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SIMEN

Studies of Industry, Environment and Energy towards 2000

by

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Abstract

This paper describes an attempt to analyze the question of how to control air pollution, without hampering further economic growth. The analytical framework is a macroeconomic planning model, extended with a submodel for air pollution. Taxes on petroleum products for heating and transportation purposes are substantially increased, with the aim of stabilizing Norwegian emissions of CO_2 and simultaneously decrease the emissions of SO_2 and NO_x. This policy change is analyzed under the restriction of balanced government budgets. The increase in revenue from the taxation of petroleum products, is counteracted by an equivalent reduction in taxes or wage income. On average this leaves production costs and competitiveness unchanged and contributes to a more efficient use of the labour force and energy.

Preface

The Norwegian Ministry of Industry initiated the SIMEN-project[1] in the spring of 1988 as a follow-up of the report from the World Commission on Environment and Development. The aim of the project was to evaluate the possibilities for industrial growth towards 2000, under different restrictions on pollution and different assumptions on domestic energy supply. Is it possible to pursue an ambitious environment policy and simultaneously achieve an acceptable economic growth? Which policy instruments should the authorities choose to modify possible target conflicts? To address these questions, it is essential to analyse the links between energy consumption and pollution in a macroeconomic setting, where the interplay between different sectors of the economy is explicitly taken into account. This report, which gives a summary of the SIMEN-project, therefore presents analyses of the whole economy - not only of industrial development.

In addition to this main report, the SIMEN-project comprises 9 sub-reports. The sub-reports discuss the prospects for some manufacturing industries in greater detail; the power intensive industries and the pulp and paper industry. In addition the sub-reports discuss issues as domestic consumption of natural gas, costs and effects of new environmental restrictions and the use of different instruments in environment and energy policies.

The state secretaries of the Ministry of Finance, the Ministry of Environment, the Ministry of Industry and the Ministry of Petroleum and Energy have acted as steering committee for the SIMEN-project. The day to day follow-up of the project has been conducted by a project group of civil servants from the same four ministries. The Central Bureau of Statistics has coordinated the SIMEN-project and had the professional responsibility for the main report. The sub-reports have been elaborated by the Resource Policy Group, the Institute of Industrial Economics, the State Pollution Control Authority, Center for Applied Economic Research at the University of Oslo and the Central Bureau of Statistics. Altogether the research effort adds up to three man years, sponsored by the participating ministries, see Appendix 1 on the organization of the SIMEN-project.

The project has benefited from informal contacts with organizations and individuals from several industries. The SIMEN-reports are therefore a result of a

[1]SIMEN is a Norwegian acronym for "Studier av Industri, Miljø og Energi"; i.e. "Studies of Industry, Environment and Energy".

cooperation between politicians, civil servants, researchers and industrialists. The experience with this kind of cooperation in the SIMEN-projects has been positive. The political "steering" has not interferred with the "professional integrity".

Several staff members of the Research Department of the Central Bureau of Statistics have contributed to the completion of the SIMEN-project. The main report is written by Brita Bye, Torstein Bye and Lorents Lorentsen. Knut Alfsen, Anne Brendemoen, Ådne Cappelen, Solveig Glomsrød, Torgeir Johnsen and Trond Sandmo have contributed with calculations and comments, while Elisa Holm and Anne Strandli have typed and edited the manuscript. The authors wish to thank all participants of the SIMEN-project for constructive cooperation.

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1 Introduction and summary

1.1 Background for the analyses

The Norwegian economy has for more than 10 years been strongly influenced by the increasing petroleum activity on the Norwegian Continental Shelf and a high level of domestic use based on petroleum incomes. The economy has become steadily more vulnerable to changes in petroleum incomes. This was clearly demonstrated by the fall in the oil-prices in 1985-86, which resulted in great deficits on the current accounts.

It is a central target for Norwegian economic policies to reduce the dependency of petroleum incomes and to increase production in other competing sectors, among others in the manufacturing industries. Such a restructuring is only possible if the profitability of competing industries is improved. Investments and know-how which otherwise would have been channeled to sheltered sectors or petroleum activities have to be transferred to competing industries to increase production capacity.

The report from the World Commission on Environment and Development (Brundtland-Commission) has greatly improved the general awareness of the links between economic growth, energy consumption and pollution. The report points out that if the economic growth continues and the composition of production and consumption is not radically changed, unacceptable environmental damages might occur. Emissions of substances like sulphur dioxides (SO_2) and nitrogen oxides (NO_x) already exceed nature's absorption capacity. Increased concentration of greenhouse gases in the atmosphere, among others carbon dioxid (CO_2) , might lead to global warming and unpredictable climatic changes. Emissions of greenhouse gases should therefore be restricted.

The Brundtland-Commission describes a sustainable development as a process of economic growth which does not deteriorate natural resources and the environment for future generations. This will also be a guideline for Norwegian policies. Norwegian industries will therefore, in the years to come, have to comply to new restrictions on pollution, partly as a result of international agreements and partly as a result of specific Norwegian targets.

Norway has signed international agreements on reduction of emissions of sulphur dioxides, nitrogen oxides and chlorofluorcarbons to air, and toxic waste, phosphorous and nitrogen to exposed parts of the North Sea. The State Pollution Control Authority has elaborated a list of 13 toxic substances which should be reduced by 60-90 percent the next 5 to 6 years. International agreements on reduction of greenhouse gases is under preparation. A future agreement will most likely include reductions in emissions of carbon dioxid (CO_2), as the major and easiest controlable source to the greenhouse problem.

The report from the Brundtland-Commission gives recommendations on energy policy which basically is deduced from the targets to reduce emissions of pollution from fossil fuels. International agreements on such reductions will have consequences also for Norwegian energy policy.

1.2 Purpose. Target groups

The analyses of the SIMEN-project focus especially on the effects on the Norwegian economy of a possible convention on reductions of CO_2 emissions, in addition to effects of the international agreements Norway have already signed on reductions of emissions of SO_2 and NO_x.

It is necessary to restructure industries, change accustomed consumption patterns and to use improved technology to achieve an acceptable economic growth, reductions of pollution and more efficient energy comsumption simultaneously. Introduction of new and tougher environmental restrictions will, however, lead to increased costs for industries, making it difficult to achieve the structural changes necessary for economic growth, balance on the current accounts and a satisfactory development in the labour market. There is a possible target conflict between less pollution and increased production and consumption in the short run.

The SIMEN-scenarios are based on evaluations of market developments for different industrial sectors, and of how quickly restructuring and introduction of new technology can be achieved. Attention has also been paid to the evaluation of which policy instruments that seem necessary to reduce pollution without unnecessarily constraining further economic growth.

Economic development must be managed such that the environment is preserved as a basis for future production and consumption. This means a change in traditional ways of thinking, towards more emphasis on coherent and long term issues.

The politicians have shown interest for the SIMEN-project since they are concerned with bringing forward realistic alternatives for social and economic development. Which development paths for the Norwegian economy are sustainable, and which policy instruments will have to be applied to achieve such a development?

Civil servants are responsible for elaborating background material for planning and policy decisions. The follow-up of the Brundtland-Commission's report demands coordination of activities between different ministries, when elaborating planning documents. Preliminary results from the SIMEN-project were used as background material for the Government's Long Term Programme 1990-1993, a

White Paper on industrial policies and a White Paper on the follow-up of the Brundtland-Commission.

For the business community, restrictions on pollution and demand for more efficient energy use mean changes in external conditions and competitiveness. It is important that changes in external condtitions are announced in advance such that firms can take these changes into account in their investment decisions. Even if measures to improve the state of the environment give social gains in the form of improved environment, better health, improved productivity and less capital depreciation - they also in the short run imply costs for the firms and for the society. Environmental restrictions also give possibilities to develop and market new products. Also this aspect of the follow-up of the Brundtland-Commission is of interest to the business community.

1.3 Follow-up of the SIMEN-project

The SIMEN-project was completed within a few months, with a total research effort of three man years. Some of the issues which have been raised in the project are fairly thoroughly discussed, whereas other important issues are hardly mentioned in passing. The SIMEN-project can therefore be followed up in several ways.

For the research community, the work on the SIMEN-project has increased the recognition that the analytical methods and models developed and used for traditional economic planning are not well suited for analysis of the relatively profound social changes that the Brundtland-Commission seems to imply.

The issues raised in the Brundtland-Commission's report are genuinely multidiciplinary. The SIMEN-project has to some extent combined social science, natural science and technological knowledge. This kind of multi-diciplinary cooperation has little tradition in Norwegian research. Both deficiencies of the analytical tools and problems with combining information from different professional groups make the conclusions of the SIMEN- project basically qualitatively. They only indicate direction and magnitude, even though they are based on quantitative analyses. The experiences from SIMEN show that the models and the cooperation between different diciplines should be further developed.

An adequate analysis of economic development and environmental issues should include all sectors and all important pollutants in one framework, and at the same time draw on sectoral information. The SIMEN-project has applied sectoral information on manufacturing industries in macro-economic analyses. For several manufacturing industries the information has been deficient, especially the information on technological development and costs of different solutions to environmental problems.

Pollution from the transportation sector is a source to several increasing environmental problems, in a Norwegian context far more severe than the environmental problems caused by manufacturing industries. It will therefore be of great interest to investigate the possibilities to develop and use more energy efficient vehicles, possibly using other mobile fuels than today. The level and composition of transport demand from households and industries are strongly dependent on the localization of work and dwelling areas, and of the supply of public transport. These issues are only rudimentary treated in the SIMEN-project.

The follow-up of the Brundtland-Commission is a prosess which demands a day-to-day comprimising between traditional economic policy, energy and environmental policies. In this process it is important to avoid short term and costly measures against single problems. Instead one should try to manage different environmental problems simultaneously and use measures which contribute to a long term solution of the problems. A cooperation between researchers, industrialists, civil servants and politicians as in the SIMEN-project can contribute to this.

1.4 Summary of the report

Chapter 2 gives a brief overview of the development of the Norwegian economy, energy consumption and emissions of selected pollutants the last 25 years. Chapter 3 discusses the challenges of energy and environmental policies, as seen from today. Chapter 4 deals with the prospects for some of the traditional manufacturing industries. These chapters give background information for the macro-economic analyses of chapter 5.

Norwegian economy, energy consumption and pollution 1962-1988

Seen in a historic perspective the economic growth of the western world was unusually high and stable in the postwar period up to 1973. The economic growth induced major changes in the composition of industries, also in Norway. Primary industries' share of total production and employment were sharply reduced, and there was a strong growth of production and employment in the service sectors. Manufacturing industries' share of total employment has been steadily reduced since the 1950s, and the share of total production has stagnated or declined since the early 1970s.

In Norway the economic growth in the period 1973-86 was higher than in most other OECD-countries and unemployment was extremely low compared to international standards. This unique Norwegian economic growth was mainly due to petroleum incomes, which made it possible to maintain a strong growth in domestic use of commodities and services. Prices and costs have grown faster than the OECD average in the 1980s.

After the fall in oil prices in 1985-86, the economic policies in Norway were tightened to curb domestic use of commodities and services. The rest of the OECD area has enjoyed a relatively strong economic growth after 1986, led by a boom in investment demand. This has led to high product prices and high capacity utilization for traditional, Norwegian export competing industries. Combined with a gradual reduction of imports, this has improved the current accounts with more than 20 billion NOK during 1987-88. (Norway's GDP was 527 billion NOK in 1987). Reduced domestic demand has also increased unemployment, and there are few signs of a transfer of resources from sheltered to competing industries.

Up to 1973 the growth in energy consumption, both electricity and oil products, grew faster than gross national product. Relatively low increases in energy prices combined with the expansion of power intensive industries in the 1960s, increased use of energy in services and households and a strong growth in road transport, contributed to increased energy consumption per unit of gross national product.

The increase in oil prices in 1973-74 and 1979-80 resulted in a sharp reduction in the consumption of oil per unit of gross national product. This was partly due to a switch from the use of oil to the use of electricity for heating purposes, partly a result of the introduction of more energy efficient technology i.e. in the transportation sector. The price of electricity to the primary market has also increased since the end of the 1970s. Higher energy prices, technological improvements and changes in the composition of industries reduced total energy consumption per unit of gross national product by 20 percent from 1973 to 1986.

The fall in the crude oil prices in 1986 gave a sharp reduction in kerosene prices, but only a moderate decline in gasoline prices due to the adjustment of taxes. Despite the fall in kerosene prices, the consumption has fallen the last few years, whereas the consumption of transport oils and gasoline have increased somewhat. The growth in electricity consumption has been lower the last two years than in the early 1980s, due to industry changes, relatively high price increases in the primary market and mild winters.

In the ten-year period 1974-84 the State Pollution Control Authority run a cleaning program in the manufacturing industries, mainly aiming at reducing emissions of pollution to water and air from some large enterprises. The investment costs of the cleaning program have been estimated to 5-8 billion 1985-NOK.

The total emissions of SO_2 increased sharply up to the beginning of the 1970s. Thereafter the emissions were reduced by 80 per cent from 1970 to 1986 as a result of increased oil prices and therefore a switch to the use of electricity, introduction of regulations against emissions from single firms and gradually stronger regulations of the sulphur contents in heavy oils.

The emissions of NO_x where tripled from 1962 to 1986, mainly due to increased transportation activities. Control measures against NO_x emissions have only been in effect since 1989 when all new private gasoline cars should be equipped with a catalytic cleaner.

The growth of CO_2 emissions has been hampered by higher oil prices. Increased transportation activities contributed, however, strongly to the doubling of CO_2 emissions in the period 1962-86. So far, no control measures aim at reducing CO_2 emissions.

Challenges in environmental and energy policies

The report from the World Commission on Environment and Development discusses the development of natural resources and the state of the environment in a global prespective. The Commission focuses on the possible dangers of an increased strain on renewable and conditionally renewable resources. The Commission is especially concerned with the limited capacity of the atmosphere and the ocean areas to absorb residual gases from combustion of fossil fuels and other pollutants. The combustion of fossil fuels releases carbon dioxides (CO_2), which is one of the major sources to the greenhouse problem. Fossil fuels are also a major source to emissions of sulphur dioxides (SO_2) and nitrogen oxides (NO_x) which contribute to the acidification of water and soil, which in turn might lead to damages to human health, loss of species and corrosion costs.

The Brundtland-Commission finds it both possible and necessary to sustain the economic growth in industrialized countries and at the same time substantially reduce energy consumption - first and foremost the consumption of fossil fuels. The reason for this "recommendation" is primarily the pollution which follows from the use of fossil fuels, but also the concern for the management of depletable energy resources.

The emissions of SO_2 can be reduced to an acceptable level by control measures which does not require new technology. There are also several ways of reducing the emissions of NO_x, but it seems more difficult to achieve large reductions in the short run. The control measures against NO_x can not be expected to give full effect until much of the existing capital equipment is replaced.

The greatest challenge to international environmental policies is probably to find measures to reduce the releases of greenhouse gases like carbon dioxide and methane (CH_4). There are available technology to clean CO_2 emissions, but the technology can only be applied for large point sources and is at the moment extremely costly. Therefore, only a reduction of the consumption of fossil fuels can bring the emissions of CO_2 down to an acceptable level.

Norway has in the last 2-3 years signed several international conventions on reduction of emissions:

- *30 percent reduction of SO_2 emissions by 1993, compared to the emission level in 1980. The government's target is to reduce emissions by 50 percent over the same period.*
- *Stabilizing emissions of NO_x at the 1987-level by the end of 1994 and a declaration that Norway will aim at a 30 percent reduction by the end of 1998.*
- *50 percent reduction of emissions of chlorofluorcarbons (CFC) by 1991 and 90 percent by 1995.*
- *50 percent reduction of emissions of toxic wastes, nitrogen and phosphorous to exposed parts of the North Sea by 1995 compared to 1985-levels.*

There are good reasons to believe that the development of international agreements on reductions of national emissions will continue. New agreements will appear and existing agreements will be renegotiated. An international agreement on 20 percent reductions of CO_2 emissions by the year 2005, has already been proposed and discussed. This is a relatively moderate proposal compared to the Brundtland-Commissions report which indicates that the industrialized countries should reduce their consumption of energy (fossil fuels) by 50 percent whithin 30-40 years.

It is certainly not reasonable that a small country like Norway should start reducing emissions of CO_2 on a unilateral basis. There are, however, several arguments for the interest in calculating the consequences such an agreement could have on the Norwegian economy:

- Norway has been one of the most active countries in the international work, arguing for the benefits of reductions of pullutants, not least through the work of the Brundtland-Commission. The signal effect of a national solution is therefore important, and might strengthen Norway's credibility.
- It is important to analyse the consequences of an agreement before the agreement is signed.
- Even though the emissions of greenhouse gases like CO_2 is an international problem, a reduction of domestic use of fossil fuels will have significant positive impacts by a reduction of local pollutants like SO_2, NO_x and particles. Thus, there are good reasons to reduce emissions other than as a contribution to solving global problems.

Administrative or regulatory instruments are the dominating control measures in Norwegian pollution policy today, whereas economic instruments are hardly used. Both types of instruments have their strong and weak sides. Two important evaluation criteria for all instruments are to which extent they give the authorities control over the amount of emissions (target efficiency), and if they lead to reductions of emissions at the lowest cost (cost efficiency).

Emission charges seem adequate when the damages are independent of where the emissions occur, and if there are many pollutants which otherwise could not easily be controlled. I.e., indirect taxes or charges seem adequate as instruments to reduce the emissions of carbon dioxide, which causes no local damages, but contributes to the greenhouse effect irrespectively of where the emissions occur.

SIMEN gives a scenario where the indirect taxes on fossil fuels are sharply increased. The indirect taxes which correct for external effects will also give public revenues. This revenue will reduce the need for other taxes which have distortive effects on the economy. In total, a change of the tax system from direct income taxes to environmental taxes, given tax level, will contribute to a more efficient use of resources in the economy.

Prospects for selected manufacturing industries

As a background for evaluating possible development paths towards 2000, the SIMEN-project includes several analyses of different manufacturing industries.

The focus has been on traditional, energy intensive, export competing industries, e.g. production of aluminium, ferro alloys and pulp and paper.

The analyses of the aluminium and ferro industries, based on micro-data, reveal great differences in the productivity of individual firms. The input of labour per unit of production varies by 30 percent in both industries. Energy efficiency varies in the same range.

By expanding the capacity of existing firms, both labour and electricity can be used more effeciently, and costs per unit of production can be significantly reduced. It is therefore assumed that at present factor prices there are some possibilities for growth in the capacity of existing firms towards the end of the century.

These tentative conclusions are heavily dependent on the price of electricity in future and renegotiated contracts. Production costs in new firms, based on 1983-contracts for electricity, are significantly higher than the costs of expanding existing capacities.

Industry, environment and energy in a macro-economic perspective

Chapter 5 presents several scenarios for the Norwegian economy towards 2000, based on different assumptions on energy supply and environmental restrictions.

The Reference scenario

The economic development of the Reference scenario is somewhat more pessimistic than in the Governments Long Term Programme 1990-1993. This is mainly due to different assumptions on oil and gas prices (20 $ 1988-prices per barrel in 2000 in SIMEN, and 25 $ per barrel in the Long Term Programme). In addition the oil production is assumed to decrease faster at the end of the 1990s in SIMEN in the Long Term Programme. Due to lower oil revenues the economic policies are less expantionary in SIMEN than in the Long Term Programme.

The calculations are for the next few years characterized by a low increase in domestic use of commodities and services and a moderate growth in the production in mainland Norway. This should be seen in the context of the extremely high growth of domestic use in the period 1984-87 and the belt-tightening after the fall in oil prices in 1986.

For the 1990s, the calculations show and average annual increase of 2 per cent in gross domestic production for mainland Norway. It is assumed that the domestic price and cost increase is lower than for the OECD area, such that Norway's competitiveness is gradually improved. The current accounts show balance from 1991 and a surplus for the rest of the 1990s. Norway's net foreign debt is therefore increasing the first few years, but is repaid by the year 2000. The calculations show an unemployment rate at the 1988-level until the middle of the 1990s, but unemployment is slightly reduced towards the turn of the century.

The increase in crude oil prices give an increase in real prices of oil products and gasoline of about 5 percent over the period 1986-2000. It is assumed that energy efficiency will improve by 0.5-1 percent per year in manufacturing industries and road transport.

Total domestic use of electricity increases from 100 TWh in 1986 to 114 TWh in 2000. The power intensive industries are assumed to use 30 TWh per year over the whole period. The use of heating oils grows by 10-12 percent, whereas the consumption of transport oils grow by approximately 20 percent during the calculation period.

In the Reference scenario, no strong restrictions on energy or environmental policies are imposed. The alternative shows what the consequenses might be if todays environmental policies are continued. Even if the Reference scenario is characterized by a modest economic growth, the increase in activity levels lead to an increase in energy consumption and a relatively rapid growth of emissions of SO_2 (18 percent), NO_x (5 percent) and CO_2 (20 percent) over the calculation period.

The effects of higher oil and gas prices

There is great uncertainty about the development of the crude oil prices on the world market. With the Reference scenario as a starting point, the impacts of higher oil and gas prices are calculated, (25 $ 1988-prices in the year 2000). Higher crude oil prices will immediately improve Norway's external balance, but higher crude oil prices will also effect the level and composition of energy consumption and pollution.

In the calculations, higher oil prices lead to a switch from oil to electricity. Electricity consumption increases by approximately 3 TWh and the oil consumption decreases accordingly. This induces a reduction in the emissions of SO_2, NO_x and CO_2 compared to the Reference scenario. If the increased electricity demand is covered by gas power, the CO_2 emissions will increase instead of decrease compared with the Reference scenario. Higher crude oil prices will give a significant improvement of the current accounts. In the calculations, Norway's foreign financial assets amounts to approximately 20 percent of gross domestic product in 2000, measured in current prices. This will allow for a more expantionary economic policy and lower unemployment rates than in the Reference scenario.

The Gas scenario

In this scenario, the possible consequences for economic activity, energy consumption and pollution from increased utilization of Norwegian gas resources are calculated. It is assumed that exports of natural gas to Sweden is combined with domestic power production and use of gas for industrial purposes.

The calculations assume the construction of a gas pipeline with a capacity of approximately 6 billion Sm^3 from Western-Norway to Eastern-Norway and further to Sweden. Up to 1995 this will lead to higher investments in gas pipelines, distribution net-work and gas fired power stations.

Given the idle capacity in the Norwegian economy, increased investments will lead to increased domestic activity level, incomes and household consumption. Higher domestic activity levels also increase imports and deteriorate the external balance compared to the Reference scenario up to the end of the 1990s. Lower domestic energy prices, which follows from the increased energy supply, thereafter improves the competitiveness of Norwegian industries and the export of traditional commodities increase. In the last years of the decade, the direct export of natural gas to Sweden gives higher incomes. In 2000, the calculated gross national product in the Gas scenario is approximately 1.5 percent higher than in the Reference scenario. The external balance is almost unchanged in the year 2000 compared to the Reference scenario. The economic benefits from an increased depletion of natural gas resources will, however, be more significant after the turn of the century.

Lower prices on electricity give an increase in electricity consumption (net) of approximately 10 TWh compared to the Reference scenario. The consumption of oil products is reduced due to a switch to electricity. After 2000, direct use of natural gas can replace some of the remaining consumption of oil products.

In 2000 the emissions of SO_2 are lower than in the Reference scenario due to lower consumption of heating oils. The effects on NO_x-emissions are almost insignificant in this scenario, whereas CO_2 emissions increase by 5-6 million tons, mainly as a result of increased gas power production.

The Environment scenarios

The calculations of the two Environment scenarios, the Regulation and the Tax scenario, illustrate two different policy approaches.

The Regulation scenario discusses which reductions of SO_2 and NO_x can be achieved by regulatory measures against individual firms, stronger restrictions on sulphur contents in oils and new technical restrictions on vehicles. For SO_2, it is possible to achieve substantial reductions in emissions by lowering the sulphur contents in oils and by regulatory measures against large enterprises. For NO_x, actual regulatory measures will give relatively small percentage reductions in total emissions. The proposed packages of short-term measures against single pollutants might also be quite costly - and lead to wasted investments - if in the longer term it is necessary to use more general instruments to reduce the consumption of fossil fuels. None of the proposed measures will reduce the emissions of CO_2.

The agreements already signed on reductions of emissions of SO_2 and NO_x, give upper bounds on the emission levels after 1993 and 1998 respectively. It is probable that future renegotiations of these agreements will imply further restrictions on emission levels. In addition, there are reasons to expect increased attention on global environmental problems like the greenhouse effect and therefore on CO_2 emissions. When evaluating different measures which can contribute to achieving environmental targets, it is therefore important to evaluate measures against these three components simultaneously. A discussion of instruments which can contribute to influence or break the links between economic growth and the consumption of fossil fuels in a longer term perspective are therefore central in the Tax scenario. The prices of fossil fuels are essential both for the choice of energy carrier and also as an incentive to develop new technology.

The Tax scenario discusses how the increase in taxes on fossil fuels can be used as instruments to reduce SO_2 and NO_x emissions and stabilize CO_2 emissions. The indirect taxes on gasoline, heating and transport oils are gradually increased such that the prices are approximately 75 percent higher than in the Reference scenario in the year 2000.

The increase in indirect taxes on fossil fuels are compensated with reductions in direct taxes, and government budgets are almost unchanged after these revisions of the tax system. In the calculations, taxes on wage incomes are reduced, and some transfers to households are increased.

It is assumed that the price increases on energy will spead up the introduction of energy efficient technology. In the calculations the energy intensity in all production sectors (with the exception of metal production), is reduced by 1 percent annualy from 1992 compared to the Reference scenario. This will lead to a reduction in energy consumption by 8 percent up to 2000. It is further assumed that such an improvement of energy efficiency is only possible with a more rapid replacement of capital equipment than in the Reference scenario. The assumptions on improvements of energy efficiency and the estimates of increased costs in a transition period, are of course highly uncertain.

In the calculations, the total effects on main macro-economic variables are small compared to the Reference scenario. There are several reasons for this. The budget share for energy is relatively low in most sectors and the indirect tax increases are compansated by reductions in direct taxes on wage income. Reductions in direct taxes are assumed to reduce nominal claims on wage increases. The change of the tax system from direct to indirect taxation thus leads to small changes in production costs for most sectors. At the same time, the productivity of the economy is increased by introducing more energy efficient capital equipment.

This combination of instruments reduces the use of fossil fuels without hampering continued economic growth. In addition, the reductions of emissions will give positive effects in the form of better health, less corrosion costs and a cleaner environment, which is not reflected in the calculations. There are, however, good reasons to underline that a major change of the tax system can effect production and incomes in single firms and regions more substantially than these calculations show.

To cover the increased demand for electricity in this scenario, it is assumed that the hydro power system is expanded faster than in the Reference scenario. This will lead to higher marginal costs of hydro power production, and the real price of electricity will be 10 percent higher in the Tax scenario than in the Reference scenario in 2000.

The total consumption of electricity increases by almost 5 percent or 5 TWh compared to the Reference scenario. This increase is due to higher demand in the primary market. The power intensive industries are assumed to maintain their electricity contracts from the Reference scenario.

The consumption of heating oils and gasoline is reduced by 35 and 19 percent, respectively, while the consumption of transport oils decrease by approximately 14 percent compared to the Reference scenario in 2000. The reduction in gasoline and transport oil consumption can partly be seen as a result of more energy efficient vehicles, reduced use of private cars and better capacity utilization in road transport.

Increased prices of energy lead to an increased potential for energy economizing. Better organization of the electricity market, restructuring of old power plants, improvements of the distribution and transmission networks, increased use of heat pumps etc., can probably increase significantly the capacity of the existing hydro power system at the prices which are assumed in the Tax scenario. This potential is not harvested in the calculations.

The emissions of SO_2 are 82 kilotons in 2000, reduced by 22 kilotons compared to the Reference scenario due to lower consumption of fossil fuels and a switch to oils with lower sulphur contents. The percentage reduction is largest for heating oils, (stationary combustion) where the SO_2 emissions are reduced by close to 50 percent.

The total emissions of NO_x are 223 kilotons in 2000, 35 kilotons lower than in the Reference scenario and 22 kilotons lower than in 1987. The largest percentage reduction of NO_x emissions compared to the Reference scenario is in stationary combustion, while the absolute reduction is largest for mobile sources.

In the Tax scenario, the CO_2 emissions are stabilized at 1987 level. Total emissions of CO_2 in 2000 is 36 million tons compared to 43 million tons in the Reference scenario. The emissions from industrial processes are higher in 2000 than in 1987 since these emissions are linked to the production level in polluting industries. The emissions from mobile sources are reduced at the same rate as the reduction of mobile fuels.

To achieve the Goverments target on 50 percent reduction in SO_2 emissions, it seems necessary to introduce new regulations against single firms, in addition to the increase in indirect taxes. The Government's target of 30 percent reduction of NO_x emissions within 1998 seems quite difficult to achieve without policy measures that induce technological changes in ocean transport and fisheries, in addition to new restrictions on road transport.

1.5 Conclusions

The macro-economic calculations indicate that it will be possible to achieve balance on the current accounts in the early 1990s and to repay the external debt by the end of next decade. The conditions are that productivity is increased and that domestic increases in prices and costs are lower than in competing countries, such that the Norwegian competitiveness is improved.

The greatest challenge to environmental policies seems to be a stabilization or reduction of CO_2 emissions, since that requires a reduction in the consumption of fossil fuels. However, a reduction in fossil fuels will also give reductions in the emissions of NO_x and SO_2.

The calculations indicate that it is possible to maintain an acceptable economic growth combined with compliance to international environmental agreements, through a combination of economic and regulatory instruments. Calculated main economic indicators like gross national product and total consumption, vary almost insignificantly between different scenarios, while the restructuring of the tax system from direct wage taxes to environmental charges gives significant environmental gains.

It should be underlined, though, that the proposed changes of the tax system are relatively dramatic. In the Tax scenario the indirect taxes on oil products are increased by 10-12 billion NOK, combined with a similar reduction in wage taxes. It is therefore questionable if the applied model has captured all the consequences of the restructuring of the tax system. The consequences for production and incomes of single firms and industries, and hence for the total economy, can be larger than the calculations indicate.

Energy consumption and emissions to air are quite different in the different scenarios. In the Tax scenario, the consumption of fossil fuels are stabilized, but the total domestic energy consumption grows by approximately 7 percent from 1987 to 2000. Even with a sharp increase in energy prices, it seems difficult to stabilize energy consumption.

The emissions of SO_2 is approximately 82 kilotons in 2000 in the Tax scenario, included emissions from ocean transport and petroleum activities. This is 45 percent lower than the 1980 level. The agreement on 30 percent reduction from the 1980 level is thus clearly within reach.

The emissions of NO_x in the Tax scenario is 10 percent lower in 2000 than in 1986. The declaration on 30 percent reduction of NO_x emissions will thus not be achieved without stronger restrictions on road and ocean transport.

The emissions of CO_2 are stabilized in the Tax scenario relative to the 1987 level, but it seems quite difficult to achieve a sustained reduction in CO_2 emissions, without new technological solutions, especially in the transportation sector.

If economic growth is increased compared to the SIMEN calculations, the challenges to the energy and environmental policies will increase - given energy technologies. On the other hand, higher economic growth will also improve the ability to carry costly environment programs, including energy research, and increase the possibilities for industrial restructuring.

In addition to the instruments analysed in the SIMEN-project, there are several measures which could contribute to a reduction in fossil fuel consumption and hence give less pollution, especially of NO_x and CO_2. Some measures are:

- Improve land use planning to reduce the need for transportation between dwelling areas, workplace, shops, kindergardens and other service institutions.

- Improve the supply of public transport in urban areas

- Differentiate sales taxes on motor vehicles by energy efficiency

- Improve the efficiency of the electricity market; equalization of prices between different consumer groups, peak load pricing, rationalization and better organization of supply units. A more efficient use of hydro power resources will reduce the need for production of electricity based on natural gas

- Reduce the growth of transportation by regulatory measures

- Improve the possibilities for using natural gas directly as a substitute for oil for heating and transportation purposes.

2 Norwegian Economy, Energy Consumption and Pollution 1962-1988

2.1 Introduction

Seen in a historic perspective, the economic growth of the western world was high and stable in the post-war period up to 1973. The increase in the Norwegian gross national product was on line with the increase in the other European OECD-countries up to the beginning of the 1970s. While the economic growth in these countries decreased markedly after 1973, it continued in Norway up to 1986. This unique Norwegian economic growth was mainly due to petroleum incomes, which made it possible to maintain a strong growth in domestic use of commodities and services. The growth of mainland Norway decreased, compared to the previous decade, but not as strongly as in the other European OECD-countries.

The economic growth has induced profound structural changes in the Norwegian economy. Primary industries' share of total production and employment were sharply reduced, while employment in the service sectors increased rapidly. Manufacturing industries' share of total employment has been steadily reduced since the 1950s, and the share of total production has stagnated or declined since the early 1970s.

The economic growth and structural changes have led to great changes in the picture of energy consumption. In the 1950s and 1960s, process industries consumed more than half of the energy demand, while the major part today goes to heating purposes and electricity specific equipment in services and households. The oil price increases in the 1970s initiated a substitution from oil products to electricity for heating purposes. Domestic electricity prices grew strongly in the first half of the 1980s. These increases in energy prices have induced a decline in the growth of total energy consumption.

Economic growth and increased consumption of fossil fuels have led to a continuous and strong increase in the emissions of NO_x and CO_2 in the post-war period. The emissions of SO_2 have, however, been substantially reduced the last 10 to 15 years as a result of control measures against process emissions from manufacturing industries and regulations of the sulphur contents in oil products. The switch from oil products to electricity for heating purposes, as a result of strongly increasing oil prices up to 1985, has dampened the growth of emissions from stationary combustion.

2.2 Economy, Energy Consumption and Pollution 1962-1986

Economy

Gross national product increased by 4.4 percent annualy in the period 1962-1986. Up to 1973, the increase in gross national product of mainland Norway was approximately the same as for total gross national product, 4.1 percent per year, figure 2.1. In the period 1973 to 1986 the economic growth in Norway was higher than in most other OECD-countries and unemployment was extremely low compared to international standards. This was mainly due to petroleum incomes, which made it possible to maintain a strong growth in domestic use of commodities and services. The boost in the petroleum sector contributed to keep the growth rate of gross national product high compared to the previous period, but the growth rate of mainland Norway fell to an average of 3 percent annually.

Household consumption grew by 3.2 percent annually in the period 1962 to 1986, significantly lower than production. The consumption growth was led by a sharp increase in consumer durables (cars, household equipment and dwellings).

Figure 2.1. Gross National Product. Norway and Mainland Norway. 1962-1986. Indices. 1962=1

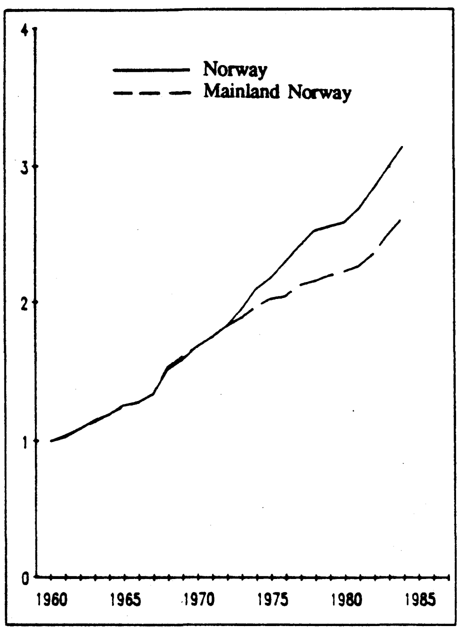
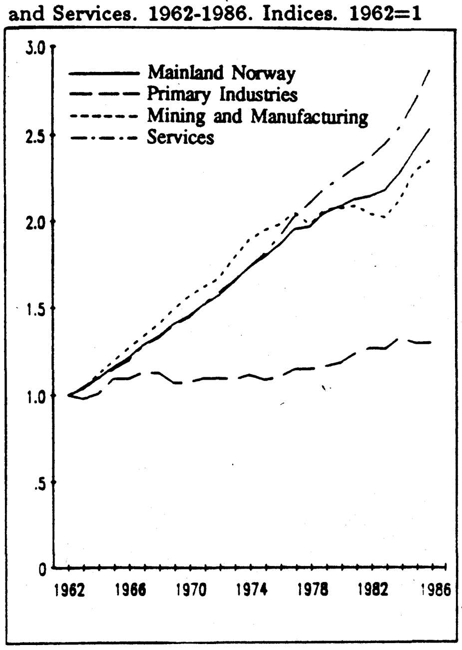


Figure 2.2. Gross Production. Mainland Norway. Primary Industries. Mining and Manufacturing and Services. 1962-1986. Indices. 1962=1



The development from 1962 to 1973 was characterized by a high growth in the production of manufacturing industries and government services, while the increase in production of private services was relatively low. The production of primary industries grew only moderately in this period.

From 1973 to 1986 the price and cost inflation in Norway was higher than for most trading partners. This deteriorated the competitiveness of traditional export and import competing industries and led to a stagnation of manufacturing industries. The growth in the service sector was relatively high in this period, figure 2.2.

Total employment grew steadily in the period 1962 to 1986, but significantly lower than the growth of production. From 1962 to 1973 the growth of man-years was on average slightly below 1 percent annually and from 1973 to 1986 slightly above 1 percent.

Energy consumption

In the period 1962-1973, the growth in energy consumption (electricity and oil products) in mainland Norway was approximately 6.5-7.0 percent on average, i.e. significantly higher than the growth of production, figure 2.3. The consumption of electricity grew somewhat stronger than the consumption of oil products, even though the relative prices of electricity and oil products were stable in this period. This development was due to the strong increase in power intensive industries and increased stocks of electricity consuming equipment in households and services.

Stable energy prices, strong growth in power intensive industries, increased consumption of energy per unit of production in services, strong growth in households' energy consumption and growth in road transport contributed to an increase in the energy intensity (total oil and electricity consumption compared to gross national product in mainland Norway) in the period 1962 to 1970, figure 2.4.

In the period 1973 to 1986 the growth rate of energy consumption in mainland Norway was only half of the growth rate of production. Increases in energy prices, both in Norway and internationaly, induced a substitution away from energy intensive products. The growth rates of Norwegian power intensive industries and pulp and paper production were only moderate in this period.

The increase in oil prices in 1973-74 and 1979-80 resulted in a decline in the consumption of oil per unit of production, partly as a result of a substitution from oil products to electricity for heating purposes, and partly as a result of technological changes in the transport sectors, figure 2.3. Sharply increased energy prices reduced the energy intensity by approximately 20 percent from 1973 to 1986, figure 2.4. In the mid-1980s, the oil product prices fell at the same time as the electricity prices were increased. This change in relative prices contributed to a halt in the substitution from oil products to electricity for heating purposes.

Figure 2.3. Gross Production, Employment and Energy Consumption. Mainland Norway. 1962-1986. Indices. 1962=1

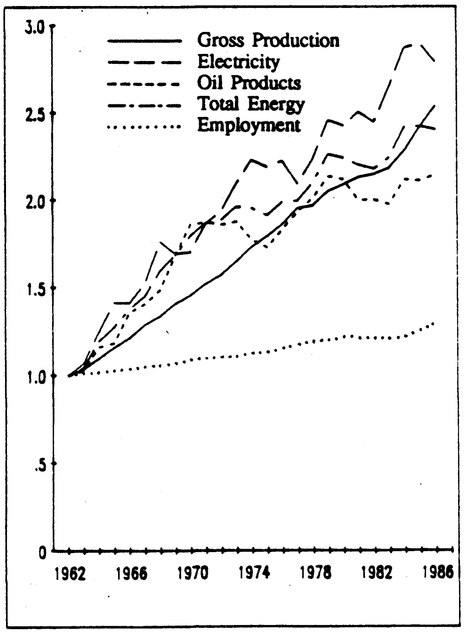
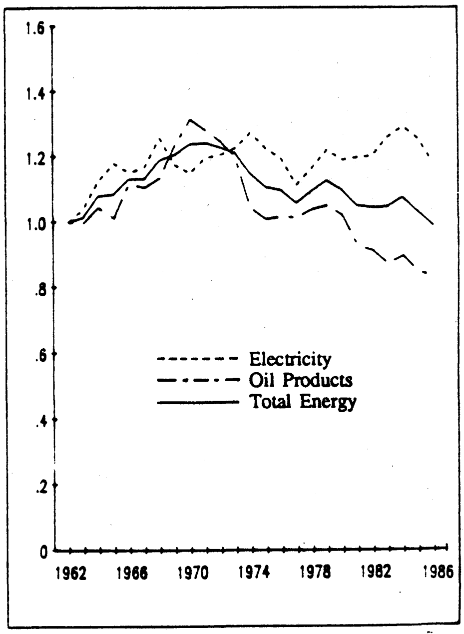


Figure 2.4. Energy intencity. Mainland Norway. 1962-1986. Indices. 1962=1



The growth of electricity consumption in service sectors was extremely high in the period 1962-1986, both as a result of high growth of production and a substitution from oil products to electricity for heating purposes. In addition, increased input of capital per unit of production in the service sector (increased building area per unit of production, increased use of EDP, heating and climate equipment), contributed to a strong growth in electricity consumption. Total energy consumption per unit of production increased up to 1973. From then on the energy intensity of the service sector has been approximately unchanged, whereas the energy intensity has declined significantly in most other sectors.

In the household sector, the energy consumption and particularly the electricity consumption, grew faster than total household consumption, despite periods of increasing real energy prices. This increase in households' energy intensity is a result of improved housing standards; an increased part of dwellings are constantly heated, the indoor temperature is increased and simultaneously the utilization of household equipment has increased sharply.

Figure 2.5. Gross Production, Employment and Energy Consumption. Service Sectors. 1962-1986. Indices. 1962=1

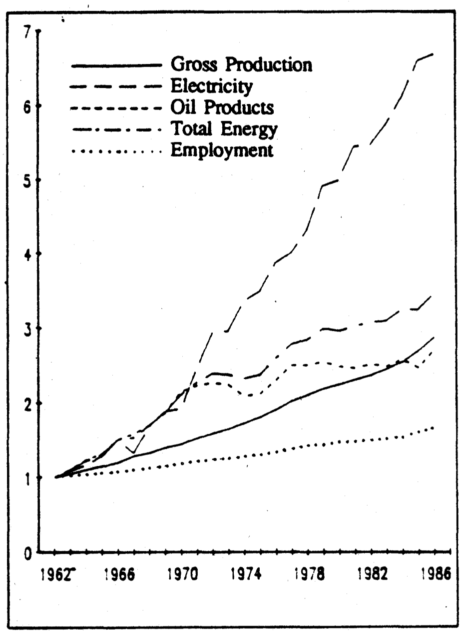
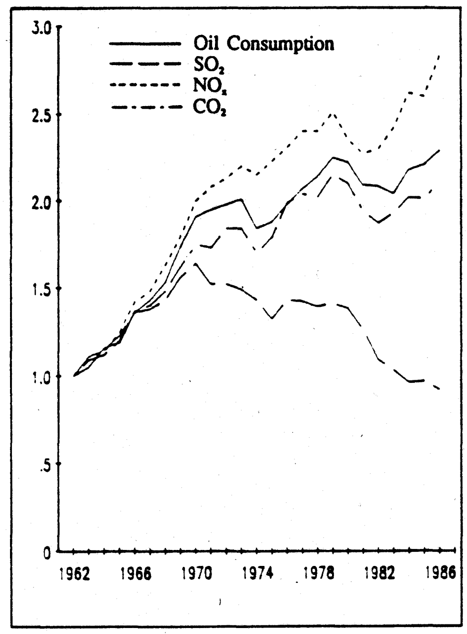


Figure 2.6. Consumption of Oil Products and Emission of SO_2, NO_x and CO_2. Norway. 1962-1986. Indices, 1962=1



Pollution

The emissions to air of SO_2, NO_x and CO_2 grew more or less propotionately to oil consumption over the period 1962- 1973.

The increases in oil prices in 1973-74, together with the clean up program for older manufacturing industries, reduced the sulphur emissions sharply. New regulatory measures of the sulphur contents in heating oils and the oil price shock in 1979-80 further reduced sulphur emissions. Altogether, the emissions of SO_2 were reduced by 80 percent from 1970 to 1986. The emissions where 100 000 tons in 1986 against 110 000 tons in 1960.

The growth rate of NO_x emissions was almost halved in the period 1973-1986 compared to the period 1962-1973, due to higher oil prices and therefore lower growth in oil consumption. The growth in emissions was, however, faster than the growth in total oil consumption over the period 1962-86, due to a faster growth in the consumption of transport oils than in the consumption of heating oils, and the NO_x emissions are higher for the high temperature combustion of transport oils. The emissions were approximately 244 000 tons in 1986, against 80 000 tons in 1960, i.e. a trippeling in the emissions over the period.

Table 2.1. Total emission to air

	1960	1973	1986
SO_2 (1000 tons)	110	162	100
NO_x (1000 tons)	80	190	244
CO_2 (Mill. tons)	16	30	35

The growth in total CO_2 emissions decreased from 5 percent annualy in the period 1962-1973 to slightly above 1 percent from 1973 to 1986. The growth in total CO_2 emissions in this period were lower than the growth in oil consumption as a result of lower growth in the emissions from process industries. The emissions were approximately 35 million tons in 1986, against 16 million tons in 1960, i.e. more than a doubling over the period.

In 1960, stationary combustion was a major source of the total SO_2 emissions, approximately 60 percent. In 1986, the emissions from processes contributed to approximately 44 percent, while the emissions from stationary combustion and mobile sources both contributed to 25 to 30 percent.

Mobile combustion is a main source to NO_x emissions. Mobile sources increased their share from 65 percent in 1960 to 85 percent in 1986.

In 1986 approximately 45 percent of the emissions of CO_2 came from mobile sources, 41 percent from stationary combustion and 14 percent from industrial processes. As a result of the strong increase in transport oil consumption, the share of mobile sources has increased from 30 percent in 1960 to 45 percent in 1986. The share of stationary combustion has declined from 64 to 41 percent, due to the substitution from heating oils to electricity.

2.3 Economy, Energy Consumption and Pollution 1986-1988

The economic development, energy consumption and pollution of SO_2, NO_x and CO_2 for the last two years, are commented on below based on preliminary figures from the national accounts, the energy accounts and the accounts for emissions to air.

Table 2.2. Shares of total emissions to air by source. Percent

		Mobile	Stationary	Process
SO_2	1960	12	59	29
	1973	14	45	41
	1986	27	29	44
NO_x	1960	66	30	5
	1973	76	20	4
	1986	86	11	4
CO_2	1960	30	64	6
	1973	42	47	11
	1986	45	41	14

Economy

There was an upsurge in domestic demand for commodities and services in 1985 and 1986. Both household consumption and investments grew sharply, especially the demand for consumer durables. The liberalization of the credit market in 1983-84 was a major reason for this boost in consumption. Imports increased sharply. During 1986 the oil prices fell, and has varied in the range of 12-16 US $ per barrel in 1987 and 1988. Petroleum incomes, which amounted to 90 billion NOK (or 18 percent of GDP) in 1985, were reduced to 50 billion NOK in 1987.

The fall in oil prices, the increased imports and the reduced exports of traditional commodities resulted in a deficit on the current accounts of approximately 27 billion NOK in 1987. The economic policies were changed to dampen the domestic demand and the growth in costs and prices. In 1988 there has been a reduction both in private consumption and investments (exclusive of ships and platforms), and the growth of gross national product for mainland Norway has stagnated.

In 1988, production in import competing industries, the trade sector and financial services declined as a result of reduced domestic demand. The traditional export competing industries, especially the metal sector, have on the other hand increased the production by approximately 8.5 percent in 1988. The export competing industries have a small share of total employment, such that the impacts on the labour market have been insignificant. Lower domestic demand has resulted in a decline in imports of traditional commodities. This has, together with the increased export of traditional industries, reduced the deficit of the current accounts by more than 10 billion NOK to 13.5 billion NOK in 1988 (exclusive of ships and platforms).

The domestic price and cost inflation was at the end of 1988 down on the same level as the rest of the OECD-area. Measured as relative labour cost per unit of production, the import competing industries still lost competitive edge in 1987 and 1988, while traditional export competing industries increased their competitiveness. In 1988 the labour productivity in manufacturing industries, measured as gross product per hour, increased by 2.7 percent. The growth in productivity was, however, slow for import competing industries and part of the service sectors, where production declined.

Energy Consumption

Total energy consumption in mainland Norway increased by approximately 0.3 percent per year in the period 1986-88. The growth was due to increased production in power intensive industries and an increase in oil consumption for transportation purposes. In all other sectors, total energy consumption declined by 2 percent per year. Much of the decline was, however, due to the fact that 1988 was a milder year than 1986. Corrected for differences in temperature, the decline was only 0.5 percent per year.

Electricity consumption increased by 1.8 percent per year. Some of the increase was due to supply of cheap, surplus hydro power, used as a substitute for oil, ecpesially in the pulp and paper industry.

Total domestic consumption of oil products was almost unchanged from 1986 to 1988. The consumption of heating oils declined by approximately 11 percent per year. About 40 percent of this decline was compensated by consumption of surplus hydro power.

The prices of crude oil fell sharply through 1986. This change in relative energy prices ended the relatively strong substitution from oil to electricity for heating purposes, experienced earlier in the 1980s.

Pollution

Total emissions of SO_2 declined from 100 000 tons in 1986 to 88 000 tons in 1988. The shut-down of the copper smelter in Sulitjelma reduced the emissions by 12 000 tons, the rest was due to a decline in the consumption of heating oils.

Preliminary figures indicate that the emissions have fallen further from 1987 to 1988.

The total emissions of NO_x increased from 244 000 tons in 1986 to approximately 245 000 tons in 1987. Preliminary figures for 1988 indicate a moderate decline from 1987.

The total emissions of CO_2 increased from 35 to 36 million tons from 1986 to 1987, and probably declined 1-2 million tons from 1987 to 1988.

3 Challenges in Environmental and Energy Policies

3.1 Challenges and Targets in Environmental Policies

The report from the World Commission on Environment and Development discusses the development of natural resources and the state of the environment in a global perspective. The Commission focuses on the possible dangers of an increased strain on renewable and conditionally renewable resources. The Commission is especially concerned with the limited capacity of the atmosphere and the oceanes to absorb residual gases from combustion of fossil fuels and other pollutants.

The Brundtland Commission finds it both possible and necessary to sustain the economic growth in industrialized countries and at the same time substantially reduce energy consumption - first and foremost the consumption of fossil fuels. The Commission draws several energy scenarios in the report. The main alternative can be interpreted as a target of 50 percent reduction in the industrialized countries' use of fossil fuels from 1985 to 2030, at the same time as the economic growth in these countries are kept at 3 to 4 percent annualy. The reason for this "recommendation" is primarily the pollution which follows from the consumption of fossil fuels, but also the concern for the management of depletable energy resources.

Environmental effects of air pollution

One of the most alarming effects of air pollution is that some of the pollutants might change the heat balance of the earth. This is referred to as the greenhouse effect, which is a result of increased concentration of greenhouse gases in the atmosphere. These gases function in the same way as a greenhouse roof, trapping the heat radiation from the earth. The greenhouse gases include chlorofluorcarbons (CFC), methan (CH_4), dinitrogenmonoxide (N_2O) and carbondioxid (CO_2). Reduced vegetation, i.e. through deforestation in tropical areas, contributes to the increased concentration of CO_2 in the atmosphere, since plants absorb CO_2 in the growth process. The CO_2 concentration is estimated to contribute to approximately half of the greenhouse effect. It is estimated that the concentration of carbondioxid in the atmosphere has increased by 8 percent since 1958 and by 25 percent 1750. If this increase continues, the average temperature of the earth will increase substantially in the longer run.

In the stratosphere (10-15 kilometers over the earth's surface), an ozone layer protects the earth against ultra violet radiation from the sun. Emissions of CFC and NO_x contribute to deplete this ozone layer. A depletion of the ozone layer will increase the exposure of ultra violet radiation at the earth's surface, and probably increase the incidents of skin cancer, and possibly reduce both terrestrial and oceanic plant growth. Monitoring data indicate that the ozone layer is already effected, especially over Antartic.

Sulphur dioxid, in the combination with particulates, increases the risk of respiratory illnesses. High concentrations of SO_2 might damage vegetation and increase corrosion. Norwegian emissions of SO_2 contributes to approximately 10 percent of the total deposition of sulphur in Norway, the rest is "imported" as acid precipitation.

Nitrogen oxides, especially NO_2, can at high concentrations increase the risk of respiratory illnesses. Nitrogen oxides also contribute to the acidification of soil and water. In the last 10 years, NO_x has been an increasing source to the acidification of Norwegian waters, both absolutely and relative to the contribution from SO_2.

Reductions of emissions

If past trends of economic growth, energy consumption and pollution continue, the world risks unacceptable and irreversible environmental damages. Even if the risk of catastrophic environmental events might be small, it is still rational to hedge against events like great climatic changes, which might bring the earth's ecological balance at peril.

A rational attitude imply that the decision makers of the economy should be given incentives to take into account the costs and damages which other actors indirectly suffer in the form of pollution of air, water and soil, and in the form of mismanagement of depletable or conditionally depletable resources. Increased use of environmental charges and other economic instruments will give the consumers and producers incentives to take into account such indirect effects.

The emissions of SO_2 can be reduced to an acceptable level by control measures which does not require new technology. There are also several ways of reducing the emissions of NO_x, but it seems more difficult to achieve large reductions in the short run. The control measures against NO_x can not be expected to give full effect until much of the existing capital equipment is replaced.

The greatest challenge to international environmental policies is probably to find measures to reduce the emissions of greenhouse gases like carbon dioxid and methan (CH_4). There are available technology to clean CO_2 emissions, but the technology can only be applied for large point sources and is at the moment extremely costly. Therefore, only a reduction of the use of fossil fuels can probably bring the emissions of CO_2 down to an acceptable level.

International agreements

Norway has in the last 2-3 years signed several international conventions on reductions of emissions.

- 30 percent reduction of CO_2 emissions by 1993, compared to the emission level in 1980. The government's target is to reduce emissions by 50 percent over the same period.
- Stabilizing emissions of NOx at the 1987 level by the end of 1994 and a declaration that Norway will aim at a 30 percent reduction by the end of 1998.
- 50 percent reduction of emissions of chlorofluorcarbons (CFC) by 1991 and 90 percent by 1995.
- 50 percent reduction of emissions of toxic wastes, nitrogen and phosphorons to exposed parts of the North-Sea by 1995, compared to the 1985 levels.

There are good reasons to believe that the development of international agreements on reductions of national emissions will continue. New agreements will appear and existing agreements will be renegociated.

An international convention on 20 percent reduction of CO_2 emissions by the year 2005, has already been proposed and discussed. This is a relatively moderate proposal compared to the Brundtland Commission's report, which indicates that the industrialized countries should reduce their consumption of energy (fossil fuels) by 50 percent within 30 to 40 years. In principle, a climate agreement should include all greenhouse gases and give incentives to a cost efficient allocation of the reductions, where e.g. the national absorbtion capacity in the form of vegetation is taken into account.

Measures against CO_2 emissions

Conventions on reductions of emissions of SO_2 and NO_x are designed as equal percentage reductions of gross emissions in all countries which have signed the agreements. It is not obvious that a future CO_2 agreement will be a blueprint of these earlier conventions.

Global reductions of emissions of CO_2, NO_x and SO_2 could most efficiently be achieved by reducing the consumption of coal, the fossil fuel which pollutes the most. Measured per theoretical energy contents the combustion of coal on average releases 45 percent more emissions of CO_2 than oil, which in turn gives 35 percent higher emissions than natural gas. The differences are even greater if one takes into account the efficiency of thermal power stations.

USA, China and the Soviet Union are the major consumers of coal. If global CO_2 emissions should be reduced, the effects on the energy markets will greatly depend of the behaviour of these great consuming countries, with respect to their consumption of coal and other energy carriers as oil, natural gas, hydro power, nuclear energy, wave, wind, and solar energy.

Per capita, Norwegian emissions of CO_2 are relatively high. Norway has 1 permille of the world's population and contributes to approximately 2 permille of the worlds total CO_2 emissions. This is due to several factors. First, the level of production and consumption in Norway is one of the world's highest. Second, the energy consumption for heating purposes is fairly high due to climatic conditions. Third, Norwegian heavy industries contribute to CO_2 emissions. Fourth, a dispersed settlement require a relatively extensive use of transportation.

It is certainly not reasonable that a small country like Norway should start reducing emissions of CO_2 on a unilateral basis. There are, however, several arguments for the interest in calculating the consequences which a CO_2 convention might have on the Norwegian economy:

- Norway has been one of the most active countries in the international work, arguing for the need for reductions of pollutants, not least through the work of the Brundtland Commission. The signal effect a national "solution" might have, and Norway's credibility is therefore important.

- It is of interest to analyze the consequences of an agreement before the agreement is signed.

- Even though the emissions of greenhouse gases like CO_2 is an international problem, a reduction of domestic use of fossil fuels will have significant local impacts, by reducing pollutants like SO_2, NO_x and particulates. Thus, there are good reasons to reduce emissions other than as a contribution to solving global problems.

3.2 Challenges in Energy Policies

In an international context, Norway is in a very favourable energy situation. Norway is self-sufficient of energy and a major exporter of oil and natural gas. Norwegian energy policies are therefore concerned with a rational management of the Norwegian energy resources to exports and domestic consumption.

An almost unique feature of Norwegian energy consumption is the high share of hydro power. Compared to electricity production based on fossil fuels, hydro power production is clean.

In 1987 the Norwegian indiginous energy consumption (exclusive of shipping) was based on 50 percent renewable energy carriers (45 percent hydro power, 4 percent bioenergy) and 50 percent fossil fuels. In comparison, the worlds total energy consumption consists of approximately 80 percent fossil fuels (British petroleum statistics, 1985). Norwegian energy consumption per capita is among the world's highest.

The market for oil products in Norway is based on world market prices for crude oil, but with significant amounts of fiscal taxes. The electricity market is strongly regulated. This might lead to non-optimal consumption both of oil products and electricity. The external costs of oil consumption is not accounted for in todays energy market. Policy measures against the consumption of oil could therefore to a great extent be deduced from environmental targets.

Hydro power is based on a renewable natural resource, but the production of hydro power also exploits conditionally renewable resources, such as unspoiled nature. A reduction of unspoiled nature and recreational services, have to be calculated as a cost in the utilization of hydro resources, and should be revealed in the prices of hydro power.

The Norwegian authorities have to make two central decisions in their management of hydro resources: capacity expansion and prices. An optimal management of hydro power resources should be based on the following principles:

- All consumers should pay the same price, corrected for user time and different distribution costs.

- Prices should be set such that the capacity is utilized at any point in time. The prices should, however, not be lower than the cost of producing an extra unit within the given capacity (short term marginal cost).

- The cost of increasing capacity of energy supply with one unit is called the long term marginal cost. The long term marginal cost is a principle for determining the optimal capacity. If the market price continuously is above the long term marginal cost, it is profitable to expand the capacity.

Several of these basic principles for a rational management of hydro power resources are violated today. The power intensive industries pay a lower price than other consumers. Also in the primary market, there are great regional differences in prices between consumer groups.

An equalization of prices would lead to a better allocation of hydro power in the economy. All consumers would then have the same incentives to economize, and those who are not willing to pay the market price, would be out of the market.

In Norwegian hydro power production, marginal costs are an increasing function of capacity. In an optimal market, this should lead to a significant economic rent. In todays market this economic rent is distributed to those consumers who pay low prices, and are given incentives to overutilize a valuable natural resource.

The price prospects for electricity are highly uncertain. Future prices depend e.g. on the costs of producing gas power, the organization of the electricity market and the possibilities for exports. Possible restrictions on the emissions of CO_2, create uncertainty as to which role gas power could play in a longer perspective. The supply of energy could therefore be a limiting factor for the economic growth of the mainland economy.

In todays market, consumers pay the same price for electricity irrespectively of the time of consumption, except in the market for surplus power where the price is determined on a daily basis by auction. By differentiating the electricity prices over the day and over the season (i.e. peak load pricing) the hydro power resources would be better utilized, and the need for further expansion of the power system would be less.

Better organization of the electricity market, rationalization and improvements of old power plants, improvements of the distribution network, more energy efficient production and transportation technology, increased use of heat pumps etc., are measures which would increase the existing hydro power capacity.

If prices on fossil fuels and electricity are increased, unconventional energy carriers as biofuels (wood, peat) and wind or wave energy could cover some of the energy demand. The supply of such unconventional energy carriers will of course be dependent on the costs of production (inclusive of environmental costs), and the prices of these alternatives relative to hydro power and conventional fossil fuels.

The development of new and more energy efficient technology is dependent on the prices of energy. The higher the prices of energy, the higher is the probability for a rapid technological development. Energy policies are, therefore, indirectly a determinant of the speed of technological development.

3.3 Instruments in Environmental - and Energy Policies

Instruments in environmental policies

A sub-group of the SIMEN-project (see Appendix 1) has evaluated todays use of instruments in environmental policies. The group tried in particular to evaluate the adequacy of increased use of economic incentives. The work of the group is presented in a sub- report.

The instruments of environmental policies are normally divided into two broad groups: Administrative and economic instruments. Administrative instruments comprise sets of rules or regulations of how much a producer or consumer could pollute. To these regulations are tied non-compliance fees or sanctions against the polluters if quotas are exceeded. Economic instruments aim at changing the behaviour of economic actors, by changing relative prices. Examples of economic instruments are charges on emissions or taxes on commodities which lead to pollution, deposit-refund systems and tradeable emission quotas.

The use of administrative instruments today

Administrative or regulatory instruments are the dominating control measures in Norwegian pollution policies today. The Pollution Act is the legal foundation for the regulation of pollution and waste from manufacturing industries and offshore activities. The Products Control Act is the basis for regulation of hazardous products.

The emissions from manufacturing industries are mainly regulated through a concession or quota system. Approximately 1500 establishments are regulated through this concession system. The concessions give a complete and detailed framework for polluting activities within these establishments. The core of a concession is maximum emissions of different pollutants.

The State Pollution Control Authority classifies establishments according the amount of pollution. The heaviest polluters are found withing the aluminium industry, pulp and paper industry, ferro-alloy industry, refineries, and petrochemical industry. Class 2 comprises mines, food processing industries and some firms within paper production. Class 3 comprises some food producers, some pulp and paper industries, plastic and chemical industries.

So far, the concessions have been designed within a negotiation system where the State Pollution Control Authority and the individual firm have tried to agree on a solution where the concern for the environment is balanced against concern for production and employment. This means that it has been difficult to introduce regulations which could not be complied to within existing or slightly modified technologies. There has, however, been some examples of a more agressive attitude from the authorities the last few years.

Todays concession system based on individual negotiations, hardly leads to a cost efficient reduction of emissions. The concession system might still be quite efficient, in cases where pollution mainly causes local damages to a recipient.

Todays concession system does not give incentives to reduce emissions below agreed levels or to introduce new and more efficient technology. The system is also costly to administer. These are arguments in favour of introducing more economic incentives.

The use of economic instruments today

The use of economic instruments have little tradition in Norwegian environmental policies, but some new charges and taxes have been introduced the last year. Most of the existing indirect taxes were originally introduced as fiscal instruments.

Indirect taxes on oil products are differentiated by sulphur content. To the basic tax of 21 øre per liter is added a sulphur tax of 1.5 øre per liter for each bracket of 0.25 percent sulphur. Taxes are refunded for those firms which can document cleaning. This sulphur tax is so small that the refund system is hardly used. This sulphur tax is one of the few indirect taxes in Norway today, introduced to give incentives to reduce consumption of a polluting product. In relation to the pollution which follows from the use of oil products the tax rate is very modest.

There are also indirect taxes on lubricants and gasoline. Gasoline taxes are differentiated, such that unleaded gasoline has a lower tax that leaded gasoline. The difference in indirect taxes on leaded and unleaded gasoline was 36 øre per liter by 1 January 1989. This difference is only 7 percent of the price of gasoline. To an average car driver, this difference is too small to give incentives to a more rapid car replacement.

Most of the indirect taxes on oil products are introduced for fiscal reasons, and their legal basis is an act from 1933. In addition to indirect taxes on fossil fuels and lubricants, there are also indirect taxes on batteries, biocides, fertilizers, non refundable packings and bottles and deposit- refund systems for bottles and cars. All these economic incentives are introduced for environmental reasons, and seem to work relatively satisfactory. It has also been proposed to introduce an indirect tax on CFC.

Evaluation of instruments in environmental policies

Both administrative and economic instruments have their strong and weak sides. To important criteria for evaluating all instruments are to which extent they give the authority control over the amount of emissions (target efficiency), and if they lead to reductions where emissions could be reduced at the lowest cost (cost efficiency). The cost of an instruments are both the direct cost to administer the instrument and the direct and indirect costs of increased resource use by producers and consumers. These costs can vary substantialy from instrument to instrument. Other criteria to evaluate instruments are their incentives to improve technology, and their effect on income distribution which can be an obstacle to the intruduction of new measures.

Emissions charges seem adequate when the damages are independent on where the emissions occur, and if there are many pollutants which otherwise could not easily be controlled. I.e., indirect taxes or charges seem adequate as instruments to reduce the emissions of carbon dioxid, which causes no local damages, but contributes to the greenhouse effect irrespectively of where the emissions occur. Chapter 5 gives a scenario where the indirect taxes on fossil fuels are sharply increased. Indirect taxes on coal, natural gas and oil products could be differentiated by the total damages they contribute to, without being administratively complicated. Such indirect taxes will never be perfectly adjusted to the damages of emission, but will lead to a more correct pricing of fossil fuels.

General economic instruments might be necessary to achieve the substantial reallocation which global pollution problems seem to demand.

Indirect taxes, which correct for external effects, will also give public revenues. These revenues will reduce the need for other taxes which have destortive effects on the economy. In total, a change of the tax system from direct income taxes to environmental charges, given tax level, will contribute to a more efficient use of resources in the economy.

Economic instruments could never totally replace regulations as an instrument against local pollution problems or as urgent measures against especially toxic substances.

Taxes are superior to regulations in reducing emissions cost efficiently, whereas regulations are superior to taxes in target efficiency. These properties can be combined in a system of tradeable quotas, i.e. the creation of a market for pollution quotas, where the quotas sum up to a total amount of pollution which is acceptable.

Tradeable quotas have the same incentives as charges on emissions, but in addition the costs of pollution (the market price of tradable quotas) automatically changes with inflation. An indirect tax, on the other hand, will need adjustment, which means administrative treatment and political decisions and the indirect tax might therefore over time loose its power as an instrument. Tradeable quotas, on the other hand, is dependent on a creation of a sort of stock exchange and a certain compliance control.

For large and medium sized firms, it is both technically and economically feasible to install meters to give a permanent surveillance of emissions. The development of monitoring technology has therefore made taxes and tradable quotas to practical instruments both in the case of emissions to air and to water. In the case of CO_2, however, indirect taxes on inputs of fossil fuels seems to be the most adequate instrument.

Indirect taxes on energy

The SIMEN-project has mainly been concerned with the question of how to use charges on energy to incorporate environmental costs of energy consumption. Correct use of indirect taxes might lead to great differences between the market price of the energy commodity and the cost of producing it. In general, there are several reasons to tax production and consumption of energy:

- If marginal costs of energy production are increasing, energy production will lead to an economic rent. The price system, including energy taxes, decides who captures this economic rent. Production taxes on electricity, or royalties on oil production, can be used by the government to collect the economic rent, which otherwise would have been collected by producers or consumers.
- An unregulated, competitive market for energy, might not reflect the scarcety of depletable resources like oil and natural gas. Indirect taxes might be used to reflect this scarceity.
- Taxes on gasoline might also be used as an indirect price of road services. Even if the consumption of road services, included depreciation, is not proportionate to the consumption of fuels, gasoline taxes might still be a good proxy for the user price. Other solutions might lead to high and unnecessary administrative costs.
- Production, transport and consumption of energy lead to several, serious environmental effects. These negative externalities might be reflected in the energy prices through taxes. The adequacy of this instrument is dependent on the proportionality between the amount of energy consumption and the negative environmental effects.
- So far, taxes on energy have to a great extent been introduced for fiscal reasons, i.e. to finance public activities. Efficiency criteria imply that one should tax factor input with low price elasticities. In the short run, energy consumption is price inelastic, which means that a change of prices will have small effects on energy consumption. In addition, a high and increasing energy consumption has been an attractive tax base.

4 Prospects for selected Manufacturing Industries

4.1 Introduction

Most Norwegian manufacturing industries are exposed to competition in international markets. E.g., 80 percent of Norwegian metal production is exported. A realistic evaluation of the growth potential for manufacturing industries, like power intensive industries and pulp and paper production, therefore demands analyses both of international product markets and of production technologies and costs.

The production capacity of aluminium and ferro products are increasing in NIC-countries and LDC-countries, with low production costs. In addition, the production costs in Norwegian "greenfield units" are higher than the average production costs of existing units. On the other hand, there seems to be possibilities to increase productivity and competitiveness in Norwegian power intensive industries by expansion of existing units.

Producers of aluminium, ferro alloys, industrial chemicals and pulp and paper are heavy consumers of energy and significant polluters. The SIMEN-project has focused on the possibilities to reduce energy consumption and pollution per unit of production in these industries.

SIMEN comprises three sub-projects for power intensive industries and pulp and paper production, Appendix 1. This chapter is a summary of the three subprojects on aluminium production, ferro alloy production, and pulp and paper production by the Institute of Industrial Economics, the Center for Applied Economic Research at the University of Oslo and the Central Bureau of Statistics. These sub-projects are used as background material for evaluating possible macroeconomic developments towards 2000 in chapter 5.

4.2 Traditional Export Competing, Manufacturing Industries

4.2.1 Power intensive industries

Power intensive industries comprise aluminium production, ferro alloy production and production of industrial chemicals. For industrial chemicals, the calculations of chapter 5 are based on the assumption that Norwegian production and export will follow the growth of international markets. The descriptions and discussions in this subsection are therefore confined to aluminium and ferro alloy production.

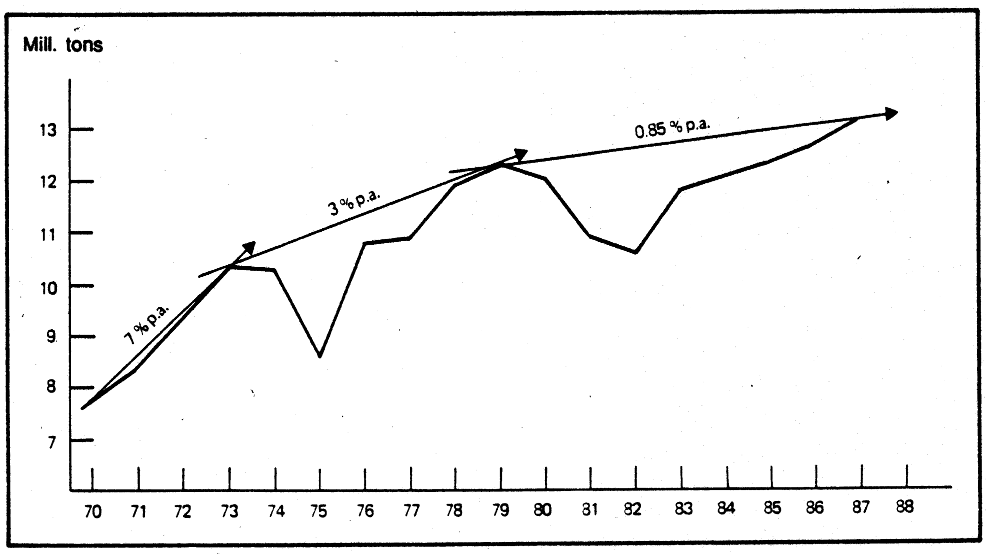
The market for power intensive products is characterized by great fluctuations in demand and hence in capacity utilization and prices. In the first half of the 1980s, the metal markets were soft and prices low. In 1982, most Norwegian enterprises showed read figures. After 1986, there has been a boost in demand, with a preliminary peak in 1988, with extremely high prices both for aluminium and ferro alloy products. Preliminary figures for 1988 show an operating surplus for metals of approximately 6 billions NOK and somewhat below 1 billion NOK for industrial chemicals.

4.2.1.1 The aluminium industry

International conditions

The report from the Institute of Industrial Economics indicates that the profitability of international aluminium production on average has been lower the last 10 to 15 years than in the previous period. This is partly due to reduced growth in demand, and partly due to a change on the producers side from oligopoly to approximately free competition.

Figure 4.1. Aluminium consumption in the Western World. Mill. tons and average annual growth. 1970-1987

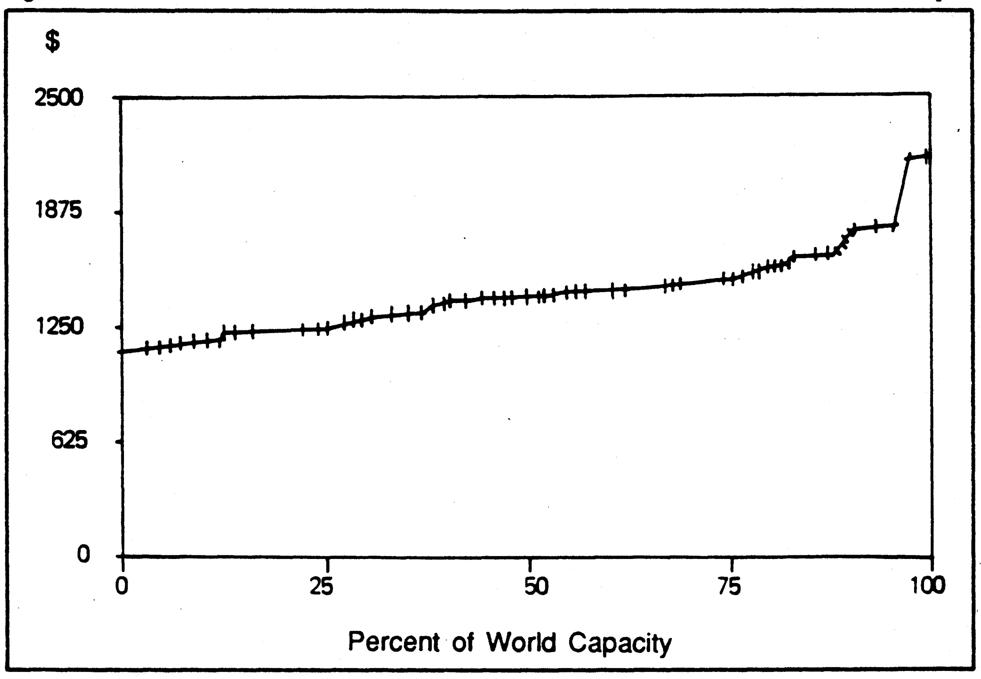


Source: Norsk Hydro.

In the 1960s, the growth of energy demand in the Western world was on average 10 percent per year, and declined to below 1 percent in the 1980s, figure 4.1. The slower growth was partly due to reduced growth of the world economy, increased competition from other products as plastic, and efficiency in the utilization of metals by the consumers. This is a production cyclus which is not unusual for manufactured products. For aluminium, the postwar period up to the early 1970s, was characterized by an introduction period with strong growth, followed by a period of saturation and increased competition from substitutes and improved efficiency and technology by the metal consumers.

The production costs between international producers of aluminium vary considerably, as shown in figure 4.2.

Figure 4.2. Total Production Cost in International Aluminium Production. 1987. US dollars per ton



Source: Resources Strategies Inc.

The figure shows that the production costs in 1987 varied between 1150 dollars per ton f.o.b. to approximately 2200 dollar per ton. The cost of the most efficient Norwegian unit was approximately 1450 dollars per ton. Approximately 60 percent of world capacity had lower costs than the most efficient Norwegian unit. The majority of the Norwegian units had in 1987 costs above 1500 dollars per ton. Approximately 75 percent of the world capacity had lower cost than these units. In a non cooperative market, which is a reasonable characterization of the aluminium market today, future prices might be expected to lie somewhat above the marginal cost of establishing new production capacity on the world market. In the short run, excess capacity might bring prices down to variable costs, and shortage of capacity might bring prices well above marginal cost. Based on international market data, the Institute of Industrial Economics has tried to establish a supply curve for aluminium on the world market.

The analyses of the Institute of Industrial Economics indicate that several countries are capable of introducing new production capacities at costs of approximately 14 to 1500 dollars per ton f.o.b. Expansion of Norwegian capacity at these costs seems hardly possible, with the possible exception of existing units.

Some LDSs have ambitious industrialization plans, which might effect the aluminium markets. If these investments plans are carried out, they might lead to excess capacity and prices which are well below the prices determined by the cost based supply curve.

Norwegian production costs

In the sub-report from the Center of Applied Economic Research and the Central Bureau of Statistics, the cost structure of Norwegian aluminium producers are analysed, based on micro-data. This study shows significant differences in cost structure between the different units.

In 1989, the most efficient Norwegian unit used 30 percent less energy per unit of production than the least efficient unit. This is due both to choice of technology and the efficiency of utilization of existing technology. Average consumption of electricity declined from 20.2 to 17.7 kWh/kg produced aluminium from 1966 to 1986. The electricity consumption in the most efficient unit declined from 16.4 to 14.9 kWh/kg over the same period.

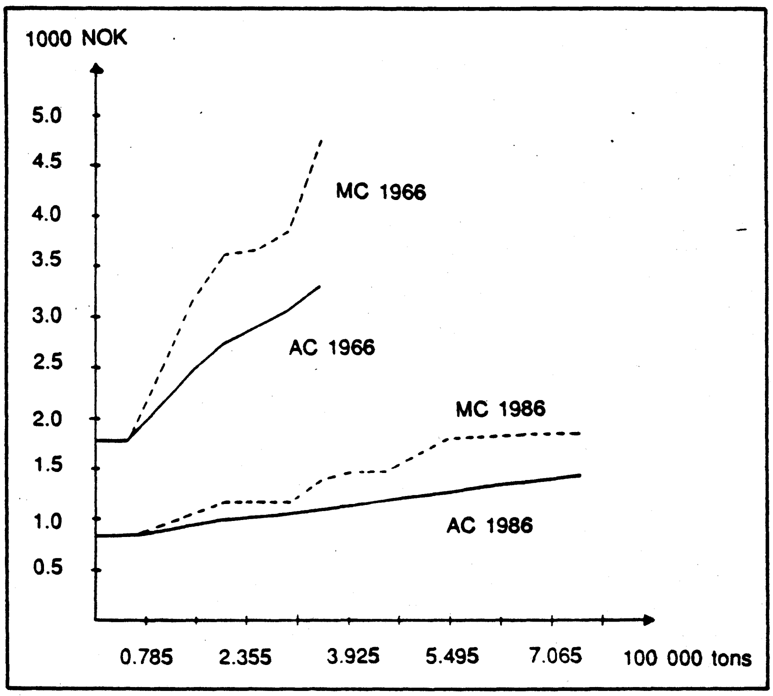
Theoretically, the minimum quantity of electricity needed to produce 1 kilo of aluminium is approximately 7 kWh/kg. In practice, this minimum quantity is inachievable, and it has been indicated that 14-15 kWh/kg on average is a reasonable target for Norwegian units towards the end of the century. That implies an average improvement of approximately 20 percent from the 1986 level.

Figures also show great differences in labour costs per unit of production. These differences are not due to differences in wages, but to differences in labour productivity. The gradual improvement of labour productivity from 1966 to 1976, seems to have stagnated in the last decade. However, the average improvement of labour productivity was 56 percent over the period 1966 to 1986, with the greatest improvements in the less efficient units. Labour costs per ton aluminium are still 30 percent lower in the most efficient unit than in the least efficient unit.

Looking at labour costs and electricity costs simultaneously, one might conclude that low energy prices indirectly have subsidized inefficient use of labour. By improving labour productivity, there are good reasons to believe that the industry might maintain or even improve its competitive position even if electricity prices are increased. In 1986, both electricity costs and labour costs amounted to approximately 15 to 20 percent of total production cost.

Figur 4.3 illustrates that the total variable costs per unit of production have been sharply reduced from 1966 to 1986. For some of the least efficient units, these costs have been cut by more than 80 percent. The figure shows curves for average and marginal costs, where the units are ranked according to increasing costs. The difference between front and average efficiency, has been substantially reduced from 1966 to 1986. There is still, however, a potential for cost reductions by moving the average towards the front.

Figure 4.3. Marginal (MC) and Average (AC) Unit Costs for Norwegian Aluminium Producers. 1966 and 1986. 1000 NOK per ton, 1986-Prices



The long term potential for reducing variable costs, can be illustrated by moving the average efficient units towards the front units, both for labour and electricity costs, which will reduce these costs by approximately 20 percent. Total costs will then be reduced by approximately 8 percent. Reductions of labour costs can be achieved without increasing other costs, whereas the reductions in electricity costs might require new investments. Todays electricity prices do not give incentives to invest in more energy efficient technology.

In 1987, the aluminium industry consumed 14 TWh electricity, most of which was delivered on low priced long term government contracts. These contracts will be renegotiated in the period 1996 to 2010. The alternative value of these contracts at the turn of the century will probably be much higher than the contract prices today. If renegotiated contracts are based on alternative values, this will probably imply a reduction in the aluminium industry instead of growth.

Emissions

The process of electrolysis in the aluminium production leads to emissions of gases, which also absorb particules from melted aluminium. The gases include components as hydrogenfluorid, particulate fluorid, sulphurdioxid, PCB and carbonoxides. The replacements of catodes and other materials lead to a deponition of large amounts of waste materials, containing fluorids.

According to the State Pollution Control Agency the fluorid problem is still not solved, despite a gradual reduction per unit of production. The State Pollution Control Agency also monitors the development of emissions of PAH, SO_2, CO_2 and other residuals. For the industry, it is important that stronger regulations could be integrated in modernization and investment plans and not introduced as immediate and accute measures.

Total emissions of SO_2 in the aluminium industry is approximately 5.500 tons per year, or 7 percent of total emissions from mainland Norway. Two firms with 28 percent of the production capacity are responsible for 67 percent of the industry's emissions of SO_2. Sea water scrubbing is already introduced in one of these units, the other needs alternative solutions.

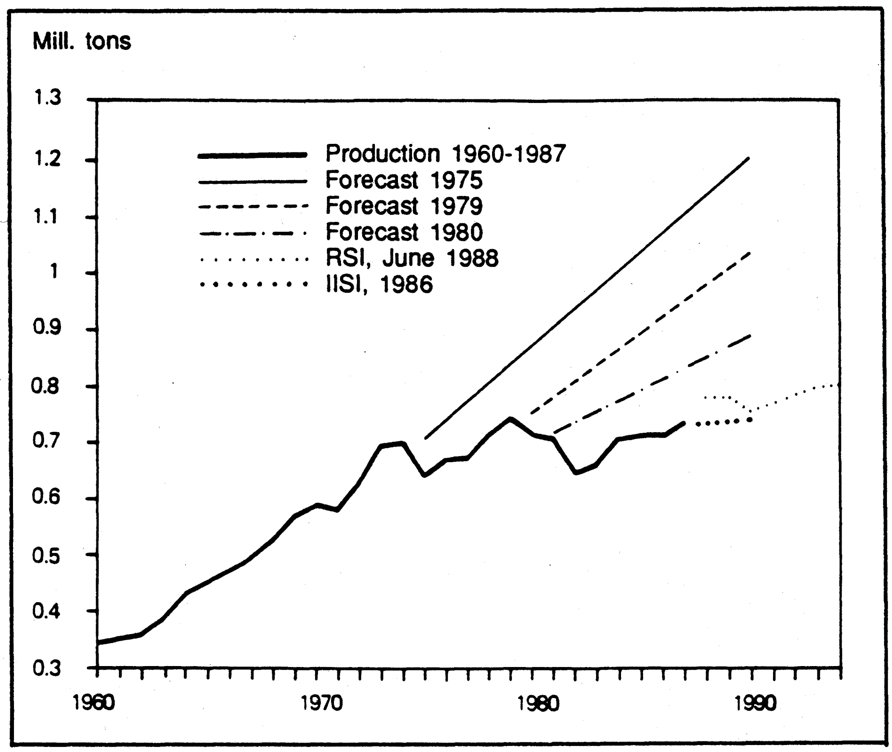
Further reductions of emissions from the aluminium industry will lead to higher costs, a deteriorated competitiveness and reduced growth potential. There are, however, good reasons to believe that the aluminium producers worldwide will have to face stronger regulations of emissions.

4.2.1.2 The ferro alloy industry

International conditions

Ferro mangan, silico mangan and ferro silicium are inputs to the steal industry. The report from the institute of industrial economics show that approximately 95 percent of ferro mangam and 70 percent of ferro silicium products, produced in the Western world are used as intemediate input to the steal industry, figure 4.4. Silicium metal is in addition used by the silicon industry and the electronics industry.

Figure 4.4. World Production of Steel. 1960-1990. Mill. tons

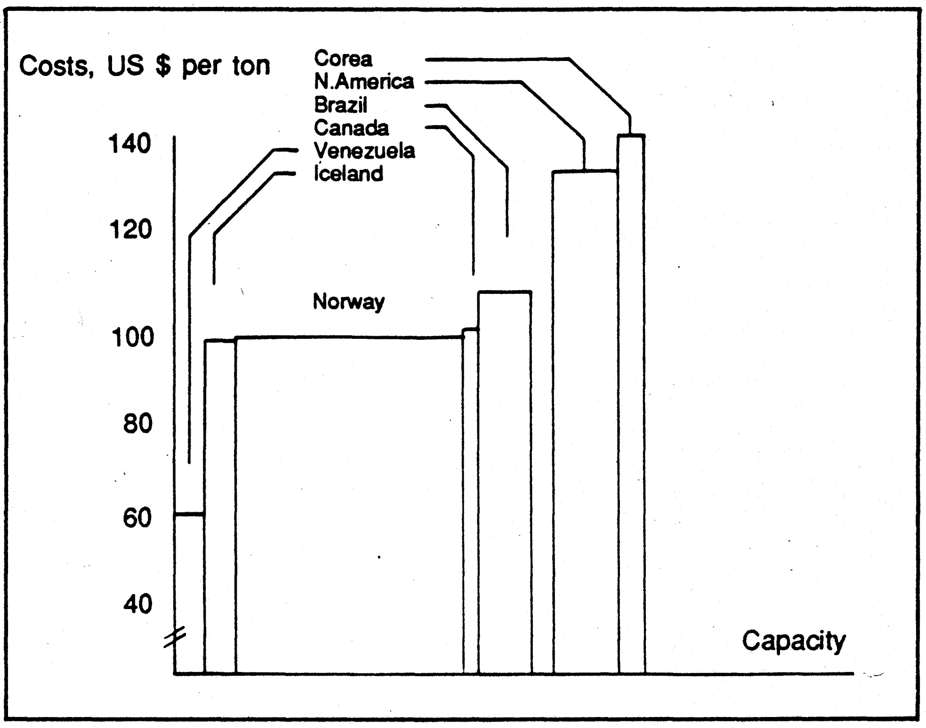


Source: Elkem.

Immediately after the second world war, when the steal consumption increased sharply, the profit margins of the ferro industry was very high. The last 10 to 15 years, the growth of the steal consumption has declined, and several producers have entered the market. Hence, the ferro industry has experienced periods with substantional excess capacity and low prices.

Internationally there are great variations in the production costs of different ferro producers. For ferro silicium, Norway is one of the major producers, figure 4.5. In 1988 only Venezuela and Island had lower production costs than the Norwegian producers.

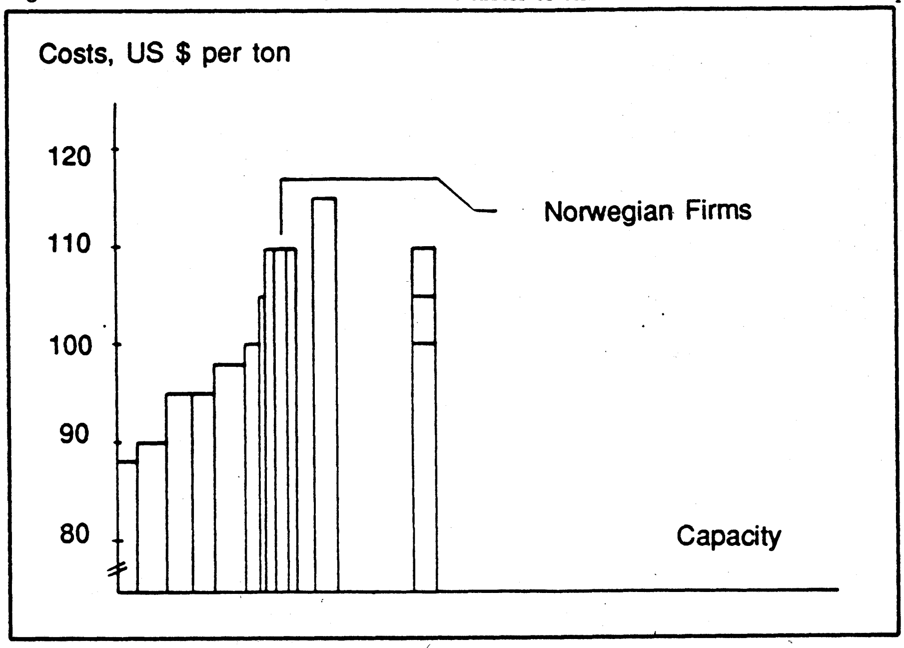
Figure 4.5. Production cost for Selected Producers of ferro Silicium. 1988. US dollars per ton



Source: Elkem.

Figures from early 1988 show that the Norwegian silicium metal producers were more cost efficient than most other European units, but somewhat less efficient than most other international producers, figure 4.6. Through 1988 there has been some cost reduction in Norwegian units.

Figure 4.6. Production Costs for Selected Producers of Silicium Metal. 1988. US dollars per ton



Source: Elkem.

For ferro silicum, the situation in 1988 is somewhat more gloomy. There is overcapacity, a stagnating market and huge investment projects in low cost areas. It is therefore most likely that the production costs in low cost countries will determine the future profitability of standard ferro silicium products. The most vaiable option for Norwegian producers therefore seems to be a substitution from standard products to more specialized products.

The prospects for ferro mangan and siliko mangan seem somewhat better than for ferro silicium, due to an oligopolistic orginization of these markets. For Europe, the 5 largest producers control 80 percent of the market for ferro mangan.

Norwegian production costs

Including partly owned enterprizes, the Norwegian units control 20-30 percent of the Western market for ferro products. Until reasently, the ferro production in Norway was characterized by production of standard products with increasing competition. Today, approximately 50 percent of production is refined to special products for deliveries in markets where there are few competitors and reasonable profitability. There are, however, signs of increased competition also in these markets.

Ferro silicium is the main product in most Norwegian units. Some units produce ferro mangan as the main product, whereas one unit produces ferrocrom. These products represent different technologies, which to some extent explain the differences in factor input.

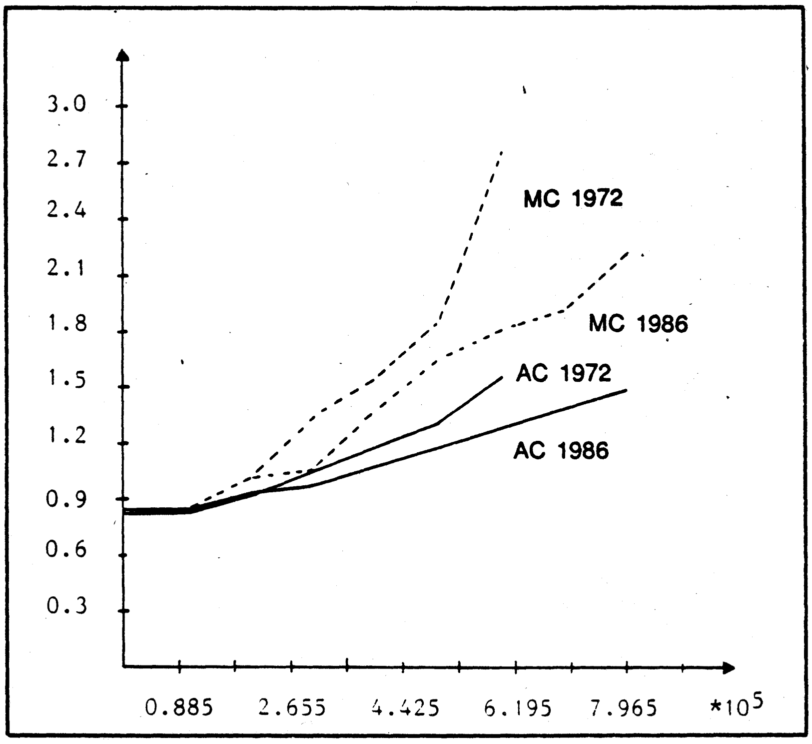
Capital costs for existing units are substantially lower than for greenfield units. Modernizations, rebuildings and expansion of existing units are assumed to incur capital costs 20 to 30 percent below capital costs of greenfield units. Expansions of existing units might also lead to rationalization of other input factors. At given factor prices, it is therefore a certain potential for expanding the production capacity firms. There is, on the other hand, no reasons to expect expansions of greenfield capacity in Norway towards 2000, unless electricity prices are kept very low.

In 1986, the ferro alloy industry consumed 6.5 TWh electricity. Parallel to the aluminium industry, the future electricity contracts will be crucial for the prospects for expansions of capacity.

There are great differences in energy consumption per unit of production between the Norwegian firms, mainly due to choice of technology. On average the electricity consumption per unit of production has been reduced by 15 percent, or approximately 1 percent per year over the period 1972 to 1986.

There are also great differences in the labour costs per unit of production between the different units. In the period 1972 to 1986 there has been an improvement in the use of labour input per unit of production by approximately 35 percent, or approximately 2 percent per year. The labour productivity in the most efficient capacity was, however, more than twice as high as in the least efficient unit in 1986. In the same way as for aluminium production, there has been a substantial reduction of variable unit costs in ferro production from 1976 to 1986. The average units have approached the front unit, but even in 1986 there was a substantial difference between the variable cost of the front unit and the least efficient capacity, figure 4.7.

Figure 4.7. Marginal (MC) and Average (AC) Unit Costs for Norwegian Ferro Alloy Producers. 1972 and 1986. 1000 NOK per ton, 1986-Prices



Emissions

Ferro alloy production is extremely energy intensive and polluting. The industry discharges SO_2, CO_2, NO_x, PAH and several heavy metals. Traditionally the problems of particulates and SO_2 have been regarded as the ferro industry's main environmental problems.

The emissions of particles from the ferro alloy industry has been regulated world wide. Only a few producers, like Venezuela and China, have not yet introduced cleaning programs. This regulations have led to few competitive changes for Norwegian producers. The reduction of emissions of particles through cleaning, has also reduced some of the other emissions. The State Pollution Control Agency consideres the particulate problem of the Norwegian ferro alloy industry as solved, but the regularity of the cleaning equipment is not yet satisfactory.

The total emissions of SO_2 from the ferro industry was approximately 10 000 tons in 1987. This amounts to 13 percent of the total domestic emissions. The State Pollution Control Agency has, however, already decided to regulate the industry stronger in the years to come. Measures against the three most polluting units will reduce the total emissions from the industry by approximately 40 percent. These new regulations might imply costs that will lead to a shut down of the least efficient and least profitable units.

4.2.2 Pulp and paper production

The pulp and paper industry is, in the same way as the production of aluminium and ferro alloys, exposed to international competition. Both in 1987 and 1988, the industry experienced high prices and approximately 100 percent capacity utilization. Despite high international demand, the return to capital in Norwegian pulp and paper industry was only 3.5 percent in 1988, calculated as operating surplus devided by capital evaluated at current prices.

Norwegian pulp and paper production has been concentrated on printing paper, mainly paper for magazine and newspaper production. These are power intensive products, but where the input of wood products per ton final product is low. Approximately 75 percent of Norwegian paper production is newspaper and magazine paper. One reason for this development of production is that paper is produced from long fibers, based on pine trees which only grow in the Northern hemisphere. This means that the competitors for these qualities are first and formost Sweden, Finland, the Soviet union, Canada and the USA, i.e. high cost countries except the Soviet union. This is different from metal production, where the competitors are NIC-countries.

International conditions

The world consumption of paper and paper products increased from 40 million tons in 1950 to 187 million tons in 1984, i.e. 4 to 5 percent per year. The last two years, the growth has been 6 percent annualy. A 1985 FAO-forecast indicates a growth of demand for paper and paper products on a global scale of 2.7 percent. In the industrialized countries which is the main market for Norwegian pulp and paper products, the estimated growth of consumption is expected to be somewhat lower. Based on the FAO- analysis, there might be room for expansion of the capacity of Norwegian pulp and paper industries.

Within year 2000, there does not seem to exist natural substitutes for the long fiber wood, which Norwegian pulp and paper industry is producing. In the long run, however, new technology might make it possible to produce good qualities based on short fiber wood from rain forests. There are also good reasons to believe that the share of production which is based on return paper will increase. The competition from substitutes like plastic for some paper products, are highly uncertain and difficult to asess for the years to come.

Norway is a relatively small producer of paper and paper products. The market share ranges from .75 percent to 3 percent for the different segments of the market. The largest exporters are Canada, Sweden and Finland and the import areas are western- Europe and the USA. Norwegian products are mainly exported to the European Comunity.

Norwegian production

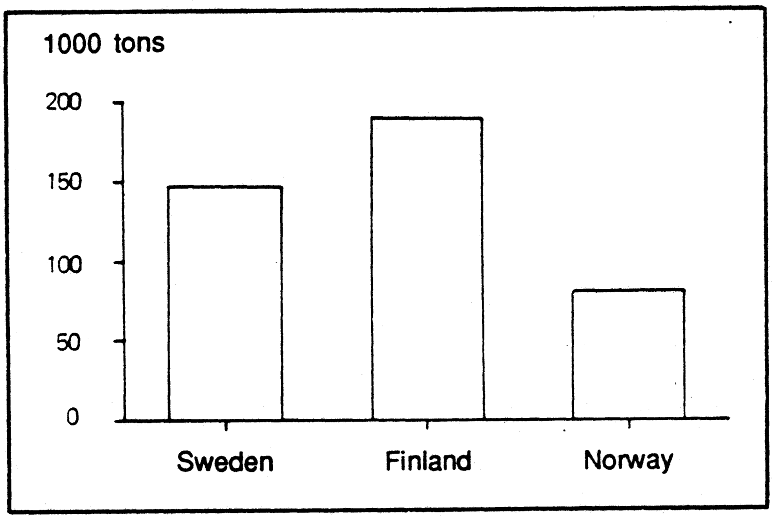
The competitive problems of the Norwegian pulp and paper industry are mainly due to high transport costs of raw materials (twice as high as in Sweden), high wage costs (15 percent higher than in Sweden), limited supply of raw materials and small units. Norwegian producers have over time become fewer and larger. A fusion of three of the major producers have been negotiated in the early 1989. Rationalization and fusion have contributed to improve the competitiveness, but still Norwegian producers are small, figure 4.8.

Similar to the studies of aluminium and ferro production, the analyses of the pulp and paper industry, show that there are great differences in costs per unit of production between different producers. In 1986 e.g., the input of electricity per unit of production was more than 50 percent higher for many producers than in the most efficient unit.

On average, the pulp and paper industry increased its productivity substantially in the period from 1972 to 1980. This development has continued in the least efficient units after 1980. Also energy efficiency has increased markedly in the period from 1972 to 1986, especially in the least efficient units. Low energy costs still give Norwegian producers a competitive advantage compared to producers in Sweden, Finland and Canada.

The differences in input per unit of production, both for labour and energy, should imply a substantial potential for further reductions of costs.

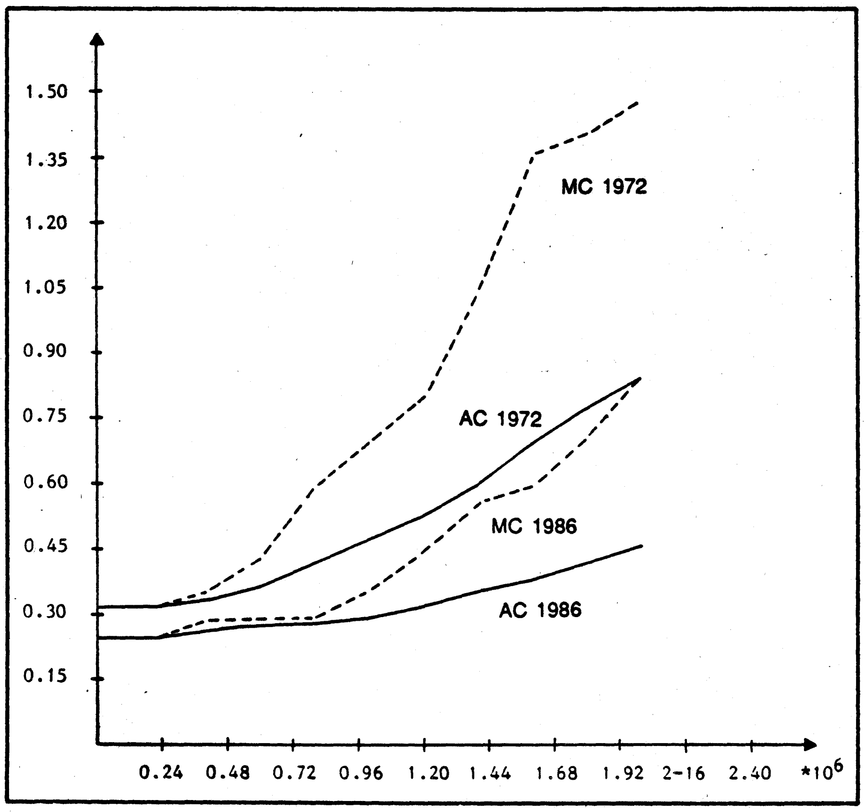
Figure 4.8. Average Capacity. Nordic Paper Producers. 1986. 1000 tons



Source: Bergen Bank, Quarterly Journal no 1. 1988.

Figure 4.9 illustrates that the average total variable unit cost for pulp and paper producers has been reduced from 1972 to 1986, especially for the least efficient units. There are still, however, substantial differences in costs between the least efficient and the most efficient units, which implies a potential for efficiency improvements by moving the average towards the front.

Figure 4.9. Marginal (MC) and Average (AC) Costs for Norwegian Pulp and Paper producers. 1972 and 1986. 1000 NOK per ton, 1986-Prices



The pulp and paper industry benefits from low priced long term electricity contracts, and in addition is a huge consumer of surplus power. The pulp and paper industry has a great potential for substituting between oil products and electricity. The soft Norwegian energy market the last couple of years, has given the industry access to hughe amounts of cheap surplus power, a situation which might continue with an expanding production capacity in the electricity sector.

If Norwegian pulp and paper producer should move along with the international technology front, the industry is facing substantial investments in the years to come. The industry's own estimate is 10 billion NOK, of which 700 million NOK will be environment investments towards 2000.

Emissions

The pulp and paper industry discharges CO_2 to air, fiber and desolved organic materials to water. The emissions to water contain chlorine, nitrogen and phosphorous.

Total emissions of SO_2 was in 1986 approximately 9000 tons. Some of these emissions could be reduced by sea-water-scrubbing. For the least efficient units, stronger regulations of emissions could imply shut-down.

4.2.3 Production of metal products, machinery and equipment

This industry has traditionally produced intermediate inputs to the rest of Norwegian manufacturing industries, power production and to petroleum activities. The reductions in building of ships, platforms and power stations has led to great problems for these composite group of intermediate producers. There are reasons to believe that this situation will continue up to 2000. Future growth seems therefore to demand a restructuring of the industry, towards new products and new markets, in the same way as the industry was restructured from 1960 up to 1988. In the calculations in chapter 5, it is assumed that the industry will continue to deliver intemediate products to the rest of the Norwegian economy, and that the exports will increase propotionately to the growth of international markets.

4.2.4 Industrial use of natural gas

Natural gas is used as a raw material for production of amonia, metanol and plastic. Approximately 850 Sm^3 natural gas is used to produce 1 ton amonia and 900 Sm^3 to produce 1 ton of metanol.

The amonia production at Herøya has a production capacity of approximately 400 000 tons. That leads to a consumption of natural gas of 350 million Sm^3. The production at Herøya might from the middle of the 1990s consume approximately 400-600 million Sm^3 natural gas per year.

The petrochemical factory at Rafnes uses etanol as a raw material for different plastic products. Only a small part of this etanol could be substituted by methan at todays technology.

In many countries, the amonia production is intergrated with the production of fertilizers, such that the free market for amonia is only 5 percent of the total production. The world consumption of amonia is approximately 105 million tons, which correspond to a consumption of 95 million Sm^3 natural gas.

In addition to a certain potential for use of natural gas to produce energy, there is a certain potential for use of natural gas to industrial processes also in Norway.

Towards 2000, the demand for industrial use is estimated to be relatively modest.

4.3 Conclusions

The growth of Norwegian manufacturing industries towards the turn of this century is dependent on international demand, domestic demand and limitations on factor supply, i.e. the supply of raw materials and energy. The producers can win or loose market shares dependent on the development of producer costs in Norway compared to the development in competitive countries. This relations are accounted for in the macroeconomic model which has been used for the calculations in chapter 5. The analysis of selected manufacturing industries, has given reason to deviate somewhat from these model relations, especially for the power intensive industries.

Both for aluminium and ferro production there are great differences between marginal costs of expanding capacity and average cost, both for capital cost and electricity costs.

Marginal costs of electricity is reflected in the so called 1983- contracts (20 øre per kWh), which is approximately twice the present average price. According to the industry's own asessments, there will be no expansions of capacity, based on 1983-contracts.

The capital costs of new and old metal factories are very different. Most existing capital equipment is written off, and has low alternative value.

The capital costs of expansion of existing firms are assumed to be substantially lower than for greenfield plants. By expanding existing capacities, it is also possible to use existing electricity more efficiently, which will contribute to lower costs per unit of production. It also seems possible to reduce the input of labour per unit of production within existing firms. The industry itself assume that the capital costs could be reduced by 20 percent without effecting production. Expansion of existing capacities therefore seems to be the most promising possibility for the metal producers.

In the macro economic calculations of chapter 5, it is assumed that the growth of metal production will be approximately 1 percent per year in the 1990s, with the same consumption of electricity and the same electricity prices as in 1989. The production growth is set equal to the growth rate of energy efficiency. Future electricity contracts are essential for the growth potential of the power intensive industries. The macroeconomic calculation are based on the assumption that these contracts will not be changed until 2000. When these contracts are renegotiated towards 2000 and beyond, the electricity will probably have a high alternative value. This is also the case for the industry's own power production. If the renegotiated contracts are based on the alternative value of electricity, the assumption of production growth of this industry might be to high in the calculations of chapter 5.

5 Industry, Environment and Energy in a Macroeconomic Perspective 1988-2000

5.1 Introduction

Main challenges to Norwegian economic policies

In the short run, the greatest challenge to Norwegian economic policies is the unusually high and increasing unemployment, combined with a deficit on the current accounts.

High international demand for traditional export competing products and shipping services, somewhat higher oil prices and oil production, have improved the current accounts significantly through 1988. The fact that Norway, despite high export prices, high activity in traditional export competing sectors and low domestic demand, has not achieved balance in the current accounts underlines the need for a restructuring of the economy.

International economic growth is expected to decline the next two years. Hence, the profitability of traditional export competing industries might be substantially lower than in 1988-89. High oil prices and oil production might still give a balance or even surplus on the current accounts in the short and medium term. This might give a momentum, but at the same time a false impression that the external economic problems are solved. In a longer term perspective, the balance of the external economy must be based on growth in other competing industries, not on a rapid depletion of a limited natural resource.

The traditional resource based, export competing industries, e.g. the metal industry, today produces at its capacity limit. The expansion of this industry is hampered by a limited supply of new electricity at a price the industry is willing to pay. At the same time, the general reduction of domestic demand has led to lower production and great problems for the import competing industries. In parts of the import competing industry, the reduction in production has been greater than the reduction in imports, which means that the industry has lost market shares. The high unemployment figures indicate that it has been relatively easy to reduce domestic demand directed towards sheltered and import competing industries, but difficult to transfer resources to new competing activities. There are few signs of a transition or restructuring so far. The investments in competitive industries declined sharply from 1987 to 1988.

The purpose of expanding competitive industries is not primarily to create employment in these industries, but to establish enough production capacity to secure external economic manouverability. This will give space for increased domestic demand for sheltered products, such that the unemployed and new-comers on the labour market can be absorbed in these sectors.

The Norwegian investment ratio, investments divided by gross national product, is fairly high compared to other OECD countries, but the return on these investments have been quite low. Norwegian industries are subsidised in several different ways. In addition to direct government support, several industries are indirectly subsidized through the tax system, sheltering from external competition and low prices on energy. These direct and indirect subsidies lead to investments which are socially unprofitable. Calculations show that, corrected for different forms of support, the return on capital is very low in many Norwegian industries, see Ministry of Finance (1988a). Subsidies lead to inefficient use of productive resources.

Many Norwegian production sectors are energy intensive and heavy polluters. Households' consumption of energy for heating purposes and equipment and their use of private cars have increased strongly as a result of the general growth of private real disposable income. The increased awareness of the links between economic growth, energy consumption and environmental issues, might make it both possible and necessary to change accustomed patterns of production and consumption. A conservation of the industrial structure, means of transportation and composition of consumption will put unnecessary constraints on the manoeuverability in a transition prosess.

Measures already introduced, have gradually reduced the emissions of SO_2, but without new measures, the emissions of SO_2, NO_x and CO_2 will increase. This implies new challenges, not only for environmental and energy policies, but also for the economic policies.

The SIMEN-calculations

The SIMEN-project studies possible paths for industrial development towards the turn of the century, and analysis to what extent these developments will be in conflict with targets for environmental and energy policies. In such analyses, it is necessary to focus on the interplay between activity levels, energy consumption and environmental issues in different sectors of the economy. Partial forecasts of individual sectors would easily be inconsistent and unrealistic. The analyses should in principle be "multisectoral and multipollutant". Macroeconomic analysis is therefore a central part of the SIMEN-project.

The analyses of environmental issues are concentrated on emissions to air of SO_2, NO_x and CO_2. So far, Norway has signed international agreements on reductions of emissions to air of SO_2 and NO_x. Analyses of adequate and feasible instruments should comprise all sectors of the economy, and the measures should be chosen such that pollution is reduced cost efficiently, without introducing unnecessary constraints on continued economic growth.

This chapter presents several alternative development scenarios for the Norwegian economy towards 2000, "the Reference scenario", "the Gas scenario" and "the Environment scenarios" which comprises "the Regulation scenario" and "the Tax scenario". These forecasts indicate possible consequences of different choices of energy and environmental policies, but none of the alternatives can be regarded as a prognosis, i.e. the most probable development.

The Reference scenario describes a possible economic development towards 2000, characterized by relatively moderate economic growth and moderate restructuring of industries, but with a gradual improvement of Norwegian competitiveness and external balance.

The consequences of increased utilization of indigenous gas resources are treated in the Gas scenario, chapter 5.3.

The consequences of stronger restrictions on pollution are presented in the Environment scenarios, the Regulation scenario and the Tax scenario, chapter 5.4.

The scenarios are calculated using the CBS-model MODAG W. This model is used by the Ministry of Finance in preparing forecasts for the Government's Long Term Programme, and by other government agencies in forecasting energy consumption and pollution. A description of the model is given in appendix 2.

The base year of the model is 1986. The forecasts are to some extent calibrated against preliminary national accounting and energy accounting figures for 1987 and 1988, and on forecasts for 1989 which where available in January-February 1989.

Such forecasts are of course highly uncertain. These uncertainties are due both to the exogenous assumptions and the model structure. No model can give a fully adequate description of the functioning of the economy over a longer period. If the Norwegian economy or the economy of Norway's trading partners are radically changed, there are reasons to believe that there will also be changes in expectations, behavioural relations and institutional conditions which the model does not adequately capture. E.g., the model relations are probably not robust enough to capture all the effects of major changes in tax policies.

Using the model for energy and pollution forecasts, it is especially important to underline the uncertainty in the model's description of technological development, and the substitution between oil products and electricity following a radical change in energy prices. The consequences for single firms and industries, and hence for the total economy, can be different from what the SIMEN-calculations show.

5.2 The Reference scenario

The Reference scenario in SIMEN deviates from the economic calculations of the Government's Long Term Programme 1990-1993 in several ways. The economic development of the Reference scenario is somewhat more pessimistic than in the Government's Long Term Programme, mainly due to different assumptions on oil and gas prices and production. Oil prices are assumed to be 20 dollars, measured in 1988-prices per barrel in 2000 in SIMEN, and 25 dollars per barrel in the Long Term Programme. In addition, oil production is assumed to decrease faster at the end of the 1990s in SIMEN than in the Long Term Programme. Due to lower oil revenues, the economic policies are less expansive in SIMEN than in the Long Term Programme. Some consequences of higher oil prices are illustrated at the end of chapter 5.2.

Assumptions

In the Reference scenario, it is assumed that the low international inflation rate of 4 percent per year continues. This leads to an increase in Norwegian import prices of approximately 3 percent, table 5.2.1. The growth of gross national product of Norwegian trading partners is assumed to be 2.5 percent annualy, approximately the same as the growth rate in these countries the last 10 years.

Table 5.2.1. Assumptions on international development and economic policy[1]. 1987-2000. Average annual growth. Percent

	87-90	90-95	95-00
International:			
Import prices	2.5	3.0	3.0
GDP trading partners	2.5	2.5	2.5
Crude oil price (NOK)	-2.0	6.5	6.5
Economic policy:			
Government consumption	1.5	2.3	2.4
Government gross investments	-1.7	1.7	1.9
Electricity prices	5.7	5.0	4.6

1) All volume figures in 1986-prices.

The oil and gas prices (with a lag of 1 year) are assumed to increase from 15 dollars per barrel in 1988 to approximately 20 dollars per barrel in 2000 (1988 prices). This development of the oil prices are based on the same assumptions as in the NOU (1988:21). In 1988, the oil price was 91 NOK per barrel. With an exchange rate for US dollars of 6.50 NOK, the oil price in the Refernce scenario will be 130 NOK in 2000. This implies a growth in real prices of oil, measured in NOK, of 3 percent annualy from 1988.

The electricity price of the primary market is assumed to follow the official calculations of the long term marginal cost of hydro power production, with a 6 percent return to capital. The real price of electricity, therefore, increases by 1.5 percent annualy in the 1990s.

The Reference scenario assumes no major changes of economic policies. Government consumption is assumed to increase by 2.3 percent, and the growth of government investments by 1.8 percent annually in the 1990s. Total taxes, as a share of gross national product, is approximately unchanged through the calculation period. The households' saving rate is assumed to increase from -1 percent in 1988 to 3 percent in 2000.

Macroeconomic results

The calculations for the next few years are characterized by a low increase in domestic use of commodities and services and a moderate growth in the production of mainland Norway, table 5.2.2. This should be seen in the context of the extremely high growth of domestic use in the period 1984-1987, and the belt tightening policies after the fall in the oil prices in 1986. The economic growth in this scenario is not a result of an expansive policy, but a gradual improvement in productivity, lower costs increases in Norway than internationally and hence an improvement of the competitive position. The growth of mainland Norway's gross national product is increasing to somewhat above 2 percent annualy towards the end of the 1990s. Lower oil production gives slightly lower growth for Norway's total gross domestic product.

Household consumption decreases from 1986 to 1990, but the growth in the 1990s is approximately the same as the growth for gross national product in mainland Norway. Towards the end of the 1990s, the growth of private consumption is again reduced as a result of lower oil production which contributes to a lower growth in disposable income.

Total gross capital formation increases only moderately over the calculation period. The growth is decreasing at the end of the 1990s, as a result of reduced investments in oil and gas activities. On the other hand, increased production and

Table 5.2.2. Macroeconomic variables. 1987-2000. Reference scenario[1]. Average annual growth. Percent

	87-90	90-95	95-00
GDP	1,6	1,9	1,0
GDP, mainland-Norway	0,9	1,9	2,1
Total domestic use	0,1	1,5	1,6
Household consumption	-0,8	1,8	1,8
Government consumption	1,5	2,3	2,4
Gross capital formation	-0,7	0,6	0,1
Gross capital formation, mainland-Norway	-2,8	0,8	2,1
Exports	4,2	2,9	0,7
Oil and gas	8,6	2,7	-5,5
Other commodities	4,6	2,8	3,3
Imports	0,3	1,9	2,1
Real disposable national income	1,4	1,9	1,6
Consumer price index	4,9	3,9	3,6
Wage costs per man-year	3,9	4,9	4,4
Employment	-0,3	0,6	0,8
Operating surplus	13,4	5,9	3,7
Manufacturing industries	12,6	2,8	7,7

1) All volume figures in 1986-prices.

operating surpluses in traditional industries, lead to higher growth of investments in mainland Norway towards the end of the 1990s. The increase of consumer prices are 3.5 to 4 percent annually in the 1990s. In the model, increases in wages are determined by import prices, consumer prices, the rate of unemployment and productivity. Wage growth is assumed to decline when unemployment increases, but gradually less as greater the unemployment is (non-linear Phillips curve mechanism, see Appendix 2). Up to 1990, real wages decline, but increases by approximately 1 percent annualy in the rest of the 1990s.

Employment, measured as man-years, increases by 0.5 percent on average over the period. The calculated unemployment is approximately at the 1988 level in the 1990s, but decreases at the end of the decade.

Total operating surplus is increasing rapidly in the first years, but is reduced towards the end of the 1990s due to lower oil and gas production. Operating surplus in manufacturing industries is growing steadily as a result of increased productivity and low increases in costs.

Export growth is high, partly as a result of the increased oil exports towards 1995, thereafter as a result of high growth in exports of traditional commodities. Low growth in domestic demand leads to low growth in imports. The current accounts show balance from 1991 and a surplus for the rest of the 1990s. Norway's net foreign debt was 110 billion NOK in 1988, or 19 percent of nominal gross national product. This share is kept almost constant up to 1991. Thereafter, the Norwegian net foreign debt is decreasing, and is repayed within 2000.

Figure 5.2.1 gives an illustration of Norway's net disposable real income over the period 1986 to 2000, and the development of the components of domestic use; household consumption, government consumption and net capital formation. The difference between disposable real income and total domestic use, corresponds to the current accounts in fixed prices. Figure 5.2.1 shows that real disposable national income is equal to domestic use in 1991-92, and that incomes are significantly higher than domestic use in the middle of the 1990s.

Supply and use of energy

Based on time series for the last 15 years, the development of energy consumption per unit of production is in the calculations assumed to decrease by 0.5 percent annualy in manufacturing industries (except metal production) and the transport sector. These assumptions reflect that the increas in real prices of energy are less in the calculation period than in the sample period 1973 to 1986. For metal production, the energy efficiency is assumed to increase by 1 percent annualy, based on information on possible productivity improvements from the industry. The power intensive industries, which comprise metal production and production of industrial chemicals, are assumed to consume the same amount of electricity as in 1988, 30 TWh, over the whole period. Production in these industries is thus assumed to grow at the same rate as productivity, see chapter 4.

It is assumed that fish farming will increase its share of total production in the fishery sector, and that the sector therefore will reduce its energy consumption per unit of production.

In the sample period, the energy intensity of service sectors increased, probably due to an expansion in office space, increased use of energy for heating purposes, ventilation and office machines. In the calculations, it is assumed that this capital deepening will be slower than in the sample period and the energy efficiencies of the service sectors are therefore kept constant.

The forecasted development of gross national product and energy consumption for mainland Norway and total manufacturing industries are shown in figures 5.2.2 and 5.2.3.

Figure 5.2.1. Real Disposable Income for Norway and Domestic Use of Goods and Services. Reference Scenario. 1986-2000. Billion 1986 NOK
Reference Scenario. 1986-2000. Indices, 1986=1

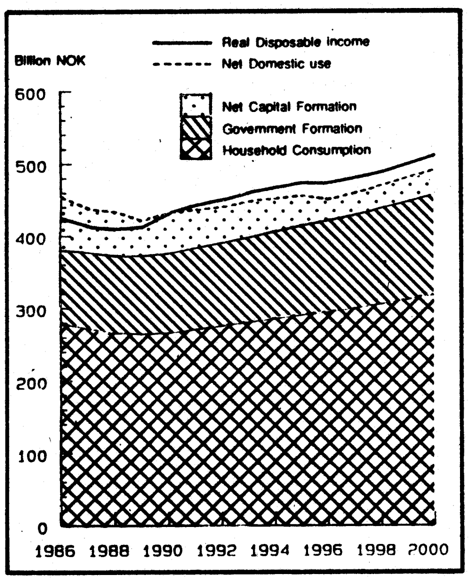
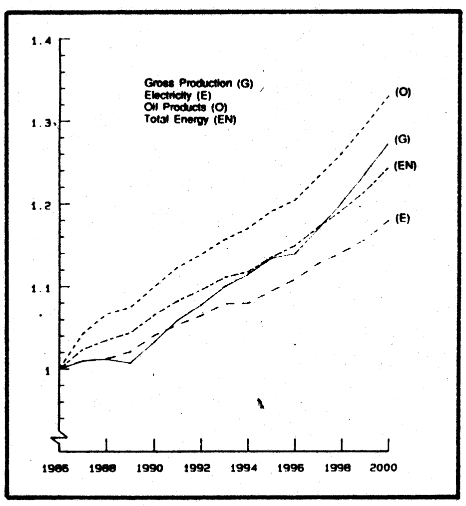


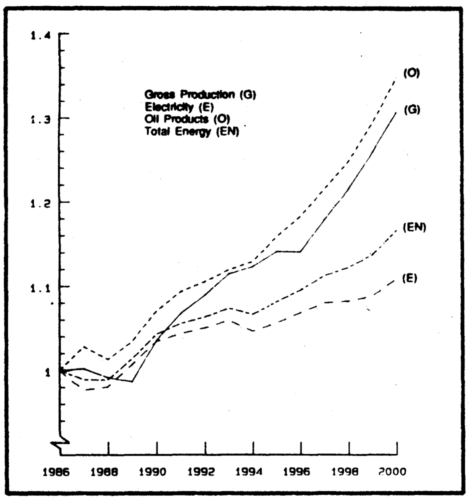
Figure 5.2.2. Gross Production, Consumption of Electricity, Oil Products and Total Energy (exclusive of gasoline). Mainland Norway.



From 1987 to 1990, total energy consumption is forecasted to grow propotionately to gross production in mainland Norway. This is due to a relatively strong growth in power intensive industries and pulp and paper production in 1987 and 1988, in addition to a relatively strong increase in households consumption of electricity in this period.

In the 1990s, both the prices of electricity and oil products are increased in real terms. The assumption of stable electricity consumption in power intensive industries after 1988, combined with increased energy efficiency for manufacturing industries and domestic transport, reduces the growth of energy consumption compared to the growth of gross national product for mainland Norway.

Figure 5.2.3. Gross Production, Consumption of Electricity, Oil Products and Total Energy (exclusive of Gasoline). Mining and Manufacturing. Reference Scenario. Indices, 1986=1



Total net power consumption (firm and surplus power) increases from 91 TWh in 1987 to 104 TWh in 2000. The primary market consumes 74 TWh and power intensive industries 30 TWh. Distribution and transmission losses are assumed to be 3 percent for power intensive industries and 12 percent for the primary market. Necessary production capacity is therefore 114 TWh in 2000, disregarding net exports or imports of electricity. Official forecasts of the average annual production capacity of the hydro power system is 112 TWh in 2000, see Norwegian Water and Electricity Board (1988). The remaining electricity demand, 2 TWh, is assumed to be covered by gas power production.

Over the period from 1987 to 2000, total consumption of gasoline increases by 22 percent, heating oils by 14 percent and transport oils by 16 percent. From 1990, the oil products prices increase by 1 percent relative to the price of electricity. This leads to a substitution from oil products to electricity for heating purposes. It is assumed that the consumption of fuel wood in households is constant at the 1986-level over the calculation period.

The strong growth in gasoline consumption is a result of increased private consumption and increased use of private cars. The consumption of transport oils grows slower than the production in the transport sector, as a result of the assumption of increased energy efficiency.

Table 5.2.3. Consumption of energy. 1986-2000. Reference scenario. Average annual growth. Percent

	1986	1987	2000	Annual growth 87-90	90-95	95-00
Total consumption (net):						
Total energy[2], PJ[3]	547	551	626	0.9	0.7	1.3
Electricity, TWh	90,5	91	104	1.0	0.6	1.3
Heating oils, kt[1]	2238	2251	2489	0.0	0.4	1.7
Gasoline, kt	1859	1935	2311	-0.7	1.8	2.3
Transport oils, kt	3066	3091	3574	1.0	1.1	1.2
Primary market (net):						
Total energy[2], PJ	428	437	510	0.7	1.0	1.7
Electricity, TWh	60,5	62	74	0.5	1.1	1.9
Heating oils, kt	1966	2001	2310	0.6	0.7	1.9
Gasoline, kt	1857	1933	2310	-0.7	1.8	2.3
Transport oils, kt	3066	3091	3574	1.0	1.1	1.2

1) kt = 1000 tons (kilotons).
2) Exclusive of gasoline.
3) Peta-Joule.

Emissions to air

In the reference scenario, the following environmental measures against air pollution are included:

- regulations of single firms producing pulp and paper, metals and industrial chemicals are assumed to reduce the emissions of SO_2 by 5 kilotons in 2000.
- The shut down of the copper smeltery at Sulitjelma reduce SO_2 emissions by 12 kilotons in 1986.
- In addition, the effects of reducing the sulphur contents in heavy oils in the 13 Southern counties and further restrictions in the cities of Oslo and Drammen are included.
- It is assumed that all new private gasoline cars are equipped with a catalytic cleaner from 1989, and that the existing stock of cars is replaced by 1998.

Environmental investments have been relatively high in manufacturing industries the last 10 to 15 years. It is assumed that new measures will not increase the investment costs compared to the previous period. In the calculations, the costs of implementing the above mentioned measures, are therefore assumed to be included in the model relations. Improved cleaning of local sewers is assumed to increase the investments of local governments substantially in the calculations.

Figure 5.2.4. SO_2-emissions. Reference Scenario. 1986- 2000. 1000 metric tons per year

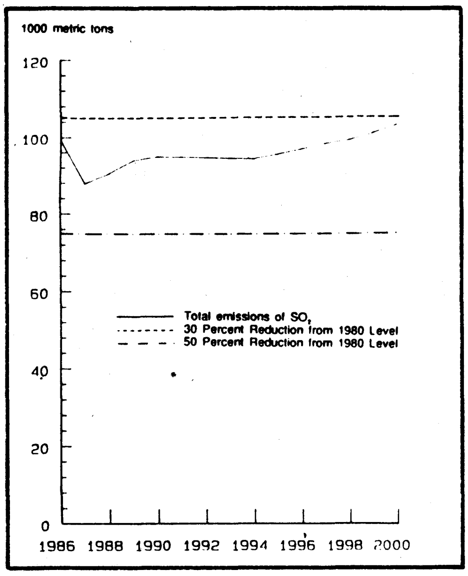
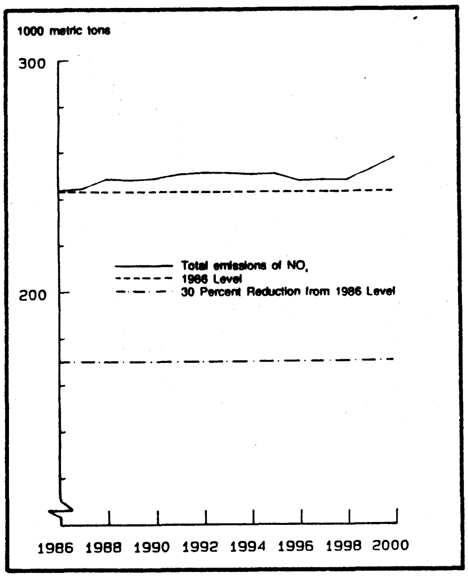


Figure 5.2.5. NO_x-emissions. Reference Scenario. 1986-2000. 1000 metric tons per year

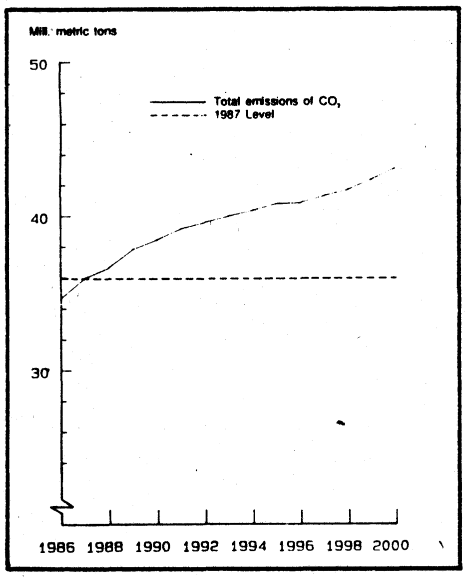


The development of SO_2, NO_x and CO_2 emissions are shown in figures 5.2.4-5.2.6 and table 5.2.4. Total emissions of SO_2 increases by 18 percent, from 88 kilotons in 1987 to 104 kilotons in 2000. The emissions of NO_x increases in the calculations by 5 percent from 245 kilotons in 1987 to 258 kilotons in 2000. This moderate growth is a result of the introduction of catalytic cleaning of private gasoline cars and the increased energy efficiency in the transport sector. The emissions from processes and stationary combustion increase by 27 and 15 percent, respectively.

The emissions of CO_2 are calculated to increase from 36 million tons to 43 million tons in 2000, a growth of 19 percent. In these figures, the emissions from possible production of gas power is not included. 2 TWh gas power will increase CO_2 emissions by 1 million tons in 2000, and the increase in total emissions will be 22 percent from 1987 to 2000.

The emissions of CO_2 and NO_x from stationary combustion decrease at the end of the 1990s. This is due to the reduction in oil and gas production, and hence reduced emissions from this sector. This decrease "compensates for" the increase in emissions from stationary combustion in other sectors.

Figure 5.2.6. CO_2-emissions. Reference Scenario. 1986-2000. Mill. metric tons per year



The growth of production and income is relatively modest in the Reference scenario. This induces low growth in the consumption of fossil fuels, which is a main source to the emissions of SO_2, NO_x and CO_2. A higher growth of production and income, however, might result in a higher consumption of fossil fuels and hence higher emissions levels.

Even if the Reference scenario is characterized by a modest economic growth, the increase in activity levels lead to an increase in energy consumption and a relatively rapid growth of emissions of SO_2, NO_x and CO_2 over the calculation period.

After the transition to catalytic cleaning of private gasoline cars, the NO_x emissions will increase if further measures are not introduced. New measures will therefore be necessary if Norway should comply to the international agreements on reductions of SO_2 and NO_x beyond 2000.

The effects of higher crude oil prices

There is great uncertainty about the development of the crude oil prices on the world market. With the Reference scenario as a starting point, the impacts of higher oil and gas prices are calculated (25 US dollars 1988 prices in the year 2000). It is assumed that this price increase will have no impacts on the world economy, which of course is a strong simplification. Higher crude oil prices will immediately improve Norway's external balance, but higher crude oil prices will also effect the level and composition of energy consumption and pollution.

Higher oil prices lead to a substitution from oil products to electricity. Electricity consumption increases by approximately 3 TWh and oil consumption decreases accordingly. This reduces the emissions of SO_2, NO_x and CO_2 in the order of 2 to 4 percent compared to the Reference scenario in 2000. If the increased electricity demand is covered by gas power, the CO_2 emissions will increase instead of decrease compared to the Reference scenario.

In these calculations, the oil prices are 20 percent higher than in the Reference scenario in 2000. It is not assumed that this will lead to increased energy efficiency.

Higher crude prices will give a significant improvement of the current accounts. In the calculations, Norway's foreign financial assets will amount to approximately 20 percent of gross domestic product in 2000, measured in current prices. This will allow for a more expansionary economic policy and lower unemployment rates than in the Reference scenario.

5.3 The gas scenario

In the Gas scenario, the possible consequences for economic activity, energy consumption and pollution from increased utilization of Norwegian gas resources are calculated. It is assumed that exports of natural gas to Sweden is combined with domestic power production based on natural gas, and consumption of gas for industrial purposes.

Assumptions

The calculations assume the construction of a gas pipeline with a capacity of approximately 6 billion Sm^3 from Western to Eastern Norway and further to Sweden. Up to 1995 this will lead to higher investments in gas pipe lines, distribution grids and thermal power stations.

In Sweden, the total demand for gas has been estimated to 4 to 5 billion Sm^3 per year in 2000 and 8 billion Sm^3 in 2010. Denmark might deliever 1 billion Sm^3 per year. The potential for Norwegian exports should therefore be up to 4 billion Sm^3 annualy at the end of the 1990s, which is also the assumption in the Gas scenario.

Domestically, gas can be used for several purposes: for power production, as a raw material for production of amonia, direct use of gas for energy purposes in manufacturing industries, direct use of gas for heating purposes in services and households and for transportation.

Table 5.2.4. Emissions to air[1,2] of SO_2, NO_x and CO_2. 1986-2000. Reference scenario. Average annual growth. Percent

	1986	1987	2000	Annual growth 87-90	90-95	95-00
Total[6]						
CO_2, mt[4]	35	36	43	2.3	1.2	1.1
SO_2, kt[3]	99	88[5]	104	2.6	0.1	1.6
NO_x, kt	244	245	258	0.6	0.2	0.5
Processes						
CO_2, mt	5	5	7	5.2	0.7	2.1
SO_2, kt	45	34	40	5.0	-1.0	1.3
NO_x, kt	11	11	14	5.2	0.4	1.1
Stationary combustion						
CO_2, mt	14	15	17	3.1	1.0	0.1
SO_2, kt	28	28	32	1.2	0.2	1.7
NO_x, kt	24	26	30	4.1	1.3	-0.5
Mobile sources[6]						
CO_2, mt	15	16	19	0.5	1.5	2.0
SO_2, kt	27	25	31	1.0	1.7	2.0
NO_x, kt	209	208	214	-0.1	0.0	0.7

1) Emissions from international shipping in Norwegian waters and petroleum activities included.
2) Gas power production excluded.
3) kt = 1000 tons.
4) mt = million tons.
5) Shut-down of the copper smelter in Sulitjelma included from 1986.
6) Of which emissions from international shipping in Norwegian waters accounts for 9 kt SO_2, 23 kt NO_x and 1 mt CO_2 in 2000.

Since there is no gas grid in Norway, most domestic use would imply substantial costs of transmission and distribution. Total transport costs per unit delievered are lowest for power production, even if the production is based on a gas pipeline to Eastern Norway. For the other alternatives, total transport costs per unit delievered will be higher, since they will demand a distribution network to several small consumers.

In the Reference scenario, the price of electricity followed the development of the long term marginal cost for hydro power. This corresponds to an increase in real prices of electricity of approximately 1.5 percent annualy from 1990. In 2000, the Reference scenario assumes a long term marginal cost of 29 øre per kWh measured in 1988 prices, referred to the power station at 6 percent discount rate for deliveres to the primary market. The production costs in a gas fired power station is 10 øre per kWh, including the cleaning costs of emissions of NO_x. If the prices of electricity based on gas is equal to the long term marginal cost for hydro power, the netback price for gas delivered at the power station will be approximately 95 øre per Sm^3 in 2000.

To increase demand for electricity in the Gas scenario, compared to the Reference scenario, it is assumed that the price of electricity to the primary market is 20 percent lower than in the Reference scenario. This implies a netback price for gas delivered to the power station of approximately 65 øre per Sm^3. The willingness to pay might be higher if the gas fired power station is located close to the consumers, such that the transmission and distribution costs for gas power is lower than for hydro power. The willingness to pay might also be higher if the efficiency rate of the gas fired power plant is higher than 50 percent, i.e. in a combined power station were the cooling water from gas power production is utilized.

In addition to the significant potential for gas power production, there is also a certain potential for indiginous use of gas to industrial processes. Up to 2000, the demand from Norwegian industries is assumed to be relatively modest. In the Gas scenario it is assumed that 0.5 billion Sm^3 is used as raw materials in industrial processes.

Direct use of gas as a substitute for oil and other fossil fuels in manufacturing industries, will require relatively large investments in transmission and distribution networks. This is also the case for direct use of gas in households and services, where the introduction of gas would also require investments in heating equipments. The efficiency rate of direct use of gas for heating purposes is, however, close to 100 percent. This implies a high willingness to pay for direct use of gas in the residential sector in the longer run. The potential seems, however, to be relatively small within 2000, due to the large investment cost. This market segment might be increased if direct use of gas is considered as an alternative in the planning of new housing areas and commercial buildings.

The prospects for direct use of gas for transportation purposes in Norway (buses, trucks, private cars, ocean transport) are uncertain. The technology is known and available, and gas vehicles are used in several countries.

Macroeconomic effects

In the Gas scenario, the investments in infrastructure and transport capacity for gas is increased substantially compared to the Reference scenario. Lower prices on electricity induce increased demand and production of electricity, and therefore higher investments in production and distribution capacity. Given the idle capacity in the Norwegian economy, increased investments will lead to higher domestic activity levels, increased incomes and increased household consumption. In the Gas scenario, the level of gross national product and household consumption is approximately 1.5 percent higher than in the Reference scenario in 2000.

Higher domestic activity levels also increase imports and deteriorate the external balance compared to the Reference scenario up to the end of the 1990s. Lower domestic energy prices, which follows from the increased energy supply, thereafter improves the competitiveness of Norwegian industries and the exports of traditional commodities increase. In the last years of the decade, direct exports of natural gas to Sweden gives higher incomes. The external balance is therefore almost unchanged compared to the Reference scenario in 2000. The economic benefits from an increased depletion of natural gas will, however, be more significant after the turn of the century.

Consumption of energy

In the Gas scenario, the production and energy consumption of power intensive industries are assumed to be unchanged compared to the Reference scenario. This is due to the fact that the industry has refused to purchase new power at prices which are equivalent to the 1983-contracts. Even if the electricity prices of the Gas scenario is 20 percent lower than the long term marginal cost for hydro power, they are higher than the 1983-contracts.

Lower electricity prices give a substitution from oil products to electricity. Electricity consumption (net) increases by 9 percent or 10 TWh, the consumption of heating oils is reduced by 6 percent and the consumption of transport oils is almost unchanged. Lower energy prices, therefore, increases total energy consumption compared to the Reference scenario, table 5.3.1.

It is not assumed that the sectoral energy consumption per unit of production is increased in the Gas scenario compared to the Reference scenario. If lower energy

Table 5.3.1. Consumption of energy. Reference scenario and Gas scenario. Level and percent deviation. 2000

	2000		
	Reference scenario	Gas scenario	Percent deviation
Total consumption (net):			
Total energy[2], PJ[3]	626	656	4.8
Electricity, TWh	104	114	9.6
Heating oils, kt[1]	2489	2342	-5.9
Primary market (net):			
Total energy, PJ	510	539	5.7
Electricity, TWh	74	84	13.5
Heating oils, kt	2310	2174	-5.9

1) kt = 1000 tons (kilotons).
2) Exclusive of gasoline.
3) Peta-Joule.

prices induce higher energy intensities, the increase in electricity consumption will be higher and the reduction in oil consumption lower than calculated. The increased electricity demand is assumed to be covered by increased supply of gas power.

Emissions to air

The emissions from industrial processes and mobile sources are almost unchanged from the Reference scenario. The total emissions are therefore mainly effected by the reduced consumption in heating oils and the increased production of thermal power.

As shown in table 5.3.2, the reductions in emissions of SO_2 are relatively small, following the reductions in use of oil products.

The major source for NO_x emissions, mobile sources, are hardly effected by the reduction in electricity prices and other changes in the economy from the Reference scenario to the Gas scenario. The reductions in NO_x emissions of 5000 tons (2 percent) is due to reductions in emissions from stationary combustion. The NO_x emissions from gas power production increases by 2000 tons, and the net reduction of NO_x emissions are therefore 3000 tons compared to the Reference scenario in 2000.

Table 5.3.2. Emissions to air[1,2] of CO_2, SO_2 and NO_x. Reference scenario and Gas scenario. Level and percent deviation. 2000

	2000		
	Reference scenario	Gas scenario	Percent deviation
CO_2, mt[4]	44	48	9.1
Of which, gas power production	1	6	
SO_2, kt[3]	104	102	-1.9
NO_x, kt	258	255	-1.2

1) Emissions from international shipping in Norwegian waters and petroleum activities included.
2) Emissions from gas power production included.
3) kt = 1000 tons.
4) mt = million tons.

The emissions of CO_2 from stationary combustion is reduced by 1 billion ton as a result of fuel substitution. The reduction of emissions from heating oils are however more than compensated by the emissions from production of 10 TWh gas power, which increases emissions by 5 million tons. Even if gas has a lower carbon content than oils, the CO_2 emissions will increase, since gas is assumed to be used in termal power plants with an efficiency rate of 0.5.

5.4 The Environment scenarios

5.4.1 Introduction

The starting point for the calculations in the Environment scenarios are the international agreements on:

- 30 percent reduction of SO_2 emissions by 1993, compared to the emission level in 1980. The Governments target is to reduce emissions by 50 percent over the same period.
- Stabilizing emissions of NO_x at the 1987 level by the end of 1994 and a declaration that Norway will aim at a 30 percent reduction by the end of 1998.

Until recently much of the focus has been on air pollution of SO_2 and NO_x. Recently, the focus has changed to an increased attention on global environmental problems as the greenhouse effect and the depletion of the ozone layer of the stratosphere, see chapter 3.

Protection of the ozone layer will demand measures which will only effect relatively few commodities and processes, and where cost competitive alternatives are available in most cases.

The major source of CO_2 emissions, one of the greenhouse gases, is combustion of fossil fuels. CO_2 is difficult and costly to clean with known technology, and emissions reductions will in practice mean reductions of consumption of fossil fuels. This might be a dominating feature of future environmental policies, and will directly or indirectly effect all economic activities. On the other hand, reduced consumption of fossil fuels will also lead to lower emissions of SO_2 and NO_x.

Historically, there has been a high correlation between growth in production, income, energy consumption and pollution. The authorities can modify this relation by introducing direct regulations either in the form of cleaning requirements, restrictions on consumption of fossil fuels or by introducing economic instruments as charges on emissions or on the use of fuels. The oil price increases in 1973-74 and 1979-80, illustrated that prices on fossil fuels are essential both for the choice of energy carrier and also as incentives to develop new technology.

The Reference scenario is characterized by a relatively moderate economic growth. Over a 14 year period, the increased activity levels still contribute to a rapid increase in the emission levels of SO_2, NO_x and CO_2. This means that the authorities will have to introduce new measures in addition to those already introduced, if the environmental targets should be achieved. When searching for new policy measures, it is important to evaluate measures to control the three components simultaneously, and the long term effects of the instruments should be given some attention. Packages of short measures against single pollutants might be quite costly - and lead to wasted investments - if in the longer run it is necessary to use more general instruments to reduce the consumption of fossil fuels.

The agreements already signed on reductions of emissions of SO_2 and NO_x, give upper bounds on the emission levels after 1993 and 1998, respectively. Future renegotiations of these agreements will probably imply further restrictions on emission levels. It therefore seems appropriate to focus on instruments which could stabilize or reduce the consumption of fossil fuels, even if the economic growth continues up to 2000 and beyond. Steering mechanisms which change relative prices, seem most promising, since they give incentives both for substitution between different energy sources and technology development.

Chapter 5.4.2 discusses regulatory measures which can be introduced to achieve the targets on reductions of SO_2 and NO_x, and the costs of implementing such packages.

Chapter 5.4.3 discusses how economic instruments, such as indirect taxes, can be used to achieve the targets, including a stabilizing of CO_2 emissions. Finally, chapter 5.5 gives a brief discussion on how one can combine direct regulations and general economic instruments to achieve environmental targets.

5.4.2 The Regulation scenario

The State Pollution Control Authority and the Ministry of Environment have evaluated different measures to reduce emissions of SO_2 and NO_x. The proposals include stronger restrictions of the sulphur content of oil products, further cleaning of manufacturing industries, new restrictions on emissions from vehicles and ocean transport, energy economizing and traffic regulation. In the Regulation scenario, the costs and reduction of emissions of NO_x and SO_2 of these proposals are calculated as deviations from the Reference scenario.

The proposals are discussed in the White Paper no. 47 (1987-88) "On the reduction of emissions of nitrogen oxides in Norway", and in a paper on reduction of SO_2 emissions by the State Pollution Control Authority. Cost efficiency, i.e. costs per unit of emissions reduction are estimated for most of the proposals. The Resource Policy Group has evaluated costs and possible reduction of emissions as a result of stronger regulations of industrial concessions and expected improvements of technology in polluting process industries. This work is published as a sub-report of the SIMEN-project, see appendix 1. Some of these changes can be characterized as most likely, whereas others are only feasable if environment policies are radically changed.

Measures against SO_2

The State Pollution Control Authority has given priority to three measures to achieve the government's target of 50 percent reduction of emissions from 1980 to 1993:

- Restrict the content of sulphur in heavy oils to maximum 1 percent in all regions of the country. This restriction is only introduced in the 13 Southern counties today. The State Pollution Control Authority has estimated the costs of producing low sulphur oils to approximately 5 percent higher than for oils with an average sulphur content of 2.5 percent. Total annual costs are thus estimated to 30 million NOK at present oil consumption.

- Further reduce in the sulphur content in refined products such as diesel and light heating oils. The costs of reducing the sulphur contents in these products from 0.23 to 0.20 percent is estimated to be less than 0.1 øre per liter.

- Introduce stronger regulations and cleaning requirements for SO_2 emissions in some of the larger establishments in the 13 Southern counties within 1993. The problem of acidification is concentrated to these counties. The measures against establishments are regulations of process emissions, and reductions will therefore be additional to the reduction following from lower sulphur content in transport and heating oils. These measures against manufacturing industries, will according to the State Pollution Control Authority, reduce SO_2 emissions by 5000 tons before 1993, but the costs are highly uncertain.

The report from the Resource Policy Group gives estimates for SO_2 cleaning costs. The costs of sea-water-scrubbing is estimated to 13-26 NOK per kilo SO_2 and lime scrubbing to approximately 35 NOK per kilo. Most establishments are located along the coast, such that sea-water-scrubbing is possible. Assuming that the average cleaning costs will be 20 NOK per kilo, the proposals against manufacturing industries from the State Pullution Control Authority will cost approximately 100 million NOK annualy.

In addition to evaluating the proposals from the State Pollution Control Authority, the Resource Policy Group has also evaluated some measures against the aluminium industry, production of industrial chemicals and ferro alloys.

For the aluminium industry, most consessions are renegotiated the last two years or will be renegotiated through 1989. The most polluting units have been asked to suggest measures which would reduce the emissions by 50 percent.

Today, only a few of the ferro alloy producers clean their emissions of SO_2. Further restrictions on the remaining units might reduce emissions by 8000 tons. Some of these regulations might imply considerable investments and reconstructions, and marginal units might not be able to carry such costs.

Production of cilicium carbide also results in large emissions of SO_2. The source of emissions is coke with a sulphur content up to 2.7 percent. Technology improvement now make it possible to reduce sulphur contents to 2 percent, and the Resource Policy Groups assumes that a further reduction to 1 percent might be realistic over a 10 year period. It is assumed that the average for the industry will be 2 percent in 2000, which represents the technology front today. Low sulphur coke is not more expensive than high sulphur coke, and the technology improvement which would reduce emissions by 1000 tons in 2000, is therefore assumed to incur no extra costs.

Table 5.4.1 shows the reduction in future emissions, given that all the above mentioned measures are introduced.

Table 5.4.1. Estimated reduction of SO_2-emissions. 1000 tons. 2000

Reduced sulphur contents in heating oils	5
Reduced sulphur contents in transport oils	3
Regulations of industries in acid areas	5
Further regulations of aluminium production	3
Further regulations of industrial chemicals	1
Further regulations of ferro-alloy production	8
Total	25

Altogether the proposed regulations are estimated to cost 300-400 million NOK annualy, including interest costs. In a macroeconomic context, these costs are relatively low, but some firms will have their costs increased substantially if these new regulations are enforced. The regulations will reduce total SO_2 emissions by 25 000 tons in 2000 compared to the Reference scenario. The emissions will then be 45 percent below the 1980 level, and the agreement of 30 percent reduction will be reached since the measures are assumed to be enforced by 1993.

Measures against NO_x

The White Paper no. 47 (1987-88) discusses the effects of introducing USA-standards for diesel cars, which will reduce the NO_x emissions by approximately 50 percent. This standard requires technical changes which will increase the production costs of private cars by 1600 NOK, small trucks by 3000 NOK and large trucks by 10 000 NOK. The White Paper also discusses the impacts of introducing California standards to small gasoline and diesel cars. For gasoline cars, California-standards means that 90 percent of NO_x emissions are cleaned, whereas the emissions are reduced by 70 percent by todays catalytic cleaners.

Table 5.4.2 shows the reductions which follows from introducing USA-standards for light diesel cars within 1990, heavy diesel cars by 1994 and California standards to all light vehicles by 1994.

There is some dispute over the effects these technical changes might have on fuel consumption, but preliminary estimates show an increase of 0-5 percent, which

Table 5.4.2. Estimated reductions of No_x-emissions from mobile sources. 1000 tons

	1995	1998	2000
Light gasoline cars	1	8	6
Heavy gasoline cars	0	1	1
Light diesel cars	1	2	2
Heavy diesel cars	2	6	8
Total	4	16	18

would contribute to an increase in the emissions both of SO_2 and CO_2. These assessments are neglected in this chapter. The annual costs of the NO_x measures are estimated to 130 million NOK in the White Paper.

Total emissions of NO_x were estimated to 245 000 tons in 1987, of which process emissions contributed only 11 000 tons. Production of fertilizers is the main source of these process emissions. Some proposed cleaning measures in the fertilizer industry will reduce NO_x emissions by 3-4 000 tons.

The White Paper on NO_x emissions, also discusses new regulations in ocean transport. The costs per ton reductions are, however, estimated to be 3 to 6 times as high as in measures against road traffic. This might imply that measures against ocean transport might not contribute to emission reductions before the end of the century, but some recent technological improvements are promising.

Other proposed measures against SO_2 and NO_x are energy economizing and regulation and stabilizing of ocean and road transport. The instruments necessary to achieve these changes are not discussed in the White Paper, but implicitly it is reasonable to assume that general economic instruments will be applied to give incentives to energy economizing and technological improvements.

5.4.3 The Tax scenario

This scenario analysis the consequences of an environmental policy aiming at stabilizing the domestic emissions of CO_2 at the 1987 level. The instrument is an increase of the indirect taxes on fossil fuels, combined with an equivalent reduction of direct income taxes.

In this scenario, the assumptions on the development of crude oil prices and the international economy is unchanged from the Reference scenario. International agreements, controlling the emissions on greenhouse gases, will probably have significant consequences for international energy markets and indirectly effect the growth of the international economy and world trade. These effects have not been studied in the SIMEN-project.

The indirect taxes on gasoline, heating and transport oils are gradually increased such that the prices are approximately 75 percent higher than in the Reference scenario in 2000. This implies a real price increase of oil products of 80 percent from 1987. Compared to the previous peak levels of 1981, the real prices of heating oils will be approximately the same and gasoline prices 50 percent higher in 2000.

To cover the increased domestic demand for electricity, the production capacity of the hydro power system is increased relative to the Reference scenario. Since hydro power capacity can only be increased at increasing costs, it is assumed that the real price of electricity is 10 percent higher than in the Reference scenario in 2000. As a consequence, the real price of electricity is 30 percent higher in 2000 than in 1986.

Theoretically, the indirect taxes on oil products should have been differentiated by the marginal damage their consumption leads to. Such marginal damages are difficult to assess. In the calculations, the increases in prices are equal for all types of oil products. Increased fuel taxes are estimated to increase public revenues by 10-12 billion 1987-NOK. The increase in indirect taxes are compensated with reductions in income taxes, and government budgets are almost unchanged after these revisions of the tax system. Compensation can be given as reductions of corporate taxes, wage taxes or as direct transfers. For the producers, the indirect taxes can be compensated by reducing the social security premium or taxes on profits. In the calculations, taxes on wage incomes are reduced, and transfers to households are increased.

The sharp increase in energy prices will hit private consumers relatively hard, since they consume approximately 30 percent of the total domestic electricity, 10 percent of the heating oil and more than 65 percent of the gasoline. Energy expenditure amounts to 8 to 10 percent of the total consumer budget. Compensating the households by reductions in wage taxes and increases in transfers, total household consumption is almost maintained after the increase in taxes on fossil fuels.

Figure 5.4.1. Purchaser Prices for Heating Oils. 1978-2000. Tax Scenario. Øre per KWh, 1988-Prices

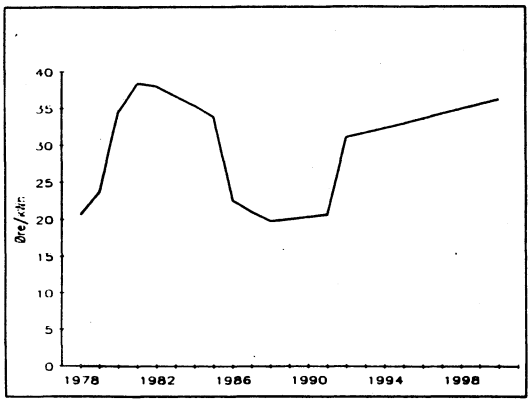
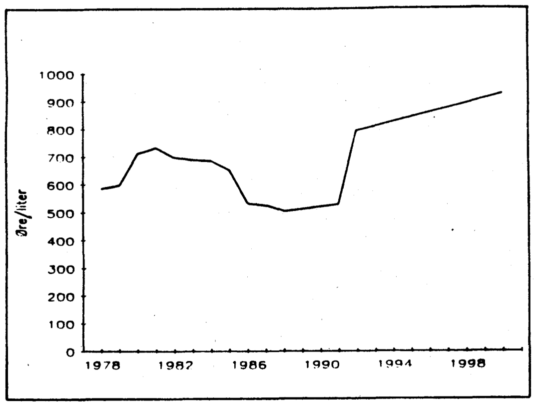


Figure 5.4.2. Purchaser Prices for Gasoline. 1978-2000. Tax Scenario. Øre per liter. 1988-Prices



The model MODAG W specifies wage relations which accounts for the effects of tax changes. The coefficients of these relations are highly uncertain, but according to the model relations, a reduction in direct taxes will reduce nominal wage increases.

Increased energy prices, will give the producers incentives to replace the existing capital equipment with more energy efficient capital. In a transition period, this will lead to increased replacement and therefore higher depreciation. In the calculations, it is assumed that depreciation will increase by 10 percent in manufacturing industries (with the exception of metal production and the refinery sector) and the transport sector compared to the Reference scenario. This increase in depreciation amounts to 3.5-4 billion 1986-NOK annually, which accumulated over the period 1992-2000 gives an increase in the replacement of approximately 35 billion 1986-NOK. As a comparison, this accumulated depreciation is equal to the huge annual investments in petroleum activities at its peak level in the middle of the 1990s.

It is assumed that the price increases on energy will spead up the introduction of new energy efficient technology. In the calculations the energy intensity in all production sectors (with the exception of metal production), is reduced by 1 percent annualy from 1992 compared to the Reference scenario. This will (cet. par.) lead to a reduction in energy consumption by 8 percent up to 2000. The assumptions of improved energy efficiency and the estimate of increased costs, are of course highly uncertain.

Macroeconomic development

In the calculations, the total effects on main macroeconomic variables are small compared to the Reference scenario. Gross national product and household consumption are approximately 1 to 2 percent lower in 2000 than in the Reference scenario.

There are several reasons for these moderate changes in macroeconomic indicators. The budget share for energy is relatively low in most sectors, on average 5 percent of total variables costs. The effects of higher energy prices are dampened by the assumed increase in energy efficiency by 1 percent annually. The real price increase of oil products by 75 percent, and the increase of electricity by 10 percent, will therefore on average increase variable costs by 0-3 percent. The effects of higher energy prices, however, unequally distributed among sectors, dependent on the composition of the total energy consumption between electricity and oil products, and the budget share for energy. Reductions in direct income taxes are assumed to reduce nominal wage increases. The change of the tax system from direct to indirect taxation thus leads to small changes in production costs and hence in production and productivity for most sectors.

The calculated effects on total production are small, but for some industries the effects are significant. The decline in production is highest for relatively energy intensive industries as production of pulp and paper, chemicals and machineries. The decline ranges from 4 to 7 percent measured as production in 2000 compared to the Reference scenario. The calculated effects for some of these energy intensive sub-sectors might be underestimated.

The change in relative energy prices, leads to higher domestic demand for electricity, and increased investments and production in the hydro power sector. This also increases the domestic activity level. At the same time the productivity of the economy is increased by introducing more energy efficient capital equipment. The compensation of private households by tax cuts and increased transfers, maintains household disposable real income and thereby household consumption. The impacts on the external economy are also small. A more rapid replacement of the capital equipment in manufacturing industries and transportation increases domestic production and imports of investment commodities. Lower domestic oil consumption, given production capacity, increases oil exports.

Supply and use of energy

Total domestic consumption of electricity increases by almost 5 percent or 5 TWh compared to the Reference scenario in 2000. This increase is due to higher demand in the primary market. The power intensive industries are assumed to maintain the production profile and the elctricity consumption from the Reference scenario.

Table 5.4.3. Consumption of energy. Reference scenario and Tax scenario. Level and percent deviation. 2000

	Level 1986	Level 1987	2000 Reference scenario	Tax scenario	Percent deviation
Total consumption (net):					
Total energy[2], PJ[3] . . .	547	551	626	590	-5.7
Electricity, TWh	90.5	91.3	104	109	4.8
Heating oils, kt[1]	2238	2251	2489	1621	-34.9
Gasoline, kt	1859	1933	2311	1873	19.0
Transport oils, kt . . .	3006	3099	3574	3085	-13.7
Primary market (net):					
Total energy[2], PJ	428	437	510	474	-7.1
Electricity, GWh	60.5	62.4	74	79	6.8
Heating oils, kt	1966	2001	2310	1476	-36.1
Gasoline, kt	1957	1931	2310	1872	-19.0
Transport oils, kt . . .	3066	3099	3574	3085	-13.7

1) kt = 1000 tons (kilotons).
2) Exclusive of gasoline.
3) Peta-Joule.

The consumption of heating oils are reduced by 35 percent, gasoline by 19 percent and transport oils by only 14 percent. The reduction in gasoline and transport oil consumption can partly be seen as a result of more energy efficient vehicles, reduced use of private cars and better efficiency in road transport.

Supply of energy

Total net electricity consumption is 109 TWh in the Tax scenario in 2000. Gross demand for electricity is then 120 TWh, including the power loss of 12 percent for delieveries to the primary market. The average annual production capacity of existing and planned hydro power plants is estimated to 112 TWh in 2000. The demand gap is then 8 TWh electricity in the Tax scenario, compared to 2 TWh in the Reference scenario. The increased demand for electricity can be covered in different ways, which will have different effects on the economy and on emissions of different pollutants.

- **Gaspower**

If the gap of 8 TWh electricity in the Tax scenario, should be covered by gas power, the CO_2 emissions will be 4 million tons higher than in table 5.4.4. If reductions of CO_2 emissions is a high priority target, substitution from heating oils to electricity based on natural gas is not an acceptable solution.

- **Direct use of natural gas for heating purposes**

Direct use of gas for heating purposes is briefly discussed in the Gas scenario, chapter 5.3. The conclusion is relatively pessimistic, but the potential might increase after 2000. A substitution from oil to direct use of gas in existing stationary combustion, might reduce CO_2 emissions by more than 40 percent. Direct use of gas for heating purposes is still not a very promising Norwegian solution if the target is to reduce CO_2 emissions, since the substitution potential is relatively small. It should be noted, though, that direct use of gas is more "energy and cost efficient" than converting gas to electricity.

- **Reorganization of the electricity market**

The Norwegian electricity market is characterized by great differences in purchaser prices between consumer groups. The power intensive industries, through their long term contracts, benefit from low prices compared to other commercial sectors. There are also great differences in purchaser prices payed by households in different regions, without any differences in basic production and distribution costs.

A deregulation of the electricity market towards a system based on willingness to pay, would reduce the need for expansion of the electricity capacity. Half of the Norwegian energy consumption is based on clean hydro power. It seems reasonable to utilize hydro power resources more optimally to achieve ambitious environmental targets.

The price of electricity is not differentiated over the year and over the day, with the exception of surplus power, where the price is determined in a short term auction market. Introducing a peak load pricing system, would lead to better utilization of the hydro power resources, and reduce the need for a further expansion of the power system. Several propositions and White Papers conserning the orginization of the Norwegian electricity market are under preparation.

- Expansion of the hydro power capacity

A third way of covering the extra demand for electricity is to expand the hydro power system. It is possible to expand the hydro power system to 127 TWh (firm power), without exploiting protected water falls. The estimated production capacity in 2000 is 109 TWh firm power. The cost estimates from the Norwegian Water and Electricity board show an increasing long term marginal costs for the remaining 18 TWh firm power. The planning and investment period for new hydro power projects has normally been approximately 10 years. According to the Norwegian Water and Electricity board, the required 8 TWh in the Tax scenario, can realistically be realized within year 2000 at the assumed prices.

- Energy economizing

Improved organization of the electricity market, improved efficiency of old power plants, improvements of distribution and transmission networks, more energy efficient production and transport technology and increased use of heat pumps, might contribute to a more efficient use of hydro power resources even at present energy prices. These measures might e.g. reduce the power losses and allow for higher consumption of electricity without increasing the total production capacity.

Increased prices of energy, as in the Tax scenario, will lead to introduction of new technology and enhance the energy economizing potential compared to the present situation. The Tax scenario does not assume energy economizing additional to the Reference scenario - which include estimates from official documents.

- Unconventional energy sources

If prices of fossil fuels and electricity increase, bio fuels (wood, peat, etc) and wind and wave power might cover some of the energy demand. The supply of these unconventional energy sources will be dependent on relative prices, but will probably not contribute significantly to domestic energy supply within 2000.

Emissions to air

The increased taxes on fossil fuels reduce consumption and therefore the emissions compared to the Reference scenario. The most significant reductions are due to lower consumption of heating oils in stationary combustion. Table 5.4.4 gives a summary of the calculations by comparing the Tax scenario and the Reference scenario in 2000 with historical numbers. Figures 5.4.6-5.4.8 show emission profiles for the calculation period and depict international agreements.

Total emissions of SO_2 in 2000 is 82 kt, which is a reduction of 6 kt from 1987. Tax differentiation is assumed to reduce the sulphur content in heavy oils from 2.5 to 1 percent in the 6 Northern counties, and the sulphur contents for diesel and light heating oils from 0.23 percent to 0.20 percent. A further reduction from 1 percent to 0.2 percent for heavy oils would cut the emissions by an additional 3 kt compared to the calculation results in table 5.4.4. Compared to the Reference scenario in 2000, the SO_2 emissions from stationary combustion is reduced by 15 percent, and the emissions are then significantly lower than in 1987. The SO_2-emissions from processes and mobile sources are lower than in the Reference scenario, but higher than in 1987. Process emissions grow proportionately to production. A marginal increase in the consumption of some transport oils gives higher emissions from mobile sources.

Total emissions of NO_x are 223 kt in 2000, which is 22 kt lower than in 1987. The highest percentage reduction of NO_x emissions compared to the Reference scenario is in stationary combustion, whereas the largest absolute reduction is for mobile sources. This is mainly a result of reduced gasoline consumption by households. Both the emissions from mobile and stationary combustion are lower than in 1987. The figures of table 5.4.4 do not include possible measures against the production of fertilizer, which could reduce emissions by 3-4 kt.

Total emissions of CO_2 are 36 mt in 2000, 7 mt lower than in the Reference scenario and the emissions are stabilized at the 1987 level. Process emissions are higher in 2000 than in 1987 due to increased production in manufacturing industries. This is compensated by a reduction in emissions from stationary sources, whereas emissions from mobile sources are unchanged.

The calculations only to a limited extent takes into account the possibilities to substitute from buses to local trains, and to transfer commodity transports from vehicles to railway. The possibilities to use natural gas as a mobile fuel for road and ocean transport are not included in the calculations. This means that the forecasts for reductions of emissions might be underestimated in the Tax scenario.

Reductions of SO_2 and NO_x emissions might improve health conditions and give efficiency gains in the form of increased labour productivity and lower expensies to medical care. In addition, less air pollution will reduce corrosion costs and cleaning expenses. It is difficult to assess this effects numerically, and they are not accounted for in the model calculations.

Table 5.4.4. Emissions to air[1,2] of CO_2, SO_2 and NO_x. Reference scenario and Tax scenario. Level and percent deviation. 2000

	Level 1986	Level 1987	2000 Reference scenario	2000 Tax scenario	2000 Percent deviation
Total					
CO_2, mt[4]	35	36	43	36	-16.3
SO_2, kt[3]	99	88[5]	104	82	-21.1
NO_x, kt	244	245	258	223	-13.6
Processes					
CO_2, mt	5	5	7	7	-0.0
SO_2, kt	45	34	40	39	-2.5
NO_x, kt	11	11	14	14	-0.0
Stationary combustion					
CO_2, mt	14	15	17	13	-23.5
SO_2, kt	29	28	32	16	-50.0
NO_x, kt	24	26	30	24	-20.0
Mobile sources					
CO_2, mt	15	16	19	16	-15.8
SO_2, kt	27	25	31	27	-22.9
NO_x, kt	209	208	214	186	-13.1

1) Emissions from international shipping in Norwegian waters and petroleum activities included.
2) Possible emissions from gas power production excluded.
3) kt = 1000 tons.
4) mt = million tons.
5) Shut-down of the copper smelter in Sulitjelma included from 1986.

Figure 5.4.3. SO_2-emissions. Tax Scenario. 1986-2000. 1000 metric tons per year

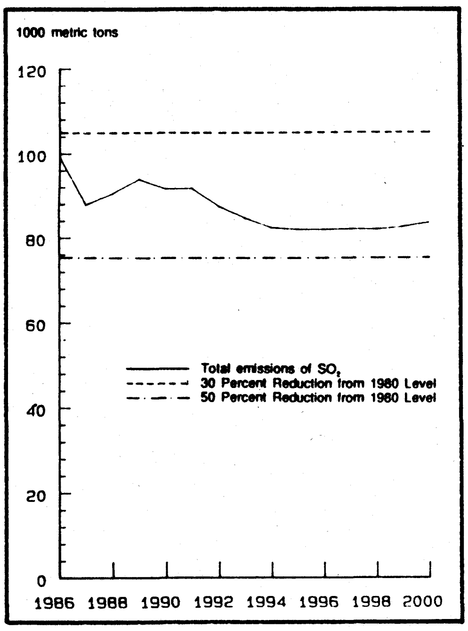
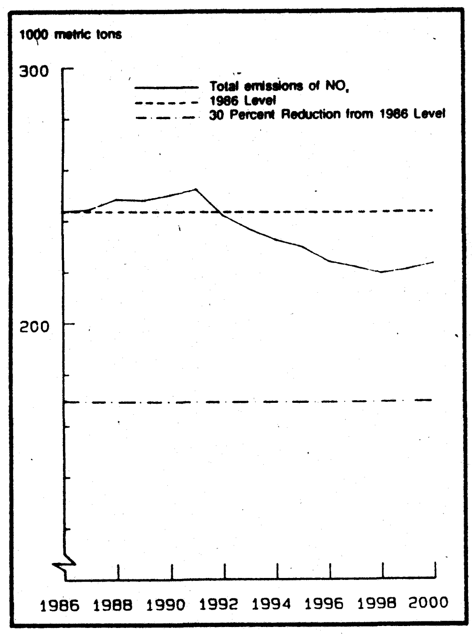
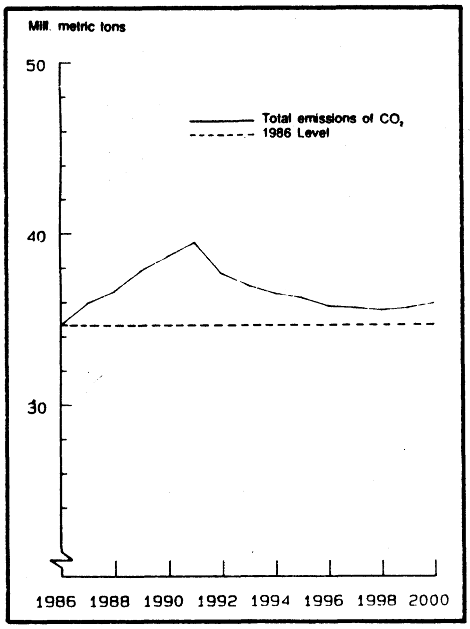


Figure 5.4.4. NO_x-emissions. Tax Scenario. 1986-2000. 1000 metric tons per year



The calculations in the Tax scenario indicate that the SO_2 agreement on 30 percent reduction from the 1980 level is clearly within reach, and that the Government's target of 50 percent reduction is possible. The NO_x agreement on stabilizing the emissions at the 1987 level is achieved, but the emissions in 2000 is more than 50 kt over the level which comply to the Governments declaration on 30 percent reduction within 1998.

Figure 5.4.5. CO_2-emissions. Tax Scenario. 1986-2000. Mill. metric tons per year



The calculations in the Tax scenario are based on assumptions which are highly uncertain. If the economic growth had been stronger, it would have been more difficult to comply to the SO_2 and NO_x agreements, and to stabilize the CO_2 emissions. Most of the tax increases are introduced in the early 1990s, such that the substitution effects and other adaptions to the tax revisions might be assumed to have taken full effect by the end of the decade. If the tax increases are introduced more gradually, the effects in 2000 might be less, due to lag effects.

5.5 Summary of the calculations

Economy

The macroeconomic calculations of this chapter, indicate that it might be possible for Norway to achieve external balance and to repay the foreign debt by the end of next decade. The conditions are improvements in productivity and lower price and cost increases domestically than internationally, such that competitiveness is improved.

The calculations also indicate that it is possible to maintain economic growth combined with compliance to international environmental agreements, through a combination of economic and regulatory instruments.

The restructuring of the tax system from direct income taxes to indirect environmental taxes, give significant environmental gains without unnecessarily hampering further economic growth. These results should be interpretated with a certain caution. The consequences for single firms and industries, and hence for the total economy, might be underestimated in the calculations. The SIMEN calculations do not include any regional effects.

Even if the effects on macroeconomic indicators are small between the different scenarios, energy consumption and emissions to air vary significantly.

If economic growth is increased compared to the SIMEN calculations, the challenges to energy and environmental policies will also increase. On the other hand, higher economic growth will also improve the ability to carry costly environment programs and increase the possibilities for industrial restructuring.

Energy

Total energy consumption is highest in the Gas scenario, as a result of lower energy prices. The consumption of electricity is 10 TWh higher than in the Reference scenario, while the consumption of oil products are somewhat lower. Gas power production is 12 TWh in the Gas scenario and 2 TWh in the Reference scenario.

In all scenarios, it is assumed that the power intensive industries consume their contracted 30 TWh electricity (equivalent to their consumption in 1988) over the calculation period. This might be unrealistic, if the alternative value of electricity is increasing towards the end of the 1990s. Even though the electricity prices are low in the Gas scenario, they are still higher than in the 1983-contracts, which the power intensive industries have declined.

In the Tax scenario, where the indirect taxes on fossil fuels are increased sharply, total energy consumption decline compared to the Reference scenario. Total oil consumption is reduced by 20 percent, while the consumption of electricity to the primary market increases by approximately 5 TWh (net). Higher energy prices give incentives to researh and development of more energy efficient technology, and the energy efficiency is increased by 1 percent annually for most sectors compared to the Reference scenario.

In the Tax scenario, the increase in domestic electricity demand is covered by hydro power production, which is 8 TWh higher than in the Reference scenario. The Tax scenario does not assume any additional energy economizing or better organization of the electricity market, compared to official documents. This might be a conservative estimate.

Future planning of electricity supply, should give special attention to the inefficient utilization of Norwegian hydro power resources. By substituting fuel oils with electricity produced as hydro power, the emissions of SO_2 and NO_x and CO_2 might be reduced. If future increases in energy demand is covered by electricity produced from natural gas or by direct use of gas, at the same time as the hydro power resources are inefficiently used, this might create unnecessary problems in achieving central environmental targets.

Pollution

The greatest challenge to environmental policies seems to be a stabilizing or reduction of CO_2 emissions, since this implies a reduction in the consumption of fossil fuels. However, such a reduction will also lead to reduction in the emissions of NO_x and SO_2.

Figures 5.5.1-5.5.3 show the emissions of SO_2, NO_x and CO_2 in the Reference scenario, the Regulation scenario and the Tax scenario. None of the proposed administrative measures in the Regulation scenario effect the emissions of CO_2.

Figure 5.5.1. Emissions of SO_2. 1000 metric tons per year. 1970-2000

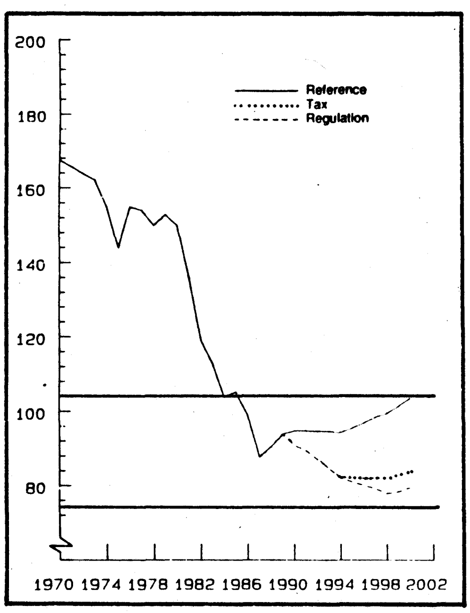
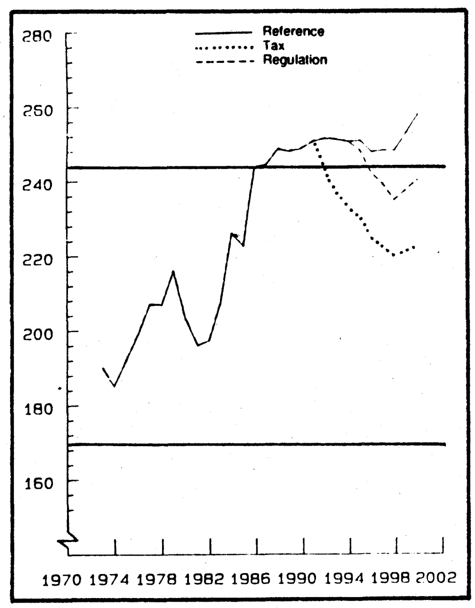
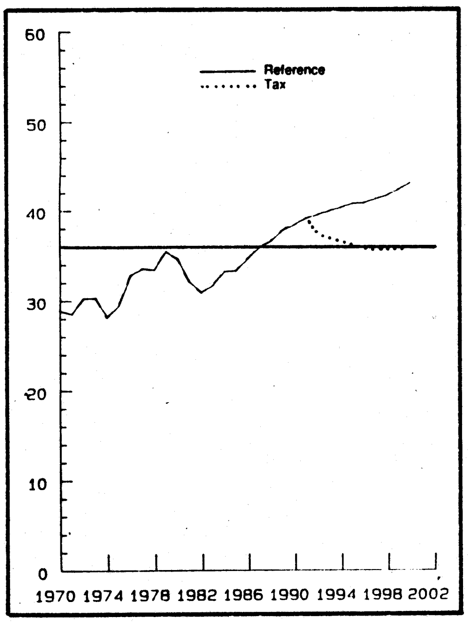


Figure 5.5.2. Emissions of NO_x. 1000 metric tons per year. 1970-2000



In the Reference scenario, with no new regulations or other measures, all three components continue to grow, and none of the international agreements will be reached.

Figure 5.5.3. Emissions of CO_2
Mill. metric tons per year. 1970-2000



The effects of SO_2 emissions are highest in the Regulation scenario, which exploits the possibilities for improved cleaning measures of manufacturing industries and regulations of sulphur contents in oil products. None of these measures, however, break the link between economic growth and the use of fossil fuels. In the longer run, economic growth will again increase emissions, and stronger restrictions will be required. The Government's targets of 50 percent reduction of sulphur emissions, can only be achieved by a combination of administrative measures and general economic instruments as indirect taxes on fossil fuels. The NO_x emissions are stabilized through the sharp increases of indirect taxes in the Tax scenario. This stabilization would have been difficult to achieve by regulatory measures.

The Government's targets of 30 percent reductions of NO_x emissions within 1998, seems quite difficult to achieve without economic incentives that induce technological changes especially in ocean transport, combined with new technical restrictions in road transport.

Price increases on fossil fuels leads to a stabilizing of the CO_2 emissions at the 1987 level in the Tax scenario, if the increased demand for electricity is not covered by gas power.

In a long run perspective, the emissions will again increase as a result of continued economic growth, if technological changes do not compensate for the increase in activity levels or indirect taxes are further increased. Without technological breakthroughs, especially in the transport sector, it will be difficult to stabilize or reduce CO_2 and NO_x emissions.

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Organization. Participants. Sub-projects

The Ministry of Industry initiated the SIMEN-project in the spring of 1988 as part of the Norwegian follow up of the report from the World Commission on Environment and Development. The project started in May 1988 and the main report was published in March 1989.

The state secretaries of the Ministry of Finance, The Ministry of Environment, the Ministry of Industry and the Ministry of Petroleum and Energy have acted as steering committee for the SIMEN-project. The day to day follow up of the project has been conducted by a project group of civil servants from the same four ministries.

The Central Bureau of Statistics has coordinated the SIMEN- project and has the professional responsibility for the main report. The sub-reports have been elaborated by the Resource Policy Group, the Institute of Industrial Economics, the State Pollution Control Agency, the Center for Applied Economic Research at the University of Oslo and the Central Bureau of Statistics. The SIMEN-project was completed within a few months, with a total research effort of three man-years, sponsored by the participating ministries. The project has benefited from informal contacts with organizations and individuals from several industries.

The following individuals have contributed to the completion of the SIMEN-project:

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The Macroeconomic Model MODAG W

Main macroeconomic features

MODAG W, applied in the analysis of chapter 5, is a model for medium term macroeconomic planning, extensively used by the Norwegian Ministry of Finance. MODAG W gives a relatively detailed description of the labour-, capital- and commodity markets of the Norwegian economy, while financial and monetary issues are assessed outside the model. For a description of the model, see Cappelen and Longva (1987) or Cappelen and Moum (1987).

The core of the model is an input-output-matrix, specifying about 40 commodities and 30 production sectors. The model describes the private sector's behaviour, while the government sector is exogenously treated. Production, labour and capital use and hence gross investments are determined by aggregate demand.

The production function (the model specifies dual cost functions) in each sector could be represented by

$$X = F\ (L, K; M, U). \tag{1}$$

Output, (X) is a function of labour (L), capital (K), materials (M) and an energy-aggregate (U) of electricity (E) and oil products (F). Substitution possibilities between labour and capital, due to changing factor prices are specified. Materials and total energy use are determined by base-year-estimated, but exogenous unit coefficients. The description of producer behaviour varies from sector to sector, but can be characterized as cost minimizing. The petroleum and shipping sectors are almost totally exogenously determined. The model thus describes the behaviour of the private sectors of the mainland economy. The producers of the mainland economy, are assumed to have a certain market power both in domestic and foreign markets.

Norwegian sectors compete on the international and domestic markets. The main explanatory variables on the export market are exogenously given market indicators and relative prices on Norwegian and international products. Imports are determined by commodity-sector differentiated, price elastic, import shares. In the short and medium term, assessments of international and government demand are the main determinants for production and employment in the mainland economy. In the longer run, the supply of labour and the development of productivity constrain production growth.

Increased Norwegian factor prices will, ceteris paribus, reduce the market shares of Norwegian producers, and lead to a reduction of competitive industries. The model does not include any strong mechanism which brings imbalances in the labour market or the external economy automaticly towards a new equilibrium.

Product prices depend on variable unit costs, capacity utilization and world market prices. Variable unit costs, P_V, vary due to input, factor prices and output,

$$P_V = \frac{P_M\ M + P_E\ E + P_F\ F + W\ L}{X} . \qquad (2)$$

Electricity prices (P_E) are directly under government control, while oil products prices (P_F) are determined by international crude oil prices, and indirect taxes.

Given total demand, both domestic and from export-markets, the producers minimizes their variable production costs of labour, materials and energy. Wage costs (W) are determined by

$$W = W(UR,\ PC,\ T,\ \tau,\ V). \qquad (3)$$

UR is the unemployment rate, PC is domestic prices, T is income taxes, τ is technical change and V is a vector of other factors. The wage-formation includes a Phillips-curve-mechanism. The larger the unemployment rate, the smaller is wage increases. Growth in domestic prices and income taxes both induce increases in wages, while labour-augmenting technical change gives less increase in the wage costs. The hyphothesis that changes in income taxes influence on the wage-rate growth has been analysed on Norwegian data, and tests are inconclusive, but such a relation is implemented in the model MODAG W, and is important when analysing how to solve pollution problems by changing the tax system. In the analysis in chapter 5, P_F is increased by increasing indirect taxes on oil-products and W is reduced through reductions of income taxes T.

The model describes household's behaviour for the supply of labour and demand for consumer commodities and housing services. The supply of labour is basically determined by demographic factors, and is relatively inelastic with respect to marginal real wages. The households demand for commodities and services are determined in a general linear expenditure system, depending on relative prices and real disposable income. Investments in dwellings and other consumer demand are dependent on household's disposable real incomes, relative prices, interest rates and an exogenously determined saving ratio.

Energy demand

Total demand for energy follows from an exogenous input coefficient and the activity level. The model specifies substitution possibilities between energy commodities i.e. between electricity and oil products. Oil products is a Leontief-aggregate of heating and transport oils. Relative prices between electricity and oil products determine the composition of energy in a CES-aggregate

$$U = \left[\delta\left(\frac{E}{\delta}\right)^{\frac{\sigma-1}{\sigma}} + (1-\delta)\left(\frac{F}{(1-\delta)}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} . \qquad (4)$$

The households' demand for energy depends on real disposible income. Also for households relative prices between electricity and oil products determine the composition of total energy demand.

Pollution

An emission model with a set of emission-coefficients links different air pollutants to economic variables in MODAG W. These coefficients are, depending on polluting component, linked to the use of materials in production processes, and the consumption of oil products for heating and transportation,

$$AI_{ki} = t_{ki} S . \tag{5}$$

AI_{ki} is emission to air of component k from source i, t_{ki} is emission-coefficient for component k from source i. S is a matrix of explanatory variables for production processes, and different types of oil products.

The emissions coefficients can be changed exogenously through the calculation period, to account for new policy measures.

The following components are included in the sub-model: SO_2, NO_x, CO_2, VOC, particulates and Pb.

Critical evaluation of the model

MODAG W is extensively used by government agencies to forecast the macroeconomic development of the Norwegian economy in a medium term perspective. Major changes in the Norwegian economy or in the economy of trading partners, might lead to changes in expectations, behavioural relations and in institutions, which the model does not adequately capture. The calculations of the SIMEN-project, especially the tax scenario, include dramatic changes of the tax system and relative factor prices. The changes in factor prices are clearly outside the sample observations, which the model is estimated on. This, of course, creates some uncertainty about the validity of the calculations.

The model has several weaknesses and was certainly not intended for analyses of major changes in economic policies as in the SIMEN-project. However, the SIMEN questions could hardly be adequately analysed without applying a macroeconomic model, describing the interplay between activity levels, energy consumption and pollution in all sectors of the economy simultaneously.

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