the high tax that is required to stabilize emissions in Norway, it is reasonable to assume that the reduction in the Gross Domestic Product caused by the stabilization will be high in Norway compared with other countries. If we compare our results with the results from Jorgenson and Wilcoxen's model and those of three other models described in A. Dean and P. Hoeller (1992), which present results for USA, we find that this is not the case. According to these four models, stabilization of emissions in USA in the year 2020 would lead to a reduction in the Gross Domestic Product of between 0.5 and 1.1 per cent. Thus our results, showing a 0.5 per cent reduction in the Gross Domestic Product as a result of stabilization in the year 2020 are in line with the estimates of GDP losses in the USA. One reason may be that oil consumption per unit of production is somewhat higher in the USA than in Norway, so that a given reduction in energy consumption leads to a greater reduction in production in the USA than it does in Norway.

To sum up, it can be said that the calculations indicate that a reduction in CO_2-emissions in Norway through imposition of taxes can be achieved without a dramatic reduction in the Gross Domestic Product. Compared with other countries, relatively high taxes are required in order to reduce the emissions. On the other hand, the cost in the form of reduced Gross Domestic Product is relatively low in Norway. Nonetheless, the very high taxes that will have to be imposed in order to achieve reductions over and above stabilization will probably result in high costs for adjustment and reorganization in the short term. These costs are not reflected in our long-term model. If possible, it would probably be wise to supplement the taxes with other measures such as direct regulation and trade in quotas.

An important factor not referred to in the calculations presented here is that a reduction in CO_2-emissions also leads to lower emissions of other gases such as SO_2 and NO_x. This will lead to gains in the form of better health, less capital depreciation, and a better quality natural environment, and may also lead to fewer traffic problems (Brendemoen et al., 1992). To what degree these gains will balance the loss in the form of a reduction of the Gross Domestic Product is uncertain, but studies indicate that they would be very considerable.

References:

Brendemoen A., S. Glomsrød and M. Aaserud (1992): *Miljøkostnader i makroperspektiv* (Environmental costs in a macroperspective). Reports 92/17, Central Bureau of Statistics (In Norwegian).

Dean A., and P. Hoeller (1992): *Costs of Reducing CO_2 Emissions: Evidence from six Global Models.* Working Paper No. 122., Economics Department OECD, Paris.

Jorgenson, D. W., and P.J. Wilcoxen (1990): *Reducing U.S. Carbon Dioxide Emissions: The Cost of Different Goals,* Harvard Institute of Economic Research, Harvard University, Cambridge, MA. In: J.R. Moroney (ed.): *Advances in the Economics of Energy and Resources.* Greenwich, JAI Press. 1991.

6. Fishing, sealing and whaling

A positive trend has been observed in the stock of North-East Arctic cod, which was estimated to 1.8 million tonnes in 1992. The catch quota for 1993 is 500 thousand tonnes, of which Norwegian fishermen are allowed to catch 208 thousand tonnes. They are also permitted to catch 40 thousand tonnes of coastal cod. The spawning stock of Norwegian spring-spawning herring was estimated to be about 2 million tonnes in 1992. The 1983 year class accounts for about 80 per cent of this stock. The stock of Barents Sea capelin has increased again after the marked decline in 1986, and in autumn 1992 the total stock was estimated to be 5.2 million tonnes.
The total catch of fish in Norwegian fisheries was 2.3 million tonnes in 1992. This is 0.4 million tonnes more than in 1991. Including crustaceans, molluscs and seaweed, the total catch in 1992 was 2.6 million tonnes, with a first-hand value of NOK 5.8 billion.

The export value of fish products (including reared salmon) increased by 3 per cent in 1992 to about NOK 15.4 billion. Export of fresh and frozen reared salmon accounted for about NOK 4.4 billion. There was a marked increase in both the export value and the export volume of fresh salmon, but a distinct decrease in the export of frozen salmon.

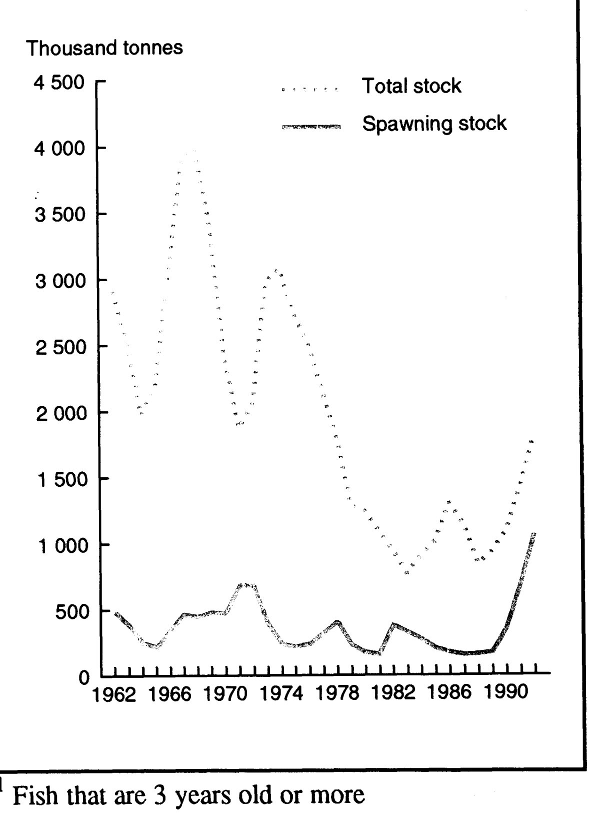
6.1. Stock development

This section reviews the development of some important fish stocks, based mainly on reports from working groups under the International Council for the Exploration of the Sea (ICES). The data are quoted with the consent of ICES.

North-East Arctic Cod

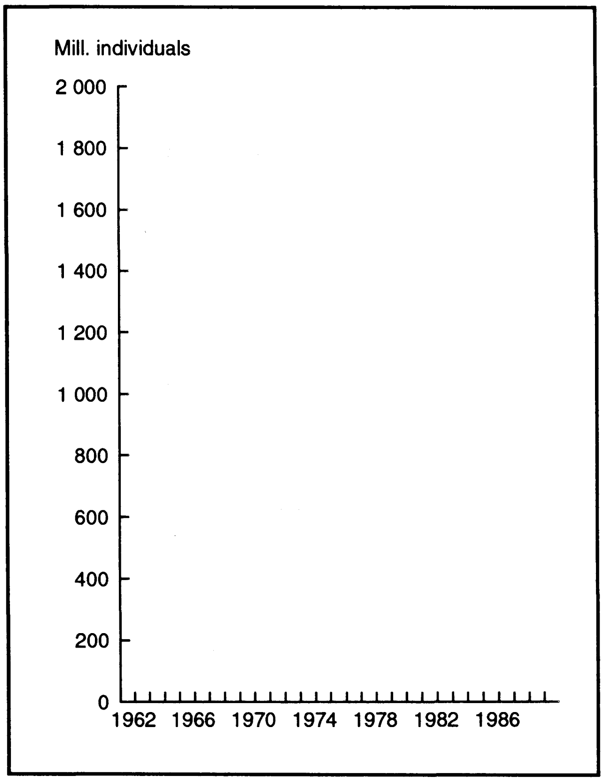
The size of the stock of North-East Arctic cod was estimated to 1.8 million tonnes at the beginning of 1992, see figure 6.1. The stock has increased as a result of reduced taxation during the period 1989-1991 and increased individual growth. The spawning stock, estimated to just over 1 million tonnes in 1992, is the highest since the early 1960s. The accounted stock of North-East Arctic cod includes fish that are more than 2 years old at the turn of the year. Figure 6.2 shows recruitment to the stock, measured in terms of the strength of the year classes when they enter the accounted stock as three-year-olds. All the year classes from the 1980s, except for the strong 1983 year class

Figure 6.1. Total stock[1] and spawning stock of North-East Arctic cod. 1962-1992. 1 000 tonnes



[1] Fish that are 3 years old or more
Source: ICES Working Group report

Figure 6.2. Recruitment of North-East Arctic cod. Year classes 1962-1989. Millions of three-year-old individuals



Source: ICES Working Group report

Table 6.1. Stock development[1]. North-East Arctic cod. 1975-1992. 1 000 tonnes

Year	Initial estimate (1)	1992-estimate (2)	Re-evaluation (3) = (2) - (1)
1975	3 600	2 730	-870
1976	4 110	2 510	-1 600
1977	2 500	2 150	-350
1978	1 920	1 790	-130
1979	1 690	1 390	-300
1980	1 500	1 240	-260
1981	1 560	1 080	-480
1982	1 410	940	-470
1983	960	760	-200
1984	730	910	180
1985	1 020	1 010	-10
1986	1 880	1 300	-580
1987	1 500	1 130	-370
1988	900	830	-70
1989	680	930	250
1990	830	1 080	250
1991	1 240	1 420	180
1992	1 800	1 800	.

[1] Initial stock size estimate and estimate in 1992.
Source: ICES Working Group report

and the more "normal" year classes from 1981 and 1982, were weak. Spawning seems to have been good, however, in 1990, 1991 and 1992. Cod usually mature when 7 or 8 years old.

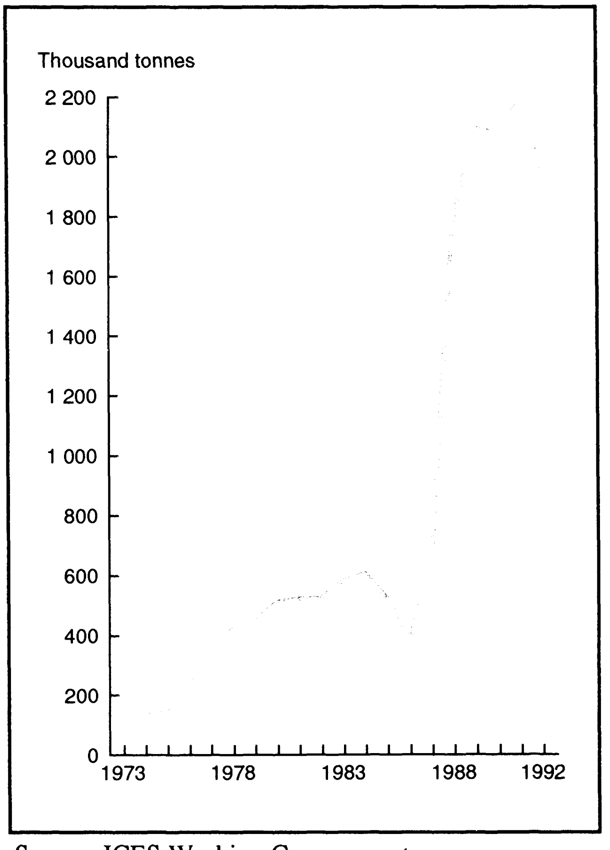
Based on the most recent estimates of the stock, marine scientists carry out recursive calculations for the development of the stock, using data on the catch and on natural mortality. In this way the estimates of the stock size in previous years are re-evaluated. Table 6.1 shows the size of the stock of North-East Arctic cod as estimated initially each year and as estimated in 1992. In 1992 the 1987 stock was estimated to have been 1 130 thousand tonnes; 370 thousand tonnes less than the original estimate.

Norwegian spring-spawning herring

The spawning stock of Norwegian spring-spawning herring was estimated to 2.2 million tonnes in 1991, see figure 6.3. A prognosis from ICES estimated the spawning stock of Norwegian spring-spawning herring to be about 2 million tonnes in 1992.

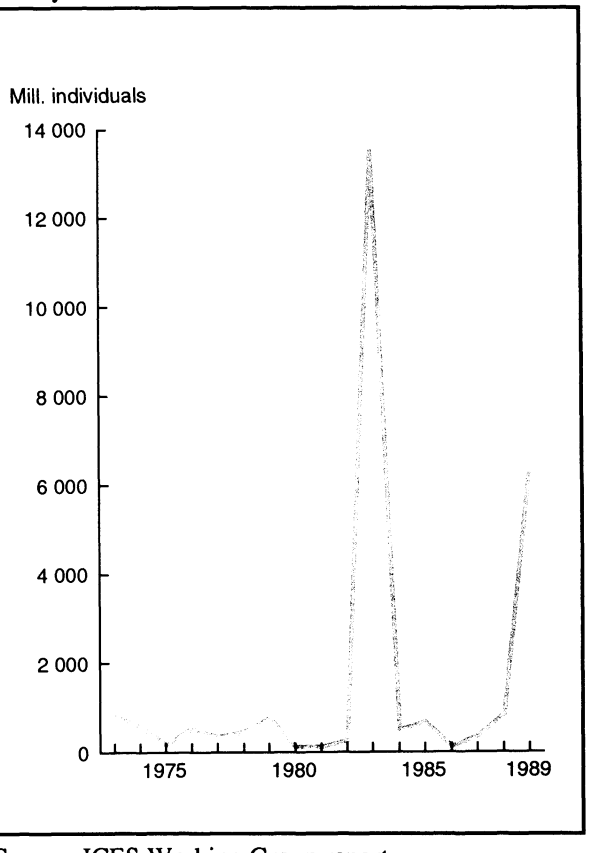
From a level of between 7 and 8 million tonnes in the 1950s, the stock was fished right down at the end of the 1960s. No spawning stock was recorded at the beginning of the 1970s, but a reasonably good year class in 1969 produced about 80 thousand tonnes of mature herring, the greater part of which spawned in 1973. Recruitment was fairly good from some of the year classes from 1973 onwards, and a particularly rich year class was recorded in 1983, see figure 6.4. The reason for the substantial increase in the spawning stock in 1988 was that the greater part of this year class spawned for the first time that year. The estimated spawning stock of 2 million tonnes in 1992 is about three times as large as the spawning stock in 1987. The year classes from

Figure 6.3. Spawning stock of Norwegian spring-spawning herring. 1973-1992. 1 000 tonnes



Source: ICES Working Group report

Figure 6.4. Recruitment of Norwegian spring-spawning herring. Year classes 1973-1989. Millions of three-year-old individuals



Source: ICES Working Group report

1991, and especially 1992, seem to be very good. The year class from 1983 accounts for about 80 per cent of the biomass of the spawning stock. Norwegian spring-spawning herring mature between 3 and 6 years of age.

In 1992 the catch quota for herring was 78 thousand tonnes. The available quota for 1993 is 200 thousand tonnes. By comparison, during the period 1964-1967 the total annual catch of Norwegian spring-spawning herring varied from 1.3 to 2 million tonnes.

Barents Sea capelin

Figure 6.5 shows the estimated size of the capelin stock (fish that are two years old or more) in the Barents Sea, based on acoustic measurements in autumn. During the period 1986-1989 the stock was very small. Since 1989 it has increased substantially and in autumn 1992 it was estimated to be 3.9 million tonnes.

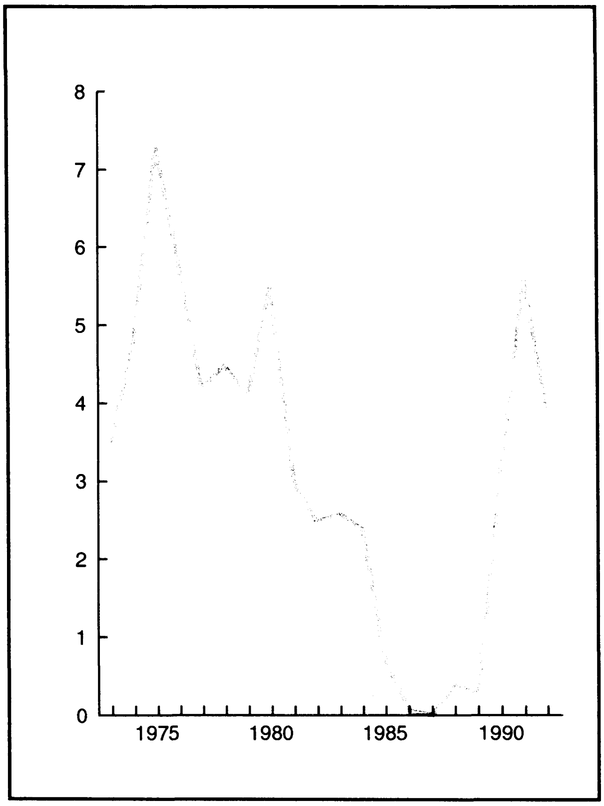
Other important stocks

Table 6.2 shows the development of several stocks of importance for Norwegian fisheries.

There was a drastic decrease for a time in the stock of North-East Arctic haddock. In 1984 the stock reached a bottom level of 50 thousand tonnes, about 5 per cent of the size in 1973. Afterwards the stock increased to 250 thousand tonnes in 1986. Since then the size of the stock has varied somewhat. The estimate for 1992 is 230 thousand tonnes.

The estimated size of the stock of North-East Arctic saithe is 500 thousand tonnes in 1992. The stocks of cod and saithe in the North Sea are declining, and the spawning stocks of both these species reached a historic minimum in 1991.

Figure 6.5. Size of the capelin stock[1] in the Barents Sea in autumn. 1973-1992. Million tonnes



[1] Fish that are 2 years old or more.
Source: ICES Working Group report

Table 6.3 shows the quotas and catches of North-East Arctic cod, North-East Arctic haddock, North-East Arctic saithe and Barents Sea capelin.

The total quota for cod was increased by 56 thousand tonnes in the course of 1992. Preliminary figures for North-East Arctic cod fished in 1992 indicate a catch of 376 thousand tonnes, plus 30 thousand tonnes of coastal cod. For 1993 the total quota of North-East Arctic cod is fixed at 500 thousand tonnes (including Murman cod). To this must be added 40 thousand tonnes of coastal cod. After transfer of part of the Russian quota, Norwegian fishermen can catch 208 thousand tonnes of North-East Arctic cod in 1993, plus 40 thousand tonnes of coastal cod. Figure 6.6 shows the relationship between quota and catch of North-East Arctic cod since 1978.

Since 1989 the quotas for haddock have been low. In 1992 the total quota was 63 thousand tonnes, after being raised by 8 thousand tonnes in the course of the year. Preliminary figures indicate a catch of 54 thousand tonnes in 1992,

Table 6.2. Stock development. 1976-1992. 1 000 tonnes

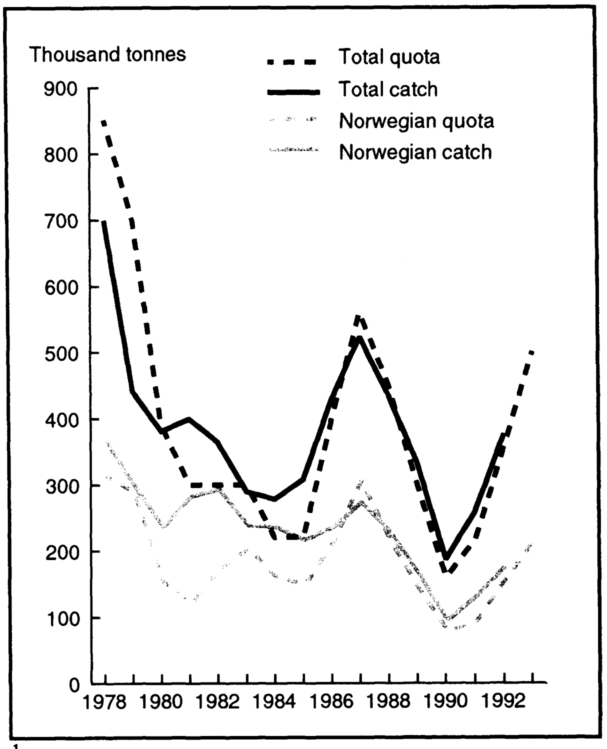
Year	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arctic saithe[2]	Barents Sea capelin[2]	Norwegian spring-spawning herring[3]	North Sea cod[2]	North Sea saithe[2]
1976	2 510	300	630	5 800	210	410	710
1977	2 150	240	500	4 200	350	320	480
1978	1 790	260	480	4 500	420	470	420
1979	1 390	320	440	4 100	450	460	380
1980	1 240	250	570	5 500	510	450	410
1981	1 080	190	550	3 000	520	550	490
1982	940	110	500	2 500	520	410	500
1983	760	70	520	2 600	580	390	500
1984	910	50	430	2 400	600	310	570
1985	1 010	150	410	700	520	350	540
1986	1 300	250	370	80	380	220	440
1987	1 130	250	380	20	640	310	350
1988	830	150	380	400	1 770	250	270
1989	930	120	350	300	2 090	180	270
1990	1 080	110	460	3 200	2 080	210	330
1991	1 420	160	460	5 600	2 180	150	280
1992	1 800	230	500	3 900	1 950	140	350

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

that is to say, less than the original quota. The total quota for 1993 is fixed at 72 thousand tonnes.

As mentioned above, there has been a strong increase since 1989 in the stock of capelin. Fishing of capelin was started again in 1991, with a quota of 850 thousand tonnes for the winter fishing and 250 thousand tonnes for the autumn fishing. The Norwegian catch amounted to 536 thousand tonnes out of a total catch of 906 thousand tonnes. A total quota of 834 thousand tonnes was agreed for the winter fishing in 1992, of which Norway was allowed to catch 500 thousand tonnes. The autumn fishing was limited to 265 thousand tonnes. Preliminary figures for the winter fishing in 1992 show a Norwegian catch of 620 thousand tonnes out of a total catch of 887 thousand tonnes. The agreement between Norway and Russia includes provisions for transfers between the two countries and allows unused parts of the quota of autumn capelin to be transferred to the winter fishing in the following year. A total quota of 600 thousand tonnes has been fixed for the winter fishing in 1993. The quota for the autumn fishing will be considered later.

Figure 6.6. Quotas and catch. North-East Arctic cod[1]. 1978-1993. 1 000 tonnes



[1] Norwegian coastal cod not included. Murman cod included.Transfer from Russian quota included.
Sources: Ministry of Fisheries and Directorate of Fisheries (quotas), ICES Working Group reports (catches)

Table 6.3. Quotas and catches, by stock. 1978-1993. 1 000 tonnes

	North-East Arctic cod		North-East Arctic haddock		North-East Arctic saithe		Barents Sea capelin	
	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch
1978	850	699	150	95	160	154	.	1 894
1979	700	441	206	104	153	164	1 800	1 783
1980	390	381	75	88	122	145	1 600	1 649
1981	300	399	110	77	123	175	1 900	1 987
1982	300	364	110	47	130	168	1 700	1 759
1983	300	290	77	22	130	157	2 300	2 375
1984	220	278	40	17	103	159	1 500	1 481
1985	220	308	50	41	85	107	1 100	868
1986	400	430	100	97	75	67	120	123
1987	560	523	250	151	90	92	-	-
1988	451	435	240	92	100	115	-	-
1989	300	333	83	55	120	122	-	-
1990	160	187	25	26	103	95	-	-
1991*	215	258	28	33	90	109	1 100[1]	906
1992*	356	376	63	54	115	..	1 099[1]	1 112
1993*	500	.	72	.	132	.	600[2]	.

[1] The agreement concerning capelin fishing includes a provision allowing unused quotas of autumn capelin to be transferred to the next years winter quota. [2] Winter capelin.
Source: Ministry of Fisheries and Directorate of Fisheries (quotas), ICES Working Group reports (catches)

Table 6.4. Norwegian catch by group of fish species. 1986-1992. 1 000 tonnes

	1986	1987	1988	1989	1990	1991*	1992*
Total	1 790	1 804	1 686	1 725	1 519	1 923	2 329
Cod	270	305	252	186	125	161	213
Haddock	58	75	63	39	23	24	38
Saithe	131	152	148	145	112	140	160
Tusk	33	30	23	32	28	27	26
Ling/blue ling	28	25	24	29	24	23	21
Greenland halibut	8	7	9	11	24	30	11
Norway haddock (red-fish)	24	18	25	27	41	50	35
Others and unspecified	24	34	29	29	30	30	30
Capelin	273	142	73	108	92	576	808
Mackerel	157	159	162	143	150	181	207
Herring	331	347	339	275	208	200	220
Sprat	5	10	12	5	6	34	33
Other industrial fish species[1]	450	500	526	696	655	447	527

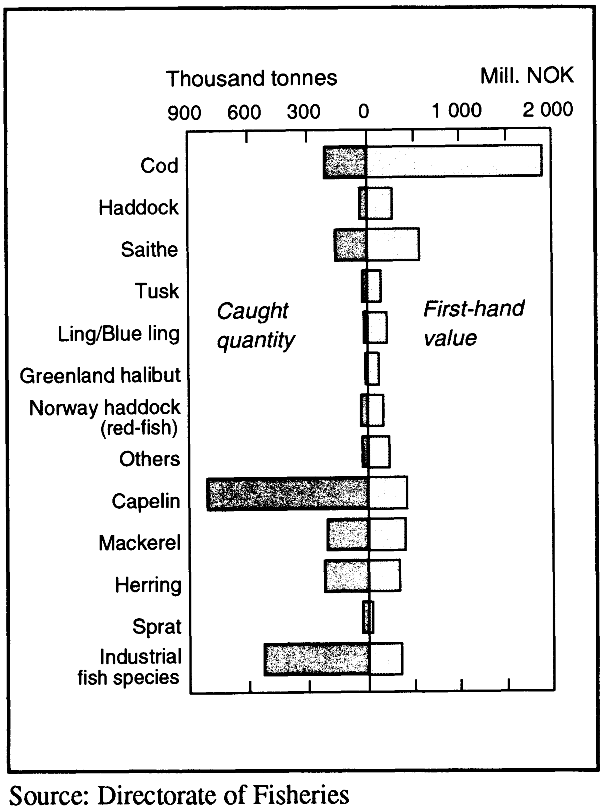
[1] Includes lesser silver smelt/greater silver smelt, Norway pout, sand eel, blue whiting, horse mackerel.
Source: Directorate of Fisheries

Catches in 1992

Table 6.4 shows Norwegian catches in the years 1986-1992. Figure 6.7 shows the first-hand value and amount of the catch in 1992. The total amount fished in 1992 was 2.3 million tonnes. This is 0.4 million tonnes more than in 1991. The main reason for the increase was the capelin fishing, where the amount of fish landed was 232 thousand tonnes more than in 1991. The catch of cod increased by 52 thousand tonnes, and the catch of industrial fish species by 80 thousand tonnes. In 1992 there was also an increase in the catch of haddock, saithe, mackerel and herring, but a decrease in the catch of Greenland halibut and Norway haddock (red-fish). There were only small changes in the catch of the other fish species listed in the table.

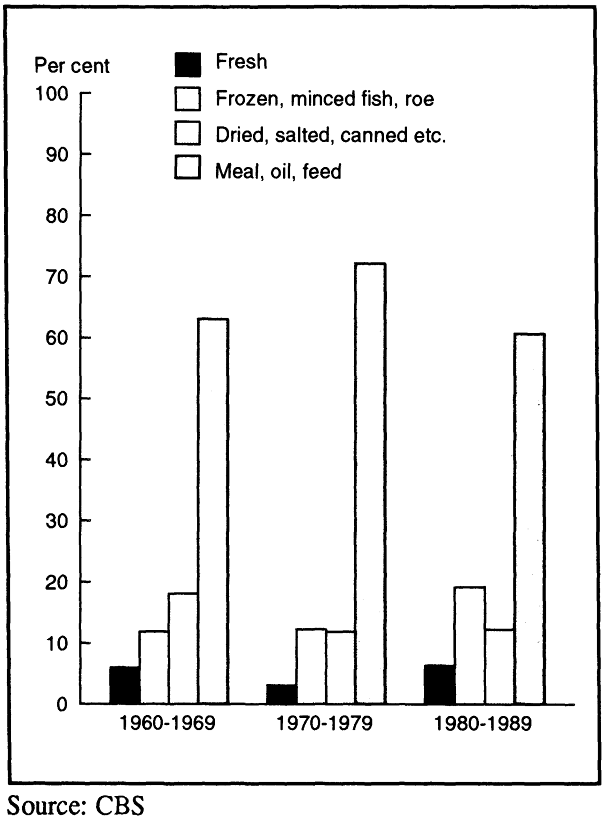
The first-hand value of the fish species listed in table 6.4 increased by 1.7 per cent to NOK 5.1 billion. The total first-hand value of the fisheries in 1992 (including crustaceans, molluscs and seaweed) was NOK 5.8 billion. Thus, the total first-hand value increased by no more than approximately NOK 8 million from 1991 to 1992. The total catch was about 2.6 million tonnes; which is 0.4 million tonnes more than in 1991.

Figure 6.7. Norwegian catch by group of fish species. 1992*. 1 000 tonnes and NOK million



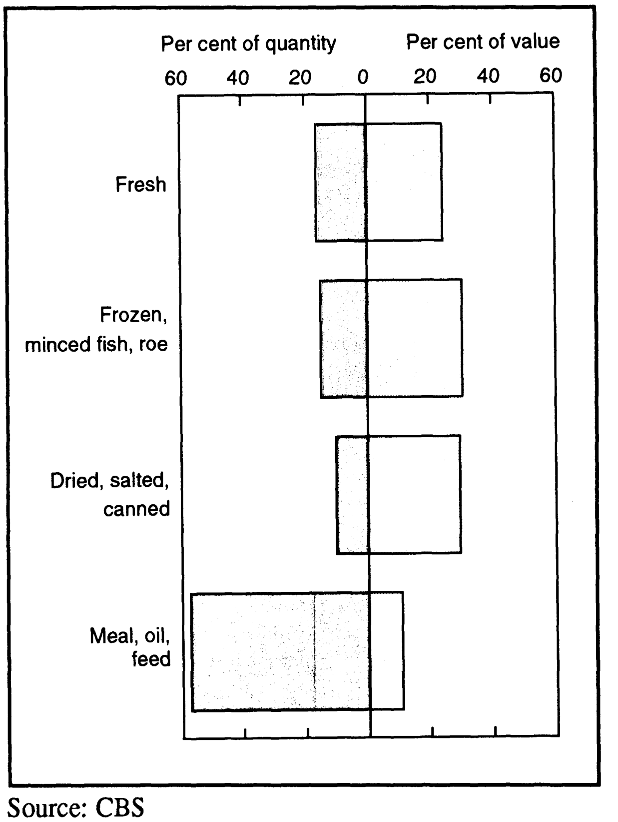
Source: Directorate of Fisheries

Figure 6.8. Total catch by disposition. Average for ten-year periods. Per cent



Source: CBS

Figure 6.9. Quantity of catch and value of catch by disposition. 1991. Per cent



Source: CBS

Use of the catch

The greater part of the catch is used for fish meal, oil and animal feed. Figure 6.8 shows the average distribution of the total catch by deposition during 10-year periods from 1960 onwards. The share of fish used fresh and for freezing has increased in recent years. Although fish meal, oil etc. dominate in volume, the other groups are more important in terms of value (figure 6.9).

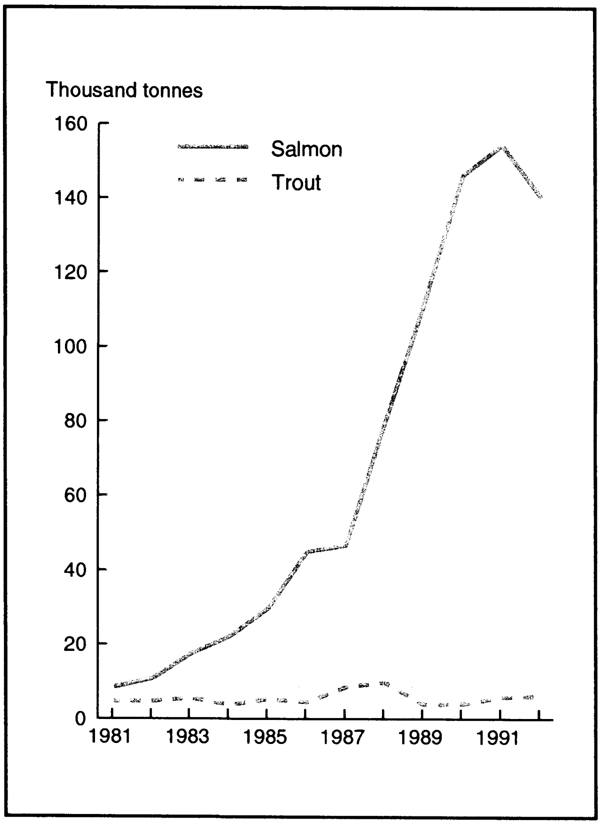
6.3. Aquaculture

There has been a marked increase in production of reared fish since this activity was started in the early 1970s. Figure 6.10 shows the development of production of reared fish since 1980. According to figures from the Norwegian Fish Farmers' Association, 154 thousand tonnes of salmon were slaughtered in 1991 and 140 thousand tonnes in 1992. Trout production amounted to about 6 thousand tonnes each of these years.

The increased production has been accompanied by a strong increase in the use of medicines in the aquaculture industry. The substances used belong to three main groups: antibacterial agents, antiparasitic agents and sedatives. Table 6.5 shows the development in the use of antibacterial agents. Total consumption reached a peak in 1987 and has since varied greatly from year to year. In 1992, the total consumption of antibacterial agents was 27 500 kg, which is 2.5 per cent more than in 1991. Consumption of antiparasitic agents was just over 5 000 kg, and of sedatives 200 kg.

Treatment of nets with antifouling agents containing heavy metals represents another environmental problem. The State Pollution Control Authority (Statens Forurensningstilsyn - SFT) estimates that about 120 tonnes of copper (Cu) is emitted per year from impregnated nets (SFT, 1992). In 1990 impregnation of nets accounted for about 25 per cent of the total emissions of copper.

Figure 6.10. Rearing of fish. Slaughtered quantities of salmon and rainbow trout. 1981-1992. 1 000 tonnes



Sources: CBS, Norwegian Fish Farmers' Association

Table 6.6 shows the exported quantities of the most important fish products during the period 1981-1992, including exports of reared fish. Figure 6.11 shows the export value of some of these products. Total exports increased by 3 per cent in 1992 in terms of value, and by 11.6 per cent in terms of volume. There has been a marked increase (about 22 per cent) in the value of exports of fresh fish, but a reduction of about 36 per cent in the value of exported frozen fish. In 1992 there has also been a marked increase in both the value and volume of fillets.

In 1992 the export value and volume of fresh and frozen reared salmon as a whole was about the same as in 1991. There was a marked increase, however, in the volume and value of fresh salmon and a marked decrease in the volume and value of frozen salmon. Table 6.7 shows that 122 thousand tonnes of reared salmon, to a value of NOK 4.4 billion, were exported in 1992. This corresponds to 29 per cent of the total export value of fish and fish products in 1992.

The total export value of fish products increased to NOK 15.4 billion in 1992, see table 6.8. This corresponds to 14.2 per cent of the total traditional export of commodities (export of commodities excluding crude oil, natural gas, ships and oil platforms).

Table 6.5. Use of antibiotics in fish farming. 1981-1992. Kg of active agent

Year	Total	Oxytetracycline chloride	Nifurazolidone	Oxolinic acid	Trimetoprim + sulfadiazine (Tribrissen)	Sulfamerazine	Flumequine
1981	3 640	3 000	-	-	540	100	-
1982	6 650	4 390	1 600	-	590	70	-
1983	10 130	6 060	3 060	-	910	100	-
1984	17 770	8 260	5 500	-	4 000	10	-
1985	18 700	12 020	4 000	-	2 600	80	-
1986	18 030	15 410	1 610	-	1 000	10	-
1987	48 570	27 130	15 840	3 700	1 900	-	-
1988	32 470	18 220	4 190	9 390	670	-	-
1989	19 350	5 014	1 345	12 630	32	-	329
1990	37 432	6 257	118	27 659	1 439	-	1 959
1991	26 798	5 751	131	11 400	5 679	-	3 837
1992	27 485	4 113	-	7 687	5 852	-	9 833

Source: Norwegian Medicinal Depot

Table 6.6. Export of some main groups of fish products. 1981-1992. 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	351.8	103.2	48.0	57.5	23.9	140.1	53.7

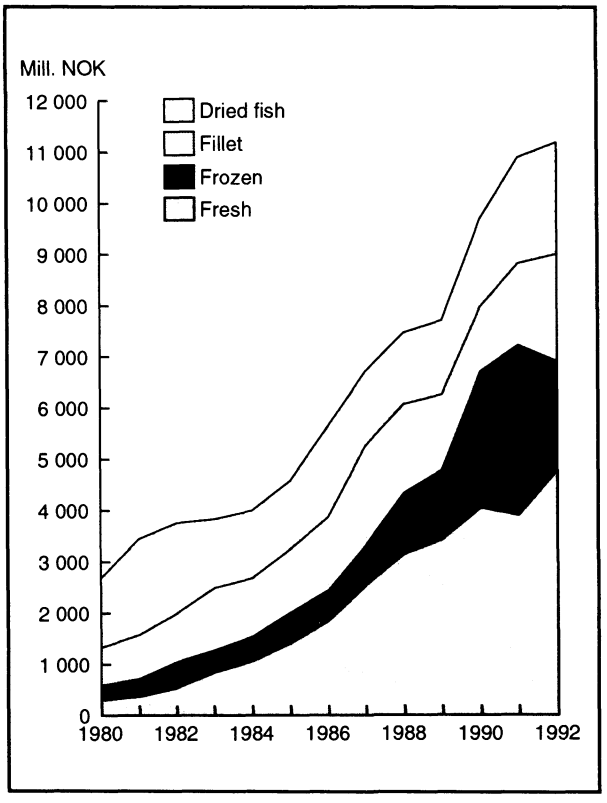
Source: CBS

Table 6.7. Export of reared salmon. 1981-1992

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	1 308.3	21.4	1 160.6	2.6	147.8
1986	38.9	1 663.7	34.4	1 458.6	4.5	205.1
1987	43.2	2 174.4	39.2	1 967.3	4.0	207.1
1988	66.0	3 079.7	56.0	2 594.9	10.0	484.8
1989	95.5	3 486.1	81.1	2 954.6	14.4	531.5
1990	130.7	4 834.9	92.8	3 423.8	37.9	1 411.1
1991	126.6	4 449.6	91.3	3 149.3	35.4	1 300.3
1992*	122.4	4 404.0	107.3	3 883.2	15.1	520.8

Source: CBS

Figure 6.11. Exports of fresh fish, frozen fish, fillet and dried fish. 1980-1992. Million NOK



Source: CBS

Table 6.8. Export value of fish products in million NOK and as percentage of other traditional exports. 1981-1992

Year	Fish and fish-products	Fish and fish products as percentage of total Norwegian exports of commodities	Fish and fish products as percentage of Norwegian exports of commodities, except crude oil, natural gas, ships and oil platforms
	Mill. NOK	Per cent	Per cent
1981	5 955	5.7	11.6
1982	5 931	5.2	11.4
1983	7 368	5.6	12.4
1984	7 675	5.0	11.1
1985	8 172	4.8	11.0
1986	8 749	6.5	12.6
1987	9 992	6.9	12.4
1988	10 693	7.3	11.6
1989	10 999	5.8	10.2
1990	13 002	6.1	11.6
1991	14 941	6.8	13.6
1992*	15 395	7.0	14.2

Source: CBS

6.5. Sealing and small whale catching

Sealing

Norwegian sealing has taken place mainly in fields around Newfoundland, in the Jan Mayen area and in the White Sea. Norwegian sealing in the Newfoundland field stopped at the end of the 1982 season. This had been the most important sealing area right from the 1950s up to the mid-1970s, and in the best seasons more than 200 000 animals were caught, see figure 6.12. From the end of the 1970s, Norwegian sealing has been moderate, with a total yield of 10 000 to 40 000 animals per season.

The catch has consisted mainly of harp seal, *Pagophilus groenlandicus,* and hooded seal, *Cystophora cristata.* Figure 6.13 shows the Norwegian catch of these species in the years after World War II. The catches have included both relatively newborn young and older seals. The catch of pups in particular has been much disputed. In recent years, Norwegian sealers have not killed pups either in the Jan Mayen area or the White Sea, and the greater part of the catch has consisted of harp seal that are one year old or more.

Small whale catching

The Norwegian catch of small whales has consisted mainly of the baleen whale, the minke whale *Balaenoptera acutorostrata,* but has also included other species belonging to the toothed whales, such as the killer whale *Orcinus orca,* the bottlenose whale *Hyperoodon ampullatus* and the pilot whale *Globicephala melaena.*

For management purposes, the International Whaling Commission (IWC) divides the North Atlantic stock of minke whale into three substocks:

- Western stock
- Central stock (Iceland, Jan Mayen)
- Eastern stock (North Sea, Norwegian Sea and Barents Sea).

Norwegian whaling has concentrated mainly on the Eastern stock. Table 6.9 shows the catch and the quotas of minke whale in the different sub-stock areas from 1978 until whaling was banned after the 1987 season.

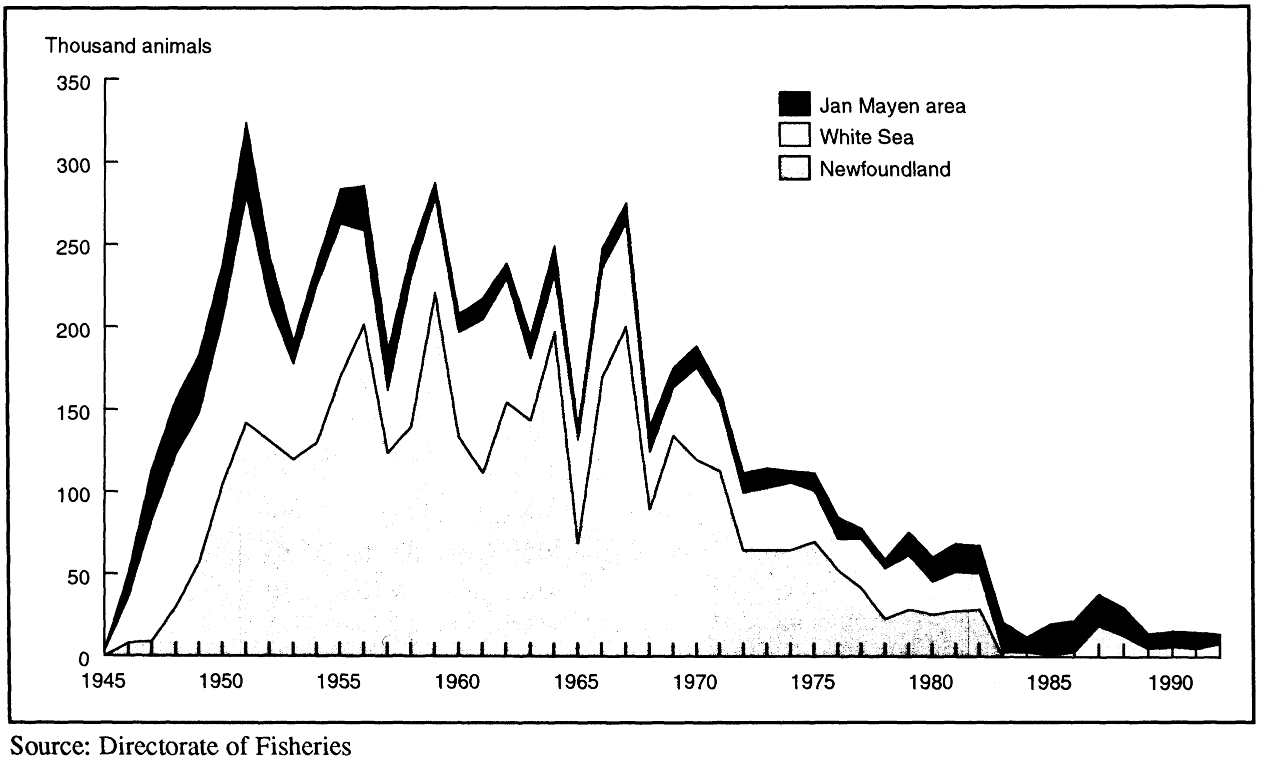
Figure 6.14 shows the catch of small whale in the years after World War II. Commercial catching of small whale was discontinued in Norway after the 1987 season. Since that time, only a few whales have been caught each season for purposes of research. In 1982, IWC imposed a temporary ban on commercial whaling, which applied until 1990. In 1985, IWC classified the Eastern stock of minke whale as a *protected stock*. Norway objected to both these decisions. Nevertheless, the Norwegian authorities stopped the whaling in 1987 while awaiting more reliable estimates of the stock.

Figure 6.15 shows a relative abundance series for minke whale in the Barents Sea for the period 1952-1983. This time series indicates the development of the stock during the period, and has been calculated on the basis of data on the catch per unit effort. In this case the effort is the number of acceptable catch days (i.e. the number of days with catch plus the number of acceptable days without catch). The time series indicates that the stock in the Barents Sea has remained relatively stable during the period and has tolerated the taxation to which it has been exposed.

The stock of minke whale in the North-East Atlantic is estimated to 86 736 individuals with a 95 per cent confidence interval of 60 736 - 117 449 (Schweder, Øien and Høst, 1993). That is to say, the probability that the true size of the stock lies within this interval is 95 per cent. This estimate of the stock has been accepted by IWC's scientific committee. A stock of this size makes whaling justified from a biological standpoint, and the Norwegian authorities have opened up for resumption of commercial whaling in 1993. The quota for the catch has not yet been fixed. This will probably be decided after the annual meeting of the IWC in May. It has been decided that 136 minke whales may be caught for research purposes in 1993.

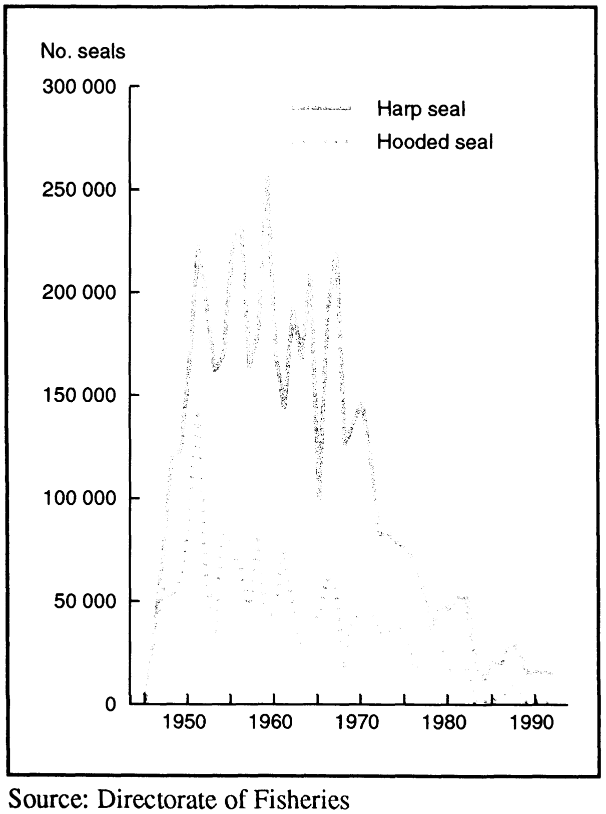
A new, regional commission for marine mammals has now been established, called NAMMCO (North Atlantic Marine Mammal Commission). The participating countries are Norway, the Faroes, Iceland and Greenland. Unlike Iceland, Norway is still a member of IWC. NAMMCO will be a management body for seals and small whales. The management of minke whale and large whale species will still take place through IWC.

Figure 6.12. Norwegian sealing, by field. 1945-1992



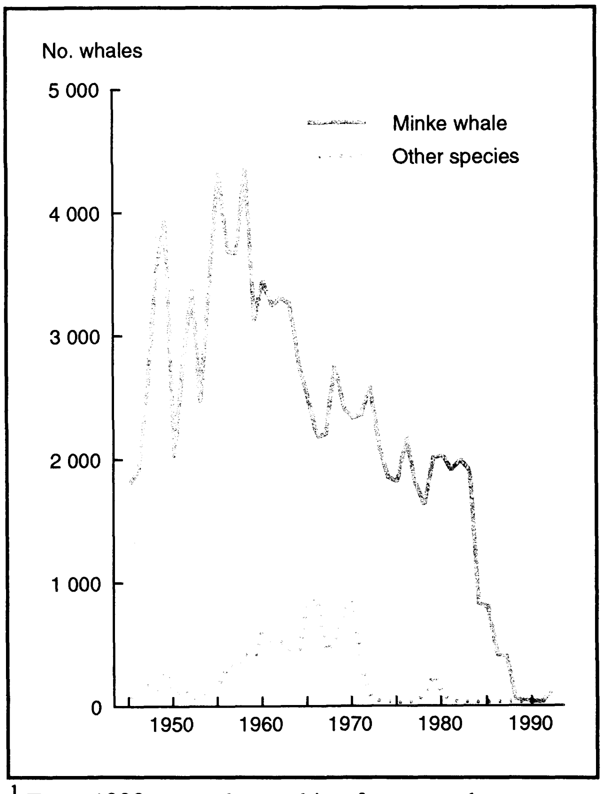
Source: Directorate of Fisheries

Figure 6.13. Norwegian catch of harp seal and hooded seal. 1945-1992



Source: Directorate of Fisheries

Figure 6.14. Norwegian small whale catching. 1945-1992[1]



[1] From 1998 onwards, catching for research purposes only

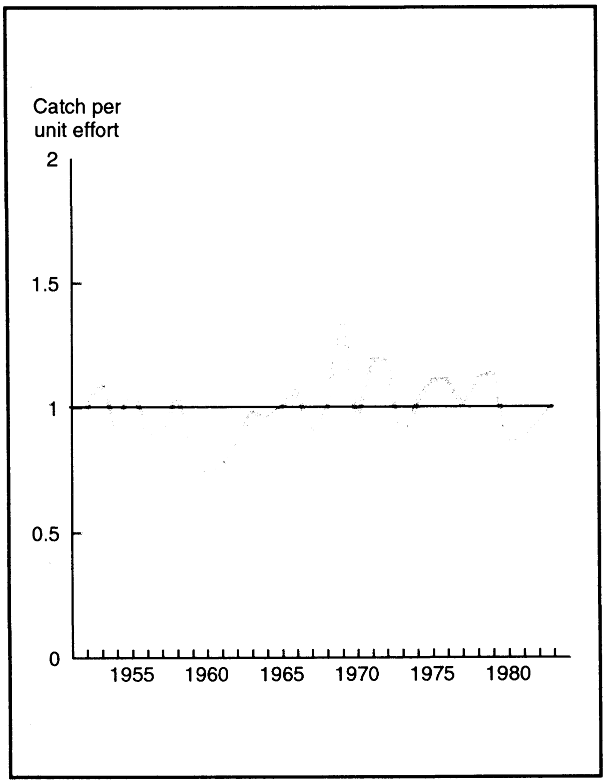
Source: Directorate of Fisheries

Table 6.9. Quotas and Norwegian catch of minke whale, by population area. 1978-1987

Year	Total catch	Total quota	North-East Atlantic		Central Atlantic		West Greenland	
			Catch	Quota	Catch	Quota	Catch	Quota
1978	1 589	1 985	1 383	1 790	131	120	75	75
1979	1 981	1 985	1 786	1 790	120	120	75	75
1980	2 001	1 985	1 807	1 790	120	120	75	75
1981	1 877	1 985	1 770	1 790	46	120	61	75
1982	1 957	1 985	1 782	1 790	109	120	66	75
1983	1 869	1 877	1 688	1 690	113	112	68	75
1984	804	809	630	635	104	104	70	70
1985	771	772	634	635	85	85	52	52
1986	383	400	329	350	54	50	-	-
1987	375	375	325	325	50	50	-	-

Source: Institute of Marine Research, 1992

Figure 6.15. Relative abundance series for minke whale in the Barents Sea. 1952-1983



Source: Schweder, T., Ø. Ulltang and R. Volden, 1991

References:

Institute of Marine Research, Norway (1992): Ressursoversikt 1992. *Fisken og Havet* (Review of resources, 1992. *The Fish and the Sea).* Special number 1, 1992. (In Norwegian).

ICES: Report of the Arctic Fisheries Working Group. C.M. 1993/Assess: 1.
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. Part I. C.M. 1993/Assess:5.
Report of the Atlanto-Scandian Herring and Capelin Working Group. C.M. 1993/Assess:6.

Schweder, T., Ø. Ulltang and R. Volden (1991): A Review of the Norwegian Catch and Effort in Northeast Atlantic Minke Whaling from 1952 to 1983. *Rep. Int. Whal. Commn 41, 1991.*

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

SFT (1992): Materialstrømsanalyse av kopper. Vurdering av alternativ (Material flow analysis of copper. Evaluation of alternatives). TA-866/1992. 92:25. (In Norwegian).

7. FORESTS

Norway has approximately 70 000 km^2 of productive forest area. This constitutes about 3.3 per cent of the total productive forest area in Europe (including Russia). Provisional figures show that 9.0 million m^3 of roundwood was cut in Norway for sale or industrial production in 1992. For many years, the amount of roundwood cut in Norway has been less than the annual growth, and the cubic mass of forest has increased substantially since the turn of the century. Measurements of forest health in Norway in 1992 show a marked reduction in crown density for pine from 1991 to 1992. In the case of spruce, the tendency towards a relatively small reduction in crown density from year to year continues. Most countries in Europe reported a decline in forest health in 1991.

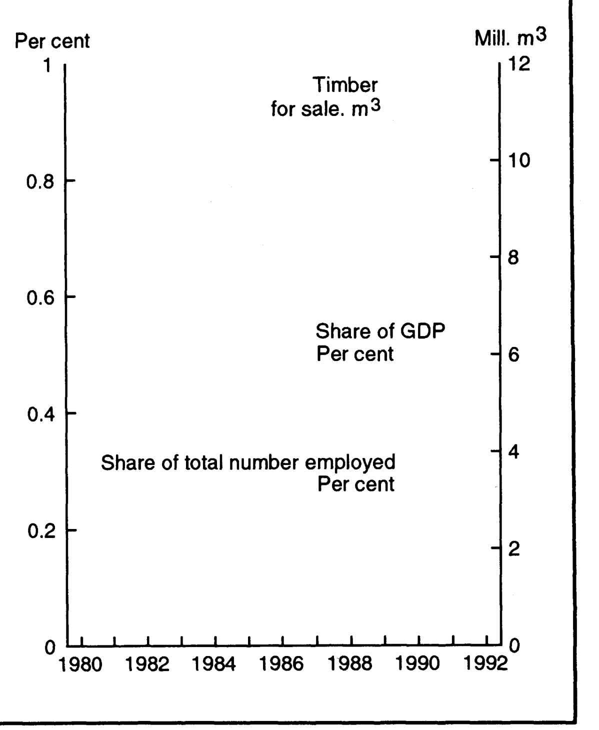
7.1. Forest in Norway

The economic importance of forest

Primary production

According to the Census of Agriculture and Forestry 1989 (CBS, 1992a), Norway has 70 400 km^2 of productive forest. The area is distributed between 125 000 properties. 78.5 per cent of the productive forest is owned by private persons and more than half of the forest properties are operated in combination with agriculture. Employment in forestry, in terms of paid employees and self-employed persons combined, has decreased from 9 900 employed in 1980 to 7 200, or 0.4 per cent of all employed in 1990 (CBS, 1992b). Preliminary figures for 1992 show that 9.0 million m^3 was cut for sale and industrial production. This is a reduction of about 9 per cent in relation to the previous year. This is the lowest figure for roundwood cut since 1985. According to the National Accounts, the value of the gross production from forestry, adjusted for input of materials, was NOK 3 987 million. This amounted to 0.6 per cent of the Gross Domestic Product (GDP). Figure 7.1 shows changes in employment in forestry, forestry's share of GDP and the volume of roundwood cut for sale and industrial production.

Figure 7.1. Employment in forestry and share of GDP. Volume of roundwood cut for sale and industrial production in 1980-1992



Source: CBS

Export and import of forest products

In 1991, Norway exported timber to a value of NOK 1 004 million. From 1988 to 1991 the value of timber exports was more than doubled. The export value of pulp and paper increased from NOK 5 812 million to 6 899 million during the same period. During the whole period from 1988 to 1991, Norway has been a net exporter of forest products. The export value of forest products totalled NOK 11 331 million in 1991, and during the same year we imported forest products for NOK 7 737 million (CBS, 1992c).

Standing volume

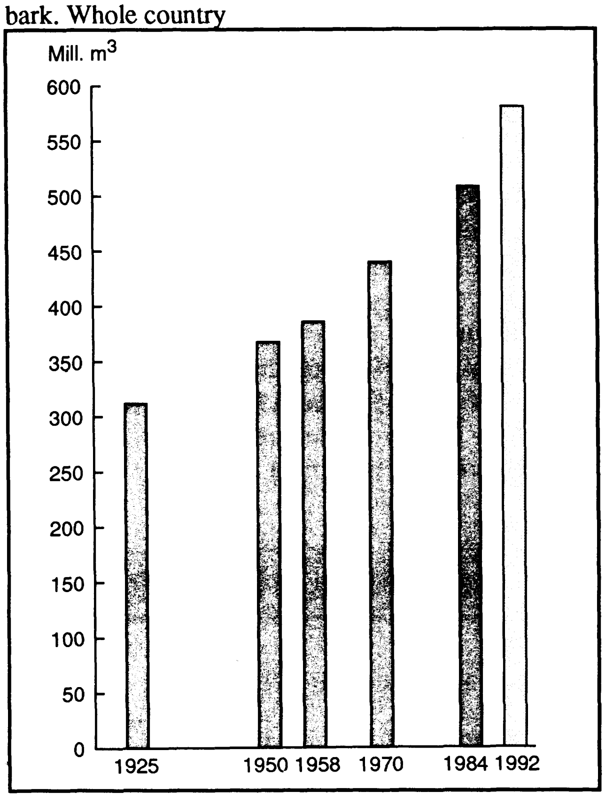
Forest is a renewable resource, with reservations. The volume is increased through growth of the trees, forest cultivation and natural regrowth, and is reduced as a result of cutting and natural mortality. The size of the stock of timber is also evaluated continuously after each new forest census. An annual account of the cubic mass, *forest balance,* shows the calculated stock of timber at the beginning and end of the year, measured in physical quantities (CBS, 1992d). The calculated forest balance for 1992 shows a cubic mass of 579 million m^3, including productive forest and forest on other land, calculated minus bark at the end of the year. This volume was distributed between 46.6 per cent spruce, 33.1 per cent pine and 20.3 per cent deciduous trees. In 1992 the annual net increase in cubic mass, not including bark, was 7.5 million m^3, or 1.3 per cent of the total cubic mass. The net increase was greatest for deciduous trees and pine. Table 7.1 shows the results of the estimated forest balance for the year 1992.

Table 7.1. Forest balance. Million m^3, not incl. bark.[1] Whole country 1992

	Total	Spruce	Pine	Deciduous
Volume per 1/1 ..	571.2	267.2	188.7	115.3
Total roundwood cut	9.8	6.7	2.0	1.1
Other mortality ..	2.0	1.0	0.4	0.5
Gross growth	19.3	10.1	5.1	4.2
Volume per 31/12	578.8	269.5	191.4	117.9

[1] The figures used for roundwood cut for sale and industrial production in 1992 are preliminary

Figure 7.2. Cubic mass of forest according to the forest censuses in 1925, 1950, 1958, 1970 and 1984. Calculated cubic mass in 1992. Million m^3, not including bark. Whole country



Source: CBS and NFI

The results of the forest surveys undertaken from 1925 to 1984 are shown in figure 7.2, together with the calculated cubic mass, not including bark, for 1992. The cubic mass of forest, not including bark, increased by about 85 per cent from 1925 to 1992. The increase was particularly strong at the end of the period.

Changes in the cubic mass, and the growth, can be explained by many different influencing factors. For many years, the roundwood cut has been more than compensated by growth. Intensive cultivation of forest has been carried out, with a view to high production of timber, and a great deal of afforestation has taken place, particularly in Western Norway. There has been regrowth of forest on other types of land. On the other hand, highly productive forest land has been used for agriculture and various other forms of development. The volume and growth may also have been affected by changes in the content of greenhouse gases, such as carbon dioxide (CO_2) and ozone (O_3) in the atmosphere, together with increased depositions of nitrogen and sulphur with rain and snow.

Forest production and assimilation of CO_2

Forest accounts for about 70 per cent of the total assimilation of CO_2 on land, which means that in a global context, changes in the forest biomass are of major importance for the content of CO_2 in the atmosphere. In the case of Norway, it has been estimated on the basis of the figures from the last two inventories (Norwegian Forest Inventories - NFI) that the annual net assimilation of CO_2 is approximately 7.7 million tonnes, or about 22 per cent of the country's total anthropogenic emissions of CO_2 during the period (Solberg et al. 1991).

Forest health status

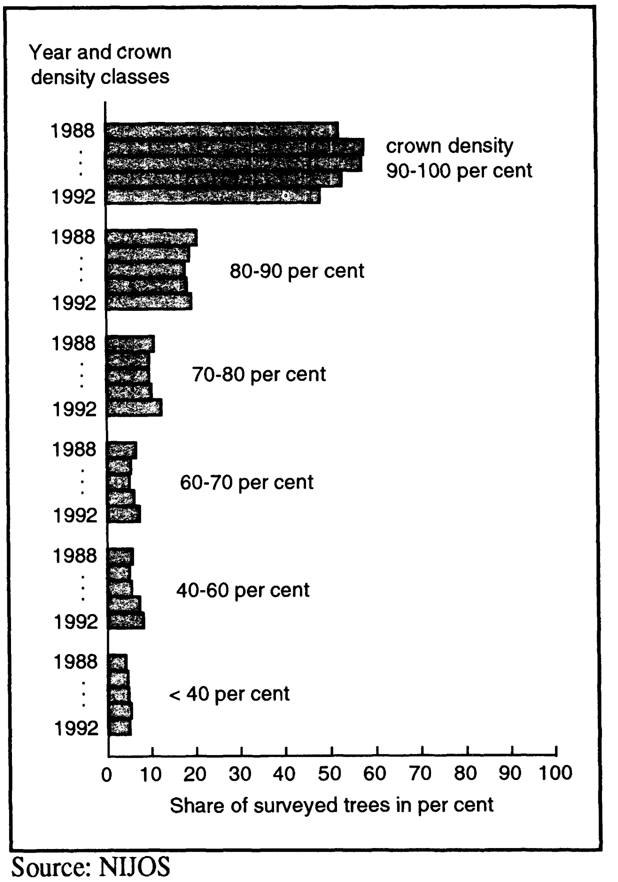
The programme to monitor forest damage was started in 1985, and is coordinated by the Norwegian Institute of Forest Research (Norsk institutt for skogforskning - NISK). The programme is part of the international system for assessment and monitoring of forest damage under FAO's European Commission for Forestry. The Norwegian Institute of Land Inventory (Norsk institutt for jord- og skogkartlegging - NIJOS) makes annual recordings of forest status which provide a nationally representative on forest health status. The data are obtained through observations made in permanent plots in a 9x9 km grid. In 1992 the recordings referred to 4 065 spruce and 2 972 pine in a total of 805 plots.

County recordings provide information on forest health status in each county. These recordings were started in 1988, and refer to 770 plots with a total of 47 000 trees distributed between 189 forestry administrative districts from Alta in the north to Lindesnes in the south. The recordings are made by the county forest administrations concerned. The results of these recordings are not representative of the country as a whole, nor of all forest in the different counties, since all the plots are chosen subjectively and do not represent equally large areas of forest. The material consists of a large number of trees and the recordings provide a valuable indication of changes over time. NISK is responsible for coordinating and processing the data.

So far, crown density and crown colour are the most important criteria used to describe forest health. Crown density is obtained by observing the foliage in the upper half of the crown in spruce and the upper two thirds of the crown in pine. The crown density of the trees is stated as a percentage of full crown density. Crown colour is evaluated in the surveyed part of the crown, and shows the share of foliage with abnormal colour. Crown colour is divided into four classes ranging from class 1, normal green, to class 4, strong yellow (> 60 per cent discolouration).

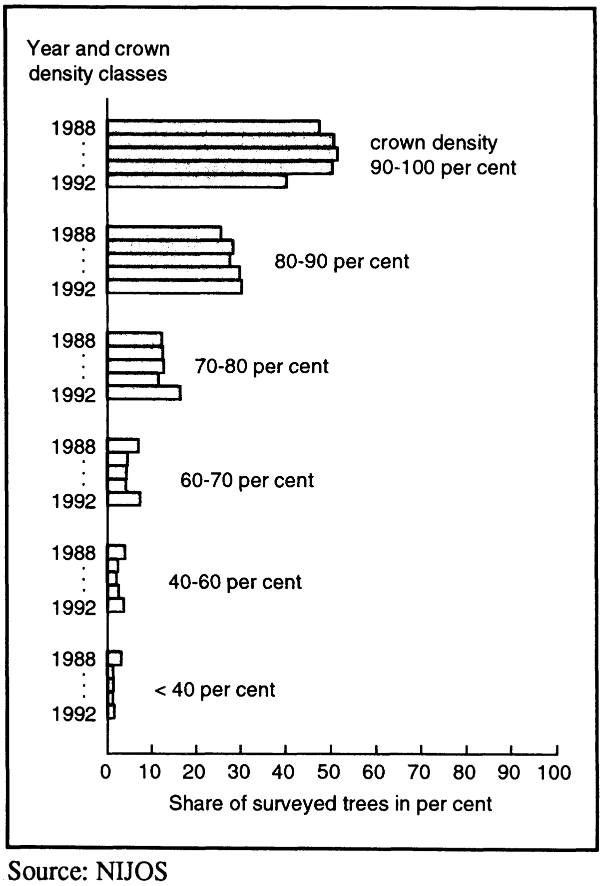
The results of the *national recordings* in 1992 (NIJOS, 1993) show forest health status in Norway as a whole, measured in terms of average crown density and crown colour. A slight decrease in crown density has been recorded for spruce every year since 1989. This year's recordings show that this tendency has

Figure 7.3. The surveyed trees by crown density class. Spruce. 1988-1992



Source: NIJOS

Figure 7.4. The surveyed trees by crown density class. Pine. 1988-1992



Source: NIJOS

continued. The average crown density for spruce decreased from 82.5 per cent in 1991 to 81.6 per cent in 1992. The main cause of the decrease is that the proportion of trees in the best crown density class (a crown density of 90-99 per cent) decreased from 52.6 per cent in 1991 to 47.9 per cent in 1992. The average crown density for pine has remained stable for several years, which makes this year's recording of a marked reduction in crown density, from 86.1 per cent in 1991 to 83.2 per cent in 1992, interesting. In the case of pine, the decrease in the share of the trees in the best crown density class was as much as 10.1 per cent from 1991 to 1992. Figures 7.3 and 7.4 show the percentage of surveyed trees in the different crown density classes for spruce and pine respectively, and changes over time.

As regards crown colour, the situation has remained fairly stable for both spruce and pine, with only small annual variations during the period 1988 to 1992.

National recordings of the crown density of birch in coniferous forest have been carried out from 1990 to 1992. The average crown density has shown a slight tendency to decrease during the period, from 79.7 per cent in 1990 to 78.4 per cent in 1992.

In 1992 a national network of observation plots was established with a grid of 18 x 18 km with a view to observing the vitality of mountain birch forest. So far the data are insufficient to draw any conclusions about the health of mountain birch forest, but it is assumed that in the long term this type of forest, owing to its exposed position in terms of weather, will be very useful for monitoring changes in climate.

The results of the *county recordings in local plots* from 1988 to 1992 (NISK, 1992) show a steady reduction in forest vitality. There are regional variations, both in crown density and crown colour. A strong reduction in crown density from 1991 to 1992 was found in northern parts of Western Norway, and during the same period, both crown density and crown colour have deteriorated in plots of spruce in Eastern Norway. Part of the deterioration in forest vitality can be explained by two consecutive dry summers in the eastern and southern parts of Norway in the last two years, and the hurricane in Western Norway and in Trøndelag at the turn of the year 1991/92.

Trees destroyed by storms

The hurricane in the northern part of Western Norway at the turn of the year 1991/92 caused extensive damage to forest in the counties of Sogn og Fjordane, Møre og Romsdal, Sør-Trøndelag and Nord-Trøndelag, and the clear-up work is still going on. In November 1992 it was estimated that a total of 2.04 mill. m^3 of forest was damaged by the hurricane (personal information, Ministry of Agriculture 1992). It is estimated that 1.80 mill. m^3 of this volume can be saved. During the fourth quarter of 1992, a total of 1.08 mill. m^3 timber was produced and sold, and 0.17 mill. m^3 was produced but not sold. The trend towards a generally weaker market for timber, and especially for wood of low quality, makes it difficult to clear up the damaged forest effectively.

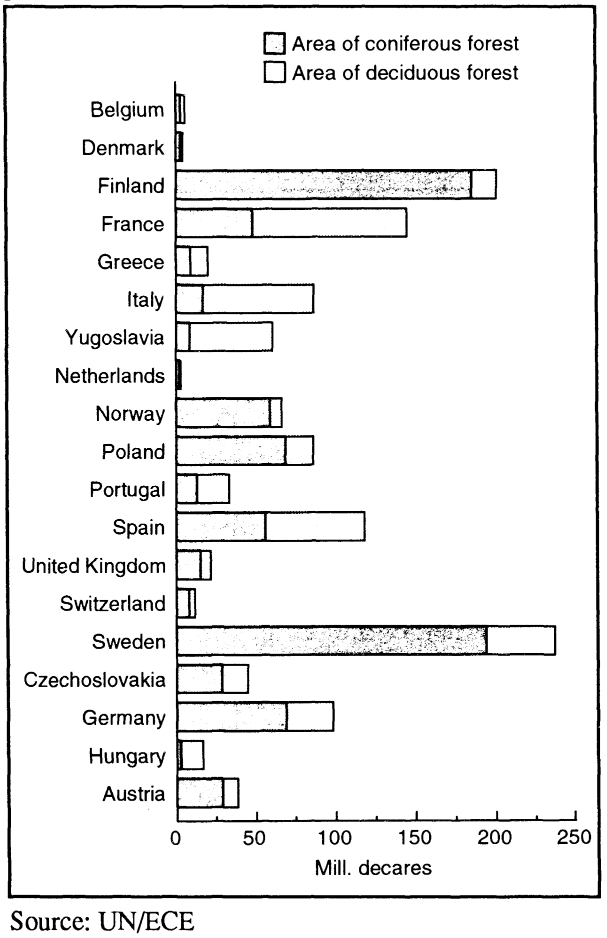
7.2. Forest in Europe

Forest resources

Forest land in Russia, Sweden and Finland accounts for respectively 14.8 per cent, 11.9 per cent and 9.4 per cent of all European forest land. The forests in these areas are dominated by coniferous trees. In Central Europe, the largest area of forest is found in France and Spain. In these countries deciduous trees dominate. Turkey has about the same amount of forest area as Finland.

Figure 7.5 shows productive forest area distributed between coniferous and deciduous forest in some European countries (UN/ECE, 1992). In 1989, the area of productive forest in Europe as a whole, including the Baltic states, Ukraine, Byelorussia, Russia and Turkey, amounted to 2.1 mill km^2.

Figure 7.5. Productive forest in some European countries. Mill. decares. Based on recordings during the period 1970-1989



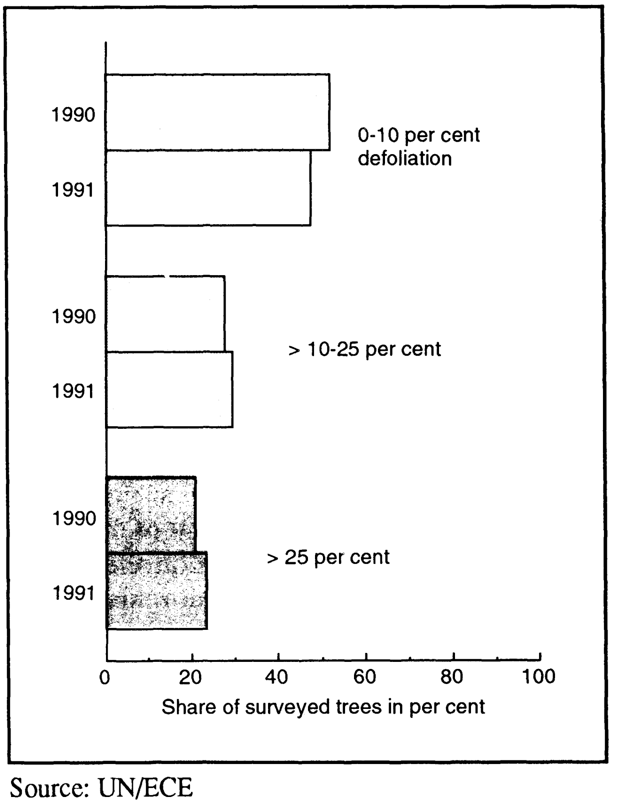
Source: UN/ECE

European forest health status

Since 1985, the Economic Commission for Europe (ECE) and the United Nations Environmental Programme (UNEP) have supported international cooperation to record and monitor damage to forest. At a joint European conference of ministers in Strasbourg in 1990, a total of 32 countries signed a convention to establish a European network of permanent observation plots for monitoring the forest ecosystem. About 70 per cent of Europe's forest is now included in a systematically organized network of trial plots with a total of 83 134 surveyed trees in 1991. Spruce, pine, silver fir, beech and oak accounted for about two thirds of the surveyed trees.

Experience from several years' recordings of forest damage in Europe (GEMS - Global Environment Monitoring System, 1990) shows that defoliation of up to 20-25 per cent does not necessarily imply reduced health status, but may be a result of the natural adjustment of the trees to variations in climate and supply of nutrients, and can thus be regarded as normal.

Figure 7.6. Percentage of plots by occurrence of defoliated trees. All kinds of trees. Europe. 1990 and 1991



Source: UN/ECE

According to UN/ECE, defoliation is divided into 5 classes:

Damage category	Percentage defoliation	Degree of damage
0	0 - 10	None
1	> 10 - 25	Slight
2	> 25 - 60	Moderate
3	> 60	Serious
4	100	Dead tree

NIJOS' measurements of crown density in Norway can be compared with UN/ECE measurements of defoliation in European countries. In principle, 80 per cent crown density will correspond to 20 per cent defoliation.

The results from the international programme to record and monitor the effects of air pollution on forest (UN/ECE, 1992) show 25 per cent defoliation in 22.2 per cent of all the surveyed trees. In general, there was a lower percentage of deciduous trees than coniferous trees in damage categories 2-4, 18.5 per cent and 24.4 per cent respectively.

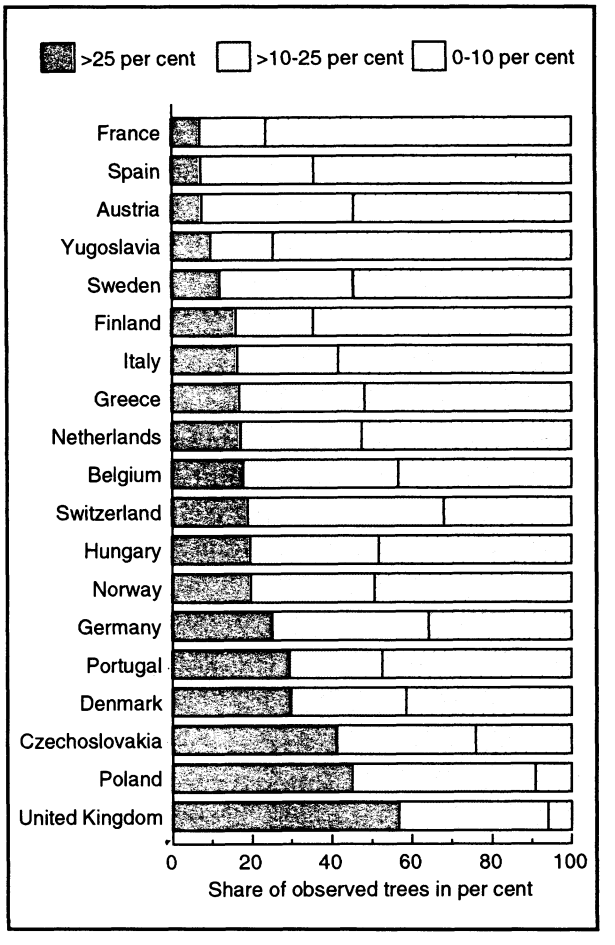
Among the coniferous trees, spruce and silver fir accounted for the highest percentage in damage categories 2-4.

In order to obtain comparable figures for the trends in the extent of forest damage over time throughout Europe, a sample of trees has been selected which are observed over several years. For the period 1990 to 1991 this sample constituted 74 per cent of all surveyed trees in 1991. Figure 7.6 shows that, in this sample, the percentage of trees with little or no defoliation decreased by 4.4 per cent from 1990 to 1991. At the same time, the percentage of trees with more than 25 per cent defoliation increased by 2.6 per cent. There was also an increase in the percentage of trees with 10-25 per cent defoliation.

The results of the observations in the individual countries show that the extent of forest damage was particularly extensive in the United Kingdom, Poland and Czechoslovakia, where 25 per cent defoliation was observed in respectively 56.7, 45.0 and 41.3 per cent of the surveyed trees. The least extensive damage was measured in France, Spain and Austria, where abnormal defoliation was found in respectively 7.1, 7.3 and 7.5 per cent of the surveyed trees. Figure 7.7 shows the extent of forest damage in some European countries. The extent varies, for example, with height above sea level, age of forest and the mix of trees. Owing to the subjective nature of the method of recording, and the large variations in climate and reforestation, caution must be exercised when comparing forest status in the different countries.

Unfavourable weather, attacks by insects and fungi, forest fires and air pollution are reported as the most important causes of forest damage. There are different conceptions of the importance of air pollution for forest health status (GEMS, 1990), but in most European countries air pollution is regarded as a main cause of damage to the forest ecosystem.

Figure 7.7. Distributions of surveyed trees by defoliation. All kind of trees. European countries. 1991



Source: UN/ECE

References:

Global Environment Monitoring System - GEMS (1990): Forest Damage and Air Pollution. Report of the 1989 Damage Survey in Europe.

Lunnan, A., Navrud, S., Rørstad, P.K., Simensen, K. and Solberg, B. (1991): *Skog og skogproduksjon i Norge som virkemiddel mot CO_2- opphopning i atmosfæren* (Forest and forest production as an instrument preventing accumulation of CO_2 in the atmosphere). Skogforsk no. 6, 1991. In Norwegian.

International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests - UN/ECE (1992): *Forest Condition in Europe.* 1992 Report.

Norwegian Institute of Land Inventory - NIJOS (1993): *Report 1992. Program "Overvåking av skogens sunnhetstilstand"* (Programme "Monitoring of forest health status"). In Norwegian.

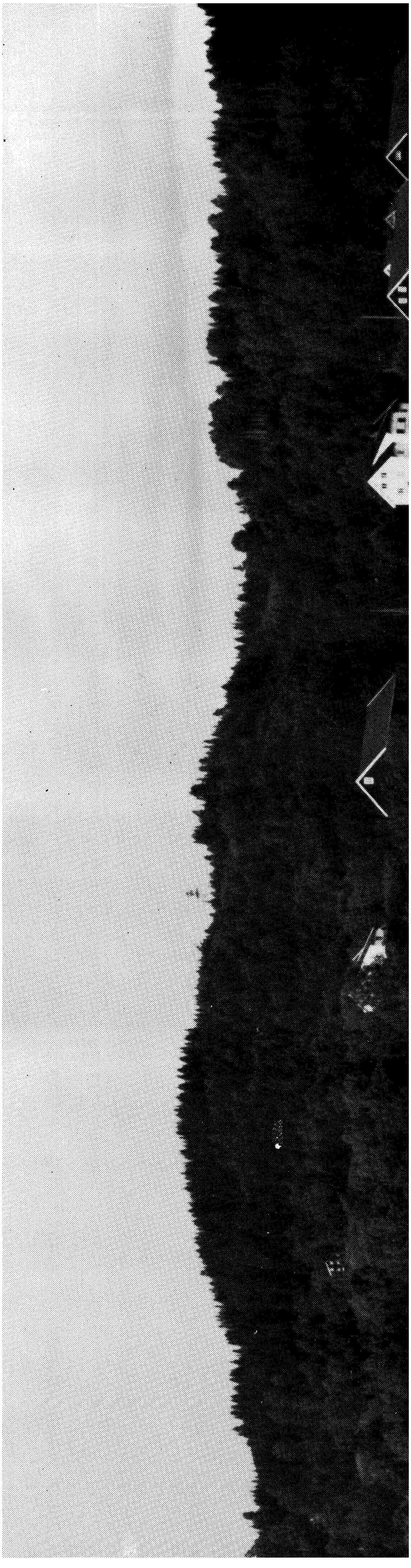
Norwegian Institute of Forest Research - NISK (1992): *Fylkesvise lokale overvåkingsflater. Vitalitetsregistreringer 1992* (Local county monitoring plots. Vitality survey 1992). In Norwegian.

Central Bureau of Statistics - CBS (1992a): *Landbruksteljing 1989. NOS Skogbruk og utmarksressursar* (Census of Agriculture and Forestry, 1989. Forestry and outfield resources).

Central Bureau of Statistics - CBS (1992b): *Skogstatistikk 1991* (Forestry statistics, 1991).

Central Bureau of Statistics - CBS (1992c): *Statistical Yearbook 1992.*

Central Bureau of Statistics - CBS (1992d): *Ressursregnskap for skog 1987-1991.* Interne notater 92/15 (Resource accounts for forest 1987-1991. Internal notes series 92/15). In Norwegian.



8. AGRICULTURE

The economic importance of agriculture has decreased in postwar years. During the period 1949-1991, agriculture's share of total employment sank from 21.8 to 4.6 per cent, and its share of the Gross Domestic Product decreased from 8.5 to 1.6 per cent.

Today, agriculture is responsible for 25 per cent of the inputs of nitrogen and 12 per cent of the inputs of phosphorus to the North Sea. There are indications that pollution from agriculture has been reduced in recent years. In 1989/90, 83 per cent of the grain land in the counties with land draining into the Skagerrak was ploughed in the autumn, in 1991/92 the amount had decreased to 69 per cent. A large share of the pollution from agricultural land is due to the fact that the fields are without a protective vegetation cover in autumn, winter and spring. In 1989, 72 per cent of the domestic animal manure in the counties along the coast of the Skagerrak was spread in the growing season. In 1991 the share had increased to 76 per cent. In 1989, in the same counties, split fertilization of grain was practised on 8 per cent of the grain land. In 1991 the share had increased to 12 per cent. Consumption of nitrogen in commercial fertilizer has remained stable throughout the 1980s, but consumption of phosphorus has been considerably reduced.

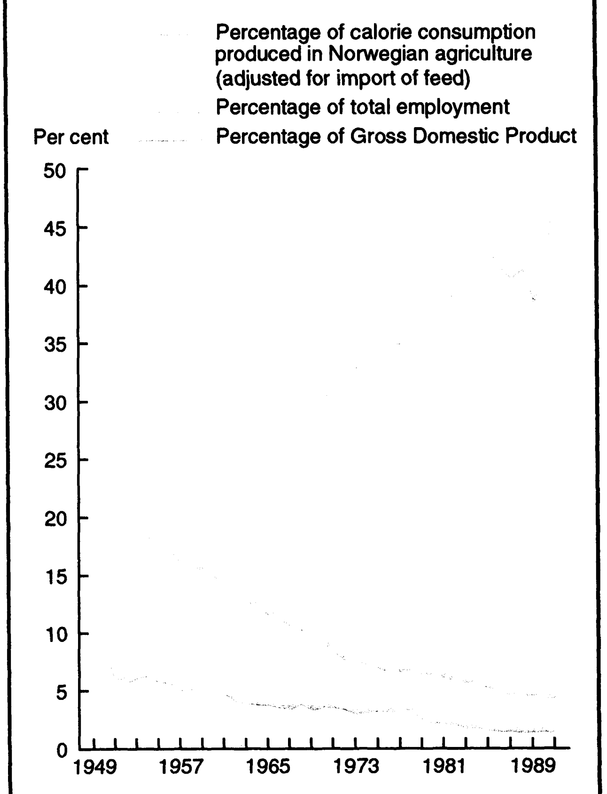
8.1. The economic importance of agriculture in Norway

In the last decades, agriculture has become of steadily decreasing importance for Norway's national economy. In figure 8.1 we have chosen three indicators which illustrate the importance of agriculture.

The share of calorie consumption produced in Norwegian agriculture (adjusted for imports of feed)

This shows the size of the agricultural production in relation to the population's demand for food products. Calculations are available from 1970 onwards. Agricultural production's share of the population's calorie consumption increased from 30 to 49 per cent during the period 1970 to 1991 (National Nutrition Council, 1992). The main reason for the uneven increase is annual variations in growing conditions. From 1970 to 1991, the volume of agricultural production increased by 36 per cent (Budget Committee for Agriculture, 1992).

Figure 8.1. The importance of agriculture. Some indicators. Percentage of total national figures



Sources: CBS, National Accounts, National Nutrition Council

Share of total hours of paid employment

In 1949, 21.8 per cent of the total employment in Norway occurred in agriculture. In 1991 this share had fallen to 4.6 per cent. In absolute figures the number of normal man-years in agriculture decreased from about 300 thousand in 1949 to about 81 thousand in 1991.

Share of the Gross Domestic Product

The Gross Domestic Product (GDP) expresses the value of the production in the country minus the costs of materials inputs. Agriculture's share of the GDP has declined steadily in post-war years, from 8.5 per cent in 1949 to 1.6 per cent in 1991. For the period as a whole, this is about the same relative decrease as for employment.

[illegible]

Discharges and their sources

One of the most serious pollution problems caused by agriculture is the discharge of the *nutrients nitrogen (N) and phosphorus (P)* to water. Excessive discharges of nutrients contribute to eutrophication and periodical blooms of algae. When the algae die, their biomass decomposes, consuming oxygen gas in the water masses. Sometimes the algal blooms produce toxic substances.

Other substances that pollute the environment are *organic material, soil particles and micro-pollutants* (e.g. heavy metals and chemical pesticide residues). In this report the information on pollution from agriculture is limited to discharges of nitrogen and phosphorus.

The total inputs of nitrogen and phosphorus to the Skagerrak are estimated to 1 650 tonnes P and 42 600 tonnes N (State Pollution Control Authority - SFT, 1992). (This is the area covered by the "North Sea Declaration", that is to say, the Declaration of Ministers in London in 1987 concerning protection of the North Sea, where the states adjacent to the North Sea agreed, inter alia, to reduce their discharges of nutrients by 50 per cent from 1985 to 1995. The counties affected by this agreement are Østfold, Hedmark, Oppland, Akershus, Buskerud, Vestfold, Telemark, Aust Agder and Vest Agder. In the following pages these counties will be referred to as "the algal counties"). Agriculture is responsible for roughly 25 per cent of the inputs of nitrogen and about 12 per cent of the inputs of phosphorus to the North Sea.

The discharges of nutrients from agriculture can be traced to two types of sources; point discharges and diffuse discharges (area runoff). Point discharges are mainly effluent from stores of manure and silage. Area runoff includes nutrients lost from cultivated land. Point discharges can be reduced considerably by sealing the stores. Runoff from cultivated land is more difficult to control, because these leakages are closely connected to management practices, type of soil and variations in climate.

The calculations show that the loss of nutrients from area runoff is much greater than the loss from point sources (Centre for Soil and Environmental Research - Jordforsk, 1991). On average, about 90 per cent of the discharges are area runoff. The share from area runoff is slightly higher for nitrogen than for phosphorus.

Agricultural practices affecting pollution

The farming operations which have the greatest impact on runoff of nutrients are fertilization and soil preparation. To follow the trend in pollution from agriculture it is necessary to start by studying changes in farming practices and land use. The measured values for pollution in the recipients are influenced by inputs from several sources in addition to agriculture, and the discharges will vary considerably from year to year depending on variations in the weather and in snow melting.

The available statistics which throw some light on agriculture's contribution to pollution are presented below. Some of the results deviate slightly from those presented in last year's version of this report. This is because the calculations have been carried out again with slightly different assumptions, and with better coordination of the information from the different data registers. Nevertheless, all the trends are the same. Most of the figures are taken from the report "Resultatkontroll jordbruk

1992" (Evaluation of results in agriculture 1992) (CBS, 1993).

Land use

In 1992, the area of agricultural land was estimated to 10.1 million decares. This is 3.3 per cent of Norway's total land area. Runoff of nutrients from fully cultivated land is greater per unit area than runoff from forest and mountain land. Fully cultivated land can be divided into two main categories: crop land (which is usually tilled annually) and meadow (land with grass crops which is only tilled at intervals of several years). Loss of soil (erosion) is much greater from crop land than from meadow, and in general the loss of nutrients is also greater from crop land.

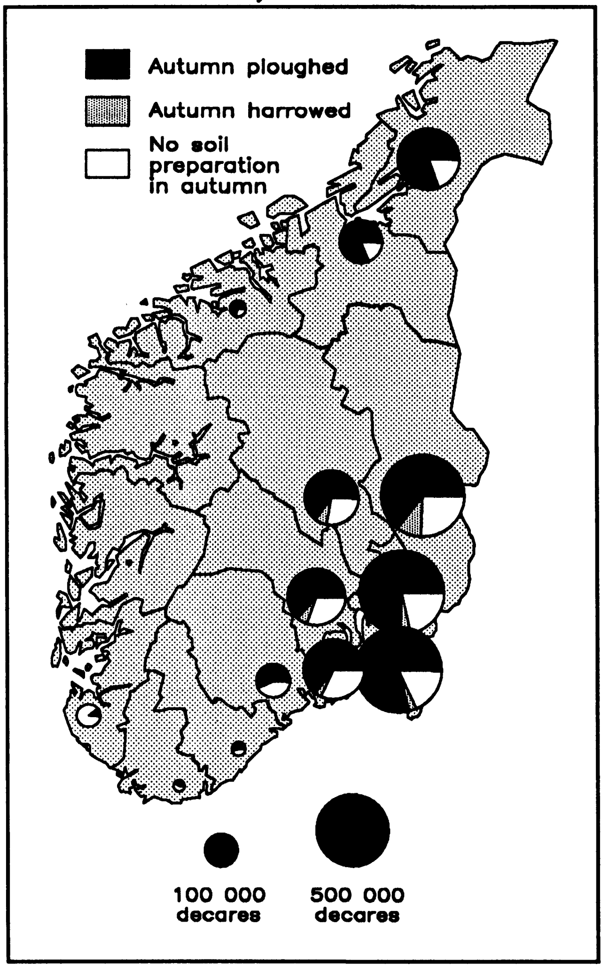
Therefore, provided that other conditions remain constant, a change in the area of agricultural land or a substantial change in the ratio between meadow and crop land indicate a change in the discharges of nutrients. According to the figures stated in the applications for production subsidies, the area of fully cultivated land increased by 5.5 per cent from 1985 to 1992. Fully cultivated meadow increased by 4.8 per cent and crop land by 6.2 per cent. It is assumed, however, that the main reason for the increase is that farmers applied for a production subsidy for a larger share of the land. Therefore the real increase in the area of agricultural land is more uncertain.

Soil preparation

The traditional method of preparing land for grain production is to plough the land in the autumn and do the levelling and harrowing in spring. This means that the land has no cover of vegetation throughout the autumn and winter and is thus exposed to erosion from water and wind. Erosion of soil from crop land is the most important source of runoff of phosphorus, and a substantial loss of soil each year will also reduce the productive capacity of the land in the long term.

Less soil preparation, particularly in the autumn, will reduce erosion. Harrowing in the autumn, instead of early ploughing in autumn, reduces erosion by an average of 30 to 40 per cent, and if all soil preparation is postponed until spring, erosion is reduced by an average of

Figure 8.2. Grain land distributed between autumn ploughed land, autumn harrowed land and land with no soil preparation in autumn. Autumn 1991/spring 1992[1]. Southern Norway. Decares.



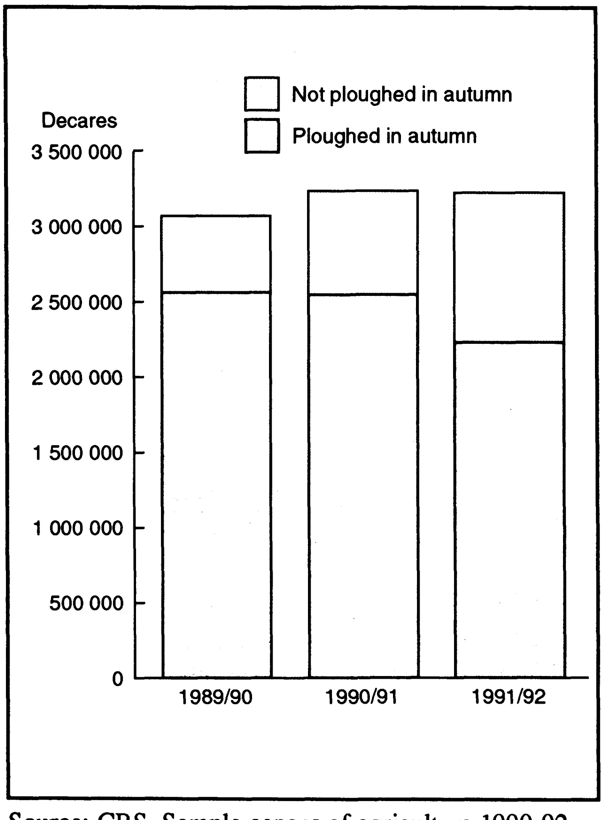
[1] For Trøndelag and Western Norway the figures apply to autumn 1990/spring 1991.
Source: CBS, Sample census of agriculture 1991 and 1992

about 60 per cent (Eggestad, 1992). In absolute figures, the reduction is greatest on land that is steep or consists of readily erodible soils (silt).

Figure 8.2 shows the area used for grain production distributed between autumn ploughed fields and fields that are not ploughed in the autumn (harrowed and/or ploughed in spring).

Rogaland is the county with the clearly lowest proportion of autumn ploughed land, 11 per cent. In Hedmark, Oppland, Buskerud and Vestfold, about 65 per cent of the grain area is ploughed in the autumn. Of the algal counties, Akershus and Østfold are the ones with the largest share of land with high erosion hazard. In

Figure 8.3. Changes in area of grain land ploughed in autumn in the"algal counties" 1989/90-1991/92. Decares



Source: CBS, Sample census of agriculture 1990-92

Table 8.1. Share of grain land ploughed in autumn in counties with a large area of grain land. 1989/90-1991/92

	Percentage autumn-ploughed area		
	1989	1990	1991
Whole country	82	78	..
"The algal counties"	83	79	69
Østfold	92	87	79
Akershus	90	84	74
Hedmark	76	72	65
Oppland	75	72	65
Buskerud	82	78	63
Vestfold	84	80	64
Telemark	74	64	53
Rogaland	10	11	..
Sør-Trøndelag	75	80	..
Nord-Trøndelag ...	82	80	..

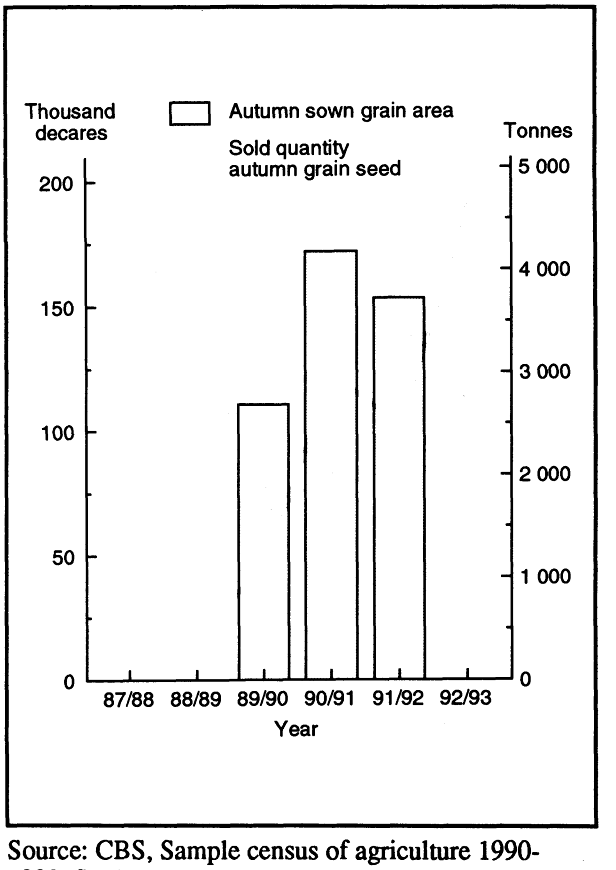
Source: CBS, Sample census of agriculture 1990-1992

Table 8.2. Grain area, with percentage sown in autumn. Selected counties. 1991

	Total grain area[2] 1 000 decares	Percentage autumn-sown
Whole country[1]	3 880	4.4
"Algal counties"	3 225	4.8
Østfold	715	8.4
Akershus	704	5.7
Hedmark	684	0.9
Oppland	294	1.0
Buskerud	322	3.4
Vestfold	359	7.9
Telemark	112	2.9
Rogaland[1]	55	0.2
Sør-Trøndelag[1]	180	0.0
Nord-Trøndelag[1]	370	0.8

[1] Autumn 1990
[2] Figure calculated from the Sample Census of Agriculture.
Source: CBS, Sample census of agriculture 1992

Figure 8.4. Area of autumn-sown grain and sales of seed for autumn grain. 1987/88 - 1992/93



Source: CBS, Sample census of agriculture 1990-1992, Statkorn spite of this, they are the counties with the highest proportion of autumn ploughed grain land; 79 per cent in Akershus and 74 per cent in Østfold.

Figure 8.3 shows changes in the area of autumn ploughed land in the algal counties, while table 8.1 shows the changes for certain specific counties.

There has been a clear decrease in the share of grain land ploughed in the autumn. The decrease is particularly strong from 1990 to 1991. Since 1991 the Ministry of Agriculture has paid farmers to postpone soil preparation until spring on grain land with particularly high erosion hazard. In 1991/92 the Ministry paid out NOK 45 million, and in 1992/93 the sum had risen to NOK 76 million. Autumn ploughing is therefore expected to be further reduced in 1992/93.

Autumn grain

Autumn grain is relevant in the areas most suitable for grain production. The vegetation cover established in the autumn reduces erosion by about 30 per cent compared with the erosion occurring with spring grain, when the land is ploughed in early autumn (Eggestad, 1992). Nitrogen runoff in the autumn is also considerably reduced as a result of plant growth. Table 8.2 shows the proportion of grain land sown in the autumn in 1992.

Østfold and Vestfold are the counties where autumn sowing is most common, and account for about 8 per cent of the area devoted to grain. These are also the two counties with the best climate for grain production.

Figure 8.4 shows changes in the area with autumn sown grain and sales of seed for autumn grain during the last three years.

Except for the decrease from 1990 to 1991, the area of land sown with autumn grain has increased in recent years. The figure shows that the trend in the area of autumn-sown grain conforms well with the sales figures for seed for autumn grain. Mild winters and drought in early summer enhance the advantage of autumn grain.

Use of manure

How and when the manure is spread is of decisive importance for runoff of nutrients. The lesser the plants absorb of the nutrients contained in the manure, the greater the share that disappears into the air (evaporation of ammonia and denitrification) or is carried away with the water running off the land spread with manure. The degree of absorption of nutrients depends on the following conditions:

1. The amount of manure spread per unit of land.
2. When the manure is spread in relation to plant growth.
3. When the manure is earthed in after spreading.
4. The type of storage and method of spreading.

There is no reliable information on items 3 and 4.

Quantity spread

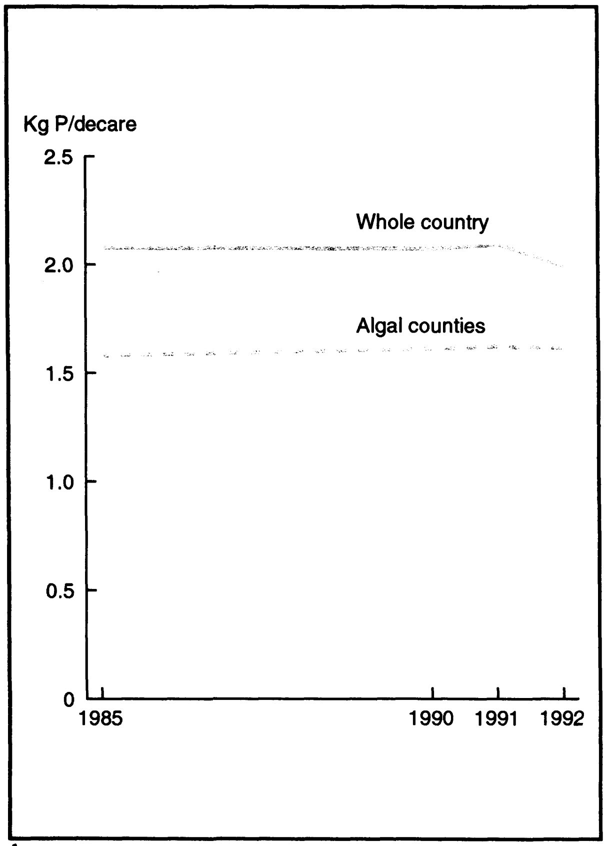
Figure 8.5 gives some indication of the amount of manure spread per unit of land. The figure shows only small changes in the amount of phosphorus from manure per decare of fully cultivated land on farms rearing animals during the period 1985-1992.

One way of expressing local surplus (concentration) of manure is to calculate how large a share of all manure would be in excess if no farm had less than 4 decares of fully cultivated land per animal manure unit during the period (According to the Ministry of Agriculture (1989) the number of animals can be expressed in so-called "animal manure units"). This share is shown in figure 8.6. According to the Ministry of Environment's regulations concerning animal manure (Ministry of Environment, 1989), by 1995 every farm must have at least 4 decares of spreading area per animal manure unit.

There has been a distinct reduction in the amount of "surplus" manure from 1985 to 1992.

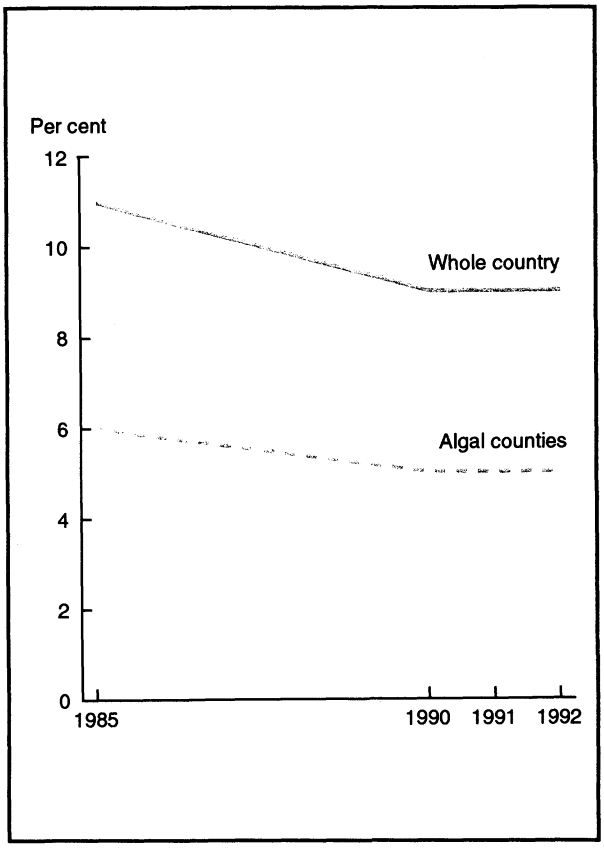
The share of all farms that rear animals and have less than 4 decares of spreading areas per animal manure unit has increased from 18 to 19 per cent. During the same period the number of farms that rear animals has decreased by 18 per cent (from 70 000 to 57 000), while the number

Figure 8.5. Average quantity of manure used per decare fully cultivated land[1]. The whole country and the "algal counties". 1985-1992*. Kg P/decare



[1] Land on farms with no animals not included.
Source: CBS, Applications for production subsidies 1985-1992

Figure 8.6. Surplus manure in relation to a requirement for 4 decares of spreading area per animal manure unit. 1985-1992. Per cent of all manure



Source: CBS, Applications for production subsidies 1985-1992

of animal manure units (the amount of manure) has decreased by about 8 per cent.

All in all, the calculations indicate that high concentrations of animal manure are becoming less of a problem, which indicates lower runoff of nutrients from this source.

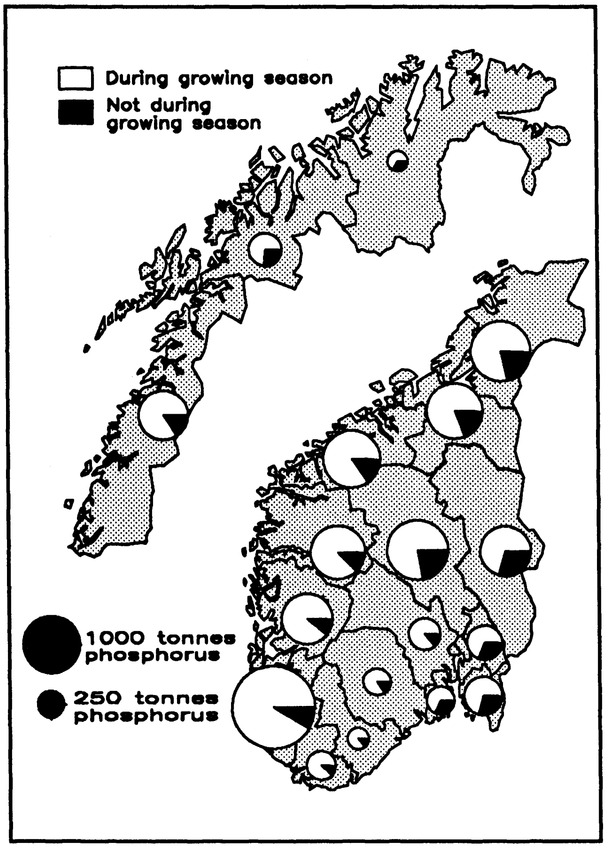
It is important to recognize that the problems connected to manure are also influenced by a number of conditions other than those mentioned above. Firstly, it is assumed that the quantity of manure produced per animal has not changed during the period. Secondly, some of the animals (for example, sheep, goats, young cattle) graze in outfield areas for part of the year. This reduces the amount of manure deposited on cultivated land. Thirdly, farmers can extend their spreading area, for example, by including surface cultivated land or by hiring spreading area from other farms. Based on information from the Census of Agriculture in 1989, 2.5 per cent of the manure was spread on areas other than the farmer's own land.

Time of spreading

If the nutrients in the manure are to be used effectively it is important to spread the manure in the growing season. Figure 8.7 shows the amount of manure spread during spring farming operations and at other times during the growing season and the amount spread outside the growing season.

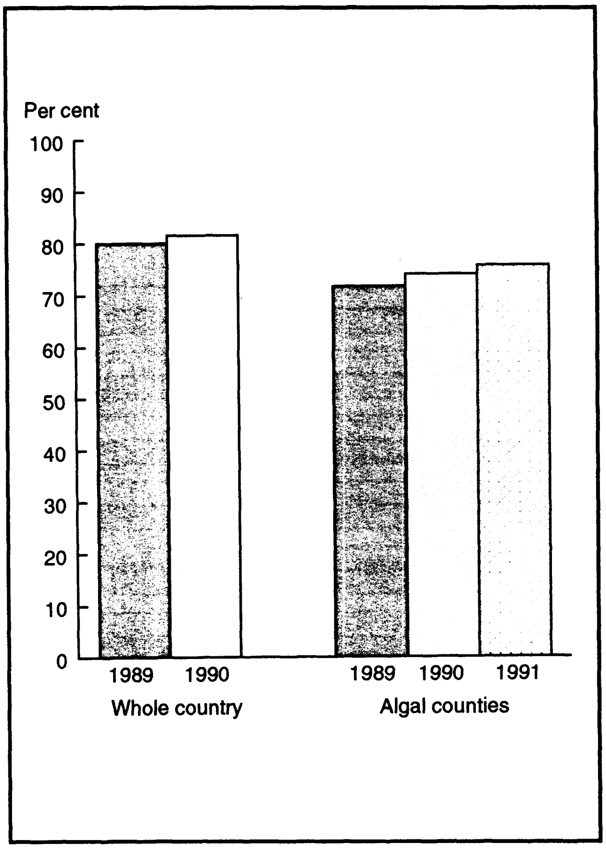
The best result is found in Rogaland, the county with the clearly highest animal density. In this county 92 per cent of the manure is spread during the growing season (1990). In the counties covered by the North Sea Declaration, a large proportion is spread outside the growing season, but in these counties the quantity of

Figure 8.7. Quantity of manure spread, showing amount spread during spring farming operations/at other times during the growing season, and amount spread outside the growing season



Source: CBS, Sample Census of Agriculture 1991 and 1992

Figure 8.8. Share of manure spread in the growing season in the "algal counties" and in the country as a whole. 1989-1991. Per cent



Source: CBS, Sample Census of Agriculture 1990-92. Applications for production subsidies 1989-91

manure is not as great in relation to the spreading area.

Figure 8.8 shows the trend for the share of the manure spread during spring farming operations and in the growing season during the period 1988-1991.

According to the sample censuses, the share of manure spread in the growing season increased during the period 1989-1991. The tendency was the same in the individual counties, except in Vestfold, where this share decreased from 1990 to 1991.

Manure storage capacity

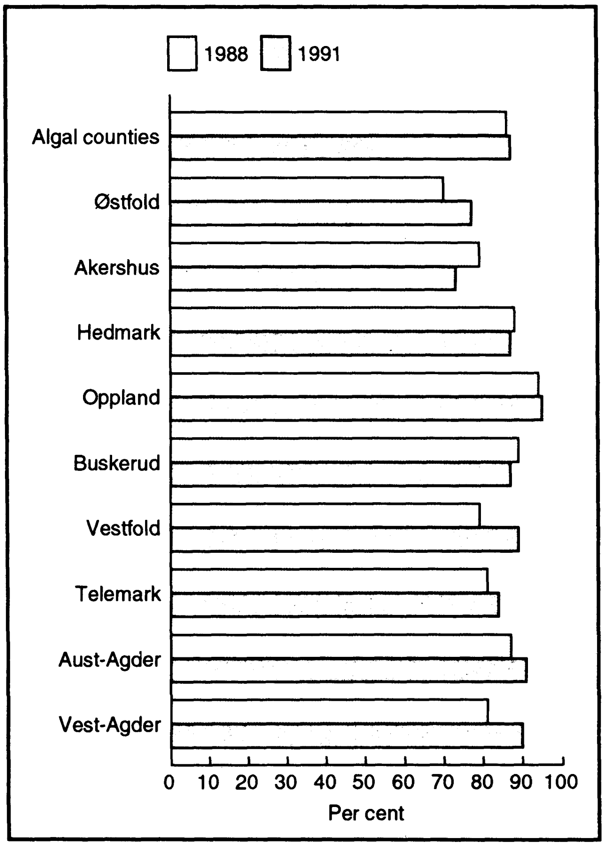
According to the Ministry of Environment's regulations concerning animal manure it is not permitted to spread manure on snow or frozen ground. It is permitted to spread it in the autumn, after the growing season, provided that the manure is earthed in immediately. This is a favourable time for many farmers from the point of view of work.

In order to be able to spread the manure in conformity with the regulations it is necessary to have sufficient storage capacity to cover at least 7-8 months' indoor feeding if the animals remain indoors all year round. To be able to spread all the manure in the *growing season* it is necessary to have 9-11 months' storage capacity.

Figure 8.9 shows how much of the manure is found on farms with enough storage capacity to be able to spread the manure in accordance with the regulations.

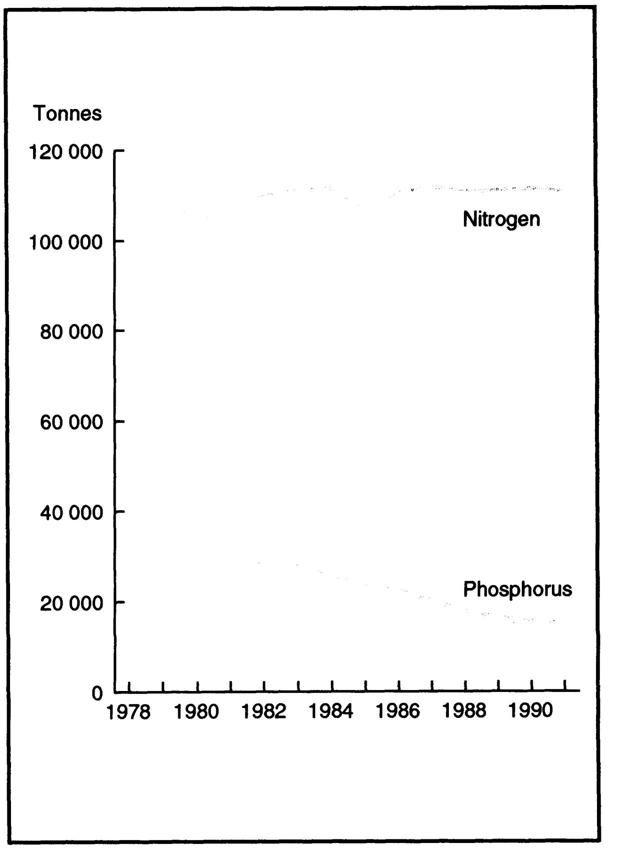
In the "algal counties" in 1988, about 57 per cent of all the manure was produced on farms with sufficient storage capacity to be able to spread the manure *in the growing season.* In 1991 the figure had increased to 63 per cent. During the same period the change in what can

Figure 8.9. Share of the total manure found on farms with sufficient storage capacity to spread the manure according to the regulations. 1988 and 1991. Per cent



Source: CBS, Census of Agriculture 1989 and Sample Census of Agriculture 1992

Figure 8.10. Sales of nitrogen and phosphorus in commercial fertilizer in Norway. 1978-1991. Tonnes



Source: The National Association of Purchasing Pools, National Agricultural Inspection Service

be spread in accordance with the regulations was minimal; from 86 to 87 per cent. (In this report, spreading "in accordance with the regulations" means having 7 months or more of indoor feeding capacity, and spreading "in the growing season" means having 9 months or more of indoor feeding capacity. The figures must be regarded as average, the growing season and the period of time when the ground is frozen naturally vary with the climatic conditions).

The main reason for the positive trend is an expansion of the farms' storage capacity for manure. Since 1989, the sum of NOK 275 million has been paid out for technical environmental measures (Ministry of Agriculture, 1990-92). About half of this money has been spent on increasing the capacity of the manure stores. The purpose of increasing the storage capacity is to be able to spread the manure at the most favourable time, and the subsidies are awarded for environmental reasons.

Spreading of commercial fertilizer

During the last 10 years, sales of nitrogen in commercial fertilizer has remained stable around 110 000 tonnes per year. Sales of phosphorus have clearly decreased, and were down to 14 800 tonnes in 1991/92 compared with 29 000 tonnes in 1979/80. Figure 8.10 shows sales of N and P in commercial fertilizer since 1978.

Table 8.3 shows average N and P fertilization of grain land and meadow in the country as a whole and in the "algal counties".

During the period for which statistics are available, only small changes have occurred in the amount of commercial fertilizer spread per decare. The clearest tendency is reduced P fertilization to meadow. The figures for 1978 and

Table 8.3. Average nitrogen and phosphorus fertilization to grain and fully cultivated meadow. The years 1978 and 1988-91. Whole country and the "algal counties". Kg/decare

	Nitrogen					Phosphorus				
	1978	1988	1989	1990	1991	1978	1988	1989	1990	1991
Grain										
Whole country	10.6[1]	10.6	10.6	10.7	..	..	2.2	2.2	2.1	..
"Algal counties"	11.0	11.0	11.0	11.1	11.1	..	2.2	2.2	2.2	2.1
Fully cultivated meadow										
Whole country	14.3[1]	13.8	13.7	13.7	..	..	2.5	2.3	2.2	..
"Algal counties"	12.7	12.9	13.0	13.1	12.7	..	2.6	2.5	2.4	2.2

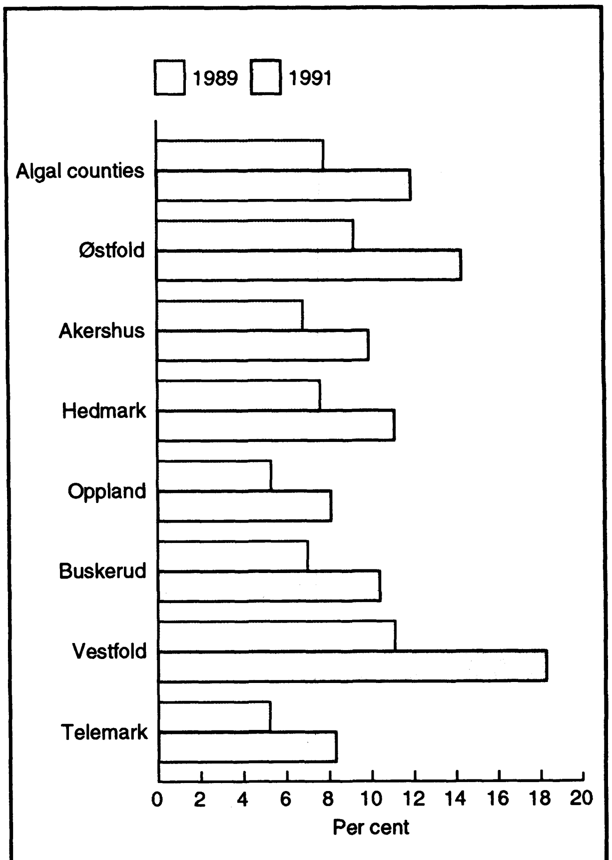
[1] Nordland, Troms and Finnmark not included
Source: Census of Agriculture 1979 and 1989, Sample Census of Agriculture 1990-92

1988 are based on total recordings, while the figures for 1989 and after are based on a 20 per cent sample.

If the nitrogen fertilizer is spread in several doses (split fertilization), the fertilization can be better adjusted to the needs of the plants. This means that the plants absorb a larger share of the nutrients in the fertilizer, which is both economic for the farmer and leads to less loss of surplus nutrients in the runoff. Figure 8.11 shows how large a share of the grain area was fertilized in several doses in 1989 and 1991.

There was a marked increase from 1989 to 1991 in the share of grain land that was split fertilized. In 1991 this share was 12 per cent. The increase was largest in Vestfold, where the share rose from 11 to 18 per cent of the total grain area. Split fertilization is associated in particular with production of wheat (in the case of wheat, a price subsidy is awarded for increased protein content, and split nitrogen fertilization normally increases the protein content). Vestfold and Østfold are the counties most suitable for wheat production, so it is in these two counties that the largest share of the grain land is fertilized in two stages.

Figure 8.11. Share of grain land with split fertilization. Selected counties. 1989 and 1991. Per cent



Source: CBS, Sample Census of Agriculture 1990 and 1992

References:

Budget Committee for Agriculture (1992): *Volum- og prisindekser for jordbruket. Regnskapsårene 1959-1991* (Volume and price indexes for agriculture. Accounts for the years 1959 - 1991). (In Norwegian).

Eggestad, Hans Olav (1992): *Tiltak mot jorderosjon og avrenningstap av fosfor og nitrogen fra jordbruksarealer* (Measures against soil erosion and loss og phosphorus and nitrogen through runoff from agricultural land). Centre for Soil and Environmental Research, Ås. (In Norwegian).

JORDFORSK (1991): *Avrenning og effekt av tiltak i landbruk* (Runoff and effect of measures in agriculture). Part report for the National North Sea Plan (Revised edition). Project no. 1347, Centre for Soil and Environmental Research, Ås. (In Norwegian).

Ministry of Agriculture (1989): *Retningslinjer om lagring og spredning av husdyrgjødsel* (Guidelines for storage and spreading of manure). (In Norwegian).

Ministry of Environment (1989): *Forskrift om husdyrgjødsel* (Regulations concerning animal manure). (In Norwegian).

National Nutrition Council (1992): *Utvikling i norsk kosthold* (Trends in the Norwegian diet). (In Norwegian).

SFT (1992): *Nasjonale samletall for forurensingsutslipp 1991.* (National total figures for discharges of pollutants). SFT Report 92:03. (In Norwegian).

CBS (1992): *Natural Resources and the Environment 1991.* Report 92/1. Central Bureau of Statistics, Oslo-Kongsvinger.

CBS (1993): *Resultatkontroll jordbruk 1992. Tiltak mot avrenning av næringssalter og jorderosjon* (Evaluation of results in agriculture 1992. Measures against runoff of nutrients and soil erosion). Report 93/12. Central Bureau of Statistics, Oslo-Kongsvinger. (In Norwegian).

9. WASTE WATER TREATMENT PLANTS

The Central Bureau of Statistics and the State Pollution Control Authority have jointy initiated annual registration of data from all waste water treatment plants in the country. 35 new waste water treatment plants were built in 1991, with a total capacity of 430 000 population units (p.u.). At the end of 1991, the total number of such plants in Norway was 1638. The plants had a total hydraulic capacity of about 4.5 million p.u. and a total hydraulic load of about 3.4 million p.u. This represents an increase in capacity of about 10 per cent compared with the year before. A corresponding survey was carried out for 1990, and surveys of somewhat smaller scope for the years 1978, 1982, 1983 and 1988.

9.1. Background

In 1991, the Central Bureau of Statistics (CBS) and the State Pollution Control Authority (Statens Forurensningstilsyn - SFT) established a data base on all the waste water treatment plants in Norway in order to make it easier to:

- check that the large investments in the sewerage sector are giving the intended environmental gains
- check that national goals are being realized and that the international agreements entered into will be fulfilled
- identify problem areas, to provide a basis for considering where to take action
- prepare official statistics from the sewerage sector.

The waste water drainage system can be divided roughly into two parts; the pipeline network, including pump stations and spillways, and the actual waste water treatment plants, with outlets.

The pipeline network in Norway varies greatly in age. The oldest parts consist of wooden pipes laid in the early part of this century. Concrete pipes were common during an intermediate period, but most of the pipes laid in recent years are of PVC. The total length of pipes is about 30 000 km.

The pipeline network can also be divided by function. In a separate system, the pipes for storm water and ordinary waste water are separate, while in a combined system the storm water and ordinary waste water are carried away in the same pipe.

9.2. Methodology

CBS and SFT have jointly developed an electronic registration form with computer controls (SSBAVLØP) for collection of information on the country's waste water treatment plants. The system has been installed and is now in use at all county environmental agencies, which are also responsible for updating the information each year. The data are sent to CBS on disc. The system was made operative in 1991, so that the data set for 1990 is the first collected by this method.

The records cover data on time of establishment, geographical location, ownership, capacity, load, chemicals, purification principles, analysis results, sludge treatment methods, sludge disposal, and recipients.

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

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

So-called *"high-grade" waste water treatment plants* include plants with a biological and/or chemical phase.

Biological plants include activated sludge plants, trickling filters and biological discs. In biological plants, readily degradable organic material is removed by means of microorganisms.

Chemical plants include primary precipitation plants and secondary precipitation plants. In these plants the chemicals are added during the purification process in order to remove phosphorus from the waste water. The chemicals used are mainly aluminium sulphate, ferric chloride or calcium. In secondary precipitation the chemical precipitation is preceded by sedimentation.

Chemical/biological plants combine a biological and a chemical stage, and include pre-precipitation, post-precipitation and simultaneous precipitation plants. In the pre-precipitation plants the chemicals are added before the biological stage, and in post-precipitation plants they are added afterwards. In simultaneous precipitation plants the chemical precipitation takes place simultaneously with the biological degradation.

Unconventional plants include sand filter plants, infiltration ditches, biological dams, biological dams with precipitation and precipitation dams.

The group *"other/unknown"* includes plants where the purification principles are not known, or where special adaptations or a specific purification technique make it unnatural to place the plant in any of the main groups defined above.

Population equivalents (p.e.) mean waste water from industry, institutions, service activities etc. converted into an equivalent number of persons producing a specific volume of waste water.

Population units (p.u.) are the number of permanent residents plus the number of population equivalents in an area.

Box 9.1. Definitions

Capacity and load

A total of 1638 waste water treatment plants were registered in 1991, with a total hydraulic capacity of about 4.5 million p.u. and an hydraulic load of about 3.4 million p.u. The registration included only plants with a capacity of more than 50 p.u.

In 1988, 700 waste water plants were registered, with a total capacity of 2.9 million p.u. and a load of 2.3 million p.u. In 1990 the number of registered plants had increased to 1387, with a total capacity of 3.9 million p.u. and a total hydraulic load of 2.9 million p.u. However, the figures for 1988 and earlier are not directly comparable with the figures for 1990 and 1991, owing to a slight change in the way the plants are classified. Infiltration ditches, sludge separators and screens were not included in the total figures for 1988. In 1988, these types of plants were presented separately, and comprised 590 plants with a total capacity of 439 000 p.u. and a load of 330 000 p.u.

Table 9.1 shows that the total number of plants has increased from 1290 in 1988 to 1638 in 1991. During the same period the capacity increased by 33.1 per cent and the load by 29 per cent.

In 1991, 35 new waste water treatment plants were taken into use, with a total capacity of 430 000 p.u., implying that the rest of the increase in the number of plants, and in the capacity, from 1990 to 1991 is because some old plants were registered that had not been registered before.

The largest of the 35 new plants is the Central Waste Water Treatment Plant in Jæren, with a capacity of 240 000 p.u. This plant was taken into trial operation in December 1991.

The decrease in the number of biological and chemical/biological plants does not represent a true decrease. The reason for the apparent decrease is that several plants have reported special adaptations and have thus been transferred to the group "other purification principles".

In 1991, the greater part of the capacity of waste water treatment plants referred to *plants based on chemical precipitation,* either alone or combined with a biological stage (figure 9.1). A total of 461 such plants were registered. These have a combined capacity of 3.1 million p.u. (68.5 per cent of the total capacity) and a combined load of 2.4 million p.u. (70.7 per cent of the total load).

Mechanical plants make up the largest group in terms of number, i.e. 677 plants, and represent a capacity of 1 million p.u. (20.6 per cent of the total capacity). The load on these plants is 0.6 million p.u. (19.2 per cent of the total load).

Table 9.1. Waste water treatment plants. Number, capacity and load, by purification principle. 1988, 1990 and 1991

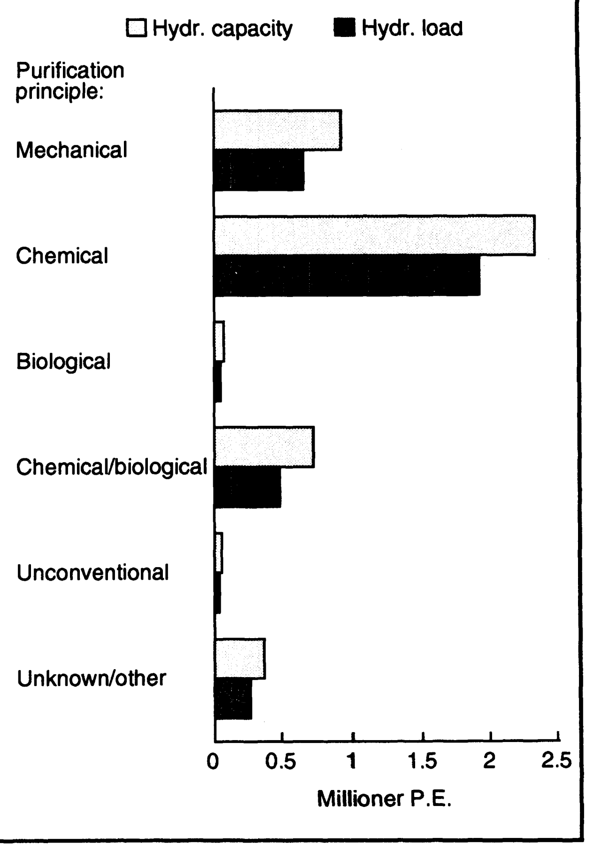
Year	Number	Capacity	Load
		1 000 p.u.	
Total			
1988	1290	3365	2649
1990	1387	3877	2907
1991	1638	4480	3416
Biological			
1988	156	87	54
1990	131	72	47
1991	137	71	48
Chemical			
1988	149	1604	1333
1990	169	1891	1605
1991	181	2346	1930
Biological/chemical			
1988	296	732	606
1990	283	720	481
1991	280	724	484
Mechanical/ unconventional[1]/ other[2]			
1988	689	942	656
1990	804	1194	774
1991	1040	1339	955

[1] For 1990 and 1991, *unconventional plants* include biological dams and biological dams with precipitation. In the statistics for 1988 these types of plants were categorized either as biological plants or biological/chemical plants, but in the above table they are categorized as unconventional plants.

[2] *Other* includes plants that have not reported which type of purification technology is used, and plants with special adaptations.

Source: CBS

Figure 9.1. Waste water treatment plants. Capacity and load, by purification principle. 1991. Million p.u.



Source: CBS

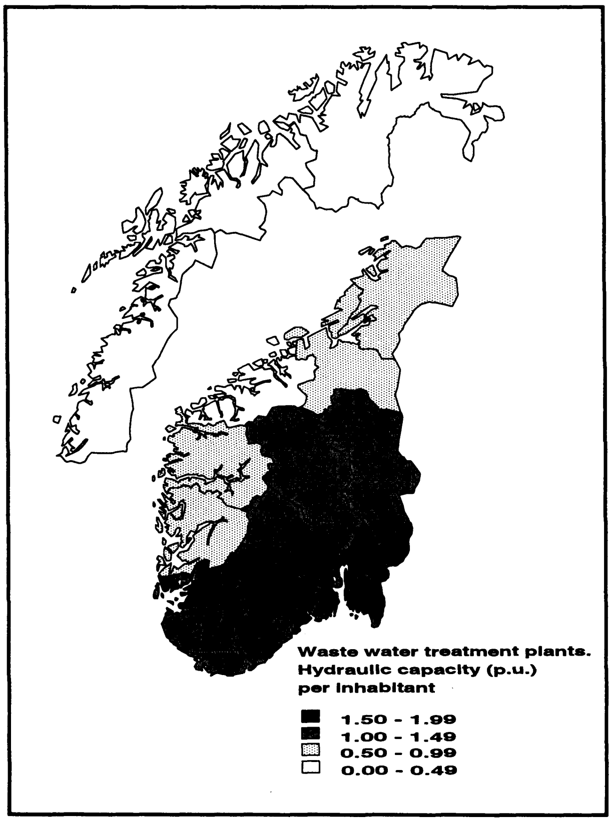
The *biological plants* have a combined capacity of just over 70 000 p.u. (1.6 per cent of the total capacity) and the load on these plants is about 48 000 p.u. (1.4 per cent of the total load).

The remaining plants have a combined capacity of 0.4 million p.u. (9.3 per cent of the total capacity) and the combined load on these plants is 0.3 million p.u. (8.8 per cent of the total load).

The capacity of the waste water treatment plants is highest in Eastern Norway (figure 9.2). For example, the plants serving Oslo/Akershus have a capacity of more than 1.5 p.u. per inhabitant.

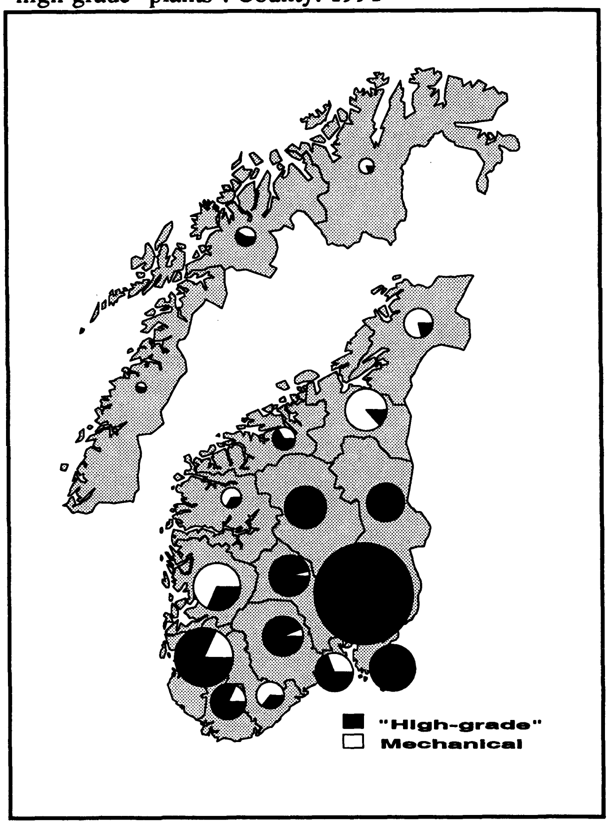
Figure 9.3 shows that in Eastern Norway, most of the waste water is treated in so-called "high-grade" plants (biological, chemical or chemical/biological), while in Western Norway and further north most of the water is treated in mechanical plants. No purely mechanical plants with a capacity of more than 50 p.u. are regis-

Figure 9.2. Waste water treatment plants. Hydraulic capacity per inhabitant (p.u.)[1]. County. 1991



[1]The figure includes plants with a reported capacity of more than 50 p.u., and does not include small waste water treatment plants in sparsely populated areas.
Source: CBS

Figure 9.3. Waste water treatment plants. Hydraulic capacity (p.u.) distributed between mechanical and "high-grade" plants[1]. County. 1991



[1]The figure includes plants with a reported capacity of more than 50 p.u., and does not include small waste water treatment plants in sparsely populated areas.
Source: CBS

tered as operative in Oslo, Akershus, Oppland or Hedmark.

Figure 9.4 shows the localization of the different waste water treatment plants, their capacity, and which purification process they employ. The figure includes only plants with a capacity of 5 000 p.u. or more. Most of the largest waste water treatment plants are found in the southern parts of the country, mainly in connection with the larger towns.

Ownership

Most of the waste water treatment plants (98 per cent) are municipally owned, either by one municipality or by several municipalities jointly.

Most of the large intermunicipal treatment plants are located in Hedmark, Rogaland, Østfold and Akershus. Vestfjorden Avløpsselskap (VEAS), in Akershus, serves large parts of Oslo and parts of Akershus. This is a chemical plant and alone has a capacity of 0.7 million p.u.

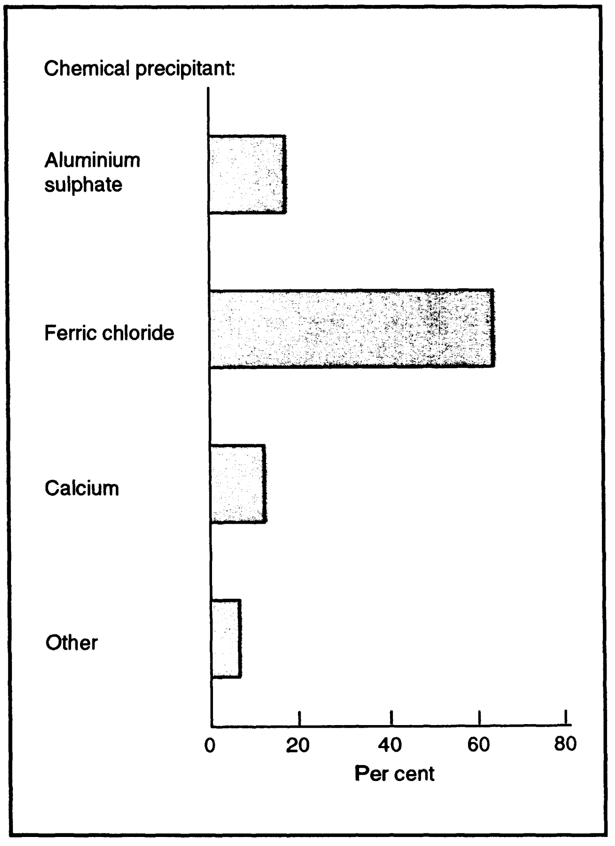
The waste water treatment plants in West Norway, Trøndelag and North Norway are owned almost without exception by the municipalities.

Chemicals

Consumption of chemicals is recorded in most of the plants with a chemical stage (figure 9.5).

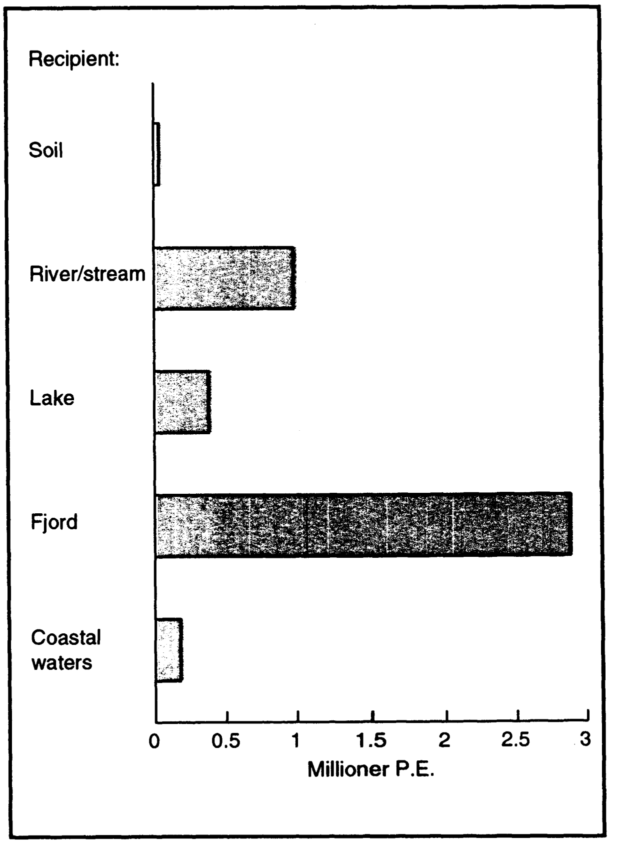
The chemicals most commonly used to precipitate phosphorus are aluminium sulphate, ferric chloride and calcium. Ferric chloride alone accounts for just less than 65 per cent of the consumption of chemicals, while aluminium sulphate accounts for just over 17 per cent. Calcium constitutes just over 10 per cent. The

Figure 9.5. Waste water treatment plants. Chemicals consumption by type of chemical. 1991. Per cent



Source: CBS

Figure 9.6. Waste water treatment plants. Capacity, by recipient. 1991. Million p.u.



Source: CBS

two largest plants in Norway, together accounting for about 25 per cent of the total capacity, use mainly ferric chloride in the precipitation process.

Recipients

Figure 9.6 shows that waste water treatment plants with a combined capacity of almost 2.8 million p.u. discharge into fjords, and plants with a combined capacity of 1 million p.u. discharge into rivers or streams.

Discharges from waste water treatment plants

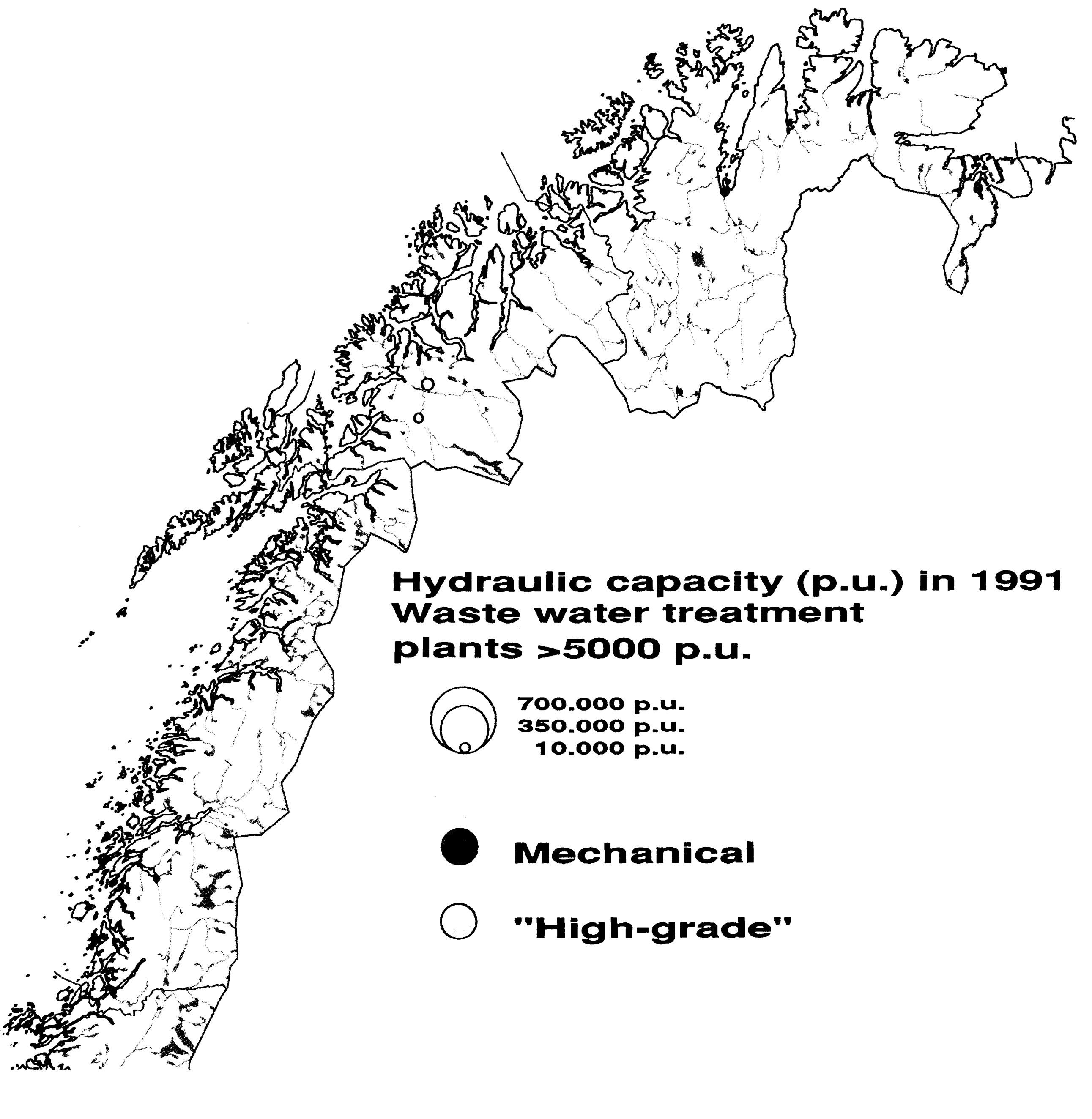
The results are based on reported discharge figures (values from analyses of discharges) from the waste water treatment plants and on estimated values for plants that have not reported such figures. In the case of Rogaland, the central waste water treatment plant for Jæren was taken into (trial) operation in December 1991. This plant is therefore not included.

The estimated values are based on the hydraulic load on the plant, a consumption of water of 400 litres per person per day, a specific quantity of pollution for each person, e.g. 1.7 grammes per person per day for phosphorus, and the purification efficiency of the treatment plant based on the type of plant (table 9.2).

Table 9.2. Waste water treatment plants. Specific amounts of pollution and purification efficiency by type of plant

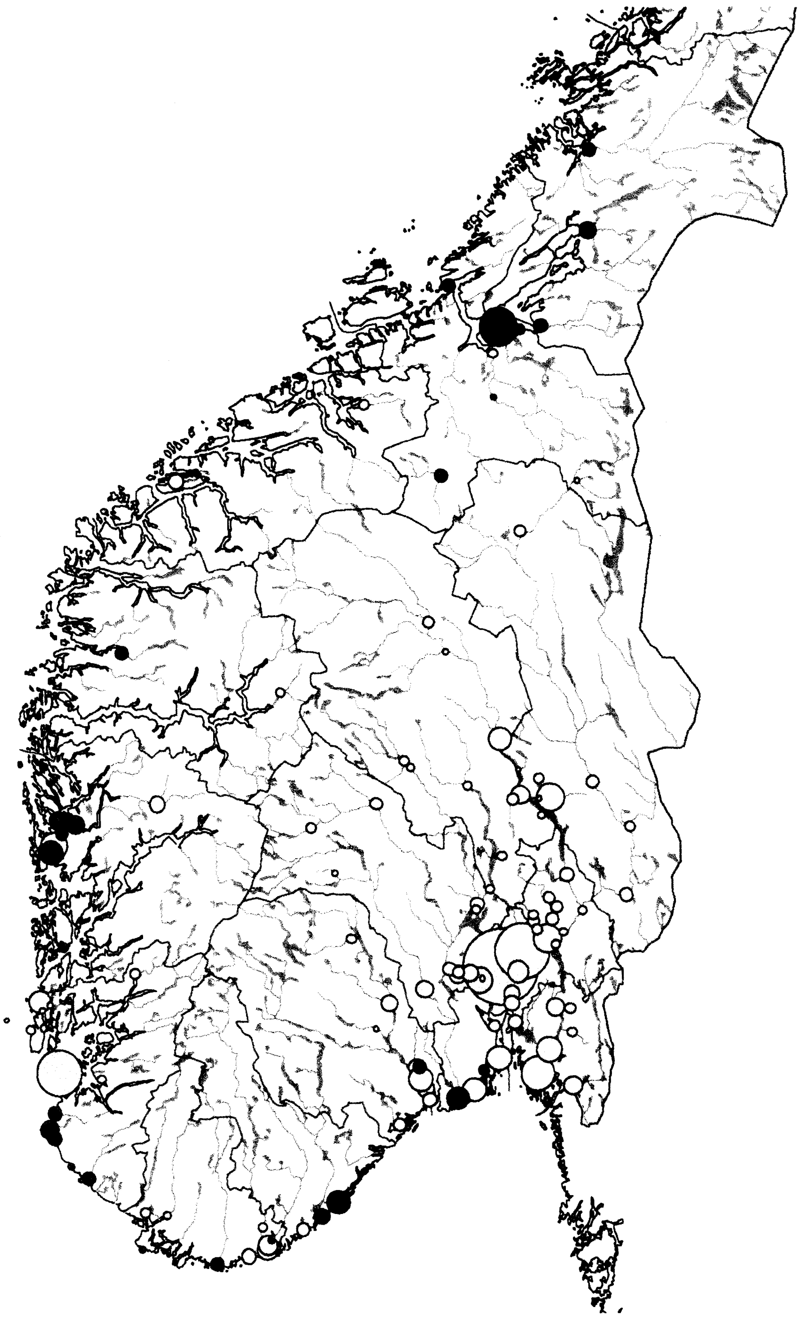
Substance	Specific amount pollution	Percentage reduction, by type of plant			
	gramme/person/day	mech.	chem.	biol.	biol/chem.
Phosphorus	1.7	15	90	30	95
Nitrogen	12.0	15	20	20	25
COD	94.0	30	80	90	95
SS	42.0	50	90	90	95

Figure 9.4. Waste water treatment plants. Localization and capacity of mechanical and "high-grade" plants. Plants with an hydraulic capacity of 5000 p.u. or more. 1991



Source: CBS

Figure 9.4 (cont.). Waste water treatment plants. Localization and capacity of mechanical and "high-grade" plants. Plants with an hydraulic capacity of 5000 p.u. or more. 1991



Source: CBS

Table 9.3. Waste water treatment plants. Percentage of the reported hydraulic load with estimated values. 1991

County	Percentage of stated hydraulic load with estimated values			
	P	N	COD	SS
Total	20	68	83	38
Østfold	2	100	100	100
Akershus	0	22	93	8
Oslo	1	1	100	1
Hedmark	8	100	28	8
Oppland	2	100	95	100
Buskerud	7	100	65	8
Vestfold	3	100	99	15
Telemark	9	100	16	49
Aust-Agder	7	100	7	7
Vest-Agder	46	66	48	45
Rogaland	96	100	100	96
Hordaland	71	100	100	100
Sogn og Fjordane	100	100	100	100
Møre og Romsdal	100	100	100	100
Sør-Trøndelag ...	21	100	90	21
Nord-Trøndelag .	86	100	93	56
Nordland	24	24	24	24
Troms	60	100	50	100
Finnmark	39	100	100	39

Source: CBS

Table 9.4. Waste water treatment plants. Discharge values for phosphorus (P), nitrogen (N), chemical oxygen demand (COD) and suspended substances (SS). 1991. Tonnes/year

County	P	N	COD	SS
Total	526	10360	39740	14910
Østfold	9	760	1470	340
Akershus	25	2620	7430	1 450
Oslo	7	590	390	320
Hedmark	6	540	1600	290
Oppland	6	580	1080	290
Buskerud	15	650	1830	610
Vestfold	47	580	3360	2040
Telemark	15	480	1870	340
Aust-Agder	16	240	1470	650
Vest-Agder	38	400	2940	660
Rogaland	81	600	3700	1180
Hordaland	74	730	3530	1090
Sogn og Fjordane	18	140	690	230
Møre og Romsdal	12	110	560	180
Sør-Trøndelag ...	84	690	4370	3650
Nord-Trøndelag .	46	360	2130	1140
Nordland	6	60	260	110
Troms	13	140	560	190
Finnmark	8	90	500	150

Source: CBS

A large number of the plants reported discharge values for phosphorus (P), so that the estimated values refer to discharges from only 20 per cent of the hydraulic load for the country, the rest are reported figures (table 9.3). In the case of suspended substances (SS), the values have been estimated for 38 per cent of the hydraulic load. For nitrogen (N), the figures for 83 per cent of the load are estimated values, and for chemical oxygen demand (COD) the figures for 68 per cent of the load are estimated values.

There are large variations in the counties with regard to how large a percentage of the discharges is stated in terms of estimated values. It is mainly West Norway and North Norway that report only few values from the results of analyses. For the counties bordering the North Sea, the values are mainly based on analyses.

The values for the discharges are very uncertain, and the values for phosphorus are therefore rounded off to the nearest tonne, and the other values to the nearest 10 tonnes.

On the basis of the above, the discharges from waste water treatment plants in 1991 are calculated to 526 tonnes phosphorus and 10 360 tonnes nitrogen. The corresponding values are 39 740 tonnes for COD and 14 910 tonnes for SS (table 9.4).

10. WASTE

The work of collecting nation-wide, regular statistics on waste and recycling of waste has been an important field of development for CBS, in cooperation with the State Pollution Control Authority (Statens Forurensningstilsyn - SFT) and international agencies. Calculations based on a survey conducted in 1992 show that 2.2 million tonnes of municipal waste was generated in Norway in 1991. Less than 5 per cent of the household waste was recycled.

In recent years there has been a marked improvement in the data on hazardous waste. At SFT's request, a nation-wide registration has been carried out of waste disposal sites and contaminated ground with hazardous waste. Hazardous waste has been found, or is suspected to exist, in almost 2 000 sites. 90 per cent of these sites are located less than 1000 m from residential areas. According to A/S Norsk Spesialavfallselskap (Norwegian Hazardous Waste Corporation Ltd.), 87 000 tonnes were delivered to the Norwegian system for management of hazardous waste in 1992. 51 per cent of this waste was oily waste and 38 per cent was waste from oil drilling operations.

Waste from households and industry constitutes a serious source of pollution. The problems are connected to both present and previous disposal of waste. Many waste disposal sites that are no longer used, particularly sites containing industrial waste, may contain hazardous substances that leak out into the environment. Sites are also being discovered where dangerous substances have been deposited illegally.

According to the Pollution Control Act, residues/waste can be divided into the following main types:

**Consumer waste:* Ordinary waste, including large objects such as furnishings etc. from households, small shops etc. and offices. The same applies to waste of a similar nature and quantity from other activity.

**Production waste:* Waste from industrial activities and service activities which in type and quantity is significantly different from consumer waste.

**Special waste:* Waste which cannot be appropriately treated together with consumer waste because of its size, or because it may lead to serious pollution or risk of injury to persons or animals (hazardous waste). (In practice, special waste that is not hazardous, but is waste that is too large to be dealt with together with consumer waste, is calculated into the other two categories).

The designation *municipal waste* is used for all waste that is dealt with by the municipal waste collection and management systems. Municipal waste includes the greater part of all consumer waste, varying components of the production waste and some hazardous waste. Often the waste is divided into two main categories depending on origin: *Industrial* waste and *household* waste. Most of the household waste ends up in the municipal system of collection and disposal.

Table 10.1 shows the amounts of the different kinds of waste generated in Norway yearly at the end of the 1980s.

At the beginning of the 1990s, waste and recycling of waste became the focus of increasing attention both in Norway (Norwegian Official Report 1990:28) and internationally (OECD, 1991). This led to a greater need to obtain an overall picture of the problem, and a need for more data, for example, in the form of regular statistics. Several limited registrations

Table 10.1. Annual quantities of waste generated yearly in Norway. End of 1980s

Type of waste	Quantity of waste 1000 tonnes per year
Municipal waste[1]	2 000
Production waste[2]	12 000
Car wrecks, large household appliances	70
Sewage sludge	100
Hazardous waste	200

[1] Includes some production waste
[2] Uncertain estimate. Includes waste from building and construction activity, and from mining.
Source: SFT, 1989.

of waste and waste management had been carried out in Norway, but some of these were outdated, and some were not sufficiently representative and varied in coverage. The need for nation-wide statistics is specifically expressed in Report No. 44 (1991-92) to the Storting (Norwegian National Assembly) where it is stated that it is essential to develop a satisfactory system of statistics on waste and recycling of waste to make it possible, in future, to set specific goals for optimal reduction of the quantities of waste and for recycling of various groups of materials.

CBS has been given the prime responsibility for this work and has carried out a trial project for collection of data on municipal waste and recycling (CBS, 1992). According to plan, a trial project for collection of statistics on industrial waste, based on information from the different enterprises, will be carried out in 1993. The work of developing a system for collection of statistics on waste takes place in close cooperation with SFT, which also provides financial support. CBS also participates in a joint EC/EFTA project to develop waste statistics for Europe. International cooperation is important in order to achieve the best possible comparability of the statistics from different countries (see inter alia EUROSTAT, 1991).

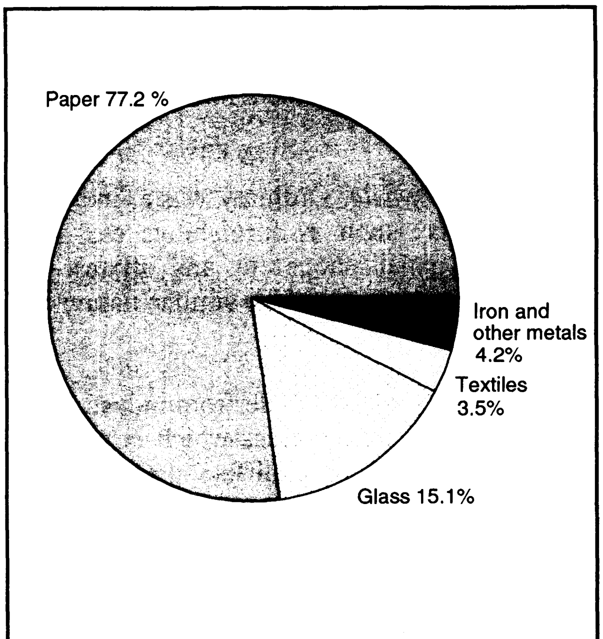
With regard to *hazardous waste,* during the last few years SFT has undertaken nationwide registrations of old waste disposal sites and A/S Norsk Spesialavfallselskap -NORSAS (Norwegian Hazardous Waste Corporation Ltd.), a company established specifically to administer the management of hazardous waste in Norway, has registered the quantities of waste delivered each year for disposal. Some of the results of these registrations are presented in sections 10.2 and 10.3.

10.1. Municipal waste and recycling

In 1992, CBS carried out a trial project for collection of data on municipal waste and recycling. 21 selected municipalities received questionnaires asking for information on the quantities of waste, according to source, and on recycling of materials, waste management, measures to deal with seepage from landfills, and cleaning of stack gases from incineration plants.

The results of the trial project provided a basis for estimating some important figures for the country as a whole: 2.2 million tonnes of municipal waste was generated in 1991. By comparison, 2.0 million tonnes of municipal waste was registered in a survey carried out by

Figure 10.1. Recycled household waste, by type of material. 1991. Per cent



Source: CBS

CBS/SFT in the mid-1980s. Less than 5 per cent of the household waste was recycled in 1991. Paper accounted for 3/4 of this amount, see figure 10.1.

The first regular collection of data will take place during the first six months of 1993, when all the country's municipalities will be included. The intention is to publish preliminary figures in summer 1993.

[illegible]

It is the goal of the Ministry of Environment and SFT to clean up the worst cases of contaminated ground by the year 2000. In 1987, in order to establish the extent of the problem, SFT started a nation-wide registration of waste disposal sites and contaminated ground containing hazardous waste. The Geological Survey of Norway (Norges geologiske undersøkelse - NGU) has been responsible for actually carrying out the project, and has developed a data base in which all the sites are plotted. The methodology and the results are described in two reports from SFT (1991 a and b). The Norwegian Defence Construction Service has used the same method to plot such sites in military areas.

The registered sites have been 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 or 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 2 717 registered sites, hazardous waste was found, or was suspected to exist in 1969 (categories 1-3). 35 per cent of these sites are municipal landfills, 18 per cent are industrial waste disposal sites and 17 per cent are defined as contaminated ground (see table 10.2). The number of military sites (265) has been updated and applies to mid-February 1993; for other sites the updated figures refer to August 1992.

Table 10.3 shows that the counties of Akershus and Telemark, followed by Østfold, Vest-Agder and Nordland, contain a larger percentage of sites in categories 1 and 2* than found in the other counties. About 90 per cent of the sites are located less than 1000 m from residential areas, and the majority are located less than 200 m from the nearest buildings, see figure 10.2.

Industrial companies and other commercial enterprises are the owners of, or are directly responsible for, most of the cases of contaminated ground or disposal sites 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. Municipal landfills containing hazardous waste account for 50 per cent of all waste disposal sites in categories 1 - 3, but for only 20 per cent of all waste disposal

Table 10.2. Waste disposal sites and contaminated ground containing hazardous waste, by category[1] and type of site[2]. 1992

Type of site	Total	Category 1	2*	2	3	4
TOTAL	2 717	78	42	494	1 355	748
Waste disposal sites						
Municipal landfills	1 032	12	1	149	533	337
Industrial waste disposal sites	492	20	11	124	205	132
Other waste disposal sites	629	15	6	82	247	279
Contaminated ground						
Industrial ground	273	8	19	55	191	-
Other contaminated ground	180	10	1	36	133	-
Waste disposal sites with contaminated ground	111	13	4	48	46	-

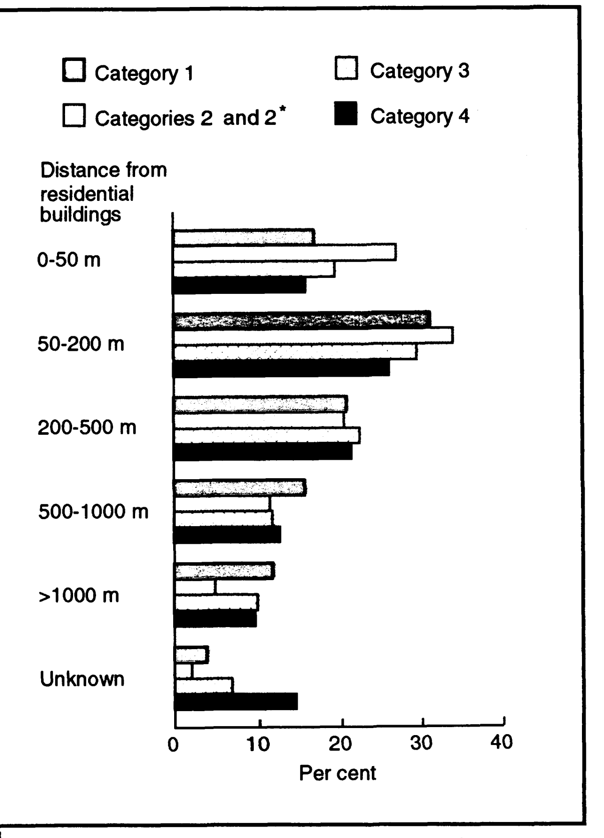
[1] See text for a definition of the categories.
[2] In addition, 40 unranked sites in Finnmark.
Source: SFT

Table 10.3. Waste disposal sites and contaminated ground with hazardous waste. County. 1992

	Number of sites	Number in categories 1 and 2*
Whole country	2 717	120
01 Østfold	119	11
02 Akershus	261	21
03 Oslo	101	7
04 Hedmark	99	6
05 Oppland	121	6
06 Buskerud	200	2
07 Vestfold	191	3
08 Telemark	102	18
09 Aust-Agder	110	5
10 Vest-Agder	137	11
11 Rogaland	158	4
12 Hordaland	173	5
14 Sogn og Fjordane .	112	4
15 Møre og Romsdal .	102	2
16 Sør-Trøndelag	161	3
17 Nord-Trøndelag ...	167	1
18 Nordland	198	11
19 Troms	122	-
20 Finnmark[1]	83	-

[1] 40 unranked sites in addition.
Source: SFT

Figure 10.2. Waste disposal sites and contaminated ground containing hazardous waste. Different categories of sites[1], by distance from the nearest residential area. 1992. Per cent



[1] See text for an explanation of the categories.
Source: SFT

sites in categories 1 and 2*. The types of hazardous waste found in municipal landfills often come from small and medium-sized industrial enterprises, since in many cases the larger industrial enterprises have established their own waste disposal sites.

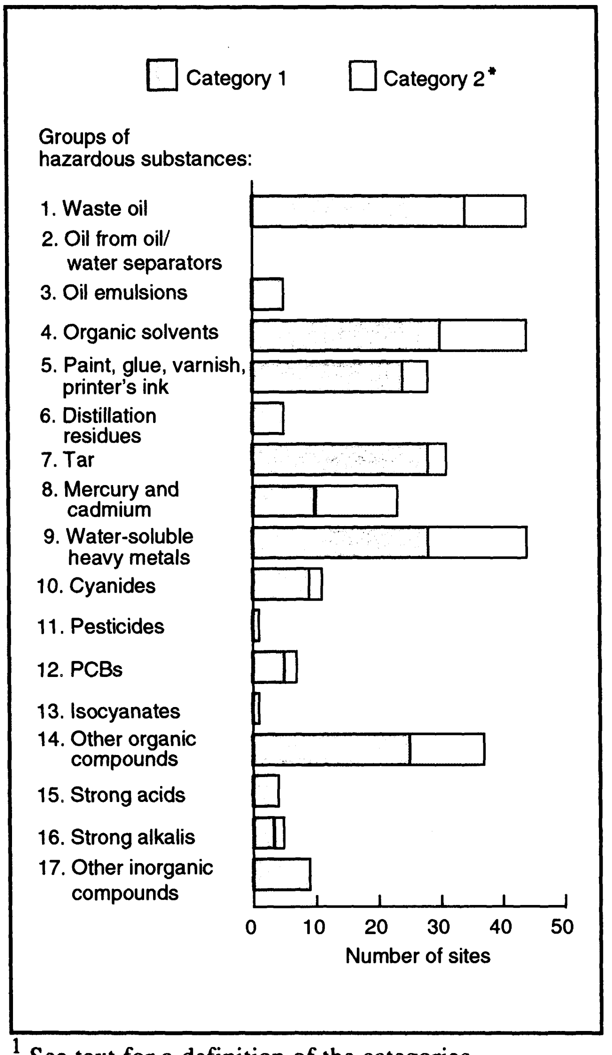
The most commonly registered types of hazardous waste are *organic solvents and water-soluble heavy metals,* see figure 10.3. Waste oil and other oily residues, paint, glue and varnish, tar and other organic material are also common. Most of the tar and other organic material comes from the smelting industry.

In the case of 75 per cent of the sites in categories 1, 2* and 2, the reason for the ranking is the risk of water pollution and the fact that the site conflicts with the use of the area for recreation. The sites are often located on the banks of rivers, or along fjords or near the coast, see figure 10.4.

It is likely that many sites have not yet been discovered. This is because lack of capacity has made it necessary to give higher priority to some branches of industry than to others. Some additional registrations may be necessary in connection with shipbuilding, road building and mining. The coverage is considered to be very good for municipal landfills, but not as good for contaminated ground.

The results from the nation-wide registration 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 measures are intended to be implemented by the year 2000, and the goal is to reduce risk of serious pollution from these sources to a minimum. The total costs are estimated to NOK 2 - 3 billion. Table 10.4 shows the status of the efforts in August 1992 for the sites given highest priority (categories 1 and 2*).

Figure 10.3. Waste disposal sites and contaminated ground with hazardous waste. Occurence of different groups of hazardous waste at the sites in category 1 and category 2*[1].



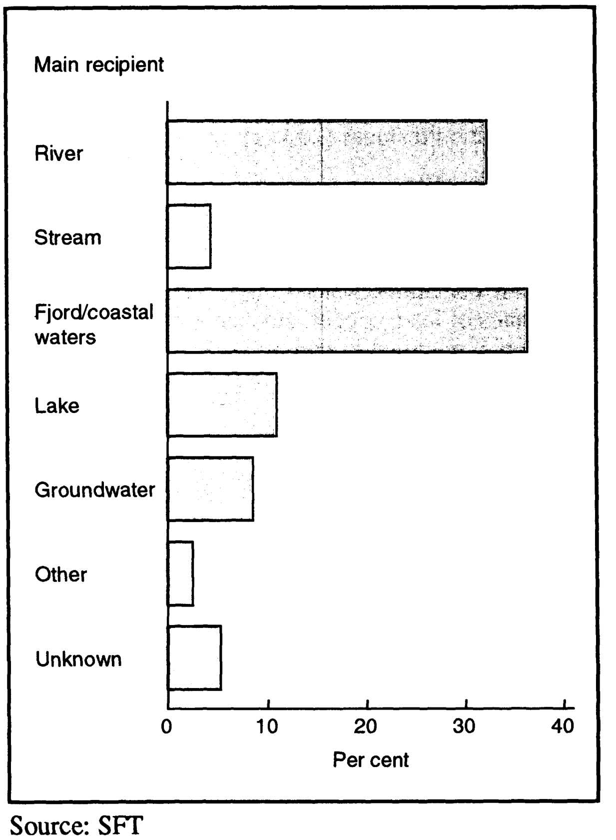
[1] See text for a definition of the categories.
Source: SFT

Table 10.4. Waste disposal sites and contaminated ground containing hazardous waste[1], by status as regards implementation of measures. August 1992

	Total	Measures not started	Investigations in progress	Measures in progress	Measures completed
Category 1	61	18	32	7	4
Category 2*	42	4	31	2	5

[1] Defence Establishment sites not included
Source: SFT, 1992

Figure 10.4. Waste disposal sites and contaminated ground containing hazardous waste[1], by main recipient. 1992. Per cent



Source: SFT

10.3. Delivery of hazardous waste

Uncontrolled dumping of hazardous waste has caused serious damage to the environment in many countries and has resulted in coercive measures to compel the involved companies to clean up the pollution, the payment of large sums in compensation, winding up of enterprises and several bankruptcies (Ministry of Environment, 1985).

The Pollution Control Act provides the legal foundation for controlled management and disposal of hazardous waste. The regulations concerning hazardous waste, laid down in pursuance of the Act, apply to the following groups of substances (if the quantity in brackets is exceeded, the generator is required to deliver the waste to an approved collecting site):

1. Waste oil (200 kg)
2. Oily waste from oil/water separators and oily waste water (200 kg)
3. Oil emulsions (1000 kg)
4. Organic solvents (20 kg)
5. Waste paint, glue, varnish and printer's ink (200 kg)
6. Distillation residues (200 kg)
7. Tars (200 kg)
8. Waste containing mercury or cadmium as a chemical compound or in metallic form (1 kg)
9. Waste containing water-soluble chemical compounds of lead, copper, zinc, chromium, nickel, arsenic, selenium or barium (10 kg)
10. Waste containing cyanide (1 kg)
11. Discarded pesticides (5 kg)

The following groups have also been defined in addition to those covered by the regulations:

12. Waste containing PCBs
13. Isocyanates
14. Other organic wastes
15. Strong acids
16. Strong alkalis
17. Other inorganic wastes

The figures for how much hazardous waste is generated are uncertain. Based on adjusted figures from around 1980, SFT has calculated that roughly 200 000 tonnes of hazardous waste was generated each year at the end of the 1980s. Although the quantity of hazardous waste is thus very small compared with the quantity of municipal waste (about 10 per cent), it nevertheless represents a serious risk to the environment owing to sometimes high concentrations of micropollutants. About 90 000 tonnes of hazardous waste was treated by the companies where the waste is generated, either by recycling or by disposing of the waste in the company's own approved system. The remaining 110 000 tonnes was delivered for external treatment in more or less controlled form. Table 10.5 shows how this 110 000 tonnes was distributed between the main groups of waste. It is estimated that less then 5 per cent of this waste comes from households (SFT, 1989).

At the turn of the year 1992/93, SFT appointed a working group to prepare more up-to-date estimates of the amounts of hazardous waste generated in Norway.

Table 10.5. Hazardous waste delivered for external treatment. End of 1980s.

Main groups	Groups of substances[1]	Quantity 1000 tonnes per year
Total		110
Waste oil	1	40
Other organic waste (combustible)	2-7, 11-14	40
Inorganic waste (non-combustible) ...	8-10, 15-17	25
Mixed organic/ inorganic waste		5

[1] See text for explanation.

Source: SFT, 1989

Table 10.6 shows that, during the last 6 years, the quantity of hazardous waste delivered to approved collection facilities has increased. The increase consists mainly of oil-contaminated drill cuttings. The quantity of waste oil remains fairly constant, around 30 000 tonnes.

A/S Norsk Spesialavfallselskap (NORSAS) was established in 1988 and is responsible for coordinating all streams of waste that are subject to regulation and cannot be handled internally by the companies themselves. NORSAS has developed a data base (NorBas) to record data on waste delivered to the system for management of hazardous waste in Norway. The companies included in the data base are identified by a company number, and the base is updated each year by linking it to CBS's register of companies. The records are based on declaration forms, and are updated monthly. In its Annual Report, NORSAS publishes statistics right down to municipal level.

Oily waste and oil waste from drilling operations together comprise about 89 per cent of the total quantity of hazardous waste delivered to the system, see table 10.7 and figure 10.5. Even when waste from oil drilling operations is excluded, Hordaland and Rogaland are among the counties delivering the largest quantities of hazardous waste, see figure 10.6. Oily waste from drilling operations means oil-contaminated drill cuttings.

Table 10.6. Delivered hazardous waste. 1987-1992. 1000 tonnes

Type of waste	1987	1988	1989	1990	1991	1992
Total	52	54	58	60	66	87
Waste oil	30	31	..	31	30	33
Other wastes	22	23	..	29	36	54

Source 1987-89: SFT.
Source 1990-92: NORSAS, 1993

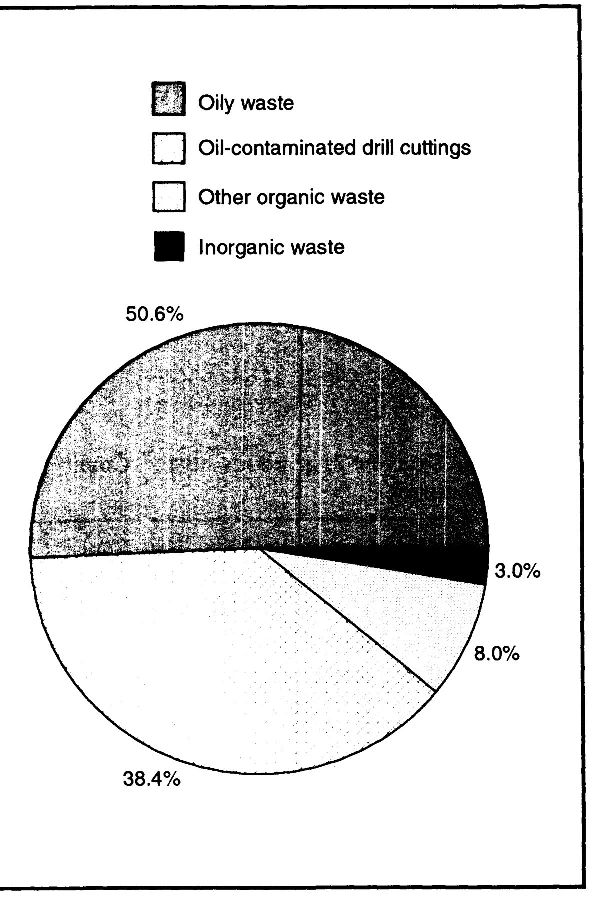
Table 10.7. Hazardous waste delivered to the system for management of hazardous waste. 1992

		Quantity tonnes
Total		87 483
1	Waste oil	32 896
2.1	Oily waste from oil-water separators	9 626
2.2	Oil-contaminated drill cuttings[1]	33 593
3	Oil emulsions	1 747
4.1	Halogenous organic solvents	196
4.2	Non-halogenous organic solvents	2 290
5	Paint, glue, varnish and printer's ink	2 825
6/7	Distillation residues and tar	264
8/9	Waste/batteries containing heavy metals	951
10	Waste containing cyanide	9
11	Discarded pesticides	13
12	Waste containing PCB	13
13	Isocyanates	14
14	Other organic waste	1 330
15	Strong acids	422
16	Strong alkalis	173
17	Other inorganic waste	1 087
18	Aerosols	4
19	Laboratory waste	29
20	Unknown	1

[1] Applies to Telemark (2), Rogaland (1787), Hordaland (4298), Sogn og Fjordane (27497), Møre og Romsdal (9) and Sør-Trøndelag (0).
Source: NORSAS, 1993

In 1992, 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, see figure 10.7.

Figure 10.5. Delivered hazardous waste, by main category of waste. 1992. Per cent



Source: NORSAS, 1993

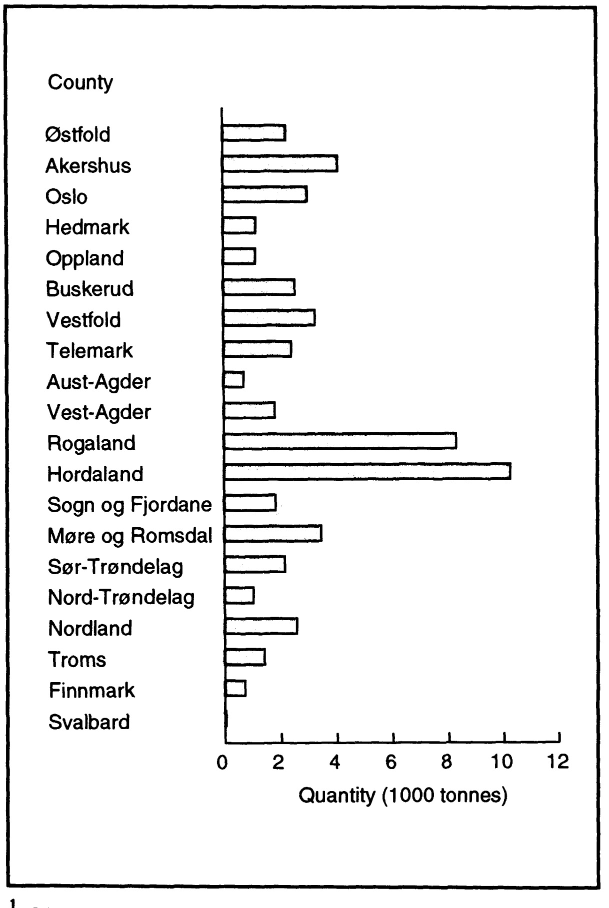
When oily waste from drilling operations is excluded, the average amount of hazardous waste delivered by each company in 1992 was 6 200 kg. The average delivery ranged from 3 400 kg from companies with an employment of less than 4 man-years, to 27 300 kg from companies with more than 100 man-years.

The most important arrangements for dealing with hazardous waste are *collection* (mainly by private transport companies with a licence), *reception* (local and regional reception facilities) and *treatment*. In 1992, 46 per cent of the waste was collected, while 49 per cent was delivered directly to the treatment facilities.

Some hazardous waste is exported for treatment in other countries after a permit has been obtained from SFT. Table 10.8 shows legal imports and exports of hazardous waste during the period 1987-1992.

The environmental authorities have considered building a *central storage facility* for hazardous waste at Hjerkinn. This proposed plan has been abandoned for the time being. The Storting (Norwegian National Assembly) has decided that the company "Norsk avfallshåndtering A/S" (a special waste management company owned partly by the State) shall itself decide where to establish a central *treatment facility* for hazardous waste. A proposal being considered at present is a coordinated Nordic solution to the problem.

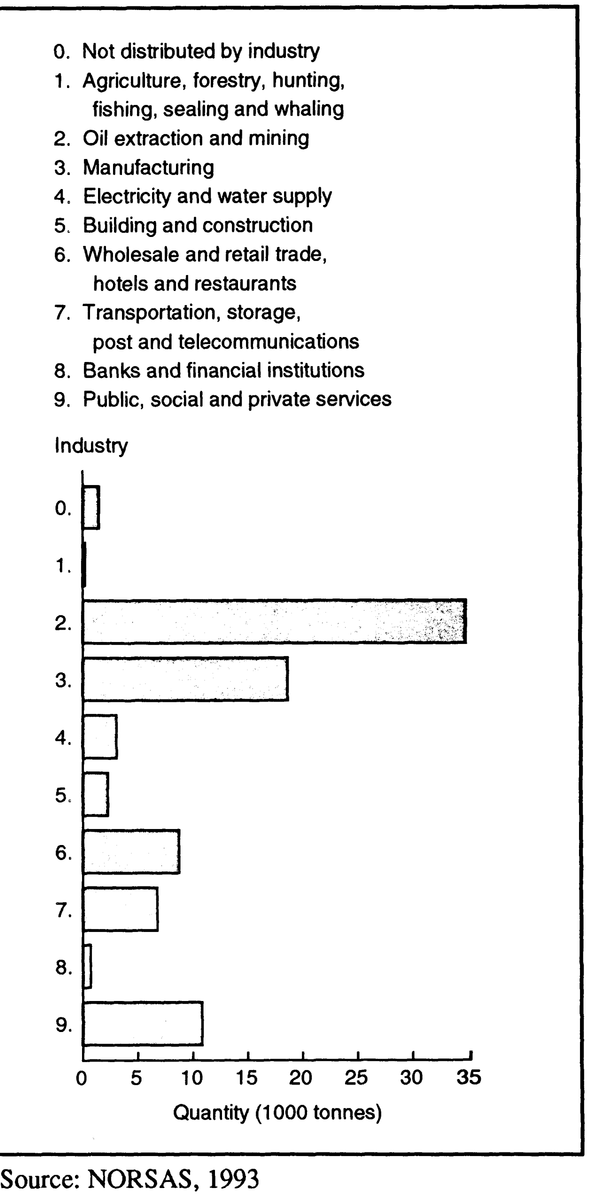
Figure 10.6. Delivered hazardous waste[1]. County. 1992. 1000 tonnes



[1] Oil-contaminated drill cuttings not included

Source: NORSAS, 1993

Figure 10.7. Delivered hazardous waste, by industry. 1992. 1000 tonnes



Source: NORSAS, 1993

Table 10.8. Export and import of hazardous waste. 1986-1992

	Total export	Of which waste oil	Total import	Of which waste oil
1986	1 700	-	-	-
1987	18 000	12 000	-	-
1988	4 000	-	-	-
1989	8 000	4 800	-	-
1990	21 800	12 500	-	-
1991	14 600	-	2 400	2 300
1992	14 500	-	6 300	4 700

Source: SFT

References:

EUROSTAT (1991): *Draft final report Compilation of Community Statistics on Waste.* Working document. Luxembourg, September 1991.

Ministry of Environment: Information brochure on hazardous waste (In Norwegian).

NORSAS (1993): *Årbok for innlevert spesialavfall 1992* (Annual Report on delivered hazardous waste 1992). AS Norsk Spesialavfallselskap, Oslo. (In Norwegian).

NOU (1990): *Avfallsminimering og gjenvinning* (Norwegian Official Report on Minimization and Recycling of Waste). NOU 1990:28. (Chapter 4 - Existing Instruments - in English).

OECD (1991): *The State of the Environment.* OECD, Paris. (97 91 01 1) ISBN 92-64-133442-5.

SFT (1989): *Langtidsplan 1990-1993.* State Pollution Control Authority. (Summary in English).

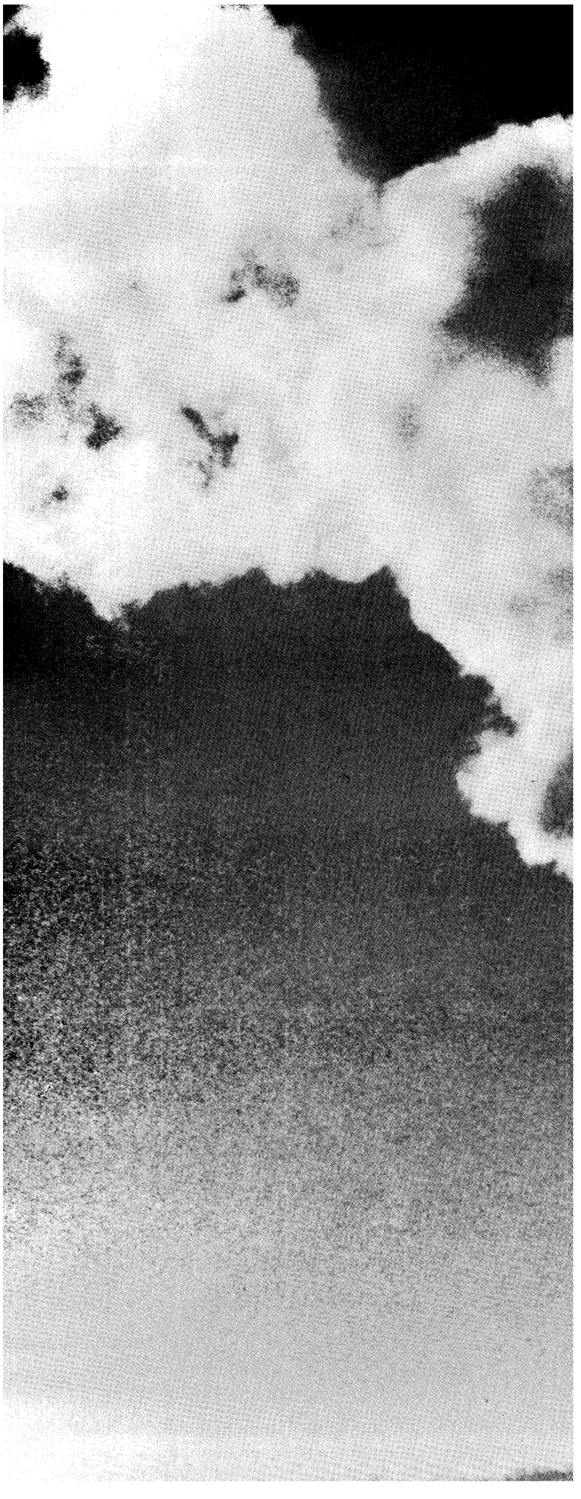
SFT (1991a): *Kartlegging av spesialavfall i deponier og forurenset grunn - sluttrapport* (Registration of hazardous waste in waste disposal sites and contaminated ground - Final Report). Report 91:01, State Pollution Control Authority. (In Norwegian, with English summary).

SFT (1991b): *Kartlegging av spesialavfall i deponier og forurenset grunn - vedlegg til sluttrapport* (Registration of hazardous waste in waste disposal sites and contaminated ground - appendix to final report). State Pollution Control Authority. (In Norwegian).

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 (In Norwegian).

CBS (1992): *Avfallsstatistikk. Prøveundersøkelse for kommunalt avfall og gjenvinning* (Waste statistics. Trial project for municipal waste and recycling). Report 92/25, Central Bureau of Statistics. (In Norwegian).

Ministry of Environment: *Report No.44 to the Storting relating to measures to reduce waste, increase recycling and ensure environmentally sound waste management.*



SOME INTERNATIONAL FIGURES

This Appendix includes some international figures for emissions to air and for energy consumption. The emission figures for Norway in this summary, which are based on data from OECD, deviate slightly from the most recent Norwegian estimates of emissions.

Emissions of SOx. 1000 tonnes. Emissions per GDP and per capita

	1970	1975	1980	1985	Late 1980s	Per unit GDP (kg/1000 US$)[1] late 1980s	Per capita (kg/cap.) late 1980s
OECD	64600	57900	53000	42200	39900	4.1	48.3
Norway	171	137	142	97	65	1.0	15.4
Denmark	574	418	447	340	242	4.1	47.2
Finland	515	535	584	371	305	5.1	61.7
Sweden	930	686	502	273	199	1.8	23.6
France	2966	3328	3339	1475	1272	2.3	22.8
Italy	2830	3331	3211	2086	2070	4.4	36.0
Netherlands	772	385	461	271	256	1.9	17.3
Portugal	116	178	267	198	205	8.7	19.9
UK	6327	5310	4847	3718	3664	7.0	63.1
Switzerland	125	109	126	95	63	0.6	9.4
W. Germany	3739	3331	3191	2431	1306	1.9	21.3
Canada	6677	5319	4643	3704	3800	9.7	146.4
USA	28400	25900	23400	21100	20700	4.7	84.0
Japan	4973	2586	1263	..	835	0.6	6.8

[1] 1988 GDP at 1985-prices and exchange rates.
Source: OECD Environmental Indicators 1991

Emissions of NOx. 1000 tonnes. Emissions per GDP and per capita

	1970	1975	1980	1985	1987	Per unit GDP (kg/1000 US$)[1] late 1980s	Per capita (kg/cap.) late 1980s
OECD	32300	34700	37700	36200	36200	3.8	44.3
Norway	159	176	192	203	233	3.6	53.7
Denmark	..	178	241	259	262	4.2	48.5
Finland	..	..	284	240	270	4.6	56.6
Sweden	302	308	332	327	325	2.9	37.4
France	1322	1608	1834	1579	1605	3.1	31.6
Italy	1410	1507	1585	1555	1570	3.4	27.3
Netherlands	427	427	540	531	553	4.2	37.9
Portugal	72	104	166	96	116	5.2	11.8
UK	2404	2365	2418	2278	2429	4.9	44.0
Switzerland	149	162	196	214	202	1.8	27.6
W. Germany	2383	2573	2981	2959	2931	4.3	46.7
Canada	1364	1756	1959	1959	1952	4.9	74.9
USA	18300	19200	20400	19800	19500	4.5	80.4
Japan	1651	1781	1400	..	1176	0.8	9.6

[1] 1988 GDP at 1985-prices and exchange rates.
Source: OECD Environmental Indicators 1991

Emissions of CO_2 from energy use. Million tonnes of carbon. Emissions per GDP and per capita

	1971	1975	1980	1985	1988	Per unit GDP (kg/ 1000 US$)[1] 1988	Per capita (tonnes/cap.) 1988
WORLD	4380	4811	5528	5802	6256	635	1.2
OECD	2427	2522	2756	2648	2793	286	3.4
Norway	7	7	9	8	9	139	2.1
Denmark	17	16	18	18	18	294	3.4
Finland	15	16	19	17	18	302	3.7
Sweden	27	26	24	22	21	194	2.5
Belgium	36	36	37	30	32	370	3.2
France	126	126	139	109	103	182	1.8
Ireland	6	6	7	7	8	392	2.2
Italy	92	97	106	101	108	231	1.9
Netherlands	44	46	50	48	51	380	3.4
Portugal	6	7	8	8	10	428	1.0
Spain	35	46	55	54	57	302	1.5
UK	187	170	167	159	163	317	2.9
Switzerland	12	11	12	12	13	125	1.9
W. Germany	208	198	219	200	198	294	3.2
Austria	15	15	17	16	16	235	2.2
Canada	94	109	124	115	124	316	4.8
USA	1209	1240	1369	1339	1433	324	5.8
Japan	217	252	261	253	272	181	2.2
Australia	48	56	63	66	71	404	4.3
New Zealand	4	5	5	7	7	301	2.0

[1] 1988 GDP at 1985-prices and exchange rates.
Source: OECD Environmental Indicators 1991

Total final consumption of energy. Mtoe. Consumption per GDP and per capita

	1970	1975	1980	1985	1989	Per unit GDP (toe/ 1000 US$)[1] 1989	Per capita (toe/cap.) 1989
WORLD[2]	3756.26	4184.54	4788.70	5025.08	5566.40	..	1.05
OECD[3]	2333.41	2485.62	2682.05	2637.55	2860.11	0.28	3.37
Norway	12.88	13.76	16.51	17.96	17.88	0.28	4.23
Denmark	16.23	14.15	15.15	13.66	13.42	0.22	2.61
Finland	16.12	17.59	19.35	19.60	22.69	0.35	4.57
Sweden	33.74	36.02	34.48	33.65	33.18	0.30	3.91
Belgium	32.43	33.35	34.67	32.06	33.80	0.38	3.40
France	122.58	131.11	144.77	138.23	142.60	0.24	2.54
Ireland	4.85	5.29	6.60	6.68	7.44	0.35	2.12
Italy	87.24	96.52	106.25	105.20	118.15	0.24	2.05
Netherlands	37.70	47.88	52.05	50.64	50.95	0.37	3.43
Portugal	5.06	6.54	8.48	9.42	12.17	0.49	1.18
Spain	32.08	43.22	50.68	50.13	58.75	0.30	1.51
UK	144.48	141.00	137.01	138.95	147.95	0.28	2.58
Switzerland	15.23	15.56	17.64	19.03	19.73	0.19	2.93
W. Germany	175.73	180.30	198.75	193.77	190.88	0.28	2.43
Austria	15.17	16.94	19.76	19.72	20.27	0.28	2.66
Canada	109.51	128.22	154.92	150.99	164.06	0.41	6.25
USA	1211.39	1238.98	1318.75	1277.20	1392.71	0.31	5.60
Japan	199.87	235.14	248.98	252.94	288.51	0.18	2.34
Australia	35.36	41.83	47.53	50.26	57.47	0.31	3.42
New Zealand	5.30	6.53	6.82	8.27	9.23	0.40	2.76

[1]1989 GDP at 1985 prices and exchange rates. [2]1970 data refer to 1971. [3]Includes Western Germany only.
Source: OECD Environmental Indicators 1991 og OECD Environmental Data 1991

PUBLIACTIONS FROM THE DIVISION FOR RESOURCE ACCOUNTS AND ENVIRONMENTAL STATISTICS AND THE NATURAL RESOURCES DIVISION 1990-1992/93

Discussion Paper:

No. 48 Glomsrød, S., Vennemo, H., Johnsen, T.: Stabilization of emissions of CO_2: A computable general quilibrium assessment

" 61 Alfsen, K.H.: Use of macroeconomic models in analysis of environmental problems in Norway and consequences for environmental statistics

" 64 Brendemoen, A. and H. Vennemo: A climate convention and the Norwegian economy: A CGE assessment

" 65 Brekke, K.A.: Net National Product as a Welfare Indicator

" 69 Alfsen, K., Brendemoen, A. and Glomsrød, S.: Benefits of climate policies: Some tentative calculations

" 71 Alfsen, K., Brekke, K.A., Brunvoll, F., Lurås, H., Nyborg, K. and Sæbø, H.V.: Environmental indicators

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

Notes

No. 90/1 Berger, K.: Dokumentasjon av OEGs analyseverktøy for norsk oljevirksomhet (Documentation of OEG's way of analyzing Norwegian oil activity). In Norwegian

" 90/2 Hetland, T., Vik, T. og Aaheim, A.: Ressursregnskap for energi. Dokumentasjonsnotat nr. 9. Tilgang og bruk av energi 1980-1987 (Resource Accounts for Energy. Documentary note no. 9. Supply and utilization of energy). In Norwegian

" 90/3 Torvanger, A.: Auka kraftprisar til kraftkrevande industri - makroøkonomiske verknader (Macro-economic effects of higher energy prices to energy-intensive industries). In Norwegian

" 90/5 Bye, B.: MODAG W benyttet til energi- og miljøanalyser: Dokumentasjon av SIMEN-beregningene (MODAG W applications in energy and environmental studies. Documentation of the SIMEN scenarios). In Norwegian

" 90/7 Moss, O.O.: Miljøstatistikk i SSB. Plattform for videre utvikling (Environmental statistics in the CBS. Basis for further development). In Norwegian

" 90/20 Vestøl, J.Å., Sødal, D.P., Aanestad, J., Holm, Ø., Høie, H., Lian, B.: Virkningen av ulike miljøtiltak i jordbruket. En modellstudie med vekt på endret produksjonsfordeling (The effect of different environmental measures in agriculture. A study with emphasis on an altered distribution of production). In Norwegian

" 90/26 Johnsen, T.A.: Produksjon, overføring og fordeling av kraft (Production, transmission and distribution of electricity). In Norwegian

" 92/15 Schøning, P.: Ressursregnskap for skog 1987-1991. Dokumentasjon av metode og resultater (Resource Accounts for Forests 1987-1991. Documentation of method and results). In Norwegian

" 92/16 Flugsrud, K., Høgset, L., Høie, H., Rypdal, K. og Sandmo, T.: Energiregnskapet 1990. Planlagte og gjennomførte endringer (Energy Accounts 1990. Planned and implemented changes). In Norwegian

" 92/17 Daasvatn, L., Flugsrud, K., Høie, H., Rypdal, K. og Sandmo, T.: Modell for beregning av nasjonale utslipp til luft. Dokumentasjon (Model for calculating national emissions to air. Documentation). In Norwegian

" 93/5 Aaheim, A. og Nesbakken, R.: Data om husholdningers stasjonære energibruk (Data on stationary energy consumption in private households). In Norwegian

Reports from CBS (REP):

No. 90/1 Naturressurser og miljø 1989 (Natural Resources and the Environment 1989). In Norwegian
" 90/1A Natural Resources and the Environment 1989
" 90/19 Høie, H., Lian, B., Vestøl, J.Å.: SIMJAR 2. Simuleringsmodell for nitrogenavrenning i jordbruket. Dokumentasjon (SIMJAR 2. Model to simulate nitrogen leakage in agriculture. Documentation). In Norwegian
" 91/1 Naturressurser og miljø 1990 (Natural Resources and the Environment 1990). In Norwegian
" 91/1A Natural Resources and the Environment 1990
" 91/7 Mysen, H.T.: Substitusjon mellom olje og elektrisitet i produksjonssektorene i en makromodell (Substitution between oil and electricity in the production sectors in a macromodel). In Norwegian
" 91/12 Johnsen, T.A.: Modell for kraftsektoren (A model for the electricity sector). In Norwegian
" 91/13 Bye, T. og T.A. Johnsen: Effektivisering av kraftmarkedet (Effectivization of the electricity market). In Norwegian
" 92/1 Naturressurser og miljø 1991 (Natural Resources and the Environment 1991). In Norwegian
". 92/1A Natural Resources and the Environment 1991
". 92/2 Ljones, A., Nesbakken, R., Sandbakken, S. og Aaheim, A.: Energibruk i husholdningene. Energiundersøkelse 1990 (Consumption of energy in households. Energy survey 1990). In Norwegian
" 92/17 Brendemoen, A., Glomsrød, S., og Aaserud, M.: Miljøkostnader i makroperspektiv (Environmental costs in a macroperspective). In Norwegian
" 92/20 Johnsen, T.A.: Ressursbruk og produksjon i kraftsektoren (Resource use and production in the power electricity sector). In Norwegian
" 92/25 Busengdal, A. og Moss, O.: Avfallsstatistikk. Prøveundersøkelse for kommunalt avfall og gjennvinning (Wastes statistics. Trial survey for municipal waste and recycling). In Norwegian
" 93/1 Naturressurser og miljø 1992 (Natural Resources and the Environment 1992). In Norwegian
" 93/2 Brendemoen, A.: Faktoretterspørsel i transportproduserende sektorer (Factor demand in transport-producing sectors). In Norwegian
" 93/10 Nesbakken, R.: Energiforbruk til oppvarmingsformål i husholdningene (Energy use for heating purposes in households). In Norwegian
" 93/12 Resultatkontroll jordbruk 1992. Tiltak mot avrenning av næringssalter og jorderosjon (Results assessment agriculture 1992. Measures to prevent run-off of nutrients to the North Sea). In Norwegian

Reprints (REPR):

No 45 Bjerkholt O., Gjelsvik E., and Olsen, Ø.: The Western European Gas Market: Deregulation and Supply Competition
" 46 Bartlett, S., Strøm S. and Olsen, Ø.: Residential Energy Demand - The Evolution and Future Potential of Natural Gas in Western Europe
" 48 Alfsen, K., L. Lorentsen and K. Nyborg: Environmental Effects of a Transition from Oil and Coal to Natural Gas in Europe
" 49 Aslaksen, I., Brekke, K.A., Johnsen, T.A. and Aaheim, A.: Petroleum Resources and the Management of National Wealth
" 50 Cappelen, Å., Gjelsvik, E.: Oil and Gas Revenues and the Norwegian Economy in Retrospect: Alternative Macroeconomic Policies
" 53 Mork, K.A., Mysen, H.T. and Olsen, Ø.: Business Cycles and Oil Price Fluctuations: Some Evidence for Six OECD Countries
" 55 Brekke, K.A. and Øksendal, B.: The high Contact Principle as a Sufficiency Condition for optimal Stopping

Social and economic studies (SES):

No. 68 Miljøstatistikk 1988 (Environmental statistics 1989) English text in figures and tables
" 73 Brekke, K.A. og Torvanger, A. (red.): Vitskapsfilosofi og økonomisk teori (Philosophy of Science and Economic Theory). In Norwegian

Weekly bulletin of statistics (WB):

No. 90/31	Ressursregnskap for energi 1988 (Resource accounts for energy 1988) In Norwegian
" 90/31	Ressursregnskap for energi 1989. Foreløpige tall (Resource accounts for energy 1989. Preliminary figures). In Norwegian
" 90/46	Fylkesvise energiregnskap for 1988 (County-wise Energy Accounts for 1988). In Norwegian
" 91/36	Ressursregnskap for energi 1989 (Resource accounts for energy 1989). In Norwegian
" 92/3	Avløpsrenseanlegg 1990 (Waste water treatment plants 1990). In Norwegian
" 92/39	Ressursregnskap for energi 1990 (Resource Accounts for Energy 1990). In Norwegian
" 92/39	Ressursregnskap for energi 1991. Foreløpige tall (Resource Accounts for Energy 1991. Preliminary figures). In Norwegian

Statistics of the week:

No. 44 1992	Avløpsrenseanlegg: Stor økning i kapasiteten (Waste water treatment plants. Large increase in capacity). In Norwegian
" 46 1992	Redusert utslipp av klimagasser: Stor effekt på kort sikt (Reduced emissions of climate gases. Marked effect in the short term). In Norwegian
" 48 1992	Villmarka utgjør nå bare 22 prosent av arealet (Now only 22 per cent of the land is wilderness). In Norwegian
" 3 1993	Ny statistikk over kommunalt avfall (New statistics on municipal waste). In Norwegian
" 6 1993	Mindre pløying om høsten (Less ploughing in the autumn). In Norwegian
" 9 1993	Vekst i flere viktige fiskebestander (Growth in several important fish stocks). In Norwegian
" 16 1993	Utslipp til luft reduseres (Reduction in the emissions to air). In Norwegian
" 16 1993	God bestand av vågehval (Solid stock of minke whales). In Norwegian
" 21 1993	Kraftig skogøkning - viktig bidrag til bedre miljø (Large increase in forests - important contribution to a better environment). In Norwegian

Economic surveys (ES):

No. 90/2	Brendemoen, Anne: Miljøavgifter på fossile brensler - hvem betaler? (Environmental taxes on fossil fuels - who is going to pay?). In Norwegian
" 91/4	Bjerkholt, O. og E. Gjelsvik: New development in the perspectives for natural gas trade in Europe
" 91/7	Brekke, K.A.: Bruken av oljeinntektene (Use of oil revenues). In Norwegian
" 3/92	Bye, T. og Lorentsen, L.: Energiloven og miljøet (The Energy Act and the Environment). In Norwegian
" 4/92	Bye, T. og Johnsen, T.A.: Utviklingen i kraftmarkedet (Developments on the electricity market). In Norwegian
" 7/92	Alfsen, K.H. og Glomsrød, S.: Å spare på skillingen, men la dalerne gå: Nytte og kostnader av klimapolitikk ("Saving the pennies but spending the pounds". Benefits and costs of the climate policy). In Norwegian
" 7/92	Birkelund, H., Gjelsvik, E. og Aaserud, M.: Energiforbruk og CO_2-utslipp: Vest-Europa - EFs karbon/energiskatt analysert i en modell med energisubstitusjon (Energy consumption and CO_2-emissions. EC's carbon/energy tax analyzed in a model with energy substitution). In Norwegian

Other publications (1992 and 1993):

Aaheim, Asbjørn: Miljø og økonomi - venner eller fiender? (Environment and Economy - friends or enemies?). Human Ecology no. 1, 1992.

Alfsen, Knut H.: Use of macroeconomic models in the analysis of environmental problems in Norway, and consequenses for environmental statistics. Statistical Journal of United Nations ECE 8, 1992, pp. 1-22.

Alfsen, Knut H. og Lorents Lorentsen: Miljø og forurensning som økonomisk problem. (Environment and pollution as an economic problem) I H. Pleym m.fl.: Miljøstudier. 3. utgave. NKI Forlaget, Bekkestua, 1992.

Bjerkholt, Olav and Eystein Gjelsvik: Common carriage for natural gas: the producers' perspective. In Hope, E. and S. Strøm: Energy Markets and Environmental Issues: A European Perspective. Scandinavian University Press: Oslo, 1992, 131-162

Bjerkholt, Olav and Kjell Arne Brekke: Practical aspects of policy analysis under uncertanity. In Strøm, S. and Trillings (eds): Global Climate Change: European and American Policy Responses. (Forthcoming).

Brekke, Kjell A.; Eystein Gjelsvik og Asbjørn Aaheim: Forvaltning av oljeinntekter, sparing og fondsoppbygging; Norge sparer mens statens oljefond går med underskudd. (Management of oil revenues, savings and reserve fund; Norway saves while the government fund declines). Sosialøkonomen. 7/8, 1992

Brekke, Kjell A. and B. Øksendal: Optimal switching in an economic activity under uncertainty. Preprint No. 9, April 1992, Department of Mathematics, University of Oslo. SIAM Journal of Optimization. (Forthcoming).

Emissions of Greenhouse Gases in Norway - 1989. National versus IPCC estimation method (Transparency study). SFT-rapport 92:29, TA-880/1992. (Utarbeidet av Kristin Rypdal, SSB).

Glomsrød, Solveig; Haakon Vennemo and Tor A. Johnsen (1992): Stabilization of emissions of CO_2: A computable general equilibrium assessment. The Scandinavian Journal of Economics, Vol. 94, 1, 53-69.

Kobila, T.Ø. (I. Aslaksen, O. Bjerkholt, K.A. Brekke, T. Lindstrøm og B. Øksendal): A class of solvable stochastic investment problems involving singular control. Preprint No. 3. Februar 1992, Department of Mathematics, University of Oslo. Forthcoming in Stochastics.

Kobila, T.Ø. (I. Aslaksen, O. Bjerkholt, K.A. Brekke, T. Lindstrøm og B. Øksendal): An application of reflected diffusions to the problem of choosing between hydro and thermal power generation. Stochastic Processes and their Applications 44, 1993, 117-139.

Ottestad Arne Knut: SSB-Avløp. Fylkesrapport 1991 (Waste water treatment plants. County report 1991). SSB 1993

Strand, J.; Knut H. Alfsen og F. Wenstøp: Verdsetting og bruk av miljøkostnader under SAMMEN-programmet. (The Valuation and Use of Environmental Cost data in the SAMMEN: (Society, Environment and Energy Research programme). Forprosjektrapport. Arbeidsnotat nr. 107/1992, Stiftelsen for samfunns- og næringslivsforskning, Oslo, 1992.

Utkommet i serien Rapporter fra Statistisk sentralbyrå etter 1. januar 1992 (RAPP)

Issued in the series Reports from the Central Bureau of Statistics since 1 January 1992 (REP)

ISSN 0332-8422

Nr. 91/18 Børge Strand: Personlig inntekt, formue og skatt 1980-1989 Rapport fra registerbasert skattestatistikk. 1992-50s. 60 kr ISBN 82-537-3618-5

- 91/19 Arne S. Andersen: Familiesituasjon og økonomi En sammenlikning av husholdningers levestandard. 1992-70s. 80 kr ISBN 82-537-3627-4

- 92/1 Naturressurser og miljø 1991 Energi, luft, fisk, skog, jordbruk, kommunale avløp, avfall, miljøindikatorer Ressursregnskap og analyser. 1992-154s. 100 kr ISBN 82-537-3651-7

- 92/1A Natural Resources and the Environment 1991. 1992-159s. 100 kr ISBN 82-537-3668-1

- 92/2 Arne Ljones, Runa Nesbakken, Svein Sandbakken og Asbjørn Aaheim: Energibruk i husholdningene Energiundersøkelsen 1990. 1992-106s. 90 kr ISBN 82-537-3629-0

- 92/3 Knut Moum (red.): Klima, økonomi og tiltak (KLØKT). 1992-97s. 90 kr ISBN 82-537-3647-9

- 92/4 Totalregnskap for fiske- og fangstnæringen 1986-1989. 1992-34s. 75 kr ISBN 82-537-3633-9

- 92/5 Tom Granseth: Hotelløkonomi og overnattinger En analyse av sammenhengen mellom hotellenes lønnsomhet og kapasitetsutnytting mv. 1992-53s. 90 kr ISBN 82-537-3635-5

- 92/6 Liv Argel: Informasjonen om Folke- og boligtelling 1990 i massemediene. 1992-68s. 90 kr ISBN 82-537-3645-2

- 92/7 Ådne Cappelen, Tor Skoglund og Erik Storm: Samfunnsøkonomiske virkninger av et EF-tilpasset jordbruk. 1992-51s. 75 kr ISBN 82-537-3650-9

- 92/8 Finn Gjertsen: Dødelighet ved ulykker 1956-1988. 1992-127s. 100 kr ISBN 82-537-3652-5

- 92/9 Kommunehelsetjenesten Årsstatistikk for 1990. 1992-56s. 90 kr ISBN 82-537-3653-3

Nr. 92/10 Pasientstatistikk 1990. 1992-73s. 90 kr ISBN 82-537-3654-1

- 92/11 Jan Lyngstad: Økonomiske levekår for barnefamilier og eldre 1970-1986. 1992-80s. 90 kr ISBN 82-537-3660-6

- 92/12 Odd Frank Vaage: Kultur- og mediebruk 1991. 1992-64s. 95 kr ISBN 82-537-3673-8

- 92/13 Offentlig forvaltning i Norge. 1992-72s. 90 kr ISBN 82-537-3674-6

- 92/14 Else Helena Flittig: Folketrygden Utviklingen fra 1967 til 1990. 1992-52s. 90 kr ISBN 82-537-3675-4

- 92/15 Lasse Sigbjørn Stambøl: Flytting og utdanning 1986-1989 Noen resultater fra en undersøkelse av innenlandske flyttinger på landsdelsnivå og utdanning. 1992-73s. 90 kr ISBN 82-537-3682-7

- 92/16 Petter Jakob Bjerve: Utviklingshjelp til offisiell statistikk i Bangladesh. 1992-22s. 75 kr ISBN 82-537-3683-5

- 92/17 Anne Brendemoen, Solveig Glomsrød og Morten Aaserud: Miljøkostnader i makroperspektiv. 1992-46s. 75 kr ISBN 82-537-3684-3

- 92/18 Ida Skogvoll: Folke- og boligtelling 1990 Dokumentasjon av kontroll- og opprettingsregler for skjemakjennemerker. 1992-48s. 75 kr ISBN 82-537-3694-0

- 92/19 Ida Skogvoll: Folke- og boligtelling 1990 Dokumentasjon av kodeopplegget i Folke- og boligtelling 1990. 1992-27s. 75 kr ISBN 82-537-3695-9

- 92/20 Tor Arnt Johnsen: Ressursbruk og produksjon i kraftsektoren. 1992-35s. 75 kr ISBN 82-537-3696-7

- 92/21 Kurt Åge Wass: Prisindeks for ny enebolig. 1992-43s. 75 kr ISBN 82-537-3734-3-

- 92/22 Knut A. Magnussen and Terje Skjerpen: Consumer Demand in MODAG and KVARTS. 1992-73s. 90 kr ISBN 82-537-3774-2

Nr. 92/23 Skatter og overføringer til private Historisk oversikt over satser mv. Årene 1975-1992. 1992-70s. 90 kr ISBN 82-537-3778-5

- 92/24 Pasientstatistikk 1991. 1992-76s. 90 kr ISBN 82-537-3780-7

- 92/25 Astrid Busengdal og Ole O. Moss: Avfallsstatistikk Prøveundersøkelse for kommunalt avfall og gjenvinning. 1992-37s. 75 kr ISBN 82-537-3782-3

- 92/26 Nils Øyvind Mæhle: Kryssløpsdata og kryssløpsanalyse 1970-1990. 1993-230s. 140 kr ISBN 82-537-3783-1

- 92/27 Terje Erstad og Per Morten Holt: Selskapsbeskatning Analyse og statistikk. 1992-118s. 100 kr ISBN 82-537-3786-6

- 92/28 Terje Skjerpen og Anders Rygh Swensen: Estimering av dynamiske utgiftssystemer med feiljusterings-mekanismer. 1992-60s. 90 kr ISBN 82-537-3792-0

- 92/29 Charlotte Koren og Tom Kornstad: Typehusholdsmodellen ODIN. 1993-34s. 75 kr ISBN 82-537-3797-1

- 92/30 Karl Ove Aarbu: Avskrivningsregler og leiepriser for kapital 1981-1992. 1993-50s. 75 kr ISBN 82-537-3807-2

- 93/1 Naturressurser og miljø 1992. 1993-144s. 115 kr ISBN 82-537-3844-7

- 93/1A Natural Resources and the Environment (Under utgivelse)

- 93/2 Anne Brendemoen: Faktoretterspørsel i transportproduserende sektor. 1993-49s. 75 kr ISBN-82-537-3814-5

- 93/3 Jon Holmøy: Pleie- og omsorgstjenesten i kommunene 1989. 1993-136s. 100 kr ISBN 82-537-3811-0

- 93/4 Magnar Lillegård: Folke- og boligtelling 1990 Dokumentasjon av de statistiske metodene. 1993-48s. 90 kr ISBN 82-537-3818-8

- 93/5 Audun Langørgen: En økonometrisk analyse av lønnsdannelsen i Norge. 1993-48s. 100 kr ISBN 82-537-3819-6

Nr. 93/6 Leif Andreassen, Truls Andreassen, Dennis Fredriksen, Gina Spurkland og Yngve Vogt: Framskriving av arbeidsstyrke og utdanning Mikrosimuleringsmodellen MOSART 1 (Under utgivelse)

- 93/7 Anders Barstad: Omfordeling og endring av miljøproblemer på bostedet (Under utgivelse)

- 93/8 Odd Frank Vaage: Feriereiser 1991/92. 1993-44s. 75 kr ISBN 82-537-3831-5

- 93/9 Erling Holmøy, Bodil M. Larsen og Haakon Vennemo: Historiske brukerpriser på realkapital. 1993-63s. 90 kr ISBN 82-537-3832-3

- 93/10 Runa Nesbakken: Energiforbruk til oppvarmingsformål i husholdningene (Under utgivelse)

- 93/11 Bodil M. Larsen: Vekst og produktivitet i Norge 1971-1990. 1993-44s. 75 kr ISBN 82-537-3837-4

- 93/12 Resultatkontroll jordbruk 1992. 1993-79s. 90 kr ISBN 82-537-3835-8

- 93/13 Odd Frank Vaage: Mediebruk 1992. 1993-38s. 75 kr ISBN 82-537-3854-4

- 93/14 Kyrre Aamdal: MAKKO - En modell til analyse av kommunal ressursbruk og tjenesteyting (Under utgivelse)

- 93/15 Olav Bjerkholt, Torgeir Johnsen og Knut Thonstad: Muligheter for en bærekraftig utvikling Analyser på World Model. 1993-64s. 90 kr ISBN 82-537-3861-7

- 93/16 Tom Langer Andersen, Ole Tom Djupskås og Tor Arnt Johnsen: Kraftkontrakter til alminnelig forsyning i 1992 Priser, kvantum og leveringsbetingelser. 1993-42s. 75 kr ISBN 82-537-3864-1

- 93/17 Steinar Strøm, Tom Wennemo og Rolf Aaberge: Inntektsulikhet i Norge 1973-1990 (Under utgivelse)

- 93/18 Kjersti Gro Lindquist: Empirical Modelling of Exports of Manufactures: Norway 1962-1987 (Under utgivelse)

- 93/19 Knut Røed : Den selvforsterkende arbeidsledigheten om hystereseeffekter i arbeidsmarkedet (Under utgivelse)

ISBN 82-537-3855-2