94/9 | Notater | 1994

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Natural resource accounting - The Norwegian approach

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Natural resource accounting - The Norwegian approach[1]

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The paper gives an overview of the Norwegian natural resource accounting system: Principles, structure, use and experiences. The original concepts are used. Examples of accounting tables and of use of the accounts for planning purposes are also included, though the emphasis of this paper is put on the principles and structure of the accounts. Some important references on both the establishment and the experiences from use of these in planning are listed.

CONTENT

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[1] Paper presented at the UNEP/ECE/UNSTAT Workshop on Environmental and Natural Resource Accounting in Modra-Harmonia, Slovakia, 21 to 23 March, 1994.

1. Introduction

The World Commission for Environment and Development has recommended that accounts of natural resources and state of the environment are developed and presented in addition to (traditional) national accounts. The UN Conference on Environment and Development in Rio de Janeiro in June 1992 emphasized natural resource and environmental accounting as important tools to obtain a sustainable development.

Natural resource and environment accounts can be integrated with or linked to national accounts in several ways. One main possibility is to integrate environment accounts with national accounts through so called satellite accounting, with the aim of adjusting gross domestic product (GDP) to account for depletion of natural resources and the environment. Such an adjustment presupposes evaluations of both natural resources and changes in the state of the environment in monetary terms.

Another way of increasing the emphasis on natural resource and environmental issues in ecomomic policy, is to link physical natural resource accounts to economic planning through models. Such models can be used to show how economic development affects the environment and how activities and measures to improve the environment (e.g. taxes) affect the development of both the environment and the economy. Monetary valuation of natural resources and the environment is relevant also within this approach, but in *analyses* and not directly within the framework of the natural resource and environmental accounting schemes. However, in both cases natural resource and environment accounts in physical terms must be used as a basis for valuation and further analyses.

The Norwegian approach is the latter, with physical natural resource accounts linked to national accounts and models based on these accounts. This paper gives a brief overview of this approach.

2. History of natural resource accounting in Norway

The work on the Norwegian natural resource accounting system was initiated by the Ministry of Environment in the early 1970s, but the system has since 1978 been developed and operated by Statistics Norway (SN). The first Norwegian natural resource accounts were established for *energy, minerals, forest, fish* and *land use* in the early 1980s (SSB, 1981; Alfsen, Bye and Lorentsen, 1987).

The purpose of these accounts was to provide better and more long term planning of exploitation of natural resources, and emphasis was put on the *resource* aspect, though some of the resources and accounting schemes also included some *environmental* aspects (i.e. land use).

It was envisaged that improved natural resource planning could be obtained by natural resource accounting giving:

- New and better data
- Better coordination
- Common presentation of information on different natural resources
- Integration of natural resource planning and traditional economic planning
- Integration of national planning and regional (subnational) planning.

Accounting techniques as such will lead to the identification of gaps in data, promote coordination and provide a common presentation scheme (i.e. material balances), whereas the integration of planning in Norway is enabled by modelling based on both the national accounts and the resource accounts. *Consistency of sector divisions* between these types of accounting schemes represents a precondition for such integrated modelling.

During the development of resource accounts in Norway, the aim was to include pressure on the environment from the extraction and use of natural resources, and in some cases changes in environmental status or quality due to this pressure. We have denoted these parts of the accounting system *environmental accounts.* However, the aim has never been to include all environmental statistics within the framework of resource accounting.

The land use accounts which were developed in the beginning of the eighties were based on point sampling on maps and air photographs, and provide a survey of land use in the whole country and in particular in urban areas (Sæbø, 1983). For urban areas tables showing changes in land use from 1955 to 1975 were set up. The point sampling was very time consuming, though to a lesser extent than complete mapping would have been. However, the demand for data and statistics was not large enough to justify the updating of these accounts. Complete land use accounts are therefore not worked out in Norway today, but for some important land use types (such as agricultural land) reasonable statistics are based on various traditional data sources.

In the beginning of the eighties there were attempts to establish resource accounts for water in Norway. This also turned out to be time consuming. One of the results of the work was the establishment of a watercourse register for Norway. But since water is not a scarce resource in general in Norway, there were no users of complete and comprehensive resource accounts in this area. The work on water accounts has therefore not been continued.

Resource policy and planning in general were larger issues in Norway in 1980 than today. Both managerial and public interests have gradually shifted towards environmental issues, such as changes in global climate and the depletion of the ozone layer. This has led to less interest for natural resource accounts, and accounts in their original form are today only worked out regularly for *energy.* However, the annual energy accounts have been supplemented by tables on *emissions of polluting components to air.* These emissions are to a large extent calculated on the basis of energy consumption figures in the energy accounts. The stock part of accounts for *fish* and *forest* (wood) are also updated regularly. But the only areas where resource accounts have been linked to macroeconomic models and used regularily in planning, are energy and, during the last few years, in particular emissions to air.

However, much work is done to establish statistics for other *environmental stresses.* Examples are *discharges of nutrients* and *waste statistics.* The extension of these statistics to describe material flows in both society and nature will represent an extention of the work on resource or environmental accounts in Norway.

Locating the work on natural resource accounting to Statistics Norway has ensured access to statistical expertise and closeness to primary statistics used in the development of the natural resource accounts. Statistics Norway is also responsible for national accounting and development and operation of the economic planning models employed by the Ministry of

Finance. The resource accounting framework is based on existing economic standards and sector classification schemes, thus ensuring general consistency in the sectoral classification of economic and resource related data and statistics. Use of a common set of standards and models in the analysis of resource issues, has facilitated the communication between the ministries responsible for the management of the economy and the ministries responsible for the management of the natural resources; e.g. the Ministry of Finance, the Ministry of Environment and the Ministry of Industry and Energy.

Today resource accounts are worked out in the department of Statistics Norway which is responsible for both economic and environment statistics, whereas economic analysis and modelling on the basis of these accounts is done by the Research department. Environment statistics in general have been given increased priority within Statistics Norway during the last few years. A development strategy for these statistics has been established in cooperation with important users, such as the Ministry of Environment and the State Pollution Control Authority. Main priority areas within environment statistics in Statistics Norway today are:
- Resource accounts for energy
- Resource accounts for fish (stocks)
- Resource accounts for forest (stocks)
- Emissions to air
- Discharges to water (in particular from population and agriculture)
- Waste and recycling
- Environmental expenditures.

3. Principles and structure of Norwegian resource accounts

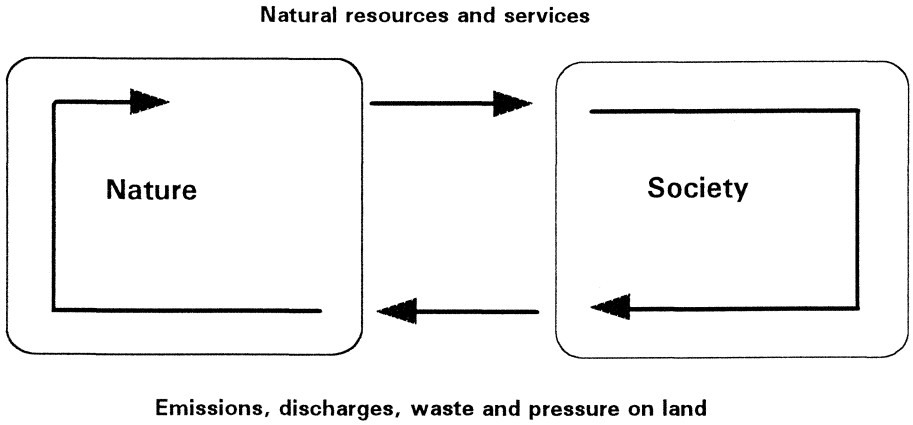
Natural resources are classified in two groups:
1. *Material resources* - resources which can be extracted or harvested from the nature. Accounts for such resources are denoted *material accounts.*
2. *Environmental resources* - resources on which possibilities for life and production are dependent. Accounts for such resources have in Norway been denoted *environmental accounts.*

The Norwegian resource accounts are mainly material accounts.

The resource accounts shall give a coherent survey of stocks (reserves), extraction and use of natural resources. Central economic planning is mainly based on the national accounts, which give a survey of economic stocks and flows in society.

The resource accounts can be seen as an extension of the national accounts to include parts of nature, but the flows between nature and society and inside society are here described in *physical units*. Figure 1 shows such extended national accounts which very simplified consist of only two sectors. The sector "nature" has stocks of natural resources and environmental quality and supplies the economy with goods (natural resources) and services (e.g. recreation services). Nature receives emissions and discharges of pollutants and waste. Factors like pressure on land also affect nature. The Norwegian resource accounts describe the reserves and extraction of natural resources, the flow of these resources through society and pressures on nature like emissions to air. The flow of pollutants through nature (illustrated by the arrow inside the nature box in figure 1) has so far not been included.

Figure 1. Resource accounts as extended national accounts



Norwegian resource accounts are kept in physical units. In addition, some calculations of the reserves or the natural capital in monetary units have been done. However, this valuation has only been done for the value of the resource as a natural resource and not for its possible value as an environmental asset.

As mentioned, the possibility for integrated economic and natural resource planning by the use of models is an important reason for linking the resource accounts to the national accounts in Norway. In practical terms this means that *the resource accounts must be based on the same sectoral divisions as the national accounts* (SNA).

Material accounts

The material accounts comprise accounts for *reserves* in nature and for the *material flow* of resources from extraction through the economy to the usage.

The reserves comprise the known and economic exploitable part of the resources, and the reserve accounts show how the reserves change in a period by discoveries, revaluations (because of changes in prices and costs and better knowledge) and extraction. Figure 2 illustrates the reserve accounts for a mineral resource.

Reserves of biotic resources are usually called *stocks*. In this case the reserve or stock accounts show how the stocks change due to recruitment (new individuals) and growth, revaluation (because of better knowledge), natural death and extraction (catch or harvest), see figure 3.

The material flow in the economy is described as a balance or a set of tables showing extraction, exports/imports, conversion and use. This part of the resource accounts is closely linked to the national accounts. In principle the only difference is that the material accounts are kept in *physical* units, while the national accounts are kept in *monetary* units. Figure 4 gives a simplified sketch of the material accounts.

Figure 2. Reserve accounts for mineral resources

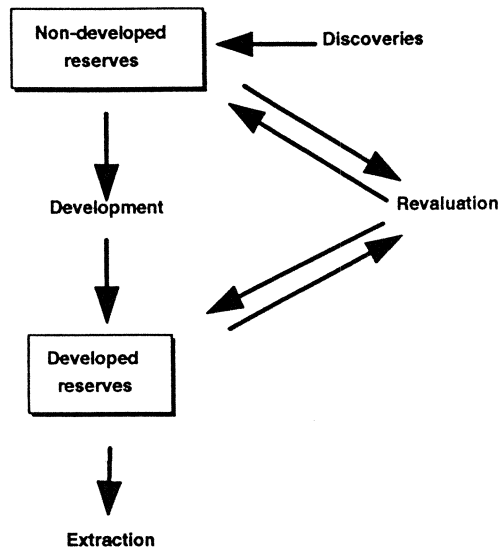


Figure 3. Stock accounts

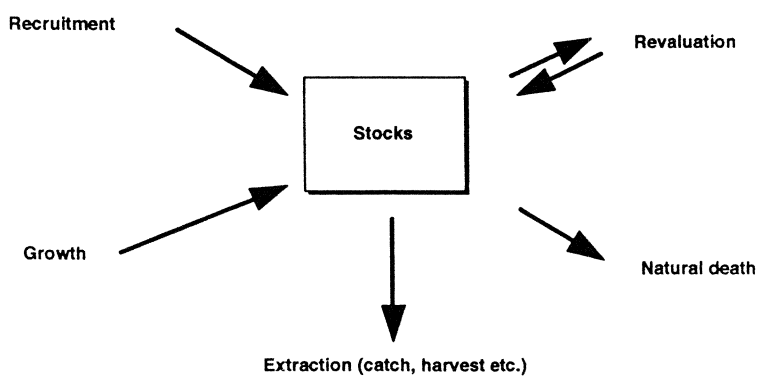
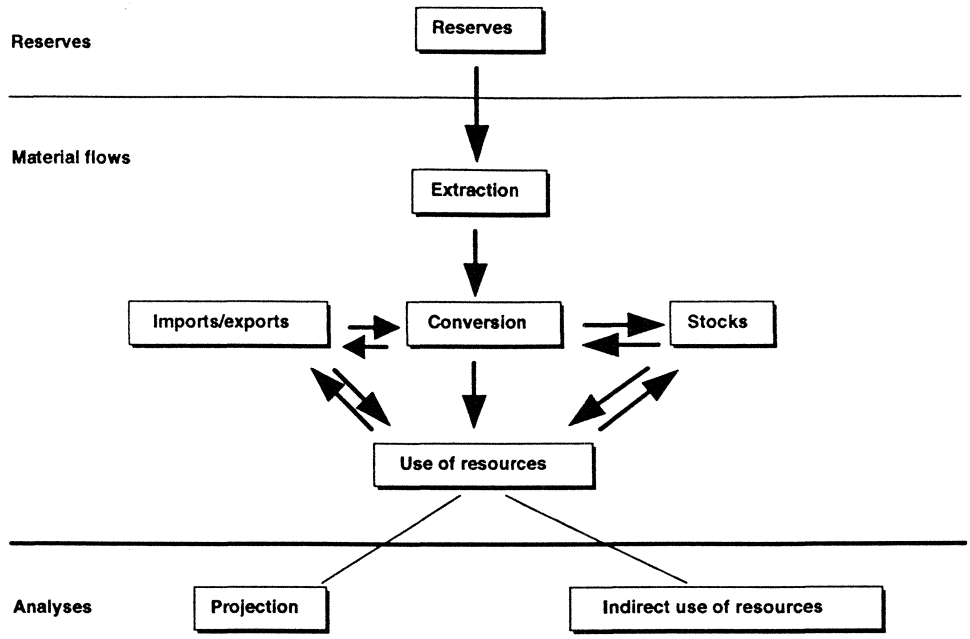


Figure 4. The material accounts



The resource accounts only follow the resource flow through a limited number of goods (raw materials and intermediate products), and will usually not keep track of the end uses of the resource. Resource accounts which are consistent with the national accounts will, however, enable the estimation of the amount of resources used for all goods and services covered by the national accounts. This is done by input-output models. The estimation of so called *indirect energy use* is one type of analysis which has been carried out on the basis of the Norwegian resource accounts.

Other types of analyses project the resource use for every sector included in models based on the national accounts. Macroeconomic models have been developed to account for use of energy. This has made it possible to study the effect of economic policies on energy use and vice versa the effects on the economy of different types of energy policies. The integration of economic planning and resource planning has been one of the main reasons for the establishment of the Norwegian energy accounts. In later years, the corresponding integration with environmental policies in the form of agreements setting limits for emissions of pollutants to air has been important. The energy accounts are the natural basis for the estimation of emission figures. These figures constitute the *emission accounts*, which are the first part of what we in Norway have called *environmental accounts.*

Environmental accounts

What has been called environmental accounts in Norway, consists of two parts:

* Emission accounts, which give a survey of emissions, discharges and waste.
* Status accounts, which give a survey of environmental status at one point of time and changes between two points of time.

Figure 1 shows the linkages between nature and society. The emission accounts represent the link between human activities and the environment, and can in principle describe all types of environmental stresses, like for instance pressure on land.

Accounts for environmental status must, contrary to the material accounts, have a spatial dimension. Environmental resources cannot be moved.

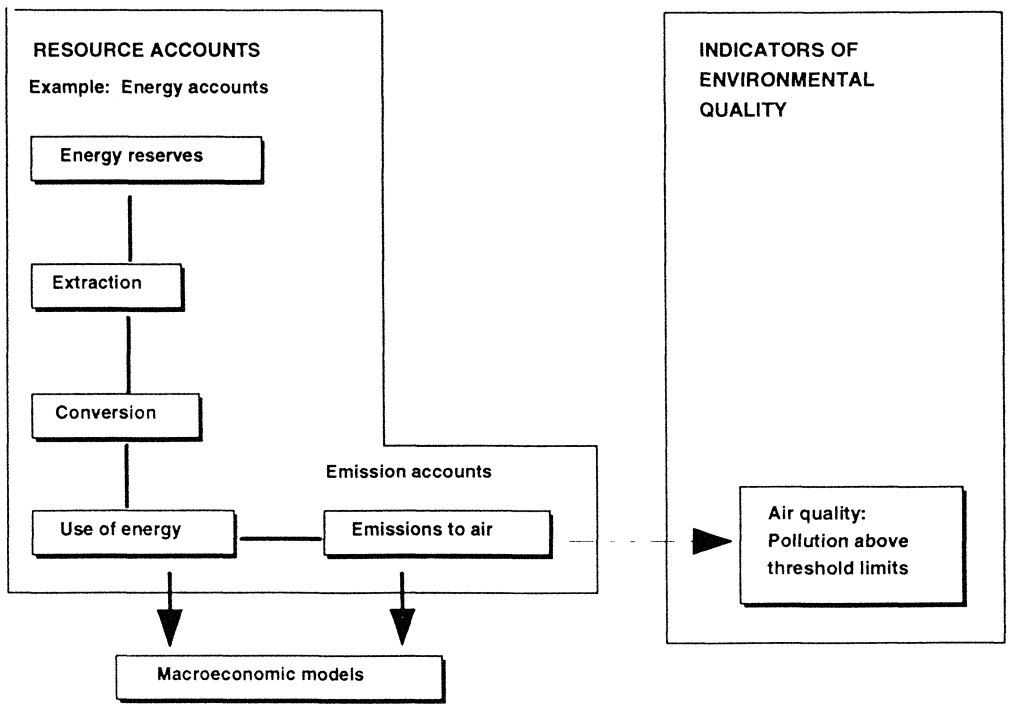
All the Norwegian resource accounts except for the land use accounts were developed as *material accounts.* The emission accounts for air also describe material flows, but in this case a flow of residuals to nature.

4. Resource accounting and environmental indicators

It is difficult to present status and changes in *environmental quality* within the framework of resource or environmental accounts. An important reason for this is the lack of well established and general, quantitative measures for environmental quality. Another reason is uncertainty and disagreement about the cause/effect chain linking environmental *pressures or stresses* and the *effects* or the *environmental status.* The work on *environmental indicators* can be seen as a contribution to solve this problem (Alfsen and Sæbø, 1993). Such indicators can both contribute to better presentation of environmental information and provide a better basis for setting priorities and following up of environmental policies.

Figure 5 shows an example of how indicators for environmental quality can supplement and complete the Norwegian resource accounts.

Figure 5. Resource accounting and environmental indicators



5. Resource accounting for analysis and economic planning

Natural resource accounting in Norway is not an aim in itself, but a way of providing systematic data for information and analytical purposes, as a basis for both environmental and economic planning. In particular information based on the energy accounts and the associated emission inventories have been integrated into more comprehensive analytical tools, by expanding macroeconomic planning models. These extended macroeconomic models are now used by the government and other administrative bodies on a routine basis. The most recent example is the Government's Long Term Programme 1994-1997.

By integrating the resource and environmental data with the economic models, several aims are achieved. First, consistency between economic planning, expected growth in energy use and the resulting emission to air is secured in the model based forecasts. Second, by providing output tables covering both economic, energy and environmental variables, the linkage between these policy areas is brought to the attention of the policy makers. Finally, by making a single modelling tool available to both the Ministry of Finance and the Ministry of the Environment (among others), communication among the different branches of the government is enhanced.

Typically, three types of questions are addressed by the integrated model:

1) What is the likely future economic development, demand for energy and emissions to air? Are environmental targets compatible with the economic goals?

2) How will a change of policy (e.g. introduction of environmentally motivated taxes or regulations) affect the projected development, both with respect to the economy and the environment?

3) How will future development in the state of the environment and energy resource availability affect the economic development?

6. Examples

Tables 1 - 4 are examples from the Norwegian resource accounts and show different aspects of accounting schemes which are of interest in a consistent setup of resource and environmental information. Results of some typical analyses using an integrated economy/resource/emission model are given in the next part of this chapter. For an overview of this model with more detailed examples, see Alfsen, 1993 and 1992.

Accounting tables

Table 1 shows the development of the Norwegian crude oil reserves. It should be noted that both the annual revaluations and for most years the increase in reserves due to new fields in size are comparable with the extraction. Thus, the reserves have increased over the last 5 years in spite of high production.

Table 1. Reserve accounts for crude oil. Developed fields and fields to be developed. 1990 - 1993. Million tonnes

	1990	1991	1992	1993
Reserves per 1/1	982	1111	1112	1222
New fields	103	93	94	4
Revaluation	108	2	122	98
Extraction	-82	-93	-106	-116
Reserves per 31/12	1111	1112	1222	1209

At today's level of production and with known extraction technology, the oil reserves in fields that have been developed or are to be developed will last 10 years. The Norwegian gas reserves, which are even larger than the oil reserves, will last 49 years. If assumed reserves in fields that are not yet licenced are added, the production periods are extended to 15 years for oil and 101 years for gas. Figure 6 shows the trends in the relationship between reserves and production. The decrease in this relation for oil is due to increased production over the last years.

Figure 6. The relationship between Norwegian reserves and production of oil and gas (R/P-rate). Developed fields and fields to be developed. 1979 - 1993

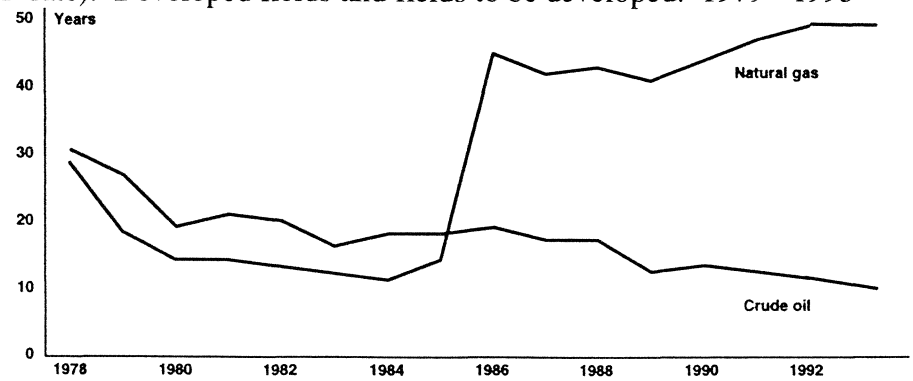


Table 2 illustrates reserve accounts for forest (wood). The forest balance reveals that the volume of wood is increasing in Norway. Annual depletion constitutes about 60 per cent of the natural growth. In fact, the volume of Norwegian forests has increased by more than 90 per cent since 1925 (figure 7). Increasing volume of forest is typical for most countries in the Northern hemisphere. This increase leads to absorption of the climate gas CO_2 , and contributes to slow down the increase of the atmospheric concentration of this gas, an increase which may lead to global warming. The CO_2-content of roundwood has been added to the table. In 1993, net CO_2 binding in Norwegian roundwood of 6.1 mill. tonnes corresponds to 18 per cent of Norwegian (antrophogenic) emissions. If we include bark, roots and other biomass linked to the trees, this figure will probably double.

Table 2. Forest balance for Norway. Mill. m^3 without bark. 1993

	Total	Spruce	Pine	Deciduous	CO_2-content in wood
					Mill. tonnes
Volume 1/1	588.1	273.7	193.4	120.9	478.3
Roundwood cut	10.3	7.0	2.1	1.1	8.4
Other mortality	2.0	1.0	0.4	0.5	1.6
Gross growth	19.9	10.4	5.3	4.3	16.2
Volume 31/12	595.6	276.0	196.1	123.5	484.4

Figure 7. Cubic mass of forest in Norway. 1925 - 1993. Million m^3

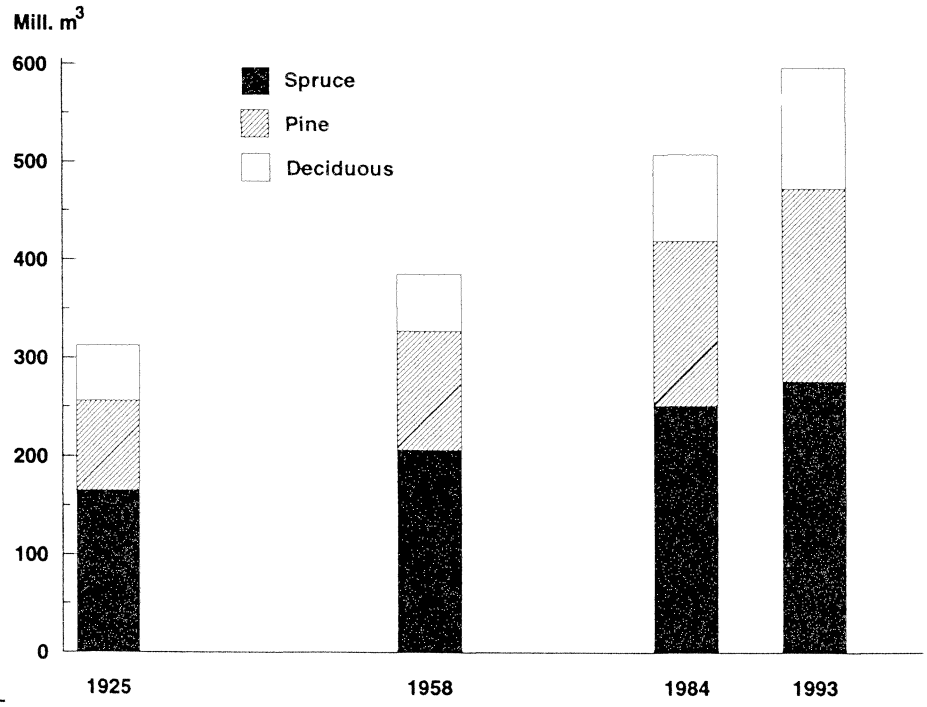


Table 3 shows the flow of energy in Norway with distribution of energy use among main industrial sectors and households. This table is based on a rather detailed table where energy use is accounted for in more than 100 sectors comparable to sectors in the national accounts system.

Table 3. Extraction, conversion and use of energy in Norway. 1992. PJ

	TOTAL	Coal and coke	Fuel-wood, waste etc.	Crude oil	Natural gas	Petroleum products	Electricity	District heating
Extraction of energy	6194	11	-	4525	1180	57	421	-
Energy use in extraction sectors	-136	-	-	-	-119	-11	-6	-
Imports and Norwegian purchases abroad	518	42	0	48	-	423	5	-
Exports and foreign purchases in Norway	-5510	-9	0	-3980	-1057	-427	-36	-
Stocks	-29	-3	-	-26	-	0	-	-
Primary supply	1038	41	0	567	4	42	384	-
Petroleum refineries	-40	-6	-	-581	-	538	-2	-
Other energy sectors, other supply	51	-1	38	-	-	8	0	6
Losses, statistical errors	-10	0	0	14	-4	6	-25	-2
Use outside energy sectors	1039	46	38	-	-	594	356	4
Ocean transport	312	-	-	-	-	312	-	-
Domestic use	727	46	38	-	-	283	356	4
- Agriculture and fishery	28	0	0	-	-	25	2	0
- Energy intensive manufacturing	192	36	0	-	-	54	102	0
- Other manufacturing and mining	106	10	20	-	-	22	54	1
- Other industries	188	0	0	-	-	107	79	2
- Private households	213	0	18	-	-	75	119	1

Emissions to air of 10 pollutants are calculated on the basis of energy accounts and other activity measures when relevant (e.g. number of cattle in the case of methane). The calculations are done for 132 industrial sectors and at the same time for 30 technical emission sources such as means of transportation and different industrial processes. For road transport, a detailed sub-model is employed. Emission coefficients are worked out in cooperation with the State Pollution Control Authority which also provides emission figures which have been measured for companies with major emissions. Consistency is thus ensured both with the National accounts and technical approaches based on classification of emission sources.

Table 4 shows the distribution of emissions by some sources. Such distributions can be set up for all economic sectors. The emission figures have also been broken down to 19 counties and 439 municipalities. For more information on the Norwegian emission accounts, see Rypdal, 1993.

Table 4. Emissions to air by source. 1992. 1000 tonnes unless otherwise specified

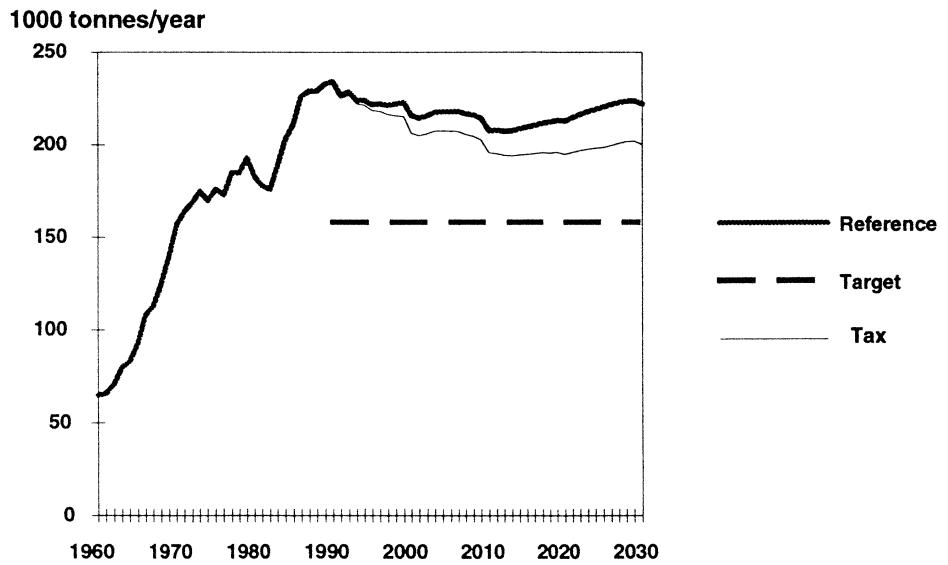
	CO_2	CH_4	N_2O	SO_2	NOx	NH_3	NMVOC	CO	Pb	Particles
	Mill. tonnes								Tonnes	
Total	34.3	293.1	13.1	37.5	219.6	39.8	265.2	851.5	150	20.3
Stationary combustion	14.0	13.1	1.4	8.9	41.6	-	10.9	123.8	1	12.8
Petroleum extraction	7.0	2.5	0.1	0.3	27.6	-	1.1	5.2	0	0.1
-- Natural gas	4.2	2.2	0.0	0.0	15.4	-	0.6	4.2	0	0.0
-- Diesel	0.4	0.1	0.0	0.3	7.2	-	0.5	0.5	0	0.1
-- Flaring	0.8	0.2	0.0	0.0	5.0	-	0.0	0.5	0	0.0
Gas terminals and oil refineries	2.3	0.3	0.1	0.1	3.4	-	0.9	0.2	0	0.1
Other industries	2.6	0.4	0.8	6.1	7.0	-	0.7	6.5	0	1.5
Houses, offices etc.	2.0	9.8	0.5	2.0	2.3	-	7.8	111.6	0	11.1
Incineration of waste	0.1	0.1	0.0	0.3	1.2	-	0.3	0.3	1	0.0
Process and evaporation	6.6	277.1	10.6	20.1	6.6	39.4	158.4	46.3	2	..
Oil and gas	0.4	9.2	-	-	-	-	114.7	-	-	..
-- Venting, leaks etc.	0.0	5.2	-	-	-	-	3.6	-	-	..
-- Oil loading	0.3	3.5	-	-	-	-	102.2	-	-	..
-- Gas terminals and oil refineries	0.0	0.4	-	2.5	-	-	8.9	-	-	..
Gasoline distribution	0.0	-	-	-	-	-	8.9	-	-	..
Paper and pulp industry	-	-	-	0.7	-	-	-	-	-	..
Chemical production	1.0	0.8	4.2	5.1	1.0	0.4	0.9	32.3	-	..
Cement and other mineral products	0.6	-	-	0.5	-	-	-	-	-	..
Manufacture of metals	4.2	-	-	11.1	5.6	-	1.3	14.0	2	..
--Ferroalloys	2.4	-	-	7.3	5.0	-	1.3	-	-	..
--Aluminium	1.5	-	-	3.0	0.6	-	-	-	-	..
--Other metals	0.3	-	-	0.8	-	-	-	14.0	-	..
Agriculture	0.2	94.4	6.5	-	-	39.0	-	-	-	..
Waste deposits	0.1	165.6	-	-	-	-	-	-	-	..
Evaporation from solvents	0.1	-	-	-	-	-	31.6	-	-	..
Other processes	0.0	7.0	-	0.3	-	-	0.9	-	-	..
Mobile combustion	13.7	2.9	1.0	8.5	171.4	0.4	95.9	681.4	147	7.5
Road traffic	8.0	1.6	0.6	3.3	79.7	0.4	76.6	638.6	140	4.2
-- Gasoline	5.1	1.6	0.3	1.0	48.9	0.4	72.0	621.4	140	0.7
---- Passenger cars	4.8	1.5	0.3	0.9	44.6	0.4	66.4	574.9	130	0.6
---- Vans	0.3	0.1	0.0	0.1	3.9	0.0	5.0	40.1	9	0.0
---- Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.5	1	0.0
-- Diesel	2.9	0.1	0.3	2.4	30.8	0.0	4.6	17.2	0	3.5
---- Passenger cars	0.3	0.0	0.0	0.2	1.1	0.0	0.3	1.3	0	0.5
---- Vans	0.7	0.1	0.0	0.6	11.3	0.0	1.7	5.9	0	1.4
---- Heavy vehicles	2.2	0.0	0.3	1.8	28.4	0.0	3.8	14.4	0	2.3
Motorbikes, snow scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.6	2	0.0
Motorized tools	0.7	0.1	0.0	0.6	11.3	0.0	1.7	5.9	0	1.4
Railways	0.1	0.0	0.0	0.1	0.6	0.0	0.1	0.2	0	0.1
Air transport	1.3	0.0	0.1	0.1	3.8	-	0.6	3.2	2	0.2
Ships and boats	3.5	1.0	0.2	4.4	75.8	-	11.7	19.9	3	1.5
-- Coastal traffic, small boats	2.1	0.6	0.1	3.1	44.4	-	10.4	17.2	2	1.0
-- Fishery	1.3	0.4	0.1	1.2	27.7	-	1.0	2.5	0	0.5
-- Mobile oil installations etc.	0.2	0.0	0.0	0.1	3.6	-	0.3	0.3	0	0.1

Analyses

Two typical examples of the use of integrated environment-energy-economy models are given. They are taken from Alfsen,1993, who gives a more detailed outline of these and other examples.

Emission forecasts without and with carbon taxes
Figures 8 and 9 show historical development and projected values for the emission of NO_X and CO_2 in Norway to the year 2030. The projections cover one reference alternative and a carbon tax alternative. The assumed tax is relatively high (of the order of US $800/tC (1989-$), corresponding to $93/barrel of oil in year 2030). It is assumed to be part of an international agreement imposing similar taxes in all other industrialized countries. The treaty affects both economic growth in world markets and the price of important commodities like crude oil and natural gas. An important assumption in the calculations is that the trade balance of Norway should be unchanged from the reference alternative. Norway has national emission targets for both NO_X and CO_2. Although specified for different years, the targets are shown as horizontal lines in the figures.

Figure 8. Historical and projected emission level of NO_X in Norway.

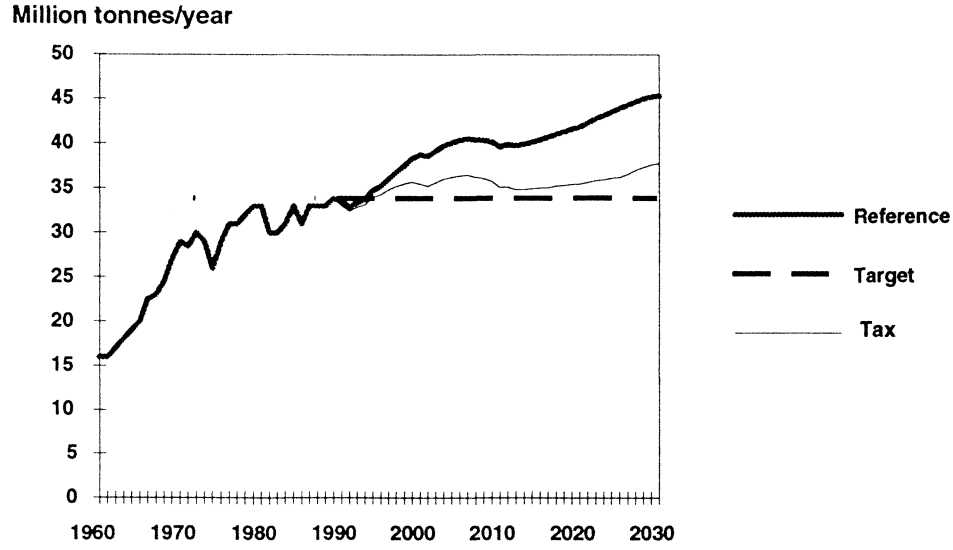


NO_X emissions have grown substantially from 1960 to 1990. New control measures, such as catalytic cleaning of automobile exhausts, are expected to eliminate this growth in the future, but this is not enough to ensure a fulfilment of the national target of 30 per cent reduction even with a high carbon tax.

CO_2 emissions have also grown over the period from 1960 to 1990, although with a declining rate the last ten years or so. However, further expected growth makes is hard to achieve the national target of stabilization, even with a high carbon tax.

It is obvious from the figures that the main problem for Norway of achieving its targets on air pollution is related to the emission of NO_X.

Figure 9. Historical and projected emission level of CO_2 in Norway.



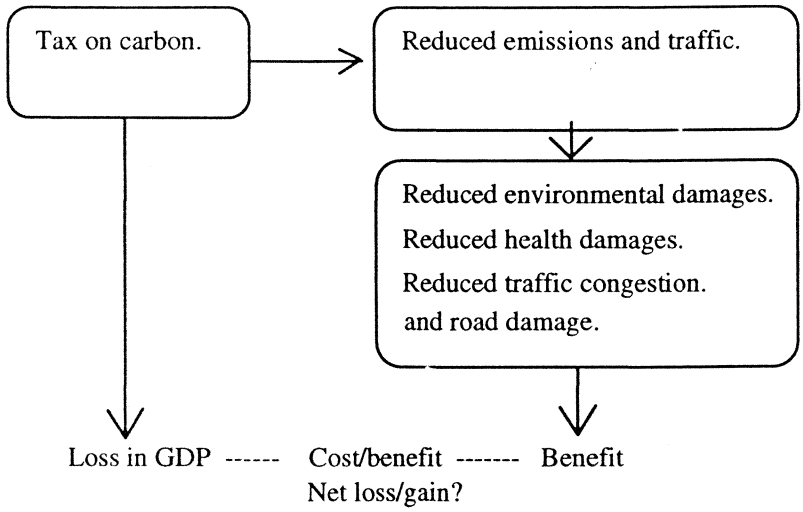
Costs and benefits of environmental control policies
In a pure economic model the effect of environmental taxes usually appears as reduced growth in macroeconomic indicators such as GDP and private consumption. By employing a macroeconomic model which includes environmental stresses like emissions, and combining it with analyses of environmental quality improvements, it is possible to estimate some of the benefits to society as well.

Environmental taxes such as energy taxes in general or carbon taxes will usually lead to less use of energy and reduced emissions of a series of polluting components. Two types of benefits of reductions in fossil fuel consumption and the associated emissions have been calculated and taken into account. One type of benefits is related to changes in emission levels of sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO) and particulate matter. These are pollutants harming e.g. human health, forests, fresh water lakes and certain types of capital equipment. In addition, the presence of these compounds reduces the welfare of the population by inflicting aesthetical damage to the natural environment. The other type of benefits is related to *reduction in road traffic*, and cover aspects such as congestion, accidents, damage to roads and noise from road traffic. For a discussion of data and assumptions, see Alfsen, Brendemoen and Glomsrød, 1992.

Figure 10 shows the structure of this macroeconomic cost/benefit analysis.

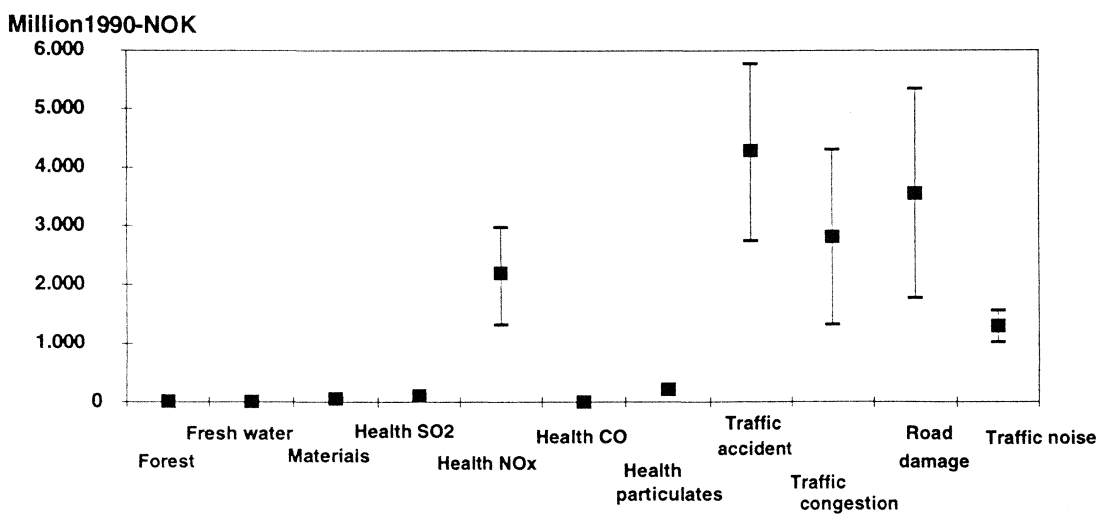
Multiplying the marginal cost of the various damage components with changes in emissions to air of the relevant compounds or with the change in demand for transport, yields a rough estimate of some of the direct benefits of environmental control policy compared to a baseline scenario. It is difficult to measure the economic cost of introducing a control policy correctly, but a rough indicator is the calculated reduction in GDP.

Figure 10. Example: Costs and benefits of environmental control policies



Benefit estimates have been calculated according to the described procedure. They are of course highly uncertain, and for this reason Monte Carlo simulations have been carried out to map the effect of the uncertainty in the marginal cost figures on the final benefit estimate. Figure 11 illustrates the composition of the benefit in the year 2030 of introducing a carbon tax of approximately US $800/tC on all CO_2 emissions in Norway, assuming that similar measures are introduced by our most important trading partners as well. It is, however, not taken into account that emission reductions in other European countries are likely to reduce the supply of oxidized sulphur and nitrogen to Norway, a supply that accounts for about 95 per cent of the acidification of Norwegian soil and lakes. As can be seen in figure 11, reducing Norwegian emissions alone gives only insignificant benefits with regard to forest, freshwater and materials (acidification).

Figure 11. Some environmental benefits due to reduced emission of local pollutants in the year 2030. Million 1990-NOK. Lower and upper limits correspond to the 25% and the 75% quartiles.



It is worthwhile to note that while the benefit is estimated to be between approximately 10 and 20 thousand million 1990-NOK in year 2030, the calculated reduction in GDP is 34 thousand million NOK in the specific example considered here.

Thus, a sizeable fraction of the economic cost of introducing a carbon tax is recouped by the fact that emissions of local pollutants, like SO_2, NO_X, CO and particulate matter, are also reduced. Also note that *these benefits are in addition to any benefits that may accrue from a reduction in the greenhouse effect,* benefits which must be believed to be the main reason for introducing carbon taxes.

7. Conclusion

In this paper the structure of the Norwegian resource accounts and their historical development have been briefly outlined. Several examples of accounting tables and economy/environment analyses have been presented. Over the years a pragmatic approach has been followed with emphasis on the use of the resource accounts. The analyses mentioned are based on slightly extended versions of disaggregated macroeconomic planning models already in use by governmental bodies. This has facilitated the introduction of environmental concerns in the planning process in Norway. The Norwegian resource accounts are kept in physical units, and monetary valuation of natural resources and the environment is performed in analyses based on but not included in the accounting schemes.

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