Economic Survey 3/91

Economic Trends in Norway

Emission to Air in Norway

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The present issue of Economic Survey contains a review of current economic trends in Norway and an outlook for 1991 and 1992. The main source of information is the quarterly national account system, which is based on less detailed information than the annual national accounts. The cut-off date for information used in this publication was 4 September 1991.

Economic Trends in Norway has been prepared by the Research Department in the Central Bureau of Statistics. Inquiries should be directed to Knut Moum or Øystein Olsen.

In addition, the present issue includes an overview of emissions to air in Norway, and analysis of some effects of potential climate policies.

ECONOMIC TRENDS

SUMMARY

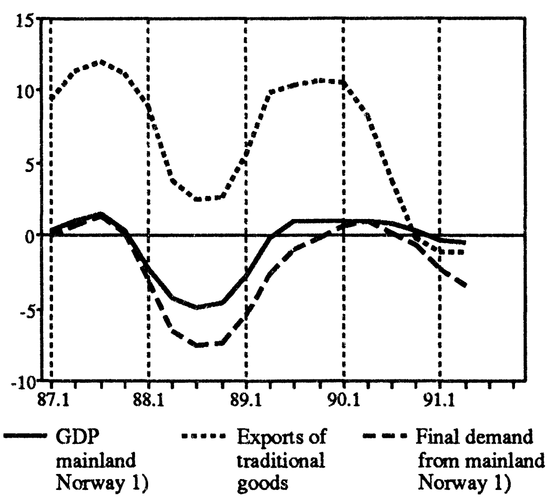
Provisional figures from the quarterly national accounts show that the decline in demand from mainland Norway continued in the second quarter of this year. Private consumption edged downwards for the third consecutive quarter. Gross fixed investment in mainland Norway continues to decline, but second quarter figures confirm that manufacturing investment has picked up. Traditional merchandise exports also exhibited a weak trend, and employment fell further in the second quarter of 1991.

Most of Norway's main trading partners are still experiencing a cyclical downturn. A recovery is, however, probably under way in the US. Partly as a result of the upturn in the US economy, growth is expected to increase gradually in our trading partner countries. Traditional merchandise exports from Norway may therefore improve slightly towards the end of this year.

Price inflation, measured by the Consumer Price Index, has abated thus far this year and is now about 2 percentage points lower than the inflation rate of our trading partners. There are signs of rising wage drift in some sectors, and the average growth in hourly wages in 1991 is likely to be approximately the same as wage growth in 1990. Due to a noticeably slower rise in prices, however, real wages in 1991 will on average grow at a faster rate than last year.

Developments in the Norwegian economy in the second quarter indicate that the projection for domestic demand in 1991 in the last Economic Survey was too optimistic. Updated projections based on the Central Bureau of Statistics' macroeconomic model KVARTS nevertheless indicate that demand from mainland Norway will pick up in the second half of 1991. Combined with a moderate recovery in traditional merchandise exports, this may result in a slight growth in mainland output in 1991, approximately on a par with the previous year. An improvement in the labour market, however, cannot be expected until the end of next year.

CYCLICAL DEVELOPMENT
(Per cent growth from previous quarter.
Seasonally adjusted and smoothed. Annual rates.)



1) Excl. oil and ocean transport.

International economy: Weak growth for several of Norway's trading partners

The economic situation is still marked by weak trends in total output and demand in several major

MAIN TRENDS IN ECONOMIC DEVELOPMENTS
Underlying tendency (from previous quarter). Annual rate. Per cent[1)]

	90.3	90.4	91.1	91.2
DEMAND AND OUTPUT VOLUME INDICATORS				
Final domestic use of goods and services	-2	-1	-2	-2
- Demand from mainland Norway	0	-1	-2	-3
- Private consumption	2	-1	-2	-3
- Government consumption	3	3	1	0
- Gross fixed capital formation, mainland Norway	-8	-6	-8	-9
Eksport	6	6	7	9
- Traditional goods	4	0	-1	-1
Imports	-3	-2	-1	3
- Traditional goods	3	2	1	4
GDP	2	2	2	1
- Mainland Norway	1	0	0	-1
LABOUR MARKET				
Man-hours worked	-1	-2	-2	-1
Employed persons	-1	-1	-2	-2
Unemployment rate[2)]	5.3	4.9	5.3	5.3
PRICES				
Consumer Price Index	3.8	4.5	3.8	3.7
INCOME				
Current balance, NOK bn[3)]	9.4	13.1	5.4	11.1

1) See "Technical comment".
2) Seasonally adjusted levels in per cent.
3) Unadjusted levels in NOK bn.

industrial countries. After the end of the Gulf war, most forecasters have nevertheless projected a recovery in the world economy during the second half of this year.

Several factors may now contribute to an improvement in economic trends in the OECD area. First, the end of the war in the Persian Gulf has resulted in greater confidence on the part of consumers and producers. Secondly, monetary policy has been eased and interest rates have dropped in some of the major countries. High interest rates and sluggish investment demand were important factors contributing to the cyclical downturn through 1990 and in 1991. Thirdly, economic developments in recent years have reduced the substantial trade imbalances between the large OECD countries. The previously sizeable current account surpluses in Japan and Germany have been reduced. The expansionary policy in Germany following the reunification of the two German states has entailed that the current account surplus is now close to zero. The counterpart to developments in Japan and Germany is that the balance of payments deficit in the US has declined. The dollar exchange rate has strengthened and the interest rate level in the US is now lower than it has been for many years. A revival in domestic demand in the US will therefore not necessarily result in unmanageable external balance problems.

A recovery in the US economy constitutes a key element in the projected international upturn. The decline in economic growth in the US also seems to have come to a halt, and developments in key short-term indicators may suggest that the recovery is now under way. GNP growth from the first to second quarter was close to zero according to provisional estimates. The strongest demand component has been consumer spending, but housing investment is also flattening out after having fallen sharply through 1990. The interest rate level in the US is now very low, and the Federal funds rate was lowered to 5 1/2 per cent in the beginning of August. The aim of this interest rate policy is, among other things, to stimulate investment which is expected to pick up markedly in 1991. In spite of some positive indications it is still very uncertain how strong the recovery in the US economy will be. If a more pronounced upturn is further delayed or is noticeably weaker than expected, this will have a sizeable impact on economic developments in other parts of the OECD area.

In Japan, GNP growth has tapered off but is still at a high level compared with most other OECD countries. Growth rates of 3 1/2-4 per cent are expected in both 1991 and 1992. Exports have gathered pace and have resumed their role as the most important growth factor. One new feature is that while exports to the US fell slightly in the first half of 1991, exports to the EC and NICs in Asia have risen sharply.

As noted, the situation in Germany is characterized by a steep increase in public expenditure as a result of reunification. So far this has contributed to output growth in the West, while production has fallen sharply in the East. While most economic indicators are still calculated separately for West and East Germany, the estimates for the current balance relate to a unified Germany. The strong expansion in domestic demand has resulted in a deterioration in the external account, and a current account deficit was registered in the first five months of this year. This is expected to be reversed to a surplus, however, as early as next year, partly as a result of sluggish domestic demand. The Bundesbank raised interest rates in mid-August this year. The financing of the federal government budget deficit is expected to keep the interest rate level high for the remainder of 1991. Unless Germany experiences a further current account deterioration, there is reason to assume that German interest rates will continue to serve as a benchmark for interest rates in other European countries.

The UK has recorded negative GDP growth since the third quarter of last year. The decline in the level of activity can primarily be attributed to high interest rates, a heavely geared corporate balance-sheet and reduced international competitiveness due to a higher growth in unit labour costs than experienced by trading partner countries. The interest rate level, however, has fallen substantially thus far this year; base rates have been lowered on several occasions, and the money market rate has followed suit. Due to a high inflation rate and sterling's weak position in the Exchange Rate Mechanism (ERM), however, interest rates in the UK are still high, with short-term rates up around 12 per cent. If domestic demand continues to be restrained by high interest rates, an economic upturn in the UK will depend on a broadly based international recovery.

In Sweden, the cyclical downturn is becoming increasingly apparent, with a fall in GDP and mounting unemployment. Sizeable bank losses have also emerged. The weak economic developments are expected to persist next year, partly as a result of the strong rise in costs in Swedish industry over a period of several years. In Denmark, on the other hand, the competitive position has improved the last few years as a result of low rises in prices and costs. Output growth, however, is relatively sluggish and unemployment has climbed further in 1991. Based on higher growth internationally, GDP is expected to rise by 2 per cent in 1992.

Forecasts for world trade point to a total growth of 3.5 and 6 per cent, respectively, in 1991 and 1992. With the exception of Germany, however, Norway's main trading partners experience a weak growth or even decline in domestic demand. Hence, the growth in Norway's export markets may be reduced to 1 per cent in 1991. Export market growth in 1992 is estimated at 5-6 per cent, however, as a result of the projected international upturn.

Relatively stable oil prices in the second quarter of this year have contributed to a downward trend in inflation rates internationally. The rate of inflation for our trading partners is still nearly 2 percentage points higher than the inflation rate in Norway, although this differential may narrow in the period ahead.

Strong growth in oil exports, but fall in traditional exports

In spite of slower growth rates in the OECD area from the second half of 1989, traditional merchandise exports remained high well into 1990. The underlying growth rate, however, declined through last year. Adjusted for normal seasonal variations, provisional figures from the quarterly national accounts show that traditional merchandise exports fell by 0.5 per cent from the first to second quarter of 1991 after rising 1.1 per cent from the fourth quarter of 1990 to the first quarter of this year.

Exports of sheltered goods expanded through 1990, and growth continued through the first half of 1991. Exports of import-competing goods also increased from the first to second quarter of this year after declining in the previous two quarters.

Exports of goods from export-oriented industries also showed a high growth through the first half of 1990, but have thereafter exhibited a weak trend. A sharp rise in exports of refined petroleum products from Mongstad is one of the reasons that traditional merchandise exports have remained buoyant. On the other hand, this entails lower net exports of crude oil than would otherwise have been possible. If refined products are excluded, traditional exports have shown a decline for three consecutive quarters. Exports of goods from export-orinted industries, excluding refined petroleum products, have fallen through the last two quarters, with a seasonally adjusted decline of 3.2 per cent from the first to second quarter. Exports of services grew by 3.5 per cent in the second quarter of this year after declining 5.2 per cent the previous quarter. Growth was particularly strong for direct purchases in Norway by non-residents.

Exports of crude oil and natural gas expanded by some 8 per cent from the first to second quarter of this year, to a level nearly 20 per cent above the average of last year. The value of crude oil and natural gas exports accounted for nearly 30 per cent of total exports in the second quarter. As a result of the surge in oil exports and sizeable exports of ships and platforms, total export volume increased by 6.5 per cent from the first to second quarter.

Weak growth internationally and a flattening out of exports of refined petroleum products will entail a low growth in traditional merchandise exports from 1990 to 1991. Traditional merchandise exports, however, may be expected to pick up through the second half of 1991 as a result of faster growth in Norway's export markets. A continued rise in exports of oil and gas in the second half of this year may nevertheless result in a growth in total exports in 1991 which is only slightly lower than the average of the last five years.

Continued weak domestic demand

Mainland demand has shown a slower underlying growth since the third quarter of 1990. The decline from the first to second quarter of 1991 was 1.2 per cent, of the same magnitude as the decline from the fourth quarter of last year to the first quarter of 1991. Private consumption showed signs of picking up through the first half of 1990, but has now fallen three consecutive quarters. The decline from the first to second quarter was 1.7 per cent (seasonally adjusted). Spending on goods fell by 1.1 per cent and spending on services, excluding housing services, dropped 1.3 per cent.

A growth of 3.7 per cent in household real disposable income last year combined with a 2.5 per cent rise in consumption resulted in an increase in the savings ratio to 2 per cent of disposable income in 1990. Households' net financial wealth, however, is still considerably lower than the average level up to the mid-1980s, while the real after-tax interest rate is markedly higher. This points to a continued rise in the savings ratio and a low level of housing investment. A strong growth in incomes and a moderate liquidity effect from the release of funds accumulated in special savings accounts allowing tax credits (SMS scheme) in the third quarter may nevertheless result in some growth in private consumption from 1990 to 1991.

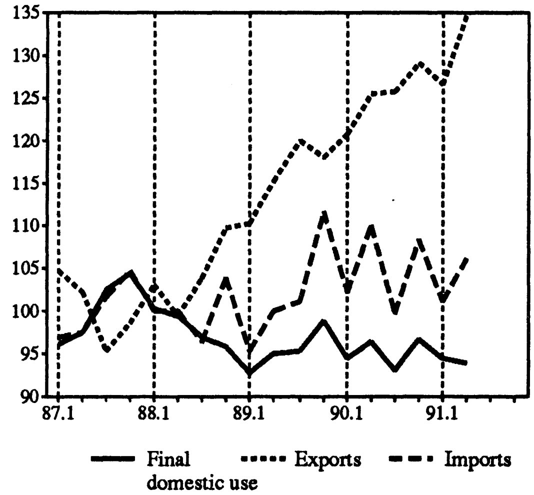
Public consumption in the first half of 1991 was about 2 per cent higher than the level in the first half of 1990. If the projections presented in the Revised National Budget in May of this year are to be achieved, public spending must expand by some 3 per cent from the first to second half of this year (seasonally adjusted).

Gross fixed investment in mainland Norway fell in both the first and second quarters of this year, after a pronounced growth in investment in manufacturing and private services, excluding housing, contributed to a rise in mainland gross fixed investment in the fourth quarter of 1990. That represented the first quarter of growth in mainland investment since the end of 1987. Manufacturing investment increased further in the first quarter of this year, but this was more than offset by a resumed sharp drop in investment in private services. Investment in service sectors continued to fall in the second quarter, albeit at a slower pace.

The Central Bureau of Statistics' investment intention survey for manufacturing and mining in the second quarter indicates that manufacturing investment will expand slightly through the remainder of 1991. If the Government's goals from the Revised National Budget are to be achieved, central government capital spending must increase sharply in the second half of this year. All total, this will entail that the decline in mainland investment will be considerably weaker this year than in 1990 in spite of a continued strong drop in housing investment and a fall in investment in domestic transport and communications.

According to the investment intention survey for oil activities in the second quarter, accrued investment costs will increase by more than NOK 9 billion at current prices from 1990 to 1991. This growth represents a direct demand stimulus equivalent to about 1.3 per cent of mainland GDP.

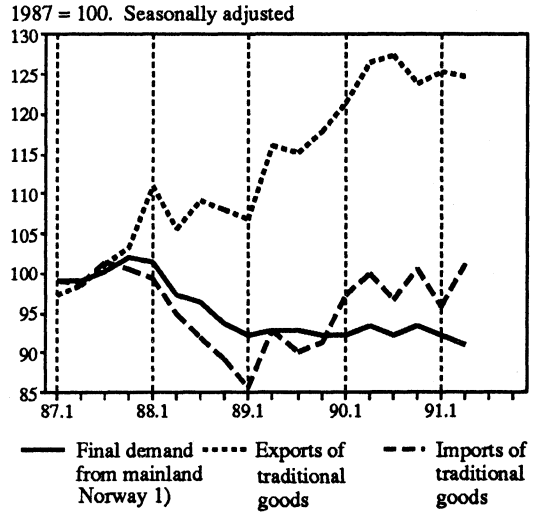
TOTAL EXPORTS, IMPORTS AND FINAL DOMESTIC USE
1987 = 100. Seasonally adjusted



Low growth in imports

Adjusted for normal seasonal variations, traditional merchandise imports grew by 5.6 per cent in the second quarter after declining 4.9 per cent in the first quarter of this year. Through 1990 and in 1991 traditional merchandise imports have shown considerable variations from one quarter to the next. The sizeable fluctations are primarily due to a combination of aircraft purchases and deliveries of submarines. In the second quarter of 1991 imports of pipes for the Zee pipeline amounted to nearly NOK 1 billion. If deliveries of aircraft, submarines and pipes for offshore activites are excluded, traditional merchandise imports have remained quite stable since the first quarter of 1990. A continued weak trend in domestic demand will result in approximately unchanged imports of traditional goods from 1990 to 1991.

EXPORTS, IMPORTS AND DOMESTIC DEMAND, MAINLAND NORWAY
1987 = 100. Seasonally adjusted



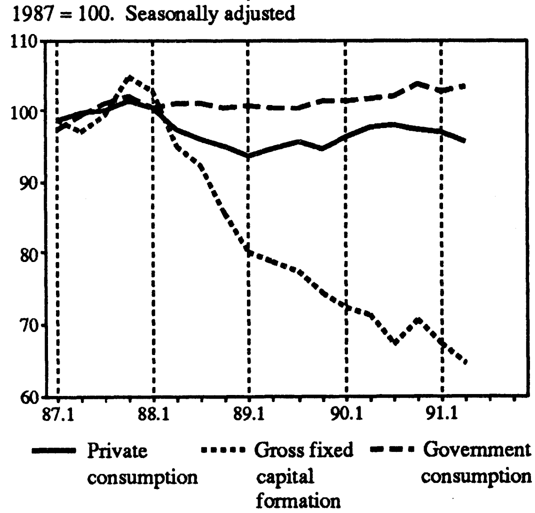
1) Excl. oil and ocean transport, and changes in stocks.

Moderate output growth in mainland Norway this year

Mainland GDP remained unchanged from the first to second quarter of this year, according to provisional estimates, following a decline in the first quarter. However, mainland Norway, excluding the public sector, recorded positive growth in the second quarter. The gross product for manufacturing expanded by 3.3 per cent (seasonally adjusted) after falling by 1.8 per cent in the first quarter. On the other hand, the gross product for building and construction, distributive trades, domestic transport and communications and banking and insurance declined in the second quarter.

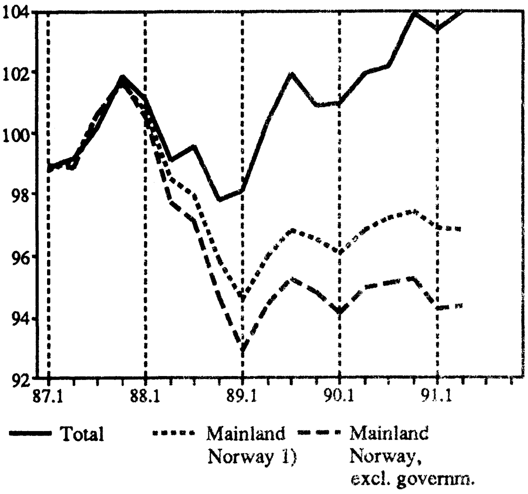
Rising investment in petroleum activities, a slight growth in traditional exports and the projected recovery in consumption will stimulate the mainland economy in the second half of this year. Along with a higher level of activity in the public sector in the second half of 1991, this will contribute to approximately unchanged growth in mainland GDP from 1990 to 1991 in spite of the weak trend in the first half of the year.

CONSUMPTION AND FIXED CAPITAL FORMATION, MAINLAND NORWAY 1)
1987 = 100. Seasonally adjusted



1) Excl. oil and ocean transport, and changes in stock.

GROSS DOMESTIC PRODUCT
1987 = 100. Seasonally adjusted



1) Excl. oil and ocean transport.

Weaker trend in the labour market

According to the Central Bureau of Statistics' labour market survey, employment has fallen the last three quarters (up through the second quarter of 1991), after increasing slightly in the second and third quarters of last year. Seasonally adjusted, employment in the first half of 1991 was 1.8 per cent below the level in the second half of 1990. Employment has thus fallen back to the level in 1984-85.

The number of people unemployed, according to the survey, has shown relatively little change through 1990 and 1991 because the labour force has generally moved in tandem with employment. On the other hand, the total number of registered unemployed and people participating in labour market measures (excluding rehabilitation) has been rising through 1991. A continued growth in labour productivity may result in a weakening of the labour market in the second half of the year in spite of a moderate growth in production.

Slower rise in consumer prices and higher real wages

The year-on-year increase in consumer prices fell from 4 per cent in the beginning of 1991 to 3.5 per cent in June and July. Lower price inflation internationally and strong competition in the wholesale and retail sector have a damping effect on the rate of price increase. The annual rise in the Consumer Price Index from 1990 to 1991 will probably be reduced to 3.5 per cent.

As a whole, the carry-over from 1990 and pay increases resulting from this year's wage settlements will contribute some 3 percentage points to annual wage growth from 1990 to 1991. The wage index for manufacturing and construction for the first quarter indicates that wage drift may have accelerated slightly in these sectors following the repeal of the Income Regulation Act last year. For the economy as a whole, wage drift in 1991 may contribute about 1.5 percentage points to annual wage growth, entailing that the average growth in wages from 1990 to 1991 may reach 5 per cent. This will result in a growth of about 1.5 per cent in real wages before taxes from 1990 to 1991.

Oil and gas exports contribute to sizeable current account surpluses

Provisional estimates show a current account surplus of NOK 16.5 billion in the first half of this year, compared with a surplus of some NOK 22 billion for 1990 as a whole. The positive trend for the current balance in the first half of 1991 can primarily be ascribed to a considerable growth in the value of crude oil and natural gas exports. An upswing in traditional merchandise exports and a continued high level of oil and gas exports may result in a current account surplus in the second half of 1991 of the same magnitude as in the first half.

Stronger growth in mainland Norway in 1992

This issue of Economic Survey also contains a model-based projection of macroeconomic developments in Norway for the second half of 1991 and all of 1992. The calculations indicate that the upturn in production and demand in mainland Norway, which is expected to take place in the second half of this year, will continue in 1992. Private consumption, according to the projections, will grow in volume by some 3 1/2 per cent, following very weak growth this year. A continued high growth in incomes, the release of SMS funds and an announced tax relief of NOK 2.5 billion will contribute to the strong growth in consumption. The reform of the tax system, however, will also contribute to a higher real after-tax interest rate next year. If households react to this with a further increase in the propensity to save from 1991 to 1992, the growth in consumption may be lower than forecast. Fixed investment in mainland Norway is projected to rise in 1992 for the first time since 1986.

In spite of a projected output growth of nearly 3 per cent in the mainland economy in 1992, employment on an annual basis will only rise slightly, and unemployment will show little change from the previous year. The labour market will improve, however, towards the end of 1992.

Conditional on an international economic upturn, the growth in traditional merchandise exports will pick up again in 1992. In addition, a continued growth in the volume of oil exports is expected in both 1991 and 1992. On the assumption that crude oil prices and the dollar exchange rate remain approximately unchanged from current levels, Norway's current balance will show sizeable surpluses in the projection period.

DEVELOPMENT TRENDS IN SELECTED MACROECONOMIC VARIABLES

Percentage change in volume in 1989 prices [1]

	NOK billion	Growth from same period previous year				Underlying tendency Annual rate (measured from previous quarter)[5]			
	1990	90.3	90.4	91.1	91.2a	90.3	90.4	91.1	91.2
Private consumption	320.2	2.7	2.4	0.4	-1.6	2	-1	-2	-3
Goods	201.6	3.1	2.3	0.0	-2.1	1	-1	-3	-3
Services	107.9	1.5	2.8	2.6	2.6	3	3	3	1
Norwegian consumption abroad	20.4	1.1	0.1	-16.6	-17.2	*	*	*	*
- Non-residents' consumption	9.8	-4.7	-0.9	-14.8	3.3	*	*	*	*
Government consumption	134.2	1.6	3.7	3.5	0.6	*	*	*	*
Central government	53.8	1.6	5.6	7.4	-1.0	*	*	*	*
Civilian	32.8	0.7	5.4	4.8	-0.7	*	*	*	*
Military	21.0	3.3	5.8	12.9	-1.4	*	*	*	*
Local government	80.4	1.5	2.2	1.4	1.7	*	*	*	*
Gross fixed capital formation	122.3	-32.8	-29.5	-8.0	-5.8	*	*	*	*
Oil and shipping	25.9	-66.5	-61.0	3.1	3.0	*	*	*	*
Mainland Norway	96.3	-12.8	-6.9	-10.6	-8.5	-8	-6	-8	-9
Manufacturing and mining	13.4	-7.7	14.6	14.9	14.0	18	25	19	3
Production of other goods	13.3	-13.4	-14.9	-12.2	-3.2	-11	-6	-2	1
Other services	69.6	-13.7	-9.3	-14.2	-13.8	-11	-11	-14	-14
Stocks (contribution to GDP growth)	16.2	(5.3)	(4.1)	(-0.5)	(0.0)	*	*	*	*
Ships and oil platforms in progress (contribution to GDP growth)	11.7	(3.2)	(2.1)	(-0.4)	(0.4)	*	*	*	*
Other stocks (contribution to GDP growth)[3]	4.4	(2.0)	(2.0)	(-0.2)	(-0.4)	*	*	*	*
Final domestic use of goods and services	592.8	-1.9	-2.8	-1.2	-2.0	-2	-1	-2	-2
- gross capital formation in oil and shipping (incl. stocks)[2]	37.7	-38.5	-47.5	-4.6	8.9	*	*	*	*
- demand from mainland Norway	550.7	-0.6	0.9	-0.8	-2.3	0	-1	-2	-3
Exports	281.8	4.8	8.6	3.1	8.3	6	6	7	9
Traditional goods	119.6	10.8	4.1	-0.1	0.9	4	0	-1	-1
Crude oil and natural gas	74.8	-4.7	11.9	15.4	24.5	14	22	22	19
Ships and oil platforms	10.8	11.2	69.2	-23.1	13.2	*	*	*	*
Services	76.7	5.1	7.3	-0.8	4.1	4	2	0	1
Total use of goods and services	874.6	0.2	0.6	0.2	1.4	1	1	1	2
Imports	240.7	-1.9	-3.4	-2.8	-2.1	-3	-2	-1	3
Traditional goods	150.1	7.0	9.3	-4.0	2.8	3	2	1	4
Crude oil	1.4	15.5	129.3	0.3	-1.5	*	*	*	*
Ships and oil platforms	18.7	-55.7	-51.9	-9.4	-44.6	*	*	*	*
Services	70.5	1.2	1.6	1.7	2.3	1	2	3	6
Gross domestic product (GDP)	633.9	0.9	2.2	1.3	2.8	2	2	2	1
- Mainland Norway	533.6	1.1	0.1	-0.6	0.9	1	0	0	-1
Oil activities and shipping	100.3	-0.1	14.1	10.9	12.9	11	14	12	9
Mainland industry	493.5	1.0	-0.2	-0.5	1.0	1	0	0	0
Manufacturing and mining	92.4	1.7	-0.3	-3.0	3.2	1	1	1	3
Production of other goods	71.3	1.0	-7.1	-2.7	-8.5	-5	-6	-7	-7
Other services	329.8	0.7	1.5	0.7	-2.1	2	2	1	0
Correction items (contribution to GDP growth)[4]	40.1	(0.2)	(0.2)	(-0.1)	(-0.1)	*	*	*	*

[1] Notes, see "Technical comment".

PRICE INDICES FOR SELECTED MACROECONOMIC VARIABLES

	Percentage change from the same period the year before				Underlying tendency annual rate (measured from previous quarter)			
	90.3	90.4	91.1	91.2a	90.3	90.4	91.1	91.2
Private consumption	4.3	4.7	4.4	4.0	5	5	4	2
Government consumption	3.6	4.7	4.4	3.9	8	8	0	1
Gross fixed captial formation	3.0	2.3	2.9	2.9	4	4	1	6
- mainland Norway	1.7	2.0	1.3	2.1	7	2	-4	3
Final domestic use of goods and services	3.5	4.4	4.1	3.9	6	5	2	3
- demand from mainland Norway	3.7	4.2	4.0	3.7	6	5	1	2
Exports	1.7	14.2	0.7	7.3	28	64	-41	6
- traditional merchandise exports	-5.7	2.8	1.2	2.6	0	32	-14	-2
Total use of goods and services	2.9	7.6	3.0	4.8	12	22	-15	4
Imports	0.4	0.2	-1.9	-0.1	-1	4	-8	6
- traditional merchandise imports	-0.5	-0.4	-3.6	-0.2	0	-1	-11	12
Gross domestic product (GDP)	3.8	10.4	14.7	6.8	18	29	-17	3
- mainland Norway	1.8	3.9	5.6	4.1	3	9	7	-3

TECHNICAL COMMENT ON THE QUARTERLY ACCOUNTS FIGURES

Footnotes: 2) Including ships, oil platforms and platform modules in progress. 3) Excluding ships, oil platforms and platform modules in progress. Contributions to GDP growth are calculated as the difference between investments in stocks in the quarter and the same quarter the previous year, calculated as a percentage of GDP the same quarter the previous year. 4) Corrected for free bank services and certain excises. The contributions to GDP growth are calcualted as the increase in the item from the same quarter the previous year, measured as a percentage of GDP the same quarter the previous year. 5) Growth from previous quarter in smoothed, seasonally adjusted series, converted to an annual rate. 6) Estimates partly based on projections. *) Percentage changes are meaningless.

Quarterly calculations: The calculations are made on a less detailed level than the calculations for the annual national accounts, and are based on more simplified procedures. The quarterly national accounts figures for the years up to and including 1989 have been reconciled against the most recently published annual accounts figures.

Gross fixed capital formation: Total gross fixed capital formation is heavily influenced by significant fluctuations in investment in oil activities. These fluctuations are inter alia due to the fact that platforms that have been under construction for several years are counted as investment in the quarter and with the capital value they have at the time they are towed out to the field.

Seasonally-adjusted figures: The quarterly national accounts are not seasonally-adjusted, as these accounts are attempts to register the actual transactions that have taken place in each quarter. Many of the statistical series thus show clear seasonal variations. These are therefore seasonally adjusted on the detailed accounts level and then added together with the other statistical series to obtain the figures presented in the tables and charts of this volume. Seasonal adjustments for the public sector's purchase of goods and services are based on estimates, as there is not enough information available yet to map out the seasonal pattern.

Underlying trend: The Norwegian economy is so small that random or single important occurrences can give wide variations in the figures. The seasonally adjusted figures are therefore smoothed so that it is possible to find the underlying trend for each series. Smoothing is an attempt to distinguish between random and systematic variations in the series.

REVISIONS OF UNDERLYING TREND

Per cent growth from previous quarter. Seasonally adjusted and smoothed. Annual rates

Publ.	87.3	87.4	88.1	88.2	88.3	88.4	89.1	89.2	89.3	89.4	90.1	90.2	90.3	90.4	91.1	91.2
							GDP mainland Norway									
June -88	1	0	-2													
Sept.-88	0	0	-1	-1												
Dec.- 88	1	1	0	-1	-2											
Feb.- 89	1	1	0	-1	-1	-2										
June -89	2	2	0	-2	-3	-4	-3									
Sept.-89	2	2	-1	-2	-4	-4	-2	1								
Dec.- 89	2	2	0	-2	-4	-4	-2	1	3							
Feb.- 90	2	2	0	-2	-3	-3	-1	2	3	2						
June -90	1	-1	-3	-4	-4	-3	-1	1	1	0	-2					
Sept.-90	1	-1	-3	-4	-4	-3	-2	1	1	1	1	3				
Dec.- 90	1	-1	-3	-4	-4	-3	-2	1	1	1	2	3	3			
Feb.- 91	1	-1	-3	-4	-4	-3	-1	1	2	1	1	2	2	2		
June -91	1	-1	-2	-4	-5	-5	-3	0	1	1	1	1	1	0	-1	
Sept.-91	1	-1	-2	-4	-5	-5	-3	0	1	1	1	1	1	0	0	-1
							Final demand from mainland Norway									
June -88	1	1	-2													
Sept.-88	0	0	-2	-4												
Dec.- 88	0	0	-2	-4	-4											
Feb.- 89	0	0	-3	-5	-4	-3										
June -89	1	0	-3	-5	-5	-4	-3									
Sept.-89	1	0	-3	-6	-7	-6	-4	0								
Dec.- 89	1	0	-3	-5	-6	-6	-5	-2	0							
Feb.- 90	1	0	-3	-5	-6	-6	-4	-2	0	1						
June -90	1	0	-3	-6	-7	-7	-4	-2	-1	-1	-1					
Sept.-90	1	0	-3	-6	-7	-7	-5	-2	0	1	2	3				
Dec.- 90	1	0	-3	-6	-7	-7	-5	-2	-1	0	1	2	2			
Feb.- 91	1	0	-3	-6	-7	-7	-5	-2	0	1	1	2	2	2		
June -91	1	0	-3	-6	-8	-7	-5	-3	-1	0	1	1	0	0	-2	
Sept.-91	1	0	-3	-6	-8	-7	-5	-3	-1	0	1	1	0	-1	-2	-3

COMMENTS ON THE REVISIONS

Revisions can either be due to new/revised quarterly figures for the current year, new/revised annual national accounts figures for previous years, or a change to a new base year for prices. Because the growth rates following the change-over to an annual rate are rounded off to the nearest whole per cent, a 1 percentage point change in the growth rate can be due to different rounding.

Published:	Price basis:	New annual accounts:	Other comments:
June -88	1986	1985-87	New seasonal adjustment programme used
Sept.-88	"		
Dec.- 88	"		
Feb.- 89	"		
June -89	1987	1986-87	
Sept.-89	"		Revised seasonal adjustment programme
Dec.- 89	"		
Feb.- 90	"		
June -90	1988	1987-88	
Sept.-90	"		
Dec.- 90	"		
Feb.- 91	"		
June -91	1989	1988-89	
Sept.-91	"		

OUTLOOK FOR 1991 AND 1992

Projections of macroeconomic developments in Norway for 1991 and 1992 are presented in this section. The calculations have been made by running the Central Bureau of Statistics' macroeconomic quarterly model, KVARTS. The aim of these calculations is to illustrate probable cyclical developments in the Norwegian economy in the period ahead. The main results from the calculations are presented in the table below, which also includes projections from other institutions. For some key variables the results from the KVARTS calculations are also shown in diagrams as seasonally adjusted and smoothed growth from the previous quarter.

The forecasts are based on the following main assumptions:

- Rising growth in demand for Norway's main trading partners through the second half of 1991 and in 1992.

- Tax relief in 1992 for households amounting to about NOK 2.5 billion compared to tax yields with an unchanged average tax rate.

- The release of funds accumulated in special savings accounts (SMS scheme) will generate a stimulus to consumption totaling about NOK 3 billion. About one third of this stimulus will appear in 1991 and the remainder in 1992.

In the calculations, output growth in mainland Norway is estimated at 0.7 per cent in 1991, which corresponds to the growth in 1990, and 2.9 per cent in 1992. A growth in public consumption, a rise in manufacturing investment and a sharp expansion in investment activity in the oil and gas sector will make a positive contribution to growth in the Norwegian economy for the rest of 1991. In 1992, according to the caculations, a noticeable rise in private consumption as well as higher demand in our trading partner countries will generate a further positive impetus to output growth in mainland Norway.

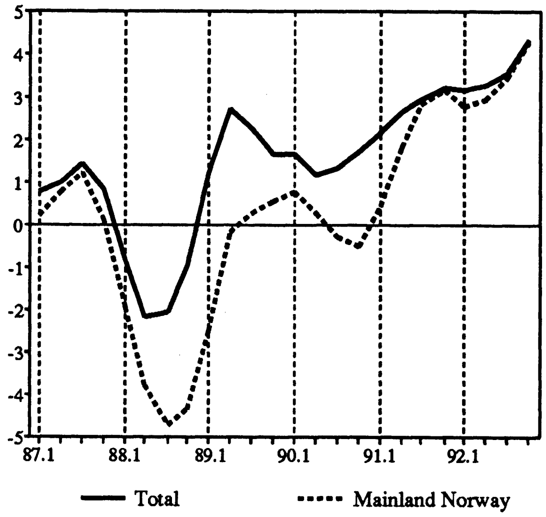
The growth projections for production, domestic demand and employment in 1991 are slightly lower than those presented in Economic Survey 2/91. One of the main reasons for the downward revision in GDP growth is a weaker than expected trend in private consumption and traditional merchandise exports through the first half of this year. The low figure for private consumption in the first half of 1991 entails that the growth in consumption for 1991 will probably end up some place between 0

THE DEVELOPMENT OF MAIN ECONOMIC INDICATORS
Percentage change in volume from pervious year unless otherwise noted[1)]

	1990	1991				1992	
	Accounts	CBS2	CBS1	MoF	OECD	CBS2	OECD
Private consumption	2.6	0.3	1.6	2.4	2.0	3.7	2.9
Public consumption	2.3	2.9	2.9	2.9	2.9	1.5	1.0
Gross fixed capital formation	-28.5	-1.2	3.4	5.3	-0.5	25.0	5.6
- mainland Norway	-9.8	-5.1	-1.2	0.5	-	4.5	-
Exports	7.8	4.3	2.7	3.9	4.7	3.5	4.0
- traditional exports	8.7	1.0	1.1	2.0	-	4.7	-
Imports	2.6	0.2	2.2	1.2	1.7	3.4	4.6
- traditional imports	9.1	1.1	2.3	3.5	-	6.2	-
Gross Domestic Product (GDP)	1.8	2.1	1.5	2.9	2.6	3.1	3.1
- mainland Norway	0.7	0.7	1.1	1.8	1.6	2.9	2.8
Man-hours worked, employees	-0.5	-1.1	-0.4	-	-	0.2	-
Unemployment rate (level)	5.2	5.3	5.3	-	5.1	5.4	4.5
Rise in wages per man-hour	5.0	4.9	4.6	4.0	-	4.4	-
Consumer Price Index	4.1	3.5	3.6	3.8	-	4.0	-
Current account (level, bill. NOK)	22.6	31.7	18.9	20.0	31.7	46.5	30.9

1) MoF: Ministry of Finance. Forecast according to Revised National Budget 1991.
CBS1: Forecast according to Central Bureau of Statistics, Economic Survey no. 5-1991.
CBS2: Forecast according to Central Bureau of Statistics.
OECD: Forecast according to OECD Economic Outlook no. 49 (July 1991.)

GROWTH IN GDP
From previous quarter, annual rate



and 1/2 per cent. The calculations point to a moderate upswing in production and demand in the mainland economy towards the end of 1991 and in 1992.

According to the projections, the growth in the Norwegian economy will be noticeably stronger at the end of 1992 than one year earlier. A mechanical extension of the calculations indicates that growth may remain high in 1993 without strong impact on wage and price growth. For technical reasons the growth projections for 1993 influence underlying growth towards the end of 1992 in the seasonally adjusted and smoothed series for key economic indicators. This help to explain why the diagrams indicate a slightly stronger growth in 1992 than the impression given by the projections for annual growh rates in the table.

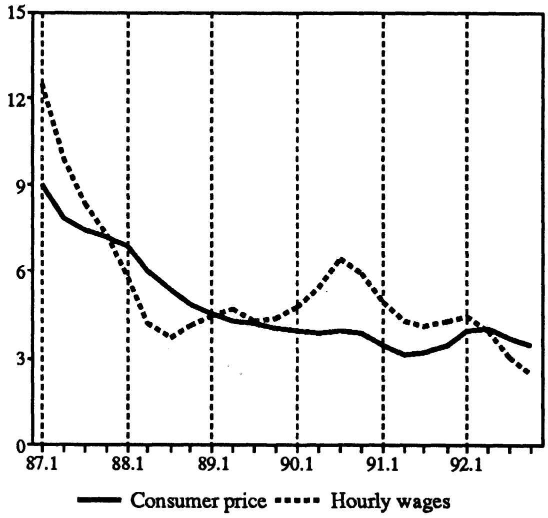
Strong international growth in 1992

The projections are based on an assumption that the sluggish trend in Norwegian export markets continues in the third quarter followed by a gradual improvement. This results in an average export market growth of slightly more than 1 per cent from 1990 to 1991, which is somewhat lower than previously assumed. A stronger expansion in the international economy later in 1992 is projected to result in a market growth of 5-6 per cent from 1991 to 1992. The calculations are further based on an average oil price of USD 20.2 and 21 per barrel in 1991 and 1992, respectively, and a dollar exchange rate which remains at about NOK 6.80. A decline in prices for traditional merchandise imports in the first half of 1991 will, according to the projections, come to a halt in the second half of the year and be replaced by a moderate rise in 1992. The prices for traditional merchandise exports are projected to rise by 2.3 per cent from 1991 to 1992 as a result of the international economic upturn.

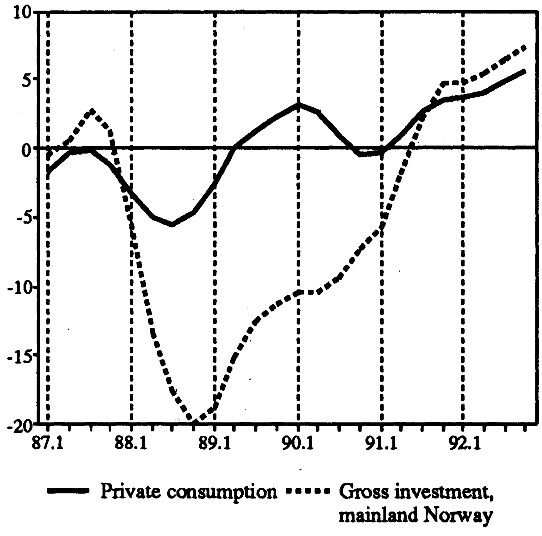
Tax relief and strong growth in public investment

The estimates for developments in employment, intermediate consumption and capital spending in the public sector for 1991 are based on the Government's economic programme as presented in the Revised National Budget. Total public consumption is projected to expand by 2.9 per cent. For 1992, we have assumed a further increase of 1.5 per cent in public consumption. Gross fixed investment is projected to rise in volume by about 20 per cent in the central government sector and by 4 per cent in the local government sector in 1991, again based on estimates in the Revised National Budget. For 1992, central and local goverment investment is projected to expand in volume by 10.5 and 2.5 per cent, respectively. A tax relief of NOK 2.5 billion has been included for personal taxes in 1992 in relation to the tax level based on unchanged average taxes from 1991.

GROWTH IN PRICES AND WAGES
From previous quarter, annual rate



GROWTH IN CONSUMPTION AND INVESTMENT
From previous quarter, annual rate



The interest rate level in state banks is also in accordance with the programme in the Revised National Budget. Interest rates in private financial institutions, which show little change in 1991, are projected to fall slightly in 1992.

Faster rise in prices next year

According to the calculations, the growth in wages will remain at about 5 per cent in 1991, and decline slightly in 1992. A low rise in import prices and continued productivity growth are the most important factors underlying a slower rise in consumer prices in 1991. The decline in oil prices in dollars, following the temporary surge in the fourth quarter of last year, also contributes to slowing the rise in prices in 1991 in spite of the increase in the dollar exchange rate through the first few months of this year. A continued high growth in wages, higher import prices and revival in domestic demand are the reasons why consumer price inflation will pick up through 1992. A continued growth in productivity and a 2 per cent rise in import prices will contribute to a growth in real wages again in 1992.

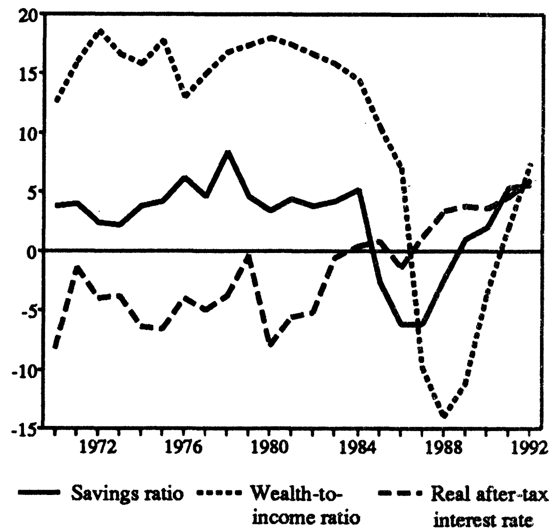
Recovery in private consumption

Following a decline in the first half of 1991, private consumption will show a marked rise in the second half of the year, according to the calculations, entailing that the growth in consumption will be 0.3 per cent on an annual basis. Housing investment, however, will continue to fall throughout 1991, but the decline will come to a halt next year. The development in private consumption and housing investment must be viewed in connection with the low level of households' net wealth which is a result of borrowing in the period 1985-89. The current ratio of financial assets (net) to income is well below the level observed in the mid-1980s (see diagram). From the same period there has been a considerable rise in the real after-tax interest rate, at the same time that house prices and the expected return on housing investment has fallen. Changes in rates of return indicate that households will want to keep a smaller percentage of their wealth in the form of housing capital and increase their net financial assets. This helps to explain why the upturn in housing investment will take place at a later time than for consumption.

A continued increase in the real after-tax interest rate in 1991 and 1992 may point to higher total saving even though low housing investment cet. par. will provide scope for higher consumption (excluding housing). In the calculations, the savings ratio increases further to about 5.5 per cent in 1991, but shows little change from 1991 to 1992.

The release of SMS funds will contribute to curbing the rise in the saving ratio in the projection period. The winding up of the SMS scheme is

SAVINGS RATIO, WEALTH-TO-INCOME RATIO AND REAL AFTER-TAX INTEREST RATE



expected to contribute about NOK 1 billion to consumption in 1991 and NOK 2 billion in 1992. According to the calculations, the household sector's net claims on financial institutions at the end of 1992 will reach the level recorded in 1986.

Turnaround in investment demand

Fixed investment in mainland Norway has been falling since the end of 1987. According to the projections, the decline will come to a halt in the last quarter of 1991, and resumed growth will take place in 1992. Mainland investment is projected to decline by 5.1 per cent in 1991, and then grow by 4.5 per cent in 1992. A growth in manufacturing investment beginning in 1991, a clear growth in general goverment investment in 1992 and a turnaround in housing investment are important factors in this picture.

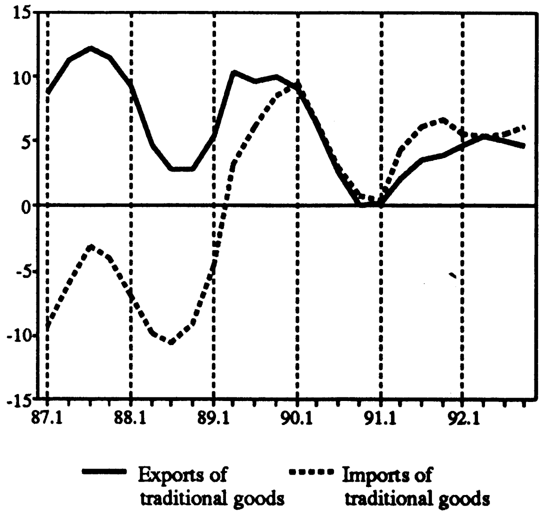
Investment in oil and gas activities will expand sharply in 1991 and particularly in 1992. Total gross fixed capital formation is thus projected to decline by 1.2 per cent in 1991, while it will increase by 25 per cent in 1992. The high growth projection in 1992 may primarily be ascribed to the planned towing of oil installations to the Snorre field.

New sizeable current account surpluses

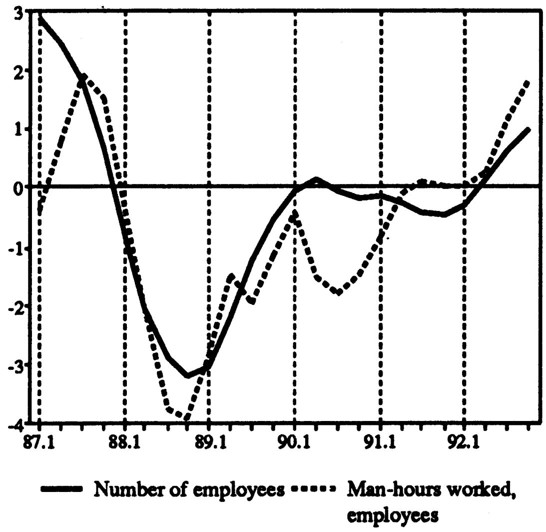
Following a protracted period of strong growth in traditional merchandise exports, the volume of traditional merchandise exports is now likely to show little change from 1990 to 1991. Higher export market growth in the fourth quarter of 1991 will stimulate exports. The rise in traditional merchandise exports will continue through 1992, entailing that the growth from 1991 will be nearly 5 per cent.

It is probable that the growth in crude oil exports will continue in 1991 and 1992 (15 1/2 and 6 per

GROWTH IN TRADITIONAL MERCHANDISE EXPORTS AND IMPORTS
From previous quarter, annual rate



GROWTH IN EMPLOYMENT
From previous quarter, annual rate



cent respectively, according to the estimates). Gas exports will remain approximately unchanged from 1991 to 1992, but as a result of higher gas prices, the value of gas exports will still increase in the projection period. The value of gross freight earnings is projected to rise slightly in 1991 and 1992. In 1991, this is primarily due to a higher level for freight rates compared with 1990, while in 1992 the rise in price and volume will make approximately the same contribution.

The surplus on the trade balance, according to the calculations, will increase in both 1991 and 1992. The main reason for this is the brisk growth in exports of crude oil. In 1992, imports will increase in volume at about the same rate as exports, but the trade balance will still show an improvement inasmuch as export prices will rise at a faster rate than import prices. Norway's net foreign debt has been reduced the last few years. Other things being equal this contributes to a reduction in Norway's net interest expenditure in 1991, but may be offset by a continued high dollar exdhange rate. Sizeable payments of share dividends (net) to foreign owners from oil companies will nevertheless entail that the deficit on the balance of interest and unilateral transfers in 1991 is expected to remain approximately unchanged from 1990. The reduction in Norway's net foreign debt as well as the current account surplus will contribute to reducing Norway's net interest expenditure in 1992; the total current balance is projected to increase substantially in both years. Norway's net foreign debt may be reduced by about two thirds from the second quarter of 1991 to the end of 1992.

Few bright spots on the labour market

In the calculations, output growth through 1991 and 1992 is not sufficient to boost employment to any great extent; the projections indicate a decline in number of man-hours worked in 1991 and a slight rise in 1992. With an approximately unchanged labour force, unemployment will remain at a high level in both 1991 and 1992. The calculations indicate, however, that the strong demand impetus to the Norwegian economy through 1992 may result in a rising and clearly positive underlying growth rate in man-hours worked and number employed towards the end of 1992.

EMISSION TO AIR IN NORWAY[1)]

Each year CBS prepares inventories of Norwegian emissions of several polluting compounds. These emissions vary with changes in production and consumption of goods and services. The total level of emissions, however, is determined partly by changes in the amount of energy used per produced unit and emissions per unit of utilized energy. The emissions contribute in their turn to the total concentration of air pollution. The inventories are a necessary part of the monitoring of environmental status, and provide a basis for analyses of future trends in emissions to air and of the effects of various pollution control measures. These measures impose costs on society, but also provide benefits in the form of reduced negative effects on human health, and reduced damage to nature and production equipment.

This chapter discusses some effects of a potential climate policy, given specific assumptions concerning international economic development and the formulation of an international agreement on climate. Estimates are presented of socio-economic costs and some benefits. The chapter concludes by discussing certain factors which may be of importance for Norway's environmental policy should Norway become a member of the EEC.

1. Air pollution - some sources and effects

The main sources of emissions to air in Norway are use of coal, coke and oil products for heating and transport, various industrial processes and evaporation. Characteristic of the emissions from *industrial processes* is that they are released from input factors other than energy. The sources of pollution by *evaporation* are solvents and oil products. It is customary to distinguish between emissions caused by combustion of fossil fuels in stationary installations, so-called *stationary fuel emissions*, and *mobile fuel emissions* from motor vehicles, aircraft, boats etc. The distinction between emissions from stationary and mobile sources is important when assessing the potential for substituting different forms of energy.

Air pollution in Norway comes partly from emissions from industry, transportation and heating systems and partly from long-range pollution from other countries (transboundary pollution). Norwegian emissions are the main source of local pollution which impairs health and damages materials, while transboundary pollution from Great Britain and the continent is the main source of acidification of the soil and of freshwater lakes in the southern part of Norway.

The emissions are determined mainly by the level and composition of production and consumption of goods and services. Economic activity requires use of energy, with associated emissions. Emissions can be reduced by cleaning or by modifying the production process. Other efforts to reduce pollution can be directed at the use of polluting production factors and products, for example by specifying quality criteria for oil, or by imposing taxes to reduce the use of especially polluting products.

The harmful effects of air pollution depend on the concentration of the different components and the duration of exposure of humans and the environment. The concentration is determined by the intensity and location of the emissions, weather conditions, spreading conditions etc. In the case of some components the damage does not occur until the concentration has exceeded a certain critical load or threshold level. For other components there are no such critical values. Even very low concentrations may be harmful to health or damage environment. This applies in particular to pollutants with carcinogenic properties. Very often, those who are hardest hit by pollution are groups who are vulnerable already, such as children and elderly, and persons with asthma.

The effects of air pollution are sometimes due to secondary pollutants. These are substances generated, for instance, through oxidation of certain components of the original emissions. Examples of so-called secondary pollutants are sulphate (SO_4), produced by oxidation of sulphur dioxide (SO_2), and ozone (O_3), created in photochemical reactions between nitrogen oxides (NO_x) and hydrocarbons or carbon monoxide (CO) under the influence of solar radiation.

1) The Central Bureau of Statistics (CBS) compiles statistics on the state of the environment and accounts for selected natural resources. CBS also develops methods and models to analyze the interrelationships between socio-economic development, resource use and environmental conditions. The publication *Naturl Resources and the Environment* gives an annual survey of this work. This article presents one of the chapters of the publication for 1990.

Table 1. Sources, damage and threshold levels associated with some polluting compounds

Compound	Source	Damage	Threshold level
Sulphur dioxide	Combustion of oil Transportation Process emissions: - Refining - Manuf. of basic metals - Silicon carbide - Paper and paper products	*Health:* SO_2 together with dust increases the risk of respiratory diseases. *Nature*: Damage to vegetation. Acidification of water and soil. Corrosion.	Health: 100-150 $\mu g/m^3$ (day) 40-60 $\mu g/m^3$ (half year) Vegetation: 30 $\mu g/m^3$ (half year)
Nitrogen oxides	Transportation Combustion of oil Process emissions: - Manuf. of fertilizers - Manuf. of basic metals	*Health*: Increase the risk of respiratory diseases. NO_2 more harmful than NO. *Nature*: Contribute to acidification of water and soil. Produce ozone through reaction with VOC or CO under influence of solar radiation. Corrosion (only to a limited degree). Influence the oxidation capacity of the atmosphere.	Health (NO_2): 200 $\mu g/m^3$ (hour) 100-150 $\mu g/m^3$ (day) 75 $\mu g/m^3$ (half year)
Carbon monoxide	Transportation Burning of wood Combustion of oil Process emissions: - Silicon carbide	*Health:* CO adheres to red blood cells and reduces the uptake of oxygen. Effects: - Increased risk of cardiac spasm - Reduced activity for healthy people - Lower birth-weight of children *Nature*: Influences the oxidation capacity of the atmosphere. Produces ozone through reactions with NO_x under influence of solar radiation	Health: 25 mg/m^3 (hour) 10 mg/m^3 (8-hours)
Volatile organic compounds	Transportation Burning of wood Combustion of oil Solvents Filling stations	*Health*: Might contain carcinogenic substances like PAH and benzene *Nature*: Produces ozone through reaction with NO_x under influence of solar radiation. Influences the oxidizing capacity of the atmosphere	
Polycyclic aromatic hydrocarbons	Burning of wood Aluminium plants	*Health*: PAH in air might cause cancer in the respiratory system	
Soot	Burning of coal Burning of wood Transportation	*Health*: Soot together with SO_2 can cause respiratory diseases. Soot is often a carrier of carcinogenic substances (Lead, PAH)	Health: 100-150 $\mu g/m^3$ (day) 40-60 $\mu g/m^3$ (half year)
Dust	Burning of coal Dust from roads (studded tyres)	*Well-being*: Dust cover on vegetation and constructions in the vicinity of the emission sources	
Lead	Gasoline-driven cars	*Health*: Increased risk of coronary diseases and spontaneous abortion. Altered behavioural pattern and reduce intelligence and fertility. Anemia	Health: 1.5 $\mu g/m^3$ (half-year)
Photo-chemical oxidants (Ozone, PAN)	Formed in the atmosphere by reactions with NO_x, CO, hydrocarbons under the influence of solar radiation	*Health*: Can cause respiratory diseases. *Nature*: Damage to forests and other vegetation *Materials*: Damage to for example rubber and plastics	Vegetation: 200 $\mu g/m^3$ (hour) Health: 100-200 $\mu g/m^3$ (hour) measured as O_3 concentration

Table 1 continued

Compound	Source	Damage	Threshold level
Carbon dioxide	Fossil fuels Deforestation/land-use changes, burning of biomass Manufac. of cement	Contributes to increased greenhouse effect	
Methane	Extraction, transportation and combustion of fossil fuels, burning of biomass, wetlands, rice fields, ruminants, etc.	Contributes directly to increased greenhouse effect, entails tropospheric ozone production and alteration of the characteristics and composition of the atmosphere. (Methane also affects stratospheric ozone.)	
Nitrous oxide	Fossil fuels, land-use changes, burning of biomass, fertilizers, microbiological processes	Contributes to increased greenhouse effect. Reduces the stratospheric ozone layer.	
Chlorofluorocarbons	Refrigeration installations, chemical cleaning, aerosols	Reduces the stratospheric ozone layer. Contributes to the greenhouse effect.	
Halons	Fire extinguishers	Reduces the stratospheric ozone layer	

Source: CBS.

Table 1 shows some sources, effects and threshold values associated with the most important air pollution problems. Limit for health damage (threshold level) means the level of pollution to which a population can be exposed without damage to health.

2. Inventories of emissions to air

Inventories of emissions to air have been compiled for sulphur dioxide (SO_2), nitrogen oxides (NO_3), carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOC) excluding methane, particulates and lead for the years 1973-1988. Inventories have been compiled for methane (CH_4) and nitrous oxide (N_2O) for the years 1987 and 1988. The State Pollution Control Authority (SFT) has estimated preliminary figures for 1989 and 1990. Cruder estimates also exist for some components for the years 1960-72.

In general, the inventories for earlier years are less detailed and more uncertain than inventories for later years. Emission inventories for later years are based on detailed surveys of energy consumption (Resource Accounts for Energy, and Manufacturing Statistics from the Central Bureau of Statistics), emission coefficients, and recorded emissions from industrial companies with a discharge permit from SFT. The figures for fuel combustion and the emission coefficients are both associated with a certain degree of uncertainty. In the case of the emission coefficients the uncertainty is greatest for N_2O, VOC and CH_4. The emission coefficients can change as more knowledge is obtained. Least uncertainty is connected to the emission coefficients for CO_2, Pb and SO_2.

Tables 2 and 3 present some of the emission coefficients used to calculate emissions. The emission coefficients are adjusted from year to year, partly because of changes in the chemical compo-

Box 1. Some chemical formulas and abbreviations

Sulphur dioxide	SO_2
Sulphate	SO_4^{2-}
Nitrogen oxides	NO_x (NO and NO_2)
Carbon dioxide	CO_2
Lead	Pb
Ozone	O_3
Methane	CH_4
Nitrous oxide	N_2O
Chlorofluorocarbons	CFC
Volatile organic compounds	VOC

Table 2. Emission coefficients for NO_x, VOC, CO and particulates. 1988

		NO_x	VOC	CO	Particulates
			kg/tonne		
STATIONARY COMBUSTION					
Natural gas	Industry	7.0	1.5	2.0	0.0
Heating	Households	2.5	0.6	6.5	0.3
kerosene	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 SOURCES					
Marine fuels	Ocean transport	70.0	2.5	5.0	1.2
			g/km		
GASOLINE					
Light vehicles	Town driving	1.65	3.7	34.8	0.06
	Highway and country driving	2.2	1.1	7.5	0.06
Heavy vehicles	Town driving	5.2	8.6	85	0.13
	Highway and country driving	7.8	2.9	28	0.13
DIESEL					
Light vehicles	Town driving	1.0	1.0	2.0	0.42
	Highway and country driving	1.5	1.0	2.0	0.42
Heavy vehicles	Town driving	9.3	1.4	2.8	0.84
	Highway and country driving	13.9	1.4	2.8	0.84

Sources: CBS, SFT (State Pollution Control Authority).

sition of the fuels and changes in combustion technologies, and finally in the light of increased knowledge about other factors which determine the coefficients. In recent years, especially emission coefficients which relate emissions of VOC, CO and particulates to consumption of marine fuels have been adjusted downwards.

Emissions of SO_2 and lead from energy use are determined respectively by the content of sulphur and lead in the energy source. CO_2 emissions from the different energy sources are decided by the carbon content of the fuel and by emissions of other carbon compounds during the combustion process. The emissions of the other components are determined mainly by the combustion conditions. Emissions from industrial processes and evaporation are determined by factors other than use of energy, such as the materials used in production, the level of activity in certain industries such as agriculture, the amount of deposited waste, etc. The emission inventories do not provide direct information on the *concentrations* of pollution which may cause damage to health, the natural environment or materials. For some components, however, a good correlation is found between measured changes in pollution concentrations and changes in the level of emissions (see section 3). Therefore the emission inventories give some indication of concentrations and the total pollution load. They thus provide a very useful basis for assessing where to introduce pollution control measures and show the effects of any measures already introduced. The emission inventories also provide the necessary data to make forecasts of emissions to air, and thereby indicate whether or not Norway is fulfilling national objectives and international agreements on reductions of emissions to air, see section 5.

Emissions to air by economic sector and source of energy

Table 4 shows emissions of SO_2, NO_x, VOC, CO, CO_2, particulates, Pb, CH_4 and N_2O from various economic sectors in 1988. Table 5 shows the same

Table 3. Emission coefficients for SO_2 and CO_2. 1988

Energy source	Kg SO_2/tonne energy source	Tonnes CO_2/tonne of energy source[1)]
Natural gas	-	2.75
LPG (propane)	-	3.00
Kerosene	0.4	3.15
Gasoline	0.7	3.15
Heating oils	4.0	3.15
Diesel	4.0	3.15
Marine fuel	4.0	3.15
Special distillate	9.0	3.15
Heavy oil LS	19.0	3.15
Heavy oil NS	44.0	3.15
Coal, industry	16.0	2.42
Coal, households	20.0	2.42
Wood	0.4	-

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.
Sources: NP, SFT.

emissions by source. Emissions from ocean transportation in Norwegian territorial waters are *not* included in the tables. In 1988 emissions from this type of activity (Norwegian and foreign vessels) amounted to about 10 000 tonnes SO_2, 24 000 tonnes NO_x, 2 000 tonnes CO, 1 million tonnes CO_2, almost 1 000 tonnes VOC, 500 tonnes particulates, just over 300 tonnes CH_4 and only small amounts of lead (Pb) and nitrous oxide (N_2O). As a rule, emissions from air traffic refer to landing and take-off cycles only. In the case of CO_2, CH_4 and N_2O, however, all emissions from domestic air traffic are included. Alternative calculations have been carried out by SINTEF (Foundation for Scientific and Industrial Research, University of Trondheim) and NILU (Norwegian Institute for Air Research) for emissions from ships in Norwegian waters and from aircraft flying in Norwegian air territory.

To some extent these calculations cover other activities and other years, and for this reason may deviate from the figures presented here.

Sectors with relatively high emissions of several compounds include private households, domestic transportation (other than private cars) and metal production, see table 4. Table 5 shows that road traffic and coastal water transport are among the largest sources of most emissions.

Emissions in Norway 1973-1990

The main features of the trend in emissions to air is determined by the basic trend of economic activity and associated use of energy, together with technological developments and special measures to reduce emissions. The historical trend in the use of different sources of energy is described in more detail in chapter 2. This section describes the most important trends in emissions of SO_2, NO_x, CO, VOC, particulates, Pb and CO_2 during the period 1973-1990. Inventories are available for CH_4 and N_2O for the last two years only. The total "greenhouse effect" of Norwegian emissions is discussed at the end of the section. Emissions from ocean transportation (shipping in foreign trade) are not included in the calculations. The figures for 1989 and 1990 are preliminary estimates from SFT, and are not distributed by sector or by source.

There was a marked reduction in **emissions of SO_2** during the period 1973-1990, see figure 1. Emissions from stationary combustion decreased from 73 000 tonnes in 1973 to about 20 000 tonnes in 1990, and emissions from industrial processes decreased from 67 000 tonnes to just over 30 000 tonnes during the same period. Reductions in SO_2 emissions are due to several factors:

- The sulphur content of several oil products has been reduced. Regulations concerning the sulphur content of heavy oils entered into force in 1977 in the coastal counties of Southern Norway and were made more stringent in the 13 southernmost counties from early 1986.
- A 10-year programme to clean up older polluting industry was started in 1974. The programme entails permits for emissions and instructions to install cleaning equipment in a number of undertakings. Cleaning has been directed mainly at emissions of particulates.
- There was a good supply of cheap surplus power in the 1980s. This led to a decrease in use of oil, especially in the pulp and paper processing industry.
- There were several mild winters at the end of the period, leading to less use of energy for heating.

Table 4. Emissions to air by sector. 1988. In 1 000 tonnes unless otherwise specified

	MSG-sector	SO_2	NO_x	CO	CO_2	VOC[1]	Particu-lates	Pb	CH_4	N_2O
					Mill. tonnes			Tonnes		
	Total	67.1	224.9	634.5	34.5	188.8	20.7	279.9	289.6	12.8
11	Agriculture	0.9	5.5	11.4	0.7	3.6	0.9	2.0	105.4	4.1
12	Forestry	0.1	0.7	3.1	0.1	1.1	0.1	0.8	0.0	0.0
13	Fishery etc.	2.0	32.8	4.1	1.5	1.9	0.6	0.7	0.4	0.1
15	Manuf. of consumer goods	3.5	2.3	1.6	0.7	0.4	0.3	0.8	0.0	0.1
25	Manuf. of production input commodities	6.1	6.7	2.8	2.4	0.7	0.5	1.2	1.6	0.2
34	Manuf. of pulp and paper products	5.4	1.5	0.4	0.4	0.1	0.2	0.1	0.1	0.2
37	Manuf. of industrial chemicals	6.9	5.3	38.3	1.9	0.8	0.1	0.0	0.0	6.1
40	Petroleum refining	3.1	1.7	0.0	1.0	2.8	0.1	0.0	0.0	0.1
43	Manuf. of metals	19.7	5.6	4.0	5.0	1.4	0.2	5.1	0.0	0.1
45	Manuf. of fabricated metal products	0.4	0.8	0.9	0.2	0.1	0.1	0.5	0.0	0.0
50	Shipbuilding and platform construction	0.1	0.2	0.2	0.1	0.0	0.0	0.1	0.0	0.0
55	Construction	0.8	7.8	4.4	0.6	1.1	0.6	1.5	0.1	0.1
63	Financing and insurance	0.0	0.5	3.8	0.1	0.4	0.0	2.6	0.0	0.0
64	Oil and gas extraction	0.4	12.6	3.7	4.7	85.1	0.0	0.0	12.7	0.3
68	Oil well drilling	0.8	6.2	0.4	0.3	1.8	0.1	0.0	1.2	0.0
71	Prod. of electricity[2]	0.5	0.9	0.4	0.2	0.3	0.1	3.5	0.1	0.1
75	Domestic road transport	2.4	27.4	21.2	2.0	5.3	2.2	9.2	0.3	0.2
76	Domestic air transport	0.2	3.6	9.8	1.6	2.1	0.2	0.0	0.1	0.1
77	Coastal water transport	7.6	41.2	3.4	1.9	1.5	0.7	0.5	0.5	0.1
78	Rail transport	0.1	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0
79	Post and telecommunications	0.1	2.0	9.4	0.2	1.0	0.1	6.2	0.1	0.0
81	Wholesale and retail trade	1.1	11.9	51.5	1.3	5.8	0.5	34.1	0.4	0.1
83	Housing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85	Other private services.	0.5	3.5	22.7	0.6	2.4	0.1	15.2	0.2	0.1
92	Defence	0.4	4.3	2.0	0.6	0.3	0.1	0.6	0.1	0.0
93S	Educ. and research (state)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
93K	Education and research (municipal)	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
94S	Health and social welfare (state)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
94K	Health and social welfare (municipal)	0.4	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0
95S	Other public services (state)	0.1	0.7	0.5	0.1	0.1	0.0	0.3	0.0	0.0
95K	Other public services (municipal)	0.0	0.1	0.2	0.1	0.0	0.0	0.2	160.0	0.0
P	Private households	3.4	38.4	433.8	6.0	68.4	12.9	194.6	6.3	0.5

1) Not incl. evaporation from storage and handling of gasoline, and from use of solvents. See table 3.5.
2) Incl. emissions from waste incineration plants.
Sources: CBS, SFT.

Table 5. Emissions to air by source. 1988. In 1 000 tonnes unless otherwise specified

Sources	SO_2	NO_x	CO	CO_2	VOC	Particulates	Pb	CH_4	N_2O
				Mill. tonnes			Tonnes		
TOTAL	67.1	224.9	634.5	34.5	248.0	20.7	279.9	289.6	12.8
STATIONARY COMBUSTION	20.8	26.5	122.2	12.6	25.1	12.6	4.0	7.3	2.0
- Industrial combustion	15.5	22.1	5.1	9.1	2.0	1.0	0.4	3.2	1.1
- Non-industrial combustion	4.9	3.4	116.6	3.4	22.8	11.5	0.2	4.1	0.8
- Incineration of waste	0.5	0.9	0.4	0.1	0.3	0.1	3.5	-	0.0
INDUSTRIAL PROCESSES AND EVAPORATION	30.2	8.6	41.8	6.7	148.1	0.0	5.0	277.6	10.0
- Pulp and paper prod.	2.7	-	-	-	-	-	-	-	-
- Industrial chemicals	6.1	4.4	38.2	1.0	0.8	-	-	-	6.0
- Mineral products	1.5	-	-	1.0	-	-	-	1.5	-
- Petroleum refining	2.5	-	-	-	2.8	-	-	-	-
- Manuf. of metals	17.4	4.1	3.6	4.5	1.3	0.0	5.0	-	-
- Agriculture, liming	-	-	-	0.2	-	-	-	-	-
- Agriculture, domestic animal husbandry	-	-	-	-	-	-	-	100.3	-
- Agriculture, fertilizing	-	-	-	-	-	-	-	5.0	4.0
- Petroleum activities[1)]	-	-	-	-	85.1	-	-	10.8	-
- Landfills (waste disposal)	-	-	-	-	-	-	-	160.0	-
- Storage of gasoline	-	-	-	-	3.1	-	-	-	-
- Filling stations	-	-	-	-	5.0	-	-	-	-
- Solvents	-	-	-	-	50.0	-	-	-	-
MOBILE SOURCES	16.1	189.9	470.6	15.2	74.8	8.1	270.9	4.7	0.8
- Automobiles	4.5	84.3	386.8	7.8	44.1	4.3	255.8	3.2	0.3
-Light vehicles	1.7	46.8	352.1	5.3	37.6	2.0	236.2	2.7	0.2
-Gasoline	1.1	44.4	348.7	4.9	35.9	1.3	236.2	2.6	0.1
-Diesel	0.6	2.4	3.4	0.4	1.7	0.7	0.0	0.0	0.1
-Heavy vehicles	2.8	37.5	34.7	2.5	6.5	2.3	19.6	0.5	0.2
-Gasoline	0.1	4.2	27.2	0.4	2.8	0.1	19.6	0.3	0.0
-Diesel	2.7	33.3	7.5	2.1	3.7	2.2	0.1	0.2	0.1
- Motorcycles, mopeds, trac-tors etc.	1.0	13.3	66.9	1.1	25.4	2.0	14.8	0.2	0.1
- Railways	0.1	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0
- Air traffic	0.2	4.0	10.5	1.9	2.2	0.2	0.0	0.1	0.1
- Coastal water transport	8.1	48.8	3.5	2.2	1.7	0.8	0.2	0.6	0.1
- Fishing fleet	2.0	32.8	2.3	1.5	1.2	0.6	0.1	0.4	0.1
- Oil well drilling	0.4	6.2	0.4	0.6	0.2	0.1	0.0	0.2	0.0

1) Including gas terminals.
Sources: CBS, SFT.

The largest reductions in emissions occurred in the pulp and paper processing sector, from 33 000 tonnes in 1976 to 5 400 tonnes in 1988. This sector consumes the largest amounts of surplus power. Emissions from energy-intensive industry (manufacture of metals and industrial chemicals) remained about the same throughout the period. There was a marked reduction in emissions from petroleum refineries, and emissions from other industry and other commercial activity, not including the transportation sector, were more than halved during the period due to emission-abatement measures such as the requirement for a lower content of sulphur in heavy oils and the changeover from oil to electricity as a source of energy. The main reason for the large reduction in emissions from 1986 to 1987 is the closing down of the smelting works at A/S Sulitjelma mines, which had been responsible for extensive emissions from industrial processes. Emissions from industrial processes were further reduced by 1 000 tonnes from 1987 to 1988, mainly as a result of reduced emissions from the pulp and paper processing sector and from oil refineries. Emissions from stationary combustion were also reduced by almost 4 000 tonnes. Emissions from mobile sources also decreased by almost 3 000 tonnes from 1987 to 1988. Total SO_2 emissions were reduced by 10 per cent from 1987 to 1988 and by a further 10 per cent from 1988 to 1989. Preliminary estimates indicate that the emission level in 1990 will be about the same as in 1989.

In 1988, the most important source of SO_2 emissions was industrial processes, which accounted for 45 per cent of the total emissions. 31 per cent came from stationary combustion and 24 per cent from mobile sources.

The industrial sectors combined accounted for about two thirds of the total SO_2 emissions, 30 per cent of this amount coming from metals production. Other important sectors for SO_2 emissions were domestic transportation, manufacture of chemical and mineral products, pulp and paper product manufacture, and production of industrial chemicals.

There was a substantial increase in **emissions of NO_x** from the beginning of the 1980s up to 1987, followed by a slight decrease, see figure 2. The greatest reduction occurred in connection with mobile sources, the main reason being reduced use of diesel and marine fuels. Combustion of these fuels is one of the most important sources of emissions of NO_x. The large increase in emissions in the early 1980s was due to increased emissions from private households. A major part of this increase in the 1980s referred to purchase and use of private cars.

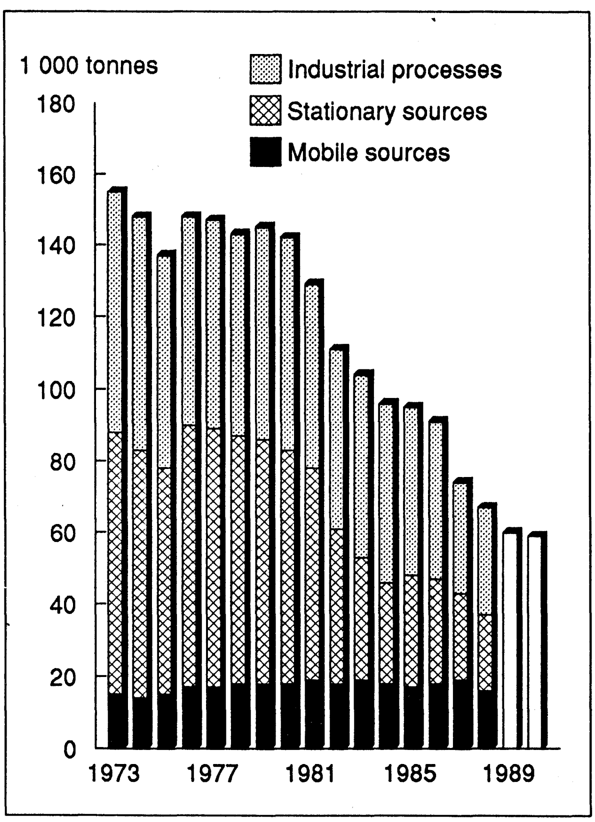
At the same time, emissions of NO_x per unit of fuel increased slightly due to higher energy efficiency in new cars. This has been counteracted to some extent by the requirement for catalytic cleaning of exhaust gases in new cars as from 1989. NO_x emissions from stationary combustion decreased during the period due to less use of heating oils, but emissions from industrial processes remained stable.

In 1988, as much as 84 per cent of the emissions of nitrogen oxides came from mobile sources. Emissions of NO_x relative to fuel consumption are much larger from diesel-driven vehicles and boats than from vehicles driven by gasoline. Stationary sources accounted for 12 per cent of the emissions of NO_x, and industrial processes for 4 per cent.

Distributed by sector, the largest emissions of NO_x in 1988 came from domestic transportation (other than private cars) (33 per cent), of which coastal water transport alone accounted for 18 per cent. Private households accounted for 17 per cent, and the fishing fleet for 15 per cent of total NO_x emissions in 1988.

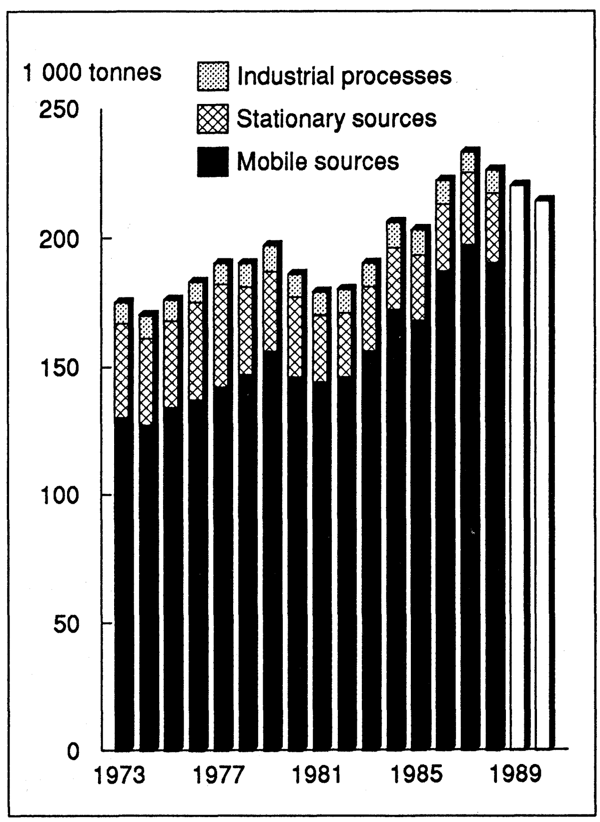
Emissions of CO remained relatively stable during the 1980s up to 1985, increased up to 1987, and then decreased towards the end of the period, see figure 3. The reason for the increase from 1985 to 1987 was the larger sales of gasoline combined with the fact that almost 70 per cent of the total CO emissions comes from combustion of gasoline. The

Figure 1. Emissions of SO_2 by source. 1973-1990*. 1 000 tonnes SO_2



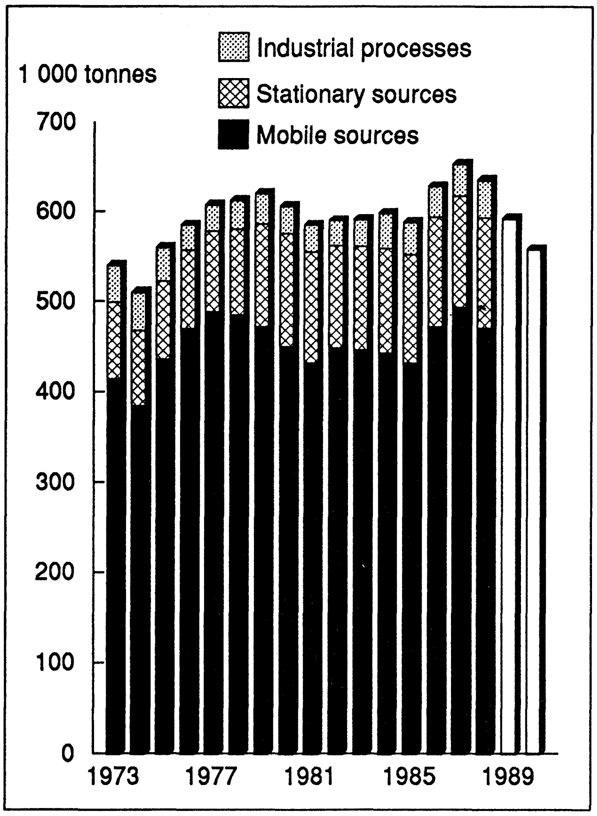
Source: CBS, SFT.

Figure 2. Emissions of NO_x by source. 1973-1990*. 1 000 tonnes NO_2



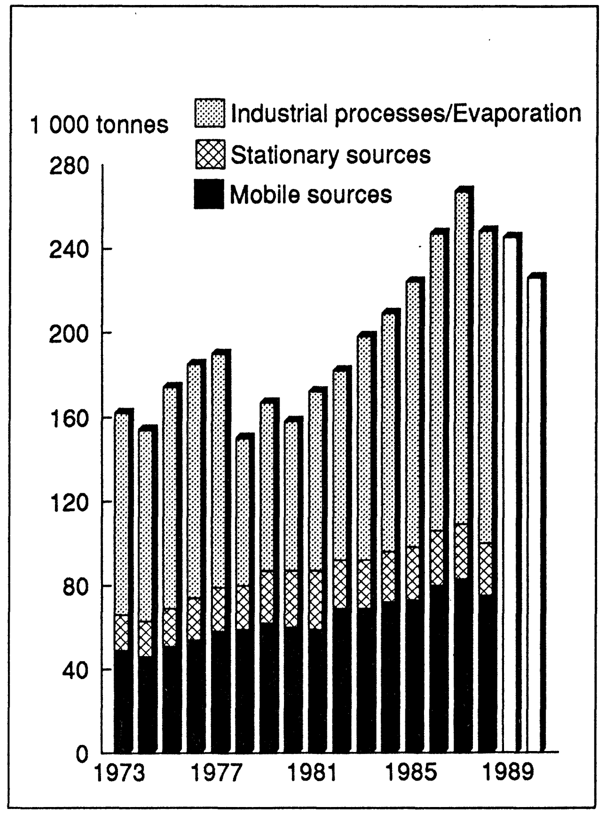
Source: CBS, SFT.

Figure 3. Emissions of CO by source. 1973-1990*. 1 000 tonnes



Source: CBS, SFT.

Figure 4. Emissions of VOC by source. 1973-1990*. 1 000 tonnes



Source: CBS, SFT.

increase in purchases and use of private cars in the 1980s had a stronger impact than improvements in technical standard. There has been a slight decrease in the sale of transport oils (inclusive gasoline) during the last two years.

Emissions of CO from industrial processes have remained stable throughout the period. Emissions from stationary sources increased slightly during the 1980s due to more use of wood for fuel. However, the estimates for wood consumption are based on uncertain data.

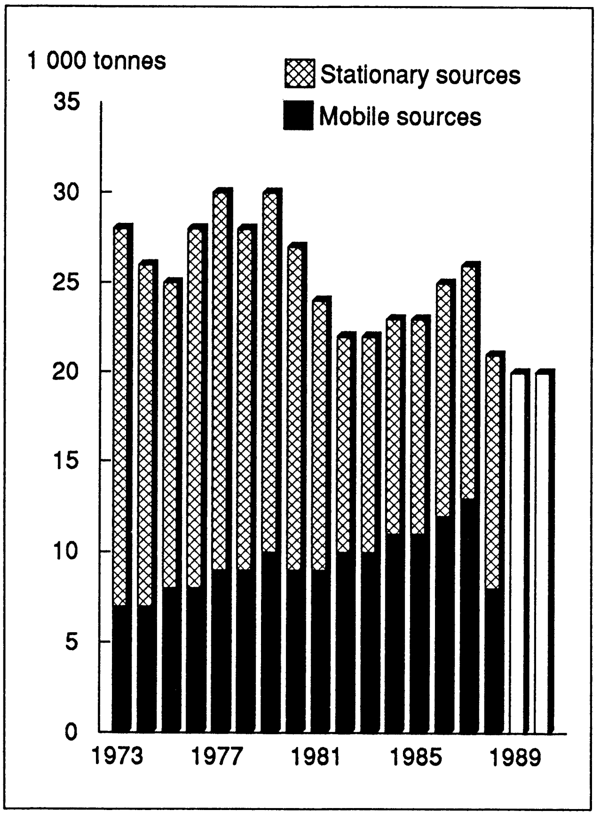
In 1988, as much as 74 per cent of the emissions of carbon monoxide came from mobile sources. Stationary combustion accounted for slightly less than 20 per cent of the total CO emissions, the main source being combustion of wood. Heating based on combustion of wood accounted for about 90 per cent of the stationary emissions of carbon monoxide. Private households are the most important source of emissions, accounting for 68 per cent of total emissions and 95 per cent of stationary emissions of carbon monoxide.

Emissions of VOC 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 gas. The increase in total emissions up to 1987 can be partly put down to landing of gas from new fields and, like the emissions of CO, to a higher level of emissions from mobile sources, see figure 4. It was not until recently that one realized the extent of VOC emissions from petroleum activities. In 1988 these emissions amounted to 85 000 tonnes.

The main sources of emissions of volatile organic compounds (VOCs) are evaporation and industrial processes other than combustion. In 1988 these sources accounted for just over 60 per cent of the total emissions. Incomplete combustion in mobile sources accounted for about 30 per cent of the emissions. The largest sources of evaporation are petroleum activities (34 per cent) and use of solvents (almost 20 per cent). Another important source of VOC emissions is evaporation connected to storage and sales of gasoline. Stationary combustion accounted for 10 per cent of the VOC emissions in 1988. The estimates for VOC emissions are fairly rough and must be regarded as uncertain. Evaporation of solvents has not as yet been distributed by sector.

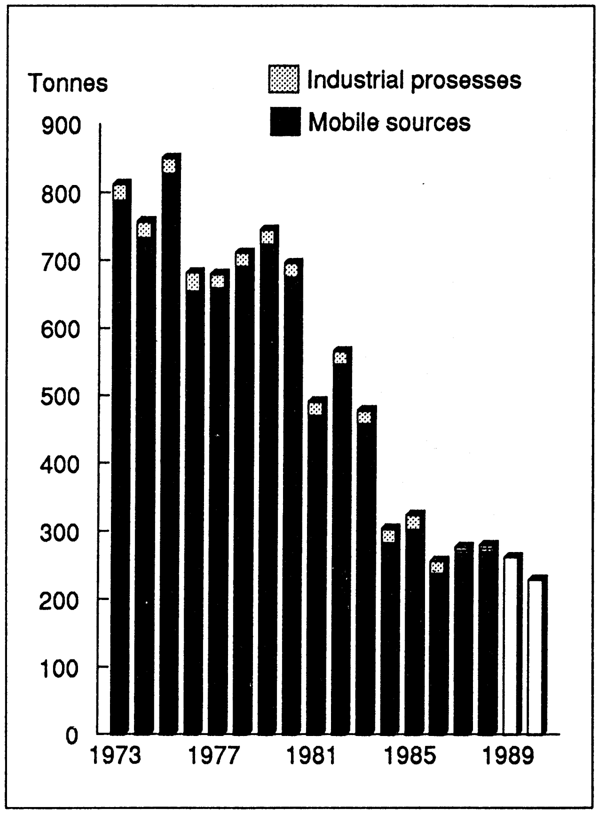
Emissions of particulates decreased from 1973 up to 1983, see figure 5. This was mainly due to less extensive stationary combustion of heavy oils. Emissions then increased up to 1987 due to high consumption of wood in private households and a

Figure 5. Emissions of particulates by source. 1973-1990*. 1 000 tonnes



Source: CBS, SFT.

Figure 6. Emissions of lead by source. 1973-1990*. Tonnes



Source: CBS, SFT.

general increase in traffic. Emissions have decreased again in recent years, especially emissions from coastal water transport.

Diesel-driven motor vehicles are the most important mobile source of emissions of particulates.

In 1988, private households accounted for more than 60 per cent of total emissions of particulates, and 19 per cent came from domestic transportation (other than private cars).

There was a marked reduction in **emissions of lead** up to 1986, see figure 6. This was due to reduced content of lead in gasoline (the regulations entered into force in 1980 and 1983) and the introduction of non-leaded gasoline as from 1986. Emissions of lead from industrial processes remained fairly stable up to 1986, after which there was a marked reduction due to the closing down of the smelting works at Sulitjelma and decreased production of iron and steel.

As much as 97 per cent of emissions of lead in 1988 came from mobile sources and are almost entirely due to addition of lead to gasoline. The rest of the emissions originate from industrial processes in the metallurgical industry, and from incineration of waste and combustion of oil.

In 1988 the most important sources of emissions were private households, wholesale and retail trade, domestic transportation (other than private cars) and other private services.

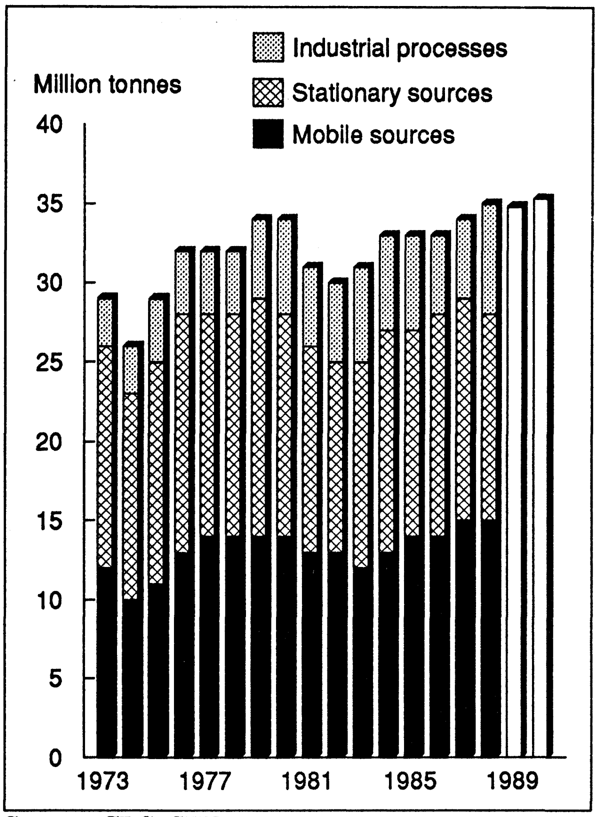
Emissions of CO_2 have fluctuated somewhat during the period. Figure 7 shows a marked reduction in emissions from 1973 to 1974, followed by an increase up to 1979/1980. Emissions decreased again up to 1982, after which there has been a slight, but steady increase. The reason for the two distinct reductions in emissions of CO_2 was reduced consumption of oil products due to the rise in oil prices in 1973-74 and 1979-80. The effects of these higher oil prices are particularly marked for CO_2, since these emissions cannot be decreased by cleaning.

Mobile sources accounted for 44 per cent of CO_2 emissions in 1988, and stationary combustion for 37 per cent. 19 per cent came from industrial processes. The largest source of CO_2 emissions was domestic transportation (other than private cars) (17 per cent), fairly equally distributed between land, sea and air transport.

Private households were responsible for 17 per cent of the CO_2 emissions, gas and oil extraction on the continental shelf for 15 per cent, metals production for 14 per cent, and chemicals and minerals production for 5 per cent.

In 1988 **emissions of the two greenhouse gases CH_4 and N_2O** amounted to about 293 000 tonnes and almost 13 000 tonnes respectively. The CH_4 emissions originated from two main sources; domestic animal husbandry, which accounted for 100 000 tonnes or 34 per cent of the emissions, and

Figure 7. Emissions of CO_2 by source. 1973-1990*. Million tonnes CO_2



Source: CBS, SFT.

waste deposit sites (landfills), which accounted for 160 000 tonnes or 55 per cent of the total emissions in 1988. There are also two dominating sources of N_2O emissions; production of nitric acid, which accounted for 6 000 tonnes or 47 per cent in 1988, and use of agricultural fertilizer, which accounted for 4 000 tonnes, or just over 30 per cent of the emissions.

A total assessment of the greenhouse strength of CO_2, CO, CH_4, N_2O, NO_x and VOC

Certain gases upset the global radiation balance by directly absorbing heat radiated from the earth.

Table 6. Greenhouse strengths of certain gases. Indirect effects are taken into account. CO_2-equivalents per kg emissions

CO_2	1
CO	4
CH_4	14
N_2O	300
NO_x	17
VOC	1.7

Source: SFT.

Other gases have an indirect impact on this balance through chemical reactions which affect concentration and distribution of substances which absorb the radiated heat. These gases and their behaviour in the atmosphere are discussed in *"Natural Resources and the Environment 1989"*, chapter 6 (CBS, 1990a).

CO_2 is the gas which makes the greatest contribution to the increased greenhouse effect. One way of estimating the relative importance of the different greenhouse gases for climate is to convert the warming effect (greenhouse strength) of these gases into CO_2-equivalents. Such conversions must be based on several assumptions, many of them somewhat uncertain. Therefore calculations of the greenhouse strength of emissions of the different gases will also be subject to a certain degree of uncertainty over and above the uncertainty connected to the physical emission figures.

Table 6 shows the greenhouse strengths used in the calculations. Indirect effects of chemical reactions in the atmosphere are taken into account. These greenhouse strengths, or climate factors, will be revised as further knowledge is obtained.

Table 7 shows emissions of CO_2, CO, CH_4, N_2O, NO_x and VOC by sector, measured in terms of CO_2-equivalents, and table 8 shows emissions distributed by source.

CO_2 is clearly the most important greenhouse gas and alone accounted for about 70 per cent of the increased greenhouse effect from the compounds included in this survey from 1988. The next most important gases in this connection are CH_4, NO_x and N_2O, each of which contributed 8 per cent. About 5 per cent of the effect was due to CO, and VOC accounted for only 1 per cent of the Norwegian anthropogenic contribution to increased greenhouse effect. Note that emissions of CFCs and halons are not included in these calculations.

In 1988, mobile sources accounted for 42 per cent of the total emissions in terms of CO_2 equivalents, with road traffic as the most important source of emissions (22 per cent), see table 8. Stationary combustion, and industrial processes and evaporation were each responsible for 29 per cent.

The industrial sectors combined accounted for almost 30 per cent of the emissions. Large quantities of greenhouse gases were emitted from energy-intensive industry in particular. 18 per cent of the emissions came from private households, 15 per cent from domestic transportation (not including private cars), 12 per cent from primary industries, another 12 per cent from private and public services, and 11 per cent from other industries, mainly petroleum activities, see table 7.

Table 7. Emissions to air by sector. 1988. Million tonnes CO_2-equivalents

Sector		NO_x	CO	CO_2	VOC	CH_4	N_2O
	Total	3.8	2.5	34.5	0.3	4.1	3.8
11	Agriculture	0.1	0.1	0.7	0.0	1.5	1.2
12	Forestry	0.0	0.0	0.1	0.0	0.0	0.0
13	Fishery etc.	0.6	0.0	1.5	0.0	0.0	0.0
15	Manuf. of consumer goods	0.0	0.0	0.7	0.0	0.0	0.0
25	Manuf. of production input commodities and investment goods	0.1	0.0	2.4	0.0	0.0	0.1
34	Manuf. of pulp and paper products	0.0	0.0	0.4	0.0	0.0	0.1
37	Manuf. of industrial chemicals	0.1	0.2	1.9	0.0	0.0	1.8
40	Petroleum refining	0.0	0.0	1.0	0.0	0.0	0.0
43	Manuf. of metals	0.1	0.0	5.0	0.0	0.0	0.0
45	Manuf. of fabr. metal prod.	0.0	0.0	0.2	0.0	0.0	0.0
50	Shipbuilding and platform construction	0.0	0.0	0.1	0.0	0.0	0.0
55	Construction	0.1	0.0	0.6	0.0	0.0	0.0
63	Financing and insurance	0.0	0.0	0.1	0.0	0.0	0.0
64	Oil and gas extraction	0.2	0.0	4.7	0.1	0.2	0.1
68	Oil well drilling	0.1	0.0	0.3	0.0	0.0	0.0
71	Prod. of electricity[1)]	0.0	0.0	0.1	0.0	0.0	0.0
75	Domestic road transport	0.5	0.1	2.0	0.0	0.0	0.1
76	Domestic air transport	0.1	0.0	1.6	0.0	0.0	0.0
77	Coastal water transport	0.7	0.0	1.9	0.0	0.0	0.0
78	Rail transport	0.0	0.0	0.1	0.0	0.0	0.0
79	Post and telecommunications	0.0	0.0	0.2	0.0	0.0	0.0
81	Wholesale and retail trade	0.2	0.2	1.3	0.0	0.0	0.0
83	Housing	0.0	0.0	0.0	0.0	0.0	0.0
85	Other private services	0.1	0.1	0.6	0.0	0.0	0.0
92	Defence	0.1	0.0	0.6	0.0	0.0	0.0
93S	Education and research (state)	0.0	0.0	0.0	0.0	0.0	0.0
93K	Education and research (municipal)	0.0	0.0	0.1	0.0	0.0	0.0
94S	Health and social welfare services (state)	0.0	0.0	0.0	0.0	0.0	0.0
94K	Health and social welfare services (municipal)	0.0	0.0	0.2	0.0	0.0	0.0
95S	Other public services (state)	0.0	0.0	0.1	0.0	0.0	0.0
95K	Other public services (municipal)	0.0	0.0	0.0	0.0	2.2	0.0
P	Private households	0.7	1.7	6.0	0.1	0.1	0.2

1) Incl. emissions from waste incineration plants.
2) Evaporation from storage and handling of gasoline, and from use of solvents, is not included in this table, see table 8.
Sources: CBS, SFT.

Table 8. Emissions to air by source. 1988. Million tonnes CO_2-equivalents

Sources	NO_x	CO	CO_2	VOC	CH_4	N_2O
TOTAL	3.8	2.5	34.5	0.4	4.1	3.8
STATIONARY COMBUSTION	0.5	0.5	12.6	0.0	0.1	0.6
- Industrial combustion	0.4	0.0	9.1	0.0	0.0	0.3
- Non-industrial combustion	0.1	0.5	3.4	0.0	0.1	0.2
- Incineration of waste	0.0	0.0	0.1	0.0	0.0	0.0
INDUSTRIAL PROCESSES AND EVAPORATION	0.2	0.2	6.7	0.3	3.9	3.0
- Pulp and paper products	-	-	-	-	-	-
- Manuf. of industrial chemicals	0.1	0.1	1.0	0.0	-	1.8
- Mineral products	-	-	1.0	-	0.0	-
- Petroleum refining	-	-	-	0.0	-	-
- Manuf. of metals	0.1	0.0	4.5	0.0	-	-
- Agriculture, liming	-	-	0.2	-	-	-
- Agriculture, domestic animal husbandry	-	-	-	-	1.4	-
- Agriculture, fertilizing	-	-	-	-	0.1	1.2
- Petroleum activities[1)]	-	-	-	0.1	0.2	-
- Landfills (waste disposal)	-	-	-	-	2.2	-
- Storage of gasoline	-	-	-	0.0	-	-
- Filling stations	-	-	-	0.0	-	-
- Solvents	-	-	-	0.1	-	-
MOBILE SOURCES	3.3	1.9	15.2	0.1	0.1	0.2
- Motor vehicles	1.4	1.6	7.8	0.1	0.1	0.1
-Light vehicles	0.8	1.4	5.3	0.1	0.0	0.1
-Gasoline	0.8	1.4	4.9	0.1	0.0	0.0
-Diesel	0.0	0.0	0.4	0.0	0.0	0.0
-Heavy vehicles	0.6	0.1	2.5	0.0	0.0	0.0
-Gasoline	0.1	0.1	0.4	0.0	0.0	0.0
-Diesel	0.6	0.0	2.1	0.0	0.0	0.0
- Small motorized tools, motorcycles, mopeds, tractors and motorized equipment	0.2	0.3	1.1	0.0	0.0	0.0
- Railways	0.0	0.0	0.1	0.0	0.0	0.0
- Air transport	0.1	0.0	1.9	0.0	0.0	0.0
- Coastal water transport	0.8	0.0	2.2	0.0	0.0	0.0
- Fishing fleet	0.6	0.0	1.5	0.0	0.0	0.0
- Petroleum activities	0.1	0.0	0.6	0.0	0.0	0.0

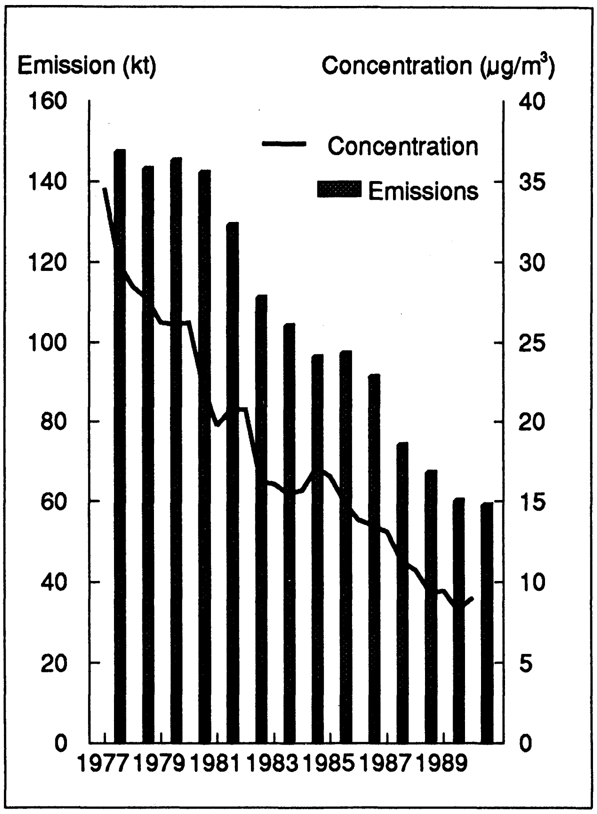
1) Including gas terminals.
Sources: CBS, SFT.

3. Trends in regional concentrations of pollutants

During the period from April 1989 to March 1990 air pollution concentrations were measured at 32 stations in 26 towns and urban areas as part of the national pollution monitoring programme (SFT, 1990a). The measurements, which give 24 hour averages for sulphur dioxide, lead, soot and nitrogen oxides, are taken at different times of the year, and the length of the time series for the different components varies. For instance, measurements of NO_2 were not started until 1986. Measurements are also taken at a number of stations in addition to the regular ones, including 9 stations in Sør-Varanger to chart the SO_2 load in the area caused by emissions from the Soviet nickel works in Nikel and Zapoljarnij.

The measurements show that the concentration of all components varies significantly over the year, with higher levels in winter and lower levels in summer. This variation is due to more oil consumption in winter for heating, and therefore increased emissions, plus the fact that pollution is not spread to the same extent in winter as in summer. Figures 8-10 show seasonal variations and changes in the average concentration of sulphur dioxide, soot and lead as measured at stations in some Norwegian towns (Fredrikstad, Oslo, Drammen, Kristiansand, Stavanger, Bergen, Trondheim and Tromsø). The figures also show changes in national emissions of these components. In general, variations in air quality, averaged for several towns, seem to follow variations in national emissions of the polluting compounds.

Figure 8. Average concentration of SO_2 in air in some larger Norwegian towns. µg SO_2 /m^3. National emissions of SO_2. 1 000 tonnes. 1977-1990



Source: NILU, CBS.

Figure 8 shows a marked decline in the average concentration of sulphur dioxide the last ten years in the towns included in the measurement programme. However, the average values indicate sporadic periods of poor air quality. In the case of some compounds, such as SO_2 and NO_2, greatest harm occurs during brief periods with high concentrations. However, the measurements show only few episodes with high concentrations of SO_2, and low concentrations during the winter of 1989/90. This is partly because this was a very mild winter, especially in Eastern Norway, which meant low consumption of oil for heating. Episodes with high concentrations of SO_2 occur most often in places with high levels of emissions from production processes at local industrial enterprises. The highest SO_2 concentrations are now measured in the counties of Østfold (Sarpsborg and Halden) and Sogn og Fjordane (Årdalstangen and Øvre Årdal). Finnmark experiences high concentrations of SO_2 due to transboundary pollution from the Soviet Union.

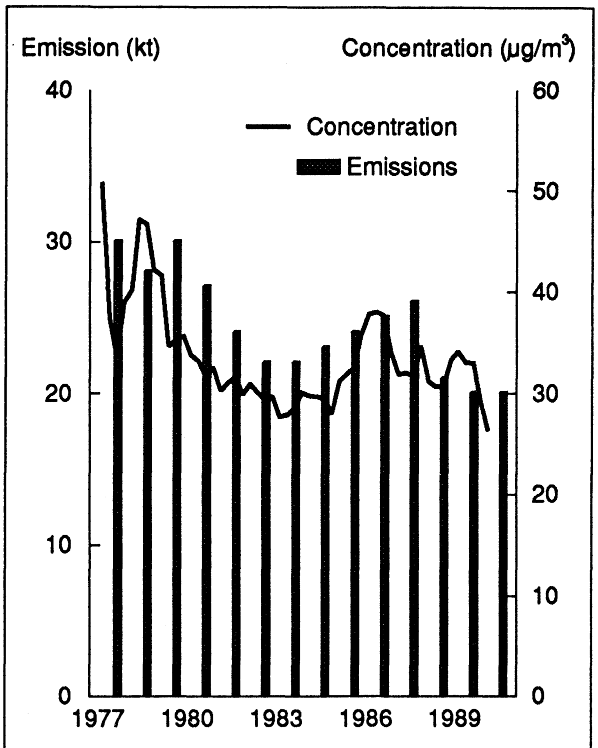
The soot concentration showed a tendency to decline at the beginning of the period, but in recent years has varied around a somewhat higher level, see figure 9.

Measurements exceeding the critical level were obtained for soot during the winter of 1989/90. The 24-hour average value (150 µg/m^3) was exceeded in Fredrikstad, Oslo, Skien and Bergen. It is safe to assume that most urban areas will experience soot concentrations above the critical level along roads with heavy traffic. Relatively high temperatures and good spreading conditions have led to a clearly lower level of soot concentrations in winter during the last three years than measured in previous years.

Lead concentrations have been reduced significantly following the gradual changeover to non-leaded gasoline. A period of marked reductions in lead concentrations in urban air early in the 1980s has been followed by smaller reductions in recent years, see figure 10. No lead concentrations exceeding the critical level were measured in the air at any station during the winter 1989-1990.

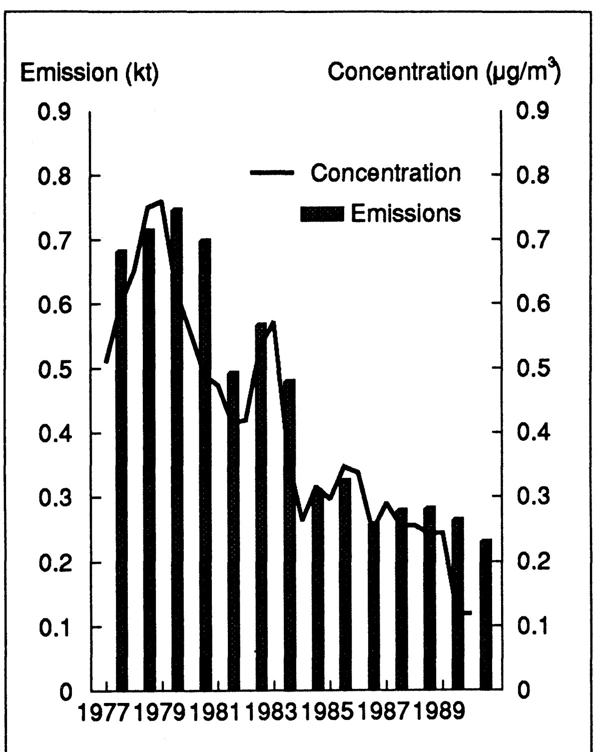
Measurements of NO_2 concentrations did not start until autumn 1986. The results show that, during the winter of 1989/90, the critical level for

Figure 9. Average concentration of soot in air in some larger Norwegian towns. µg soot/m³. National emissions of particulates. 1 000 tonnes. 1977-1990



Source: NILU, CBS.

Figure 10. Average concentration of lead in air in some larger Norwegian towns. µg Pb/m³. National emissions of lead. Tonnes. 1977-1990



Source: NILU, CBS.

the 24 hour average (100 µg/m³) was exceeded at 4 out of 13 stations. Despite this, average values were lower than in the year before. The highest 24 hour average values were measured in Drammen, Lillehammer and Bergen. The critical level for the half-yearly average (75 µ/m³) was not exceeded at any of the stations. Emissions from road traffic are the main cause of high concentrations of NO_2.

4. Emissions to air and economic development 1985-1987

Section 2 above presents figures for emissions to air distributed between private households and various industrial sectors. These figures show which sectors produce the emissions, but say nothing about the economic mechanisms which contribute to shifts in the composition of industry from year to year. This section considers how annual changes in economic variables such as private consumption, export and investments have led to changes in emissions to air in Norway. The discussion refers to the period 1985-1987 and focuses on total energy consumption, and on emissions of the three polluting compounds SO_2, NO_x and CO_2.

An illustration may serve to make the problem more explicit. There was a strong growth in private consumption in Norway in the mid-1980s. The increase in consumption was strongest from 1984 to 1985, but was also fairly strong from 1985 to 1986. In order to calculate how much the emissions increase as a result of increased consumption it is not enough to consider the trend in emissions from the private households alone. Higher consumption implies increased production of goods and services, which leads to higher levels of emissions. Moreover, the growth in production in its turn requires larger deliveries from the producers of raw materials, and this will lead to higher levels of emissions from these companies too. How much the emissions increase will depend to a large extent on what kind of goods and services the increased consumption refers to.

The effects on emissions of annual changes in private consumption, investments, export and other macroeconomic variables have been calculated using a macroeconomic model coupled with information on energy consumption and emissions to air. The model is a relatively detailed input-output model based on CBS's macroeconomic model MODIS V. It specifies 44 production sectors and 53 different groups of commodities.

The size of the most important components of the demand, the greater part of the import, and production in the public sector, primary industries, petroleum activities, refineries and power supply are determined outside the model. This makes it possible to insert figures for these variables over time. It is assumed that the relationship between input factors and produced quantity is constant for the sector concerned during the whole period, but that emissions and energy use per produced unit vary from year to year. Given these assumptions the model determines the extent of the change in production in each sector following a change in the demand for the different groups of commodities. Coupled with information on the amount of energy used and the amount of emissions per produced unit in each sector, this gives an estimate of increases (or reductions) in energy use and emissions due to changes in demand in a specific year.

This model has been used to break up the annual changes in emissions to air and use of energy. That is to say, it has been calculated how large a share of the changes in emissions and energy use each year can be put down to changes in each of the individual exogenous variables included in the model (the variables determined outside the model). The most important of these variables are mentioned above. Emissions and energy use per produced unit are also regarded as exogenous variables in this connection.

Contributions to emissions from the different components of the demand are calculated on the assumption that increased demand is covered by increased domestic production. A higher demand for products from sectors where production is determined outside the model is not included. This demand is covered by increased import or by drawing on stocks. The fact that the composition and level of import also changes during the period is taken into account as a separate item, "contribution from import". Emissions and energy use in the production of non-competing import (import of goods not produced in Norway) are excluded.

The contributions are further calculated on the assumption that emissions and energy use per produced unit remain constant throughout the year. However, the table also contains an item called "contribution due to changes in emissions and energy use", which states how much of the changes in total emissions and energy use can be put down to changes in energy use and emissions per produced unit during the period.

The economic figures are figures from the National Accounts, measured in 1988 prices, while the emissions figures are taken from CBS's inventories of emissions. Since no figures were available for CO_2 at the disaggregated level required for this analysis these figures had to be estimated specially. This means that the total figures deviate slightly from the total figures in section 2. The growth rates given here for aggregated figures in the National Accounts are in 1988 prices.

Emissions from ocean transportation (foreign trading) are not included in the calculations. This sector is responsible for large emissions, and uses as much heavy oil as the rest of the Norwegian economy combined. The figures for the item "contribution from export" especially would have been very different if this sector had been included. However, adequate data on use of energy in this sector are lacking. Furthermore, a large share of the emissions from ocean transportation will take place abroad, which makes it irrelevant, in a number of connections, to include these figures.

The emission inventories show large increases in emissions of SO_2 and NO_x from exploration drilling on the continental shelf during the period, while production in the drilling sector was simultaneously reduced. This has affected some of the results. Some reservation is necessary in regard to the emission figures for this sector, since they may not be completely reliable.

Factors explaining changes in emissions from 1985 to 1987

Tables 9 and 10 show annual changes in emissions, energy use and production for the periods 1985-1986 and 1986-1987.

According to table 9, emissions of CO_2 increased from 1985 to 1986 by almost 10 per cent. Emissions of SO_2 decreased by 7.6 per cent during this year, but emissions of NO_x increased by 9.5 per cent. In the case of all three pollutants, changes in emissions were far more dependent on changes in production than on changes in direct emissions from private households. Note that in tables 9 and 10, "contribution from production" comprises both changes in the produced volume and the contribution due to changes in emissions and energy use per produced unit.

The extent of private consumption (measured in 1988 prices) increased by 5.5 per cent from 1985 to 1986. This led to increased emissions to air both from the households themselves and from enterprises which increased production in order to meet higher consumer demand. The emissions from a higher level of production to meet increased consumption accounted for about 2 per cent of the total Norwegian emissions in 1985. If the increase in emissions from the households themselves is added to this figure, the total contribution made by private consumers to changes in emissions from 1985 to 1986 is: An increase of 3.0 per cent in total emissions of CO_2, of 1.5 per cent for SO_2, and 3.6 per cent for NO_x.

A factor of even greater importance for changes in emissions, however, was investments, which increased by 23.1 per cent from 1985 to 1986. Due to the increase in production of investment goods and raw materials, the growth in real investments alone led to an increase in emissions equivalent to more than 10 per cent of the total Norwegian emissions of SO_2. Investments also made a large contribution to changes in emissions of CO_2 and NO_x.

Import, which increased by 9.0 per cent from 1985 to 1986, had the opposite effect. This increase led to a 3-7 per cent reduction of emissions in Norway. The model assumes that increased import is matched by a decrease in domestic production.

Export decreased by 0.2 per cent in 1986, leading to a decrease of 2-4 per cent in total Norwegian emissions of SO_2, NO_x and CO_2. The reason why such a small reduction in export led to this relatively large reduction in emissions is a decrease in export of various goods and services which involve a high degree of pollution during production, for instance metals, and a simultaneous increase in export of other goods and services.

The last important factor explaining the changes in total emissions is changes in emissions and use of energy expressed as a share of the gross production in each sector. In the case of CO_2, this item accounted for 6.1 per cent of the change in emissions from 1985 to 1986. This means that, if production in 1986 had remained the same as in 1985, emissions of CO_2 would have increased by 6.1 per cent even so, because in 1986 industry in general emitted more of this gas per produced unit. There was no similar increase, however, in energy use per produced unit. An important reason is that, during that year, in some industries, particularly the pulp and paper industry, part of the electricity consumption was replaced by oil, due to a poor supply of surplus power.

In the case of SO_2, emissions per produced unit generally declined. The reason is cleaning and other measures such as the requirement to change to oil with a lower sulphur content. There was a strong increase in emissions of NO_x per produced unit. However, the uncertainty of the figures for exploration drilling may imply that the reduction in emissions of SO_2 per produced unit was even greater than shown, while the increase in emissions of NO_x may not have been as large as indicated in the table.

Table 10, covering the period 1986-1987, shows that emissions to air do not necessarily keep entirely in step with energy use and production. For instance, there was a marked reduction in emissions of

Table 9. Relative changes from 1985 to 1986 in emissions to air, energy use and production. Contribution from different macroeconomic components. Per cent of total levels of emissions, energy use and production in 1985[1)2)]

	Emissions CO_2	SO_2	NO_x	Energy use	Production[6)]
Total change 1985 - 1986	9.5	-7.6	9.5	1.3	4.7
Comprising					
- Contrib. from direct emissions and energy use in households	1.3	-0.5	1.8	1.3	-
- Contrib. from production	8.2	-7.1	7.7	0.0	4.7
Comprising:					
Private consumption	1.7	2.0	1.8	1.6	2.0
Investments	6.2	10.7	6.3	6.2	6.7
Export[3)]	-2.1	-3.6	-3.3	-2.3	-0.5
Import[3)]	-4.0	-6.8	-3.4	-4.5	-2.9
Changes in stocks[3)]	-1.0	-2.0	-0.9	-1.5	-3.1
Public production and consumption	0.2	0.3	0.2	0.3	0.5
Energy production and primary industries[4)]	1.1	0.1	1.7	-0.1	0.3
Contr. from changes in emissions and energy use[5)]	6.1	-6.8	8.5	-0.7	-
Others	-0.2	-1.0	-3.1	0.9	1.7

1) Inconsistencies in the tables are due to rounding the figures up or down.
2) Not including emissions to air and energy use in ocean transportation.
3) Contributions from export do not include export of natural gas. Contributions from import do not include import of agricultural and forestry products, oil and electricity, or non-competing imports. Contributions from stocks do not include stocks of fish products.
4) Includes petroleum activity, power supply, refineries, agriculture, forestry and fisheries.
5) Emissions and energy use as shares of gross production in each sector.
6) Measured in 1988 prices.

Table 10. Relative changes from 1986 to 1987 in emissions to air, energy use and production. Contribution from different macroeconomic components. Per cent of total levels of emissions, energy use and production in 1986[1)2)]

	Emissions			Energy	Produc-
	CO_2	SO_2	NO_x	use	tion[6)]
Total change 1986 - 1987	-3.8	-17.2	4.0	1.0	2.1
Comprising					
- Contrib. from direct emissions and energy use in households	0.3	0.6	0.5	0.4	-
- Contrib. from production	-4.2	-17.8	3.5	0.6	2.1
Comprising:					
Private consumption	-0.2	-0.2	-0.1	-0.2	-0.2
Investments	-1.3	-2.3	-2.4	-1.1	-0.8
Export[3)]	2.3	5.5	2.4	3.0	-0.2
Import[3)]	1.6	3.4	0.8	1.8	1.5
Changes in stocks[3)]	-1.7	-4.0	-0.7	-1.8	-0.7
Public production and consumption	0.4	0.4	0.4	0.4	0.7
Energy production and primary industries[4)]	2.2	1.5	2.6	1.7	1.1
Contr. from changes in emissions and energy use[5)]	-7.5	-21.2	1.3	-2.6	-
Others	0.0	-1.0	-0.9	-0.5	0.8

1) - 6) See footnotes to table 9.

sulphur dioxide that year, but an increase in use of energy.

Private consumption (calculated in 1988 prices) decreased by 1.2 per cent from 1986 to 1987. Gross investments were 1.4 per cent lower than in the preceding year. Export was reduced by 0.9 per cent, while import, which had increased substantially the year before, decreased by 7.2 per cent. The increase in the GDP measured in 1988 prices was 1.2 per cent, as against 4.1 per cent the year before.

From 1986 to 1987 too, changes in emissions were more strongly affected by changes in production, including changes in emission and energy intensities, than by changes in direct emissions from private households. Emissions from the households themselves increased only slightly during the period, and there was a slight reduction in emissions from production of consumer goods. All in all, private households caused a slight increase in emissions.

The main reason for the decrease in export was the substantial decrease in production in the ocean transportation sector from 1986 to 1987. The consequent reduction in emissions is not reflected in our figures because, as mentioned above, emissions from this sector are not included. However, export of many other products increased, which led to a slight increase in emissions of CO_2 and NO_x, and a relatively strong increase in emissions of SO_2.

The main reason for the reduction in CO_2 and SO_2 emissions from 1986 to 1987, in spite of the above, is the general reduction in emissions of these two components per produced unit throughout the different sectors. This reduction was due to a number of factors; lower energy intensity in production, change from oil to electricity, and in the case of sulphur emissions, a greater degree of cleaning and other abatement measures. Variations in the volume of production were less important.

Changes in NO_x emissions per produced unit in the different sectors contributed to an increase in total Norwegian emissions from 1986 to 1987. The main reason, however, was increased NO_x emissions in connection with drilling for oil and gas, and, as mentioned above, these figures are uncertain.

To sum up

Changes in emissions per produced unit in the different sectors were the dominating reason for changes in emissions during the period 1985 to 1987. These changes were a result of more extensive cleaning and other abatement measures, and of variations in the distribution of energy consumption between electricity and different kinds of oil. Energy use per produced unit did not vary to nearly the same extent as emissions per produced unit.

Emissions levels during the period were also affected by changes in the level of economic activity. However, relatively speaking, these changes are less important than changes in emissions per produced unit. The strong increase in investments from 1985 to 1986 was an important exception, which alone led to a marked increase in emissions of CO_2, SO_2 and NO_x. Changes in the level of private consumption, however, seem to have been of minor importance in explaining changes in emissions of these gases.

5. The impact of a possible international climate agreement on the Norwegian economy

Norway is party to several international agreements on the environment, see box 2. None of these regulate emissions of the greenhouse gas CO_2. The greenhouse problem is a global one, and can only be solved by widespread international cooperation. Even if Norwegian emissions of CO_2 account for only about 0.2 per cent of global emissions of CO_2 from fossil fuels, it is only reasonable that Norway also makes an effort to limit the increase in these emissions, or reduce them. Together with the other EFTA countries and the EEC, Norway has defined a provisional national goal to stabilize national emissions at the 1989 level. Lower Norwegian CO_2 emissions can be achieved only by reducing consumption of fossil fuels. The fact that these emissions cannot be cleaned, combined with a very large number of sources of relatively small emissions, means that the most appropriate way to reduce these emissions is to increase environmental taxes. Under certain circumstances a tax in proportion to CO_2 content will lead to cost-effective reductions of emissions. Actors with relatively high costs for marginal reduction of emissions will pay the tax, and actors with relatively low marginal costs will reduce the emissions. Cost-effectiveness is not achieved if not *all* sources of emissions are taxed.

A higher price for fossil fuel will signal to producers and consumers that consumption of this commodity causes disamenity to others in the form of pollution. In this way the price serves as a "conveyer of information". Furthermore, higher prices for fossil fuels will provide an incentive to use more energy-effective capital equipment (including means of transport) and develop alternative sources of energy. Historical data for energy use and CO_2 emissions indicate a close connection between emissions and the price of fossil fuels, see section 2. The rise in oil prices in 1973-74 and in 1979-80 both led to a marked decrease in oil consumption and CO_2 emissions. In addition to causing lower absolute consumption, the rise in oil prices led to the use of more energy-saving equipment in both industry and transport.

In addition, a tax on CO_2 opens up for the possibility of easing the taxes on other goods and services. In this way, taxes and duties which lead to loss of efficiency in the economy can be replaced by taxes which lead to better use of resources.

As part of its work for the Interministerial Committee on Climate, the Central Bureau of Statistics has analyzed the possible impacts of national and international CO_2 emission-abatement measures on the Norwegian economy. A description of calculations carried out using the long-term, general equilibrium model MSG-TAX, described in more detail in box 3, is presented below.

The reference path

The reference path used in the calculations describes a possible trend in the Norwegian economy, energy use and emissions to air up to the year 2025. The path is characterized by a relatively moderate increase in production and a somewhat higher, though moderate, increase in private consumption. Table 11 shows the trend for some main economic figures in the reference path.

Estimates for the trend in the labour force are based on projections based on CBS's demographic models. The supply of manhours is expected to increase slightly up to 2010, after which it will decrease by about 0.2 per cent per year up to 2025. In relation to the years 1970-88, the increase in the labour force is low. This is due to changes in the composition of the population, with a steadily increasing number of elderly persons.

The total stock of capital is estimated to increase by an average of 1.4 per cent per year up to the turn of the century, and by 2.3 per cent per year after the year 2000. These estimates are also low in a historical perspective, but are about the same as the observed historical increase in stock of real capital in other OECD countries. The rate of technical progress is the same as the average for the 1970s and 1980s. The real increase in the price of crude oil is expected to decline from about 2.5 per cent per year up to the year 2000 to just over 0.5 per cent at the end of the period. The international economy is expected to be marked by continued specialization and a relatively moderate growth in GDP and rise in prices in our trading partner countries.

Due to the expected high rate of technical progress, the increase in the use of input factors in domestic production, including consumption of oil products, is lower than the increase in production. In spite of the increased production, and the increasing real price of oil products, the higher level of activity and higher level of income imply an 80 per cent higher consumption of fossil fuels in 2025 than in 1987. Electricity consumption increases by about 54 per cent or 56 TWh during the period of calculation, to about 159 TWh in the year 2025. The assumptions defined for price trends for natural gas give a price of just under 23 øre/kWh for gas-based

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. Remember that the agreements may include other provisions and requirements than those stated below.

Declarations		
North Sea Declaration (1987)		
	Micropollutants	50 per cent reduction by 1995 with 1985 as base year. 70 per cent for cadmium, mercury, lead and dioxins
		Nutrients50 per cent reduction
		PCBCease all use by 1995
Conventions		
ECE (1979)	Limits on long-range transboundary air pollution	
Vienna (1987)	Protect the stratospheric ozone shield	
Protocols		
Helsinki (1985)	Sulphur	30 per cent red. 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 50 per cent by 1998 with 1986 as base year
	Halons	Stabilise use at the 1986 level by 1992
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 tetra-chloride	85 per cent reduction by 1995 and phasing out by the year 2000
	Methyl chloroform	30 per cent reduction by 1995, 70 per cent reduction by the year 2000, and complete phasing out by 2005
National goals		
	Sulphur	50 per cent red. by 1993 with 1980 as base year
	NO_x	30 per cent red. by 1998 with 1986 as base year
	CO_2	Stabilization at the 1989 level by the year 2000
	CFCs and Halons	50 per cent reduction in 1991 with 1986 as base year. Complete phasing out in 1995.

electricity delivered from the plant (1987 prices). This means that, in the year 2000, electricity from gas will compete in price with hydropower. It is therefore assumed that after the year 2000 the increased demand for electricity will be covered by electricity from gas. According to the reference path, 42 TWh of the electricity produced in 2025 will be based on gas and 117 TWh on hydropower.

As shown in table 12, increased electricity consumption leads to a marked increase in emissions to air.

The decrease in emissions of SO_2 and NO_x up to the turn of the century is due to measures that have already been adopted, such as catalytic cleaning of exhaust gases from motor vehicles and closing down several major sources of industrial pollution.

MSGTAX is a version of the macroeconomic planning model MSG-4 (Multisectoral Growth Model, Offerdal et al. 1987) used, inter alia, by the Ministry of Finance for long-term calculations of the Norwegian economy. MSGTAX is a general equilibrium model covering about 38 production sectors. It allows substitution between the input factors labour, capital, energy and materials in the production sector. Energy is an aggregate comprised of electricity and oil products, where the composition of the aggregate is determined by the relative prices of electricity and oil.

Economic development is determined in the model mainly by exogenous growth of the labour force, growth in the stock of real capital and the rate of technical change. An assumption is full utilization of available labour. Household consumption is distributed between 18 different consumer goods on the basis of price and income elasticities. Fossil fuels are included in the consumer groups "heating of dwellings" and "private transportation". Unlike in MSG, in MSGTAX the sectoral shares of exports and imports are decided by the relation between prices on the domestic and world markets. Accumulation of real capital and developments in the balance of trade in current prices are determined exogenously in the model.

Box 3. MSGTAX

In addition, emissions from combustion of oil from petroleum activities in the North Sea are reduced as a result of expected measures to reduce emissions from gas flares. The reason why emissions of VOC do not follow the same pattern as the other polluting compounds is increasing activity in the oil sector up to the turn of the century, and therefore more evaporation. Norwegian oil extraction declines after the year 2010.

After the turn of the century, the effects of the measures already implemented to reduce NO_x, SO_2 and CO_2 will be fully exploited, and the emissions increase in step with economic activity and use of energy. Emissions of CO_2 are not affected by cleaning, and therefore increase throughout the period. After the year 2000 a large share of the increase is due to introduction of electricity based on gas.

The international agreement to stabilize emissions of NO_x at the 1987 level by 1994, see box 2, is fulfilled for some years into the next century but, according to the reference path, is exceeded by more than 26 per cent in 2025. The national target for NO_x emissions is equivalent to a ceiling of 155 000 tonnes for such emissions. According to the projections, emissions will exceed the target by about 25 per cent in the year 2000 and by about 90 per cent in 2025.

The agreement on SO_2 emissions implies a ceiling of just less than 100 000 tonnes. The national target involves reducing national emissions to about 70 000 tonnes. The projections indicate that the international agreement will be fulfilled without any additional measures, while the national target will be far exceeded in 2025.

The Storting (Norwegian National Assembly) has decided, as a provisional target, to stabilize CO_2 emissions at the 1989 level by the year 2000. This is equivalent to an emission level of about 35 million tonnes. The projections indicate CO_2 emissions which exceed this level by about 17 per cent in the year 2000. In 2025 the emissions will be almost twice as high as the target.

Assuming that the international agreements and national targets reflect a seemingly reasonable environmental load in the future, it must be said that the reference path shows a trend which does not conform with environmental considerations.

The agreement scenario

The agreement scenario is intended to show the possible effects on the Norwegian economy of an international agreement to stabilize CO_2 emissions. It is assumed that the intention of the adopted agreement is to achieve almost complete stabilization of global energy-related CO_2 emissions at the 1987 level by the year 2000, followed by an increase in emissions of about 0.6 per cent per year (The "Control Policies Scenario", by the UN Panel on Climate, IPCC, 1990). Reductions in emissions are to be achieved by means of a global tax on CO_2 emissions. The tax on CO_2 is determined exogenously in the MSGTAX, and the model is used to calculate CO_2 emissions. In MSGTAX the tax is added to the purchase price of heating oil and gasoline for consumers and producers. A tax is also imposed on other production materials which cause emissions of CO_2 during the production process.

Table 11. Economic trends in the reference path. Fixed prices. Mean percentage annual increase

	1987-2000	2000-2010	2010-2025
Gross domestic product	2.0	2.0	1.5
Import	3.9	2.7	2.2
Total supply	2.6	2.2	1.7
Export	3.7	1.8	1.9
Domestic use	2.1	2.4	1.6
Private consumption .	1.8	3.4	1.4
Public consumption .	2.2	1.8	1.7
Investments	2.6	0.3	2.1

The tax is calculated on the basis of a specific tax per tonne CO_2 emissions.

The size of the tax is calculated on the basis of a number of global and national analyses of the connection between the price of fossil fuel and CO_2 emissions (CBS, 1991). The tax on CO_2 is introduced in 1995 and increases from about NOK 68 per tonne CO_2 to about NOK 1 278 per tonne in 2025, calculated in 1987 prices.

The tax on CO_2 is a source of income to the public authorities, and thus opens up for a reduction in other taxes. In principle, the effect on the Norwegian economy in general, and on distribution of income in particular, will depend entirely on how the rest of the system of taxes is changed as a result of the tax on CO_2. In MSGTAX all resources are fully utilized throughout, and economic adjustment is determined primarily by relative prices. The model automatically transfers the proceeds of the taxes back to the economy in the form of a general reduction in taxes/transfers to households. The tax on CO_2 also implies a reorganization of the tax system, and has no total contractive effect on the Norwegian economy.

Assumptions concerning international conditions

An international CO_2-agreement will influence the trend on the international energy market, and in the international economy and world trade. Higher prices for energy will lead to higher prices of products. It is assumed that the average price rise will be stronger abroad than in Norway. Expenditures on fossil fuel account for a relatively small share of the costs for Norwegian producers in relation to our trade partners. On average, if crude oil, gas and products from energy-intensive industry are excluded, nominal import prices in the agreement scenario are 5 per cent higher than the prices shown in the reference path in the year 2000, and 18 per cent higher in 2025. For the products of energy-intensive industry, the increase in prices on the world market is that same as in Norway (CBS, 1991).

Due to lower demand the price of crude oil is expected to be lower than it would be without an international CO_2-agreement. The nominal prices of crude oil and gas increase to about the same extent as shown by the reference path. In the agreement scenario the real price is about 15 per cent below the level of the reference path in 2025. The price trends for imported gasoline and heating oil are assumed to be the same as for crude oil.

Among our trade partners the annual growth in GDP is expected to be about 0.25 percentage points lower than shown in the reference path throughout the period. This is the same as if the GDP of our trade partners is reduced by 1.4 per cent in 2000 and 7.3 per cent in 2025 as a consequence of the tax on CO_2 (CBS, 1991). This is incorporated into MSGTAX in the form of equivalent reductions in the market indicators for Norwegian products on the world market, and in exogenous import.

Assumptions concerning the electricity market

The tax on CO_2 is expected to lead to a different path for energy coverage and price of electricity than shown by the reference path. In the first place, electricity from gas will be much more expensive in the agreement scenario than in the reference path, because production of electricity from gas generates large emissions of CO_2 which are subject to tax, or costs are incurred for "cleaning" the emissions. The agreement scenario assumes a technology based on an offshore gas fired power station with

Table 12. Projections of emissions. Levels[1)] and average percentage increase

	Levels				Annual increase		
	1987	2000	2010	2025	1987-2000	2000-2010	2010-2025
SO_2 (kt)	75	72	77	96	-0.3	0.7	1.5
NO_x (kt)	232	209	239	293	-0.8	1.4	1.4
CO (kt)	653	514	543	629	-1.9	0.6	1.0
VOC (kt)	266	305	334	305	1.1	0.9	-0.6
Particulates (kt)	25	23	25	29	-0.6	0.6	1.0
CO_2 (Mt)	35	41	52	68	1.2	2.4	1.8
CH_4 (kt)	286	278	281	278	-0.2	0.1	-0.1
N_2O (kt)	13	14	14	16	0.0	0.7	0.9

1) kt = thousand tonnes, Mt = million tonnes.

injection of CO_2 into oil and gas reservoirs. Calculations indicate that this technology can produce electricity at a cost of about 34 øre/kWh (1987 prices) (SFT, 1990b). This price is lower than the price of electricity from traditional gas fired power plants when the tax on CO_2 is included. Therefore, electricity from gas fired power plants becomes competitive at a much later date in the agreement scenario than in the reference path.

In the second place the higher price of fossil fuels will lead to more use of bioenergy and heat pumps, and will provide a greater incentive for energy saving, for example, in the electricity sector. Based on calculations by SFT (SFT, 1990b) it is assumed that it will pay to produce 10 TWh bioenergy, that 10 TWh can be saved by using heat pumps, and that 5 TWh can be obtained by refurbishing and upgrading the existing production and transmission system. Energy from these sources is not included in the reference path, and it is assumed that the price of electricity must exceed the highest price in the reference path before the above-mentioned sources are taken into use. This is equivalent to a price of 28 øre/kWh delivered from the plant.

Estimates from NVE (The Norwegian Water Resources and Energy Administration) indicate a production potential of about 39 TWh from new hydropower sources, excluding protected watercourses and watercourses under development. Thus, data from NVE and SFT have provided the basis for constructing a long-term marginal cost for CO_2-free electricity. For technical reasons the calculations treat all production of energy, including energy saved by use of heat pumps, as conventional hydroelectricity. The price of electricity keeps in step with NVE's estimates of the long-term marginal cost of new hydropower until this becomes equivalent to the price of energy from heat pumps, bioenergy and energy saving in the electricity sector. Once these sources of energy are completely exploited, the price of electricity again follows the long-term marginal cost of hydropower until this price reaches the price of electricity produced at offshore gas fired power plants with injection of CO_2. Electricity over and above this is produced at gas fired power stations based on the above technology.

Effects on the Norwegian economy

Table 13 shows changes in some important economic variables in the agreement scenario in relation to the reference path.

In spite of a substantial increase in the price of energy and a marked reduction in energy use, the tax on CO_2 has only a slight effect on the growth of GDP. In 2025, the GDP is 3.2 per cent lower than if no tax had been imposed. That is to say, the same level of production is reached about two years later than would have been the case without a CO_2-agreement, which is therefore no threat to economic growth. In 2025 Norway's disposable real income is reduced by 9 per cent in relation to the reference path.

The trade balance in current prices is presumed to be the same as in the reference path. The real price of oil products is lower than in the reference path, and this reduces the value of exports of oil and gas. Export of oil and gas accounts for a large share of total export at the start of the period, so that a fall in real prices has a strong effect. Thus, to preserve the balance of trade it is necessary either to increase the value of other exports and/or decrease imports. Resources are transferred to the traditional industries exposed to competition from abroad, and there is a fairly sharp reduction in consumption. As time goes on, exports of oil and gas gradually become less important. In the light of the assumed effects of a CO_2-tax on the international economy, the rise in the prices of certain commodities will be higher on the world market than in Norway. This deviation increases into the next century. Imports decline, but production of traditional export goods must still increase at the expense of production of consumer goods. In order to achieve a positive development of traditional export, wage increases must be reduced in relation to the reference path. A lower rate of wage increases, a lower real price of oil and gas, and changes in the terms of trade, lead to a stronger decline in private consumption than indicated by the decrease in the GDP alone.

It is often maintained in the course of the debate that unilateral measures by Norway would reduce the Norwegian standard of living more than an international climate agreement would. The above analysis indicates that in the long term perspective the opposite is the case, because an international agreement would lead to lower prices for our exports of crude oil and gas. Earlier studies (Glomsrød et al., 1990) indicate that the decrease in con-

Table 13. Percentage changes in the agreement scenario in relation to the reference path. Fixed 1987 prices

	2000	2010	2025
Gross dom. product .	-2.2	-2.0	-3.2
Import	-7.3	-10.2	-11.2
Total supply	-3.8	-4.6	-6.0
Export	0.4	-0.2	-5.1
Domestic use	-5.7	-6.6	-6.4
Private consumption	-10.3	-11.0	-10.8
Public consumption	0.6	0.7	0.8
Investments	-0.4	-0.6	-1.2
Disposable real income	-7.2	-8.7	-9.0

sumption is more a result of the fall in petroleum prices than of the decrease in GDP. Thus industrial development shifts towards higher production in traditional industries that are vulnerable to international competition, while the industries that are hardest hit by a tax on CO_2 are the service industries and the industries supplying consumer goods to the home market.

Effects on use of energy

Table 14 shows changes in the purchaser price index and consumption of the different sources of energy as a result of a tax on CO_2.

For industry and the public sector the higher price of heating oils averages 144 per cent in relation to the reference path in 2025. For households, the price of heating oil increases by 140 per cent and for gasoline by 60 per cent. In the year 2025 gasoline will cost about NOK 9.70 per litre in 1987 prices, of which the tax on CO_2 accounts for about a quarter.

Since the tax on CO_2 makes "uncleaned" gas-based electricity unsuitable as a source of energy for economic reasons, in the year 2025 the price of electricity for regular consumption will lie about 22 per cent above the price in the reference path. The price of electricity delivered at the plant is then about 32 øre/kWh in terms of 1987 kroner. The price of electricity for energy-intensive industry increases by about 17 per cent in relation to the reference path.

The growth in the consumption of heating oils in the public sector is expected to decrease by about 0.7 per cent annually up to the year 2000, and by 0.4 per cent annually after that year.

The tax on CO_2 leads to a marked reduction of energy use throughout the economy. As long as the energy demand can be covered by increased hydropower production and new, clean sources of energy, the tax has a greater effect on the price of heating oil than on the price of electricity. In private households some of the oil consumption will be compensated by more use of electricity, but there will also be a large decrease in total energy consumption. In private households, the tax on CO_2 will lead to a reduction of about 11 per cent in the consumption of oil and electricity combined in the year 2025. The energy-saving potential is estimated to be about 13 per cent in dwellings, at a price of energy lower than shown in the agreement scenario, and a decrease in energy use is thus not unrealistic (Report no. 61 (1988-89) to the Storting).

Electricity export is about the same as shown in the reference path.

During the period 1987 to 2025 the demand for electricity (including losses in the transmission network) increases by about 44 TWh. About 25 TWh is produced by means of heat pumps and bioenergy, or is provided through energy-saving measures in the electricity sector. The remainder is covered by traditional hydropower projects. According to the calculations, electricity from gas fired power plants not involving emission of CO_2 will not be a relevant source of energy until after 2025.

Emissions

Table 15 shows the calculated emissions to air based on the assumptions in the agreement scenario, and the percentage change in relation to the reference path.

The graded CO_2-tax leads to a reduction of almost 60 per cent in total CO_2 emissions in 2025 in relation to the reference path.

A large share of the decrease (45 per cent) is due to the disappearance of emissions from gas fired power plants. Emissions of CO_2 from oil and gas

Table 14. Purchaser price index for energy sources and commodities used in production. Consumption of sources of energy and production commodities. Percentage change in the agreement scenario in relation to the reference path

	2000		2010		2025	
	Price index	Consumption	Price index	Consumption	Price index	Consumption
Private consumption						
Gasoline	26	-21	48	-38	60	-48
Fuel	62	-39	84	-66	140	-90
Electricity	10	3	5	6	22	6
Production sectors - total						
Oil products	98	-25	118	-29	144	-37
Electricity	10	-2	5	0	22	-9

production in the North Sea are reduced by about 2.5 million tonnes by changing over to hydroelectricity instead of gas turbines. Emissions from other stationary sources, and from mobile sources, are both reduced by just over 50 per cent, and emissions from production processes are reduced by just over 15 per cent. The reduction of emissions from production processes is smaller than the reduction of emissions from combustion because the materials used in production generate CO_2 emissions in only a few sectors of industry. In these sectors, however, emissions from production processes are reduced considerably. Furthermore, in the agreement scenario, production in industries that are exposed to international competition increases relative to production in other industry, and it is these former sectors which generate the largest emissions of most components of air pollution during the production process.

The tax implies that all emissions caused by use of fossil fuel, as well as emissions from production processes, decrease. The agreement to stabilize NO_x emissions at the 1987 level is complied with. In the year 2025 the level of emissions is only very slightly higher (6 tonnes) than the level comparable to a 30 per cent reduction relative to emissions in 1986. Furthermore, the NO_x emissions are lower than this level for most of the calculated period. Thus, it can be said that the national target for NO_x emissions is achieved.

Both the agreement and the national target defined for emissions of SO_2 are fulfilled with a fairly good margin.

The main sources of emissions of methane (CH_4) are domestic animal husbandry and landfills. Therefore the tax does not affect these emissions.

Distributional effects of a tax on CO_2

An argument often used *against* widespread use of taxes in the environmental policy is that such taxes may have unfortunate distributional effects. The concern often refers to families with children, households in outlying districts or households with low income. The distributional effects for private consumers of rises in prices due to an international tax on CO_2 are calculated below. Households are grouped according to total consumption expenditure, type of household and geographical location.

An international tax on CO_2 as described in the agreement scenario will lead to a much higher price for most consumer goods. Oil products are an important input factor in the production of a large number of goods and services. Therefore an increase in the price of oil products will lead to higher production costs for both Norwegian and foreign producers, and part of this increase is passed on to the consumer. The price increase depends on how large a share of the production costs of a specific good or service refers to oil products and to what extent the increased production costs can be transferred to the price of the product. The average nominal prices of all goods and services are estimated to be about 28 per cent higher in 2025 in the agreement scenario, i.e. with a CO_2-tax, than shown in the reference path.

The distributional effects of a tax increase can be measured using a Laspeyres cost of living index. The index gives the costs of living after introduction of a CO_2 tax for a household, assuming the same consumption as before the tax was introduced. In other words, the index measures the amount of additional income required by a household to be

Table 15. Emissions in the agreement scenario and percentage change in the agreement scenario relative to the reference path

	2000		2010		2025	
	Level	Change	Level	Change	Level	Change
SO_2 (kt)	55	-24	54	-30	59	-39
NO_x (kt)	151	-28	155	-35	161	-45
CO (kt)	377	-27	345	-36	349	-45
VOC (kt)	282	-8	301	-10	256	-16
Partikler (kt)	19	- 17	20	-20	21	-28
CO_2 (Mt)	29	-29	27	-48	28	-59
CH_4 (kt)	273	-2	273	-3	270	-3
N_2O (kt)	11	-15	11	-21	10	-38

kt = thousand tonnes.
Mt = million tonnes.

able to consume exactly the same after introduction of the tax as before. Table 16 shows the Laspeyres index for total costs of living with an international tax of NOK 1278 (1987 prices) per tonne CO_2. The households are grouped according to different characteristics and are assumed to have the same pattern of consumption as in 1986-1988 (CBS, 1990b). The index in the reference path, which is the same as the index for unchanged cost of living, is equal to 1.

Therefore, after an international CO_2 agreement, the cost of living will increase by 23 per cent for a household with an average total income of less than NOK 50 000 per year during the period 1986-1988, assuming the pattern of consumption stays the same. For a household with an income exceeding NOK 300 000 the cost of living will increase by 25 per cent. If the distribution of the increase in cost of living is said to express a change in the distribution of income, the CO_2 tax will not be of much significance for distribution of income.

The main reason for this result is that the effects on prices to a large extent offset each other. For example, when the share of the total consumer tax on gasoline (*budget share* for gasoline) increases with income, and a higher price for gasoline thereby leads to the largest increase in the total cost of living for those with the highest income, then a higher price for gasoline will have a levelling effect on income. A price rise for electricity and oil for heating counteracts this levelling effect, because the budget shares of these products decrease with increasing income.

Table 16. Laspeyres indices for total consumption expenditure as a result of a tax on CO_2. The index in the reference path is equal to 1

All households	1.24
Households grouped by income. Average income 1986-88	
Up to 50 000	1.23
50 000 - 109 999	1.24
110 000 - 159 999	1.24
160 000 - 219 999	1.25
220 000 - 299 999	1.24
300 000 and above	1.25
Households grouped by type	
Single	1.24
Couple without children	1.25
Couple with children under 6 years	1.21
Couple with children 7-19 years	1.24
Single parents	1.22
Other types of households	1.26
Households grouped by geographical location	
Oslo and Akershus	1.24
Remainder of Eastern Norway	1.25
Agder and Rogaland (Southern Norway)	1.24
West Norway	1.24
Trøndelag	1.24
North Norway	1.24
Sparsely populated areas	1.24
Densely populated areas outside Oslo, Bergen and Trondheim	1.25

Grouping the households by type implies that the CO_2 tax causes slightly bigger changes in distribution of income, but in favour of the groups one normally wishes to favour. The lowest increase in the cost of living is experienced by single parents and couples with small children. This is because these households make little use of private cars. In the second place, in the agreement scenario it is necessary to lower the interest rate in society in relation to the reference path in order to preserve the balance of trade. This leads to a decrease in the price of housing. The share of the consumer expenditure referring to housing is very high for couples with small children and for single parents. This brings the cost of living index down for these groups more than for other households. The tax has the greatest negative effect for the group "other households", which includes various forms of collectives, because the budget share for housing is particularly low, and particularly high for gasoline.

If the households are grouped geographically, the calculated effects of a CO_2 tax on distribution of income are extremely small. This is because the households' pattern of expenditure on the various goods and services is much the same irrespective of where they live. There is no tendency, for example, for gasoline to account for a larger share of total expenditure among households in sparsely populated areas than among households in Oslo.

To the degree that certain groups of households have better opportunities than other households to change their pattern of consumption after the introduction of a tax on CO_2, the distributional effects may differ from those indicated above. However, distribution considerations should be ensured by means of other instruments than those connected to environmental policy and, in principle, all negative distributional effects can be compensated by returning the income from the tax in the form of special tax reductions or transfers.

6. Marginal pollution costs and external costs related to road traffic

Norway supports the principle that the polluter shall pay for any environmental damage caused by the pollution. The imposition of a tax is one way to follow up this principle in connection with emissions from combustion. Ideally, the tax can be fixed to equal the cost of the damage caused by an increase in emissions from a particular unit, i.e. equal to the marginal pollution cost.

This section first discusses the marginal pollution cost *per kilo emissions* of important polluting compounds. The figures can be regarded as average estimates for the country as a whole. These estimates are then used to calculate the marginal pollution costs *per litre consumption* of some important types of oil. In the case of autodiesel and gasoline, estimates have also been made of the marginal external costs per litre of oil consumption in road traffic. Finally, the figures for the marginal costs are used to calculate the benefit from a lower level of local air pollution and load of traffic as a result of climate policy measures.

Marginal pollution cost per kilo emissions

Increasing concern about the state of the environment has been gradually followed by extensive research on the damaging effects of air pollution. It is almost impossible to obtain a complete picture of all environmental costs, but considerable knowledge has been acquired about specific damaging effects. An attempt has been made, by amalgamating the results of several studies of partial damaging effects, to estimate the marginal environmental costs due to consumption of fossil fuels. Most of the information on damaging effects used as a basis for the calculations has been obtained from the State Pollution Control Authority (SFT), the Norwegian Institute for Air Research (NILU) and the Institute of Transport Economics (TØI). It includes estimates of negative health effects of emissions of SO_2, NO_x, CO and particulates, acidification of forest and watercourses caused by national emissions of SO_2 and NO_x, and certain specific types of damage to materials from SO_2.

The methods and assumptions used in the estimates have been described by Brendemoen and Glomsrød (1991). For example, SFT has estimated what it costs if a person is exposed to emissions that are harmful to health, i.e. concentrations exceeding the recommended critical levels of the relevant polluting compounds (SFT, 1987, 1988). This cost has then been multiplied by an estimated figure for the change in the number of persons exposed to concentrations higher than the critical level, due to changes in emissions. It is assumed that, within the relevant range of variation of emissions, the correlation between emissions and the number of persons exposed to concentrations exceeding the critical level is linear, and that this can be expected to apply to the country's five municipalities with the largest population. The estimates of the marginal health costs for the country as a whole assume that the emissions in these municipalities are the only ones that are harmful.

Marginal environmental costs connected to climate and the ozone shield, grime, unpleasant odours and corrosion of buildings and sculptures of cultural value are not included in the estimates of damage presented below. However, the estimates can be said to include the most well-known cost elements connected to local damage from use of fuel.

It must be underlined that the estimates are very uncertain. This applies especially to dose-response functions defining physical damage at a specific level of pollution, and the value awarded to the cost of specific physical damage. Moreover, most of the estimates refer to data and calculations from the years 1986-1988. They are based on the levels of emissions during these years, including geographical distribution between the different kinds of sources of pollution. It is reasonable to assume that the *marginal* damage increases with increased emissions and decreases with reduced emissions. In spite of this, for the sake of simplicity the marginal costs are assumed to be constant in the calculations presented here.

Table 17 gives estimates of marginal pollution cost *per kg emissions* for some polluting compounds.

The costs connected to negative effects on health are a dominant cost component for emissions of SO_2 and NO_x. These costs are also high per kg particulate emissions. The calculations indicate that the costs connected to emissions of CO_2 are small. NO_x and particulate emissions are linked mainly to diseases of the respiratory system. Particulates are also carriers of carcinogenic substances, see table 1. The costs of corrosion caused by marginal emissions of SO_2 are low compared with the costs of negative effects on health. The same applies to the acidification costs per kg local emissions of SO_2 and NO_x.

Table 17. Marginal pollution cost per kg emissions. Estimates in 1990 prices

	SO_2	NO_x	CO	Particulates
Total pollution costs	.22.4	89.8	0.0	65.1
Water acidification . .	0.3	0.3	.	.
Forest acidification . .	0.6	0.6	.	.
Negative health effects	17.8	88.9	0.0	65.1
Corrosion	3.7	.	.	.

Marginal pollution costs and road traffic-related costs per litre oil consumption

Based on the specific marginal costs in table 17, an estimate has also been made of the marginal pollution cost *per litre consumption* of some of the most important types of oil, see table 18. The estimates take into account that consumption of the different oil products generates emissions of several polluting compounds. The calculations are based on emission coefficients from 1987.

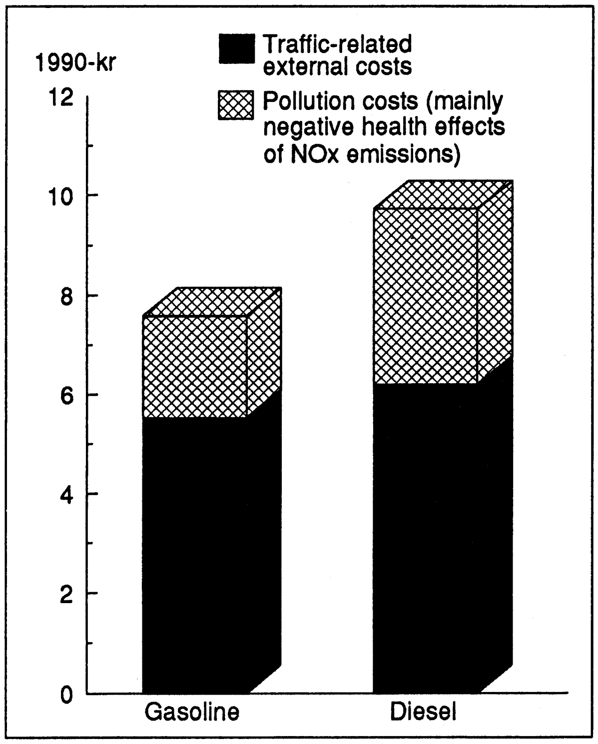
Table 18 also presents estimates of the additional external costs connected to road traffic, i.e. traffic accidents, queues, wear and tear of roads and noise. The estimates are based on data from SFT and TØI. The traffic-related marginal costs are not directly connected to consumption of fuel, but mainly to use of the roads. The original estimates were in terms of NOK per vehicle-kilometre. However, for the sake of comparison they are converted in the table to NOK per litre of consumed transport fuel. Like the estimates for pollution costs, the estimated traffic-related additional costs are uncertain.

The costs are highest for consumption of gasoline and autodiesel and refer in particular to the negative health effects of NO_x. Diesel consumption also causes certain costs connected to negative health effects of SO_2 emissions and particulates. The calculations indicate relatively high external traffic-related costs per litre consumption of gasoline and diesel.

Figure 11 shows the external costs connected to consumption of 1 litre gasoline or diesel in road traffic.

Emissions of NO_x are the main cause of negative effects on health from combustion of kerosene, heating oil and heavy oil. In the case of heavy oil, however, some of the negative health effects are due to emissions of SO_2.

Figure 11. Marginal pollution cost and traffic-related cost per litre gasoline and diesel



As mentioned above, the cost figures in tables 17 and 18 can be regarded as average figures for the whole country. Marginal environmental costs will

Table 18. Marginal pollution costs and traffic-related costs per litre oil product. Estimated in 1990 prices

	Kerosene	Heating oil	Heavy oil	Gasoline	Diesel
Total pollution and traffic-related costs	0.08	0.13	0.47	7.59	9.72
Acidification, SO_2 and NO_x	0.00	0.01	0.02	0.02	0.03
Negative health effects, SO_2	0.00	0.04	0.19	0.01	0.10
Negative health effects, NO_x	0.06	0.07	0.15	2.00	3.26
Negative health effects, CO	0.00	0.00	0.00	0.00	0.00
Negative health effects, particulates	0.01	0.01	0.04	0.03	0.12
Corrosion	0.00	0.01	0.07	0.00	0.01
Total pollution costs	0.08	0.13	0.47	2.06	3.52
Traffic accidents	.	.	.	1.32	1.48
Queues	.	.	.	1.41	1.58
Wear of roads	.	.	.	1.77	1.99
Noise	.	.	.	1.02	1.15
Total traffic-related costs	.	.	.	5.53	6.20

Table 19. Reduction in pollution and traffic-related costs relative to the reference path through implementing international agreements on climate. NOK billion (1987 prices)

	Year		
	2000	2010	2025
Total reduction of costs . . .	12.3	18.2	27.2
Acidification of forests and watercourses	0.1	0.1	0.1
Total negative health effects	5.1	7.0	10.6
Negative health effects, SO_2	0.2	0.3	0.5
Negative health effects, NO_x	4.7	6.4	9.8
Negative health effects, CO .	0.0	0.0	0.0
Negative health effects, particulates	0.2	0.2	0.3
Corrosion	0.1	0.1	0.1
Traffic accidents	1.7	2.6	3.9
Flow of traffic	1.8	2.8	4.2
Wear on roads	2.3	3.5	5.2
Noise from traffic	1.3	2.0	3.0

probably vary considerably with the localization of the emissions, depending on the original concentration of the pollution and the density of the population. The estimates indicate the marginal pollution cost of gasoline consumption to be about NOK 12 per litre, but similar estimates for sparsely populated areas lie under the national average, which is NOK 2 per litre, calculated in 1990 prices.

The basic data used to calculate the damage assume a confidence interval for each estimate. These intervals are fairly big. They indicate, for instance, a confidence interval of NOK 2-18 per litre for the estimate of the marginal cost connected to consumption of gasoline, traffic-related costs included, in 1990 prices.

In spite of this uncertainty, the cost calculations in tables 17 and 18 give some indication of the size of some of the most important external marginal costs. The calculations indicate that the greatest economic benefit is to be obtained from reducing NO_x emissions and improving the organization of road traffic.

Benefits of measures related to climate

The climate policy measures described in the agreement scenario in section 5 imply a lower gross domestic product for this alternative relative to the reference path. However, neither of these scenarios take into account the external costs connected to local pollution and traffic. Using the estimates of marginal costs presented above, calculations have been carried out which indicate the value of a reduction in local pollution and better organization of traffic as a result of the climate policy measures. Table 19 shows the estimated benefit obtained in the agreement scenario relative to the reference path. The assumptions of the two scenarios and their effects on the economy are described in section 5.

Table 20. Changes in GDP in the agreement scenario relative to the reference path. Benefits from reduced emissions in the agreement scenario. NOK billion (1987-prices)

	Year		
	2000	2010	2025
Changes i GDP in the agreement scenario relative to the reference path . . .	-15.5	-17.2	-34.3
Economic gain by reducing emissions in the agreement scenario	12.3	18.2	27.2

The calculations indicate health and environmental benefits in the order of NOK 12 billion (1987 prices) in the year 2000, NOK 18 billion in 2010 and NOK 27 billion in 2025. The greater part of the benefit refers to improved health due to reduced emissions of NO_x and a lower load of road traffic.

In table 20 the benefit of implementing an agreement on climate is compared with the reduction in the GDP in the agreement scenario relative to the reference path. A large share of the lost production due to the climate policy measures is compensated by benefits connected to less disamenity from traffic and from pollution by substances other than CO_2.

Although the calculations are uncertain, they show that there are probably substantial economic benefits to be obtained by introducing measures to reduce CO_2 emissions, over and above the impacts these measures are expected to have on climate.

7. EEC and emissions to air in Norway

The Norwegian authorities' use of environmental policy measures may be affected in future by Norway's relationship to the EEC. Furthermore, the choice between membership of the European Economic Community, an agreement on a European Economic Cooperation Area (EECA) or some other form of association will influence the development of the Norwegian economy, which will in turn affect emissions to air, water and soil.

This section briefly discusses how Norway's relationship to the EEC could affect emissions of harmful substances to the air. There are many issues that have not been clarified as yet with regard to the

EEC policy in the near future. Therefore the following presentation must be regarded as a preliminary summing up of the situation, based on information available at the end of 1990.

According to plan, the EEC's internal market will become effective as from 1 January 1993, a situation which many people expect will lead to stronger economic development in EEC member countries. If this growth leads to larger emissions of sulphur and nitrogen oxides than envisaged if no such internal market were established it will also lead to more acid rain over Norway. It is unlikely, however, that Norwegian adjustment to the EEC will have any marked impact on emissions within the EEC. Therefore the discussion in the following pages focuses on factors which could conceivably influence emissions to air in Norway.

Environmental policy in the EEC and "the four freedoms"

Until quite recently, protection of the environment was a field where each of the EEC countries designed its policy independently of the others. There are still large differences between the EEC countries in this area. In more recent years, however, environmental issues have been considered more as a common concern, and the EEC now takes up common environmental problems to a much greater extent than it did only a couple of years ago. It has been decided to establish a European Environmental Agency with the task of obtaining, coordinating and analyzing environmental data from EEC countries.

In the statutes of the EEC (Treaty of Rome) it is emphasized that all directives relating to harmonization of the legislation of member countries shall be based on a high degree of protection with regard to health, environment, consumer protection and safety. All member countries are free to lay down more stringent rules for the environment than the rest of the EEC, provided that this does not obstruct the principle of free flow of goods.

In addition, there is access to deviate from the provisions concerning free trade if this is necessary in order to take care of important environmental considerations. In such cases, environmental considerations and free trade considerations will be weighed in each individual case by the EEC Court or the EEC Council of Ministers.

A couple of examples serve to illustrate the above situation: Denmark's deposit return system for bottles favoured the Danish breweries, and was therefore said to obstruct trade. The EEC Court accepted the depos it return system, however, although with certain modifications, because it believed that it was motivated by true environmental considerations. In Greece, the authorities wanted to subsidize cars equipped with catalytic converters by a sum far exceeding the cost of the converter. This case ended by a resolution in the EEC Council of Ministers, deciding that the maximum subsidy used by member states could not exceed the cost of the catalytic converter.

When the internal market is introduced in 1993, the intention is to do away with all border control within the EEC. Goods, services, capital and labour shall pass freely between member countries. It will then be difficult, or impossible, to check whether national provisions are complied with. For example, the abandonment of border control will make it easy to import large quantities of goods for sale which do not comply with national quality criteria, or are subject to lower taxes abroad than at home.

The EEC is therefore in the process of coordinating all provisions which require control at internal borders. This affects the regulations in a number of areas, for example, tax policies and measures to prevent spread of plant and animal diseases. Of greatest interest for emissions to air are the rules concerning quality requirements for products, and tax policies.

If Norway joins the EEC, border control between Norway and other EEC countries will be removed. It has not yet been relevant, however, to do away with border control in connection with an EEA agreement. Therefore, an EEA agreement will allow Norway to maintain special Norwegian provisions, for instance, a different tax policy, than would be possible with full membership.

Today, emissions to air from Norwegian industry are regulated mainly by means of permits from the State Pollution Control Authority. There is nothing to prevent Norway from continuing this practice after Norwegian approximation to, or membership of, the EEC. It may well be that more stringent requirements than those imposed abroad might, if considered alone, impair the competitive ability of Norwegian industry. However, for the enterprises themselves it is not the environmental requirements alone but the costs as a whole that are important. In principle, the increased costs due to environmental requirements can be counterbalanced, for example, by reducing the tax on the company, if this is expedient.

Common product requirements

Before the border control is removed the countries will have to agree on rules for labelling of products, quality standards etc. They will also have to agree which agencies are to have the right to approve a product. The principle is that if a product is approved in one EEC country it can also be sold in all other EEC countries. Therefore, as a general rule, product requirements based on environmental considerations must also be common to the whole EEC area.

Probably the most important provisions affecting emissions to air are those relating to exhaust emissions from private cars. Up to now, the EEC provisions in this respect have been less restrictive than in Norway. It now appears, however, that the EEC is going to adopt a new directive on exhaust gases from motor vehicles, leading to EEC regulations based on about the same level of emissions as the Norwegian provisions. However, the measurement and control routines used by the EEC to ensure compliance with the exhaust emission regulations are not the same as used in Norway. This may be of some importance, partly because exhaust emissions from cars vary considerably with the pattern of driving. It is possible that the EEC's measurement routines give more opportunity to manufactures to "tailor make" the cars to comply with the requirements, without this leading to equally small emissions when the car is driven in traffic.

Harmonization of environmental taxes

EEC is working to harmonize the rates of taxes in the different countries. As yet, agreement has not been reached on the size of the tax. This question requires a unanimous decision by the Council of Ministers, and the different countries have different interests in this matter.

If Norway becomes a member of the EEC, the Norwegian rates will have to be harmonized to a large degree with the rates fixed by the EEC. An EEA agreement, on the other hand, will not apply to harmonization of the policy on duties and taxes (at least not to start with). Therefore EEC membership will probably limit freedom of action as far as environmental taxes are concerned. However, whether or not this would imply lower environmental taxes than would otherwise have been imposed in Norway depends on the level of the taxes imposed by the EEC.

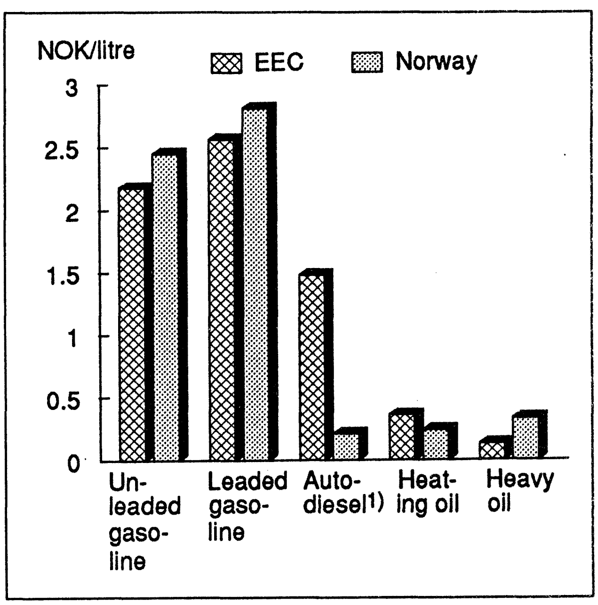
The most recent proposal from the EEC Commission concerning the level of exhaust emissions was presented in 1989, but has not yet been adopted by the Council of Ministers. The proposal includes guidelines for permitted variations in VAT, as well as special taxes on alcohol, tobacco and mineral oils. It is not proposed to harmonize other taxes. The proposal is based on a level equivalent to the approximate EEC average. In the case of gasoline, a minimum limit has been fixed for the tax, but in the case of diesel oil, heating oil and heavy oil it has been proposed that the taxes can vary between a maximum and minimum limit. It is also proposed to fix "target rates", and that member countries shall be allowed to change their taxes only if this brings the tax level closer to the target rate. So far, no specific level has been proposed for these target rates.

It is difficult to compare the rates of taxes in the EEC and Norway, since both updated figures from the EEC are lacking and figures that have been adopted by the Council of Ministers. However, figure 12 presents the rates proposed by the EEC Commission in 1989 compared with the Norwegian rates in the same year. Norwegian taxes on oil products have been increased substantially since that time, a situation which can probably be put down to an increasing will to use environmental taxes. However, a similar change of attitude also seems to have taken place within the EEC, so that it would not be fair to compare the EEC proposal with the Norwegian rates for 1991.

In 1989, the Norwegian taxes on gasoline were somewhat higher than EEC's suggested minimum limits, but the difference is not very big. Denmark, France, Italy and Ireland all had higher taxes on gasoline at that time.

The tax on diesel is difficult to compare, due to the Norwegian tax based on the number of kilometres driven. For an ordinary private car using 1 litre diesel per 10 kilometres the Norwegian diesel and kilometre tax combined was equivalent in 1989 to a tax of NOK 1.69 per litre diesel. This is slightly higher than the interval proposed by the EEC Commission. For consumers of large quantities of diesel, however, (heavy transport and machinery) the tax is lower in Norway.

Figure 12. Special taxes on mineral oils. Proposal from the EEC Commission, December 1989, and Norwegian taxes in 1989. NOK per litre. (Conversion factor: 1 ECU = NOK 7.60)



1) Kilometre tax not included.

The Norwegian taxes on heavy oil were higher than in the EEC proposal, but the tax on heating oil, on the other hand, was quite a lot lower.

There is reason to believe that the EEC Commission will submit a new proposal which will deviate in some respects from the one described above. In December 1990 the EEC Commission presented a working document which discusses use of environmental taxes. The idea seems to be a system involving a general tax on energy, plus a tax on CO_2. The general tax on energy is not to apply to renewable sources, but is otherwise the same for all sources of energy. The CO_2-tax is to be graded according to the size of the emission of CO_2 from the particular source of energy. Nuclear power is subject to the energy tax only. It is proposed that part of the income from these taxes should be earmarked for environmental projects.

Harmonization of taxes and emissions to air in Norway

The Central Bureau of Statistics has analyzed the effects on emissions to air in Norway of possible harmonization of taxes to the EEC level. The analysis was carried out using the MODAG W model. The reference path is more or less the same as used in the SIMEN Project (a study of industry, energy and environment) (SIMEN, 1989). The rates in the proposal from the EEC Commission in 1989 were compared with the rates in Norway the same year. Norwegian tax rates which were not compatible with the EEC Commission's proposal were changed in the model, to bring them within the intervals proposed by the Commission. No other changes were made in relation to the reference path. Thus the analysis refers only to changes in the actual taxes - possible changes as a result of membership of, or adjustment to, the EEC are not evaluated.

In this analysis no typical environmental taxes were changed. The taxes on gasoline did not conflict with those proposed by the EEC, although ideally the taxes on heavy oil and heating oil should have been adjusted. However, changes in the taxes on heavy oil and heating oil pull in different directions, and the model does not distinguish between the two types of oil.

Harmonization of the taxes in 1989 would nevertheless have led to a considerable reduction in the level of Norwegian taxes as a whole, mainly due to a marked reduction in the tax on alcohol and tobacco, and of VAT on a number of important products. This would reduce the price of a number of groups of commodities, and would lead to a change in both the level and mix of production and consumption. This in turn could change the pattern of emissions. Therefore it is quite feasible that a harmonization of taxes (in isolation) could lead to a higher (or lower) level of emissions, even if the harmonization did not affect any typical environmental taxes.

Two alternatives were considered: In the first, the changes in taxes led to large loss of income to the public sector, but in the second alternative the lower taxes were neutralized by a higher property tax and reduced transfers to the private sector. Neither of these alternatives led to any substantial increase in emissions. After a ten-year period emissions of NO_x, SO_2 and CO_2 were about 1-2 per cent higher than in the reference path.

General economic development

Increased economic growth in the EEC will lead to more environmental problems unless the degree of cleaning and other measures is increased at the same time, or changes take place in the composition of production and consumption. In 1989, a working group appointed by the EEC Commission (Task Force on the Environment and the Internal Market, 1989) presented a report on the environmental impacts of the internal market. It is estimated that, given no new environmental measures, the introduction of the internal market will lead to a level of SO_2 emissions from the EEC countries in the year 2010 about 8-9 per cent higher than would otherwise have been the case. Emissions of NO_x are estimated to be 12-14 per cent higher in 2010 with an internal market than without one. As mentioned above, these estimates assume that no new environmental measures are introduced, which is a very unrealistic assumption in today's situation.

The task force concluded that changes in the composition of industry are more likely to exacerbate the environmental problems than solve them. This is to a large degree due to the expected large increase in road transport.

It is difficult to say whether such a conclusion is also applicable in Norway's case. Participation in the internal market (as a member of the EEC, or not as a member) will probably lead to increased reciprocal trade and more road traffic. However, it is by no means certain whether the individual sectors of Norwegian industry will gain or lose by the introduction of the internal market. This will depend on whether or not they are able to compete with foreign companies. There are large differences in the extent of pollution from the different sectors, and a shift in the composition of industry will therefore strongly influence emissions - in a positive or negative direction. The extent of the increase in road traffic will depend on developments in other industries which use the services of the transport industry.

Conclusions

The environmental policies of the EEC and of Norway are not very different. On certain points, e.g. requirements for labelling and use of toxic and/or carcinogenic chemicals, the Norwegian regulations are more stringent than those of the EEC. In other areas, e.g. industrial contingency preparedness against serious accidents, and protection of birds, the EEC regulations are more restrictive. As far as provisions concerning emissions to air are concerned, it seems as if the regulations in the EEC and in Norway seldom conflict. Extensive emissions to air from Norwegian companies are regulated at present through discharge permits from the State Pollution Control Authority, and this practice does not present a problem in relation to the EEC regulations.

If Norway chooses to adjust to the EEC through an EEA agreement, it is unlikely that any extensive harmonization of taxes will be necessary. In the case of Norwegian membership of the EEC on the other hand, Norwegian taxes will probably have to be harmonized with those applying in the EEC. This will not, however, lead to lower environmental taxes in Norway if the EEC maintains a lower level than desired by Norwegian politicians. The EEC tax policy has not yet been decided but, in the light of present indications it is not an obvious conclusion that harmonization of Norwegian taxes to the EEC level would imply lower taxes.

Another point is that if Norway became a member of the EEC it would be difficult to stipulate more stringent criteria for exhaust emissions from motor vehicles in Norway than in the rest of the EEC. However, the exhaust emission criteria which are expected to be approved by the EEC are about the same as those which apply in Norway at present.

The choice of type of association with the EEC may affect both economic growth and the composition of industry in Norway. There are large differences in the extent of pollution from the different industrial sectors, so that a shift in composition could be decisive for changes in the level of emissions. More comprehensive macroeconomic analyses are required before it is possible to state whether membership of the EEC, an EEA agreement, or staying outside the EEC internal market, will lead to the lowest emissions to air in Norway.

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Economic Survey

Issued quarterly.
Subscription price NOK. 120,
single copy NOK. 30.
Inquiries and subscription orders should be sent to Information office in the Central Bureau of Statistics. The publications are issued on commission by H. Aschehoug & Co. and Universitetsforlaget, Oslo, and is also available through booksellers.

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ISBN 82-537-3035-7
ISSN 0800-4110