Results from the Norwegian Environmental and Economic Accounts and Issues Arising from Comparisons to Other Nordic NAMEA – Air Emission Systems

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Abstract

A brief introduction of hybrid accounts (NAMEA), highlighting some of the challenges in developing these accounts, provides background information for the more detailed analysis work presented in the paper. Specific Norwegian uses of the hybrid accounts data for the development of national- and industry-level time series with decoupling and emission intensity indicators are presented. When possible, the factors influencing the developments are identified including the effects of policy. In general, the indicators show that the Norwegian economy is showing weak decoupling and decreasing emission intensities connected to most types of air emissions, however, certain industries are not making progress in these directions. Decomposition analyses show that it is often technology advancements that result in major improvements in industries as well as increases in energy efficiency, but other factors are also important. The time series data also provide evidence that the long-term policy focus for reducing acidification air emissions is reducing these types of emissions. Examples from a Nordic comparison of NAMEA-air data show some of the strengths and weaknesses of hybrid accounts when making international comparisons. One conclusion from the Nordic comparisons was that nationally consistent data are not necessarily internationally consistent because the current national NAMEA-systems are not yet fully harmonized. The Norwegian experience shows that using hybrid environmental and economic accounts (NAMEA) provides consistent, coordinated data and results in more reliable indicators and a more solid foundation for analyses.

Introduction

There are basically two major approaches to combining economic and environmental information. One approach is to convert one type of information into the units of the other in order to allow the information to be combined or added together. The other approach is to keep the different types of information in their original units and link the two data sets together.

The first approach is primarily used when a valuation is calculated for environmental assets or degradation. There are a variety of valuation methods and approaches that are used in these conversion processes. This approach, however, can be sensitive to the estimation methods used (such as the choice of discount rates etc.) and often the criticisms to these conversion approaches can block the regular incorporation of these estimates into environmental and economic statistical systems.

On the other hand, if the environmental data and the economic data are kept in their original units and the two data sets are then linked together, this approach has been successfully incorporated into regular statistical production in a number of countries, for example the Netherlands, Austria and Norway, to name a few. However, the two data sets need to be coordinated and use the same definitions before they can be combined. This can be easier said than done.

Often environmental statistics use a geographic definition whereas, economic statistics use industry categories and an economic definition. Another difference between the two systems can be the definition of a country. For the national accounts, the residence principle is a major criteria for determining which economic activity will be included. However, for air emissions, the definition is often based more on a geographic definition of the country. The differences can be substantial for a country like Norway that has a large ocean transport industry. This industry is included in the economic activity but is excluded from the official national air emissions for reporting to the Kyoto Protocol (although these data are included as supplementary information). Developing industry-based data that uses the same definitions and groupings as the national accounts is the key to developing hybrid accounts.[1]

Hybrid accounts (NAMEA: National Accounting Matrix including Environmental Accounts)

When combining environmental and economic information into hybrid accounts there is, in general, no attempt to convert physical units into monetary units, or *vice versa*, which means that these accounts largely avoid the problems associated with placing a monetary value on the environment but the accounts are flexible enough to include valuation information if this is considered desirable and asset accounts are included in the hybrid accounts. For example, the Netherlands include valuations of their oil and natural gas resources in their NAMEA matrices and Finland includes valuations of their forest and peat resources. Keuning (1996) describes the most important difference between the NAMEA-approach and the SEEA[2] as being the starting points. The NAMEA starts from an expansion of the national accounts substance accounts (input-output tables) whereas the SEEA focuses on an expansion of the standard asset accounts with accounts for non-produced natural assets.

There is a wealth of statistics covering the environment and the economy but it can be a challenge to integrate these sets of information. Often classifications and definitions do not match, so constructing an overall information system for monitoring and analyzing environment and economic trends is important. The NAMEA system is one approach to developing this type of information system. Keuning (1997) advocates the use of the basic principles of the national accounts to a wider range of statistics and in particular with environmental statistics. The system can function as a monitoring tool but also as an analysis framework. Keuning also suggests that analyses based on NAMEA-based information can yield projections and simulations for attributes that have not yet been incorporated into econometric models but have been included in the accounting system.

1. Hybrid accounts are also known as NAMEAs which stands for National Accounting Matrix including Environmental Accounts. This terminology was originally coined in the Netherlands. "NAMEA" and "hybrid accounts" are used interchangeably in this paper.

2. SEEA is the abbreviation for System of Economic and Environmental Accounts.

A description of the Dutch NAMEA and about the method for developing this approach can be found in de Haan and Keuning (1996), Keuning, van Dalen and de Haan (1999) and Keuning and de Haan (1998). The accounting system developed by the Dutch is a symmetric social accounting matrix system in which there are the same number of columns and rows and there is a balancing item included in the system to balance the differences in the column and row totals.

The Nordic NAMEAs on the other hand start with the symmetric input-output tables from the national accounts and extend these to include primarily environmental and employment data, resulting in a rectangular shaped system (Hellsten, Ribacke and Wickbom 1999, Hass and Sørensen 1998, Jensen and Pedersen 1998). This differs from the Dutch NAMEA system that is symmetrical or square in shape. The Dutch system is a full social accounting matrix with balancing entries whereas the Nordic approaches only enter detailed emissions across the rows. The Nordic approaches are slightly different from the system in the Netherlands but the most important features of the accounting system are included.

Countries outside the Nordic region have also developed these types of NAMEA environmental accounting systems. See for example, Japan (Ike 1999), United Kingdom (Vaze and Balchin 1996, Vaze 1999) and for a summary of other EU-15 countries plus Norway that have NAMEA systems (Eurostat 1999, 2001).

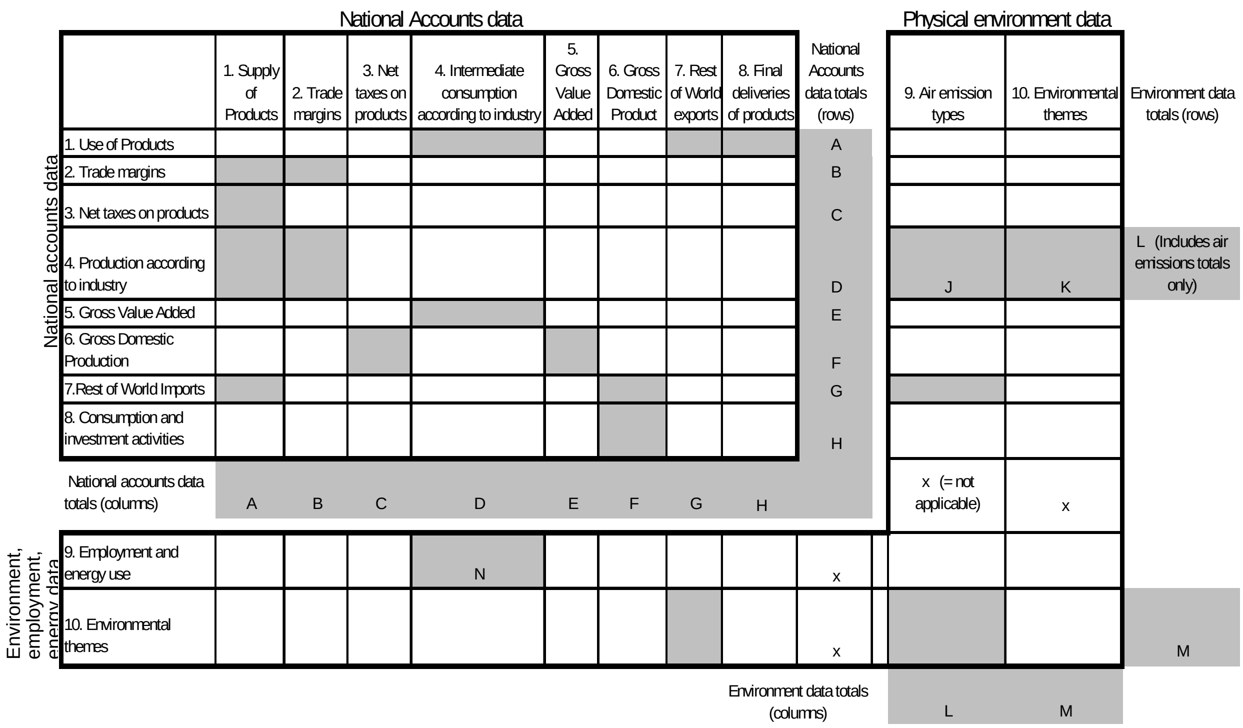
Norwegian NAMEA

Figure 1 is a schematic of the Norwegian NAMEA matrix. The shaded areas show where there are entries in the matrix. The row "Production according to industry" and the column "Intermediate consumption according to industry" can be shown for approximately 65 different NACE categories. The inner upper left-hand box is the national accounts supply and use table. The column totals and row totals for this area of the accounting system will be equal. This principal is illustrated in the figure by showing the row and column totals by the same letter.

The physical environment and employment data is then added by extending the national accounts supply and use matrix to the right and bottom. In the Norwegian NAMEA system there are eighteen different types of air emissions included in column 9, "Air emission types," and three environmental themes are included in row and column 10, "Environmental themes." The three environmental themes are the greenhouse gases theme, the acidification theme and the tropospheric ozone precursors theme. Combining certain emission types together leads to the calculation of these themes (or indices). See the appendix for the calculation formulae for these themes.

The row and column totals for the emissions data also need to be equal (shown in the figure by "L" and "M"). Areas "J" and "K" are where the emissions data are found according to the NACE industry groups. The data for this analysis have been taken from these areas in the Norwegian NAMEA matrix. The employment and energy data are found in area "N" where this information is also listed according to industry (NACE) groups. Since the row and column totals need to be equal, this provides a check whether the information included in the accounting system is correctly entered. The row and column totals are only additive if the units are the same; in other words, it is not valid to add entries in the economic section together with the entries in the environment section.

Figure 1. **Schematic of Norwegian NAMEA-matrix**



Source: Hass and Skaborg 2000 (adapted originally from Hass and Sørensen 1998).

In this matrix, the emissions from other countries that are deposited within the national borders and the acidification emissions that are transported outside the borders are included under the export and import row and column 7. Because these transboundary data are included, the national totals for the various air emissions could not be taken directly from the matrix system. National totals needed to be re-calculated excluding the import/export data.

The Norwegian NAMEA system includes emissions occurring from ocean transport in row 4, “Production according to industry” (area “J”). When this area is expanded to show all of the 65 NACE groups, ocean transport is found under NACE 61.101 Ocean Transport. It could be argued that these emissions should be shown as exports or outside of the industry section of the matrix since these emissions are not occurring within the national borders. Emissions from international shipping are not included in the EMEP transboundary calculations which are used for import and export estimates of acidification emissions. Denmark (Jensen and Pedersen 1998) shows emissions from international shipping in a separate row that is not part of the industry section of the matrix. There are a number of important issues arising when trying to decide where to include various types of emissions in the NAMEA system and these issues can be important when attempting international comparisons.

The NAMEA system is very flexible and can be adapted to include a variety of environment-related data. Appropriate additional columns and rows are simply added to the matrix to accommodate the new information. Solid waste, energy use, new types of air emissions, water use, land use and environmental protection expenditure are all areas under development in different countries for inclusion in their respective hybrid accounts (see Sørensen, *et al*. (2001) for the latest developments in the Norwegian NAMEA system). In the next section the Norwegian NAMEA-data will be presented, highlighting in particular the different uses of the data in trend analysis and policy evaluation whenever possible.

Norwegian hybrid accounts (NAMEA) for 1990-2001

Results from the Norwegian hybrid accounts show that certain economic activities have a large influence on the economic and environmental trends. Having a time series of data broken down according to industries allows trend changes to be observed as well as the results of some government policies. In this section, the economic, air emission and greenhouse gas intensity trends for Norway as a whole and for selected significant portions of the economy will be briefly presented and discussed.

Economic, air emission and greenhouse gas intensity trends for Norway

Figure 2 shows the economic, air emission and greenhouse gas intensity trends for Norwegian activity (defined in accordance to the residence principle as used in the national accounts). The growth rates for the period 1990-2001* (the data for 2001 are preliminary) for total value added for Norway is higher than the growth rates for all of the different types of air emissions. A pronounced difference is seen with respect to emissions of acidification precursors (NO_x, NH_3, SO_2) which have declined 8% while total value added has increased 46%. The largest change in any of the 18 air emission components included in the Norwegian NAMEA is seen for lead emissions which were reduced by 96% over this same time period.

The emissions profile for Norway is heavily influenced by ocean transport. On average over the 11-year period, ocean transport contributes 19% of greenhouse gas emissions (in CO_2-equivalents), 51% of acidification emissions (in Potential Acid Equivalents) and 31% of tropospheric ozone precursors (in Tropospheric Ozone Forming Potentials). When this sector is removed from the Norwegian economic and emissions profile (see Figure 3), the variation in the trends is reduced and the observed changes are slightly larger.

Ocean transport is an important source of world wide air pollution but is excluded from the Kyoto Protocol and is often not included in discussions regarding international air emissions or indicator definitions. Due to the importance of shipping to the Norwegian economy, Norway has actively worked within the International Maritime Organization (IMO) to encourage improvements in the air emissions from maritime fleets.

In 1987 at the International Conference on the Protection of the North Sea, Ministers of North Sea states agreed to initiate actions to improve quality standards of heavy fuels in order to help reduce marine and atmospheric pollution. And for the Norwegian ocean going fleet, the acidification emissions have been reduced by almost 6% although greenhouse gas emissions are nearly unchanged and tropospheric ozone precursors (especially due to NO_x) have increased.

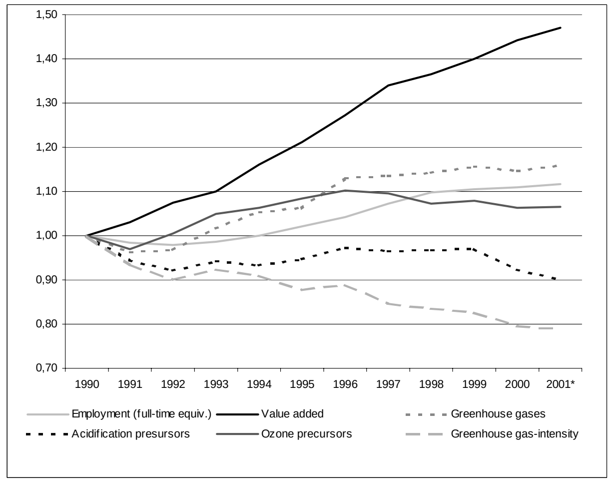
In 1997 the Protocol of 1997 (MARPOL Annex VI) was adopted which required certain air emission reductions and included establishing the Baltic Sea as a designated SO_x Emission Control area. As of 31 March 2003 there are, unfortunately, only 8 contracting states covering 26% of world tonnage so that the convention has not yet entered into force.

Figure 2. **Economic, air emission and greenhouse gas intensity trends for Norway (total), 1990-2001* (Index 1990 = 1)**[1]

1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

Source: National Accounts and Environmental Accounts, Statistics Norway.

Figure 3. **Economic, air emission and greenhouse gas intensity trends for Norway excluding ocean transport, 1990-2001* (Index 1990 = 1)**[1]



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

Source: National Accounts and Environmental Accounts, Statistics Norway.

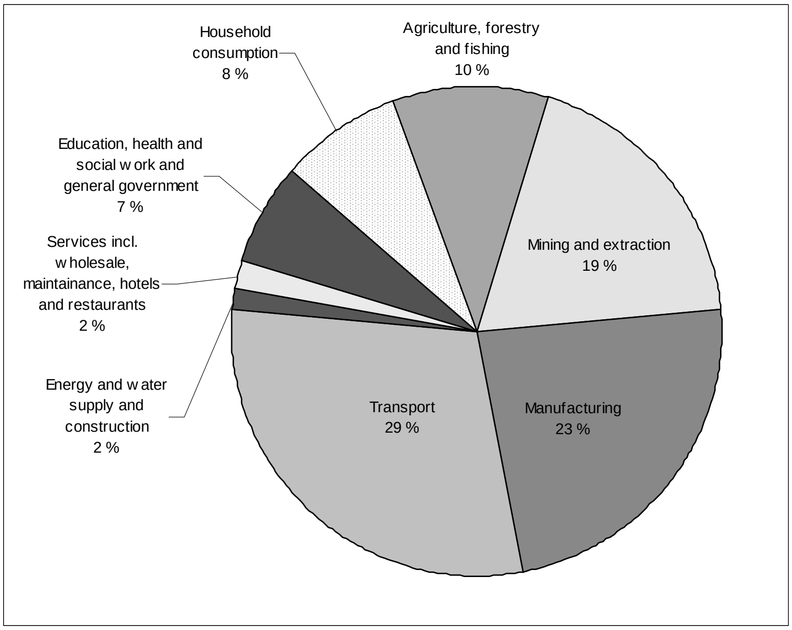
The trends in the time series figures show that the economic growth in Norway has been greater than the growth in the various air emissions. This is particularly shown by the greenhouse gas-intensity indicator[3] line in the graphs. This downward sloping line shows a reduction in the greenhouse gas intensity of the Norwegian economic activity, in other words, there has been greater growth in the economy than in greenhouse gas emissions. This is a positive development. Some specific reasons for recent changes in CO_2 emissions include lower activity in the ferroalloy (metals) industry, less use of diesel in crude petroleum and natural gas extraction, reduced production of refined oil products and reductions in coastal traffic. With respect to other greenhouse gases, emissions of N_2O (nitrous oxide) have increased from the manufacture of commercial fertilizers, as have emissions of perfluorocarbons (PFCs) from aluminium production.

Identifying more general factors behind the trends in Norwegian air emissions has been done by a decomposition analysis. Bruvoll and Medin (2000 and 2003) have identified 8 factors that have influenced the trends in Norwegian emissions. Their analyses show that, whereas, economic growth alone would have resulted in major emissions increases, this has been counteracted primarily by more efficient use of energy and by the increased use of abatement technologies. In addition, they found that the substitution of cleaner energy for more polluting energy sources, other technological advances and political actions have contributed to the positive trends but to a much lesser degree. As we will see, these factors and others will be important when examining trends in selected industries.

3. Calculated as: greenhouse gas emissions in CO_2-equivalents / value added in constant 1995-prices (see Gugele and Roubanis 2003).

Figure 4 shows the importance of various industries with regards to their greenhouse gas emissions stemming from their economic activity in 2000. Again, the transportation sector (including ocean transport) dominates as is shown by the largest portion of the pie diagram (27%). This is also the case for ozone and acidification precursors, 42 and 62% respectively, for this sector. Mining and Quarrying is second in emissions of ozone precursors, contributing 30% of the Norwegian totals, while agriculture, fishing and forestry is second in acidification precursor emissions with 14%.

Figure 4. **Greenhouse gas[1] emissions from emitting sectors. Norway total, %, 2000**



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

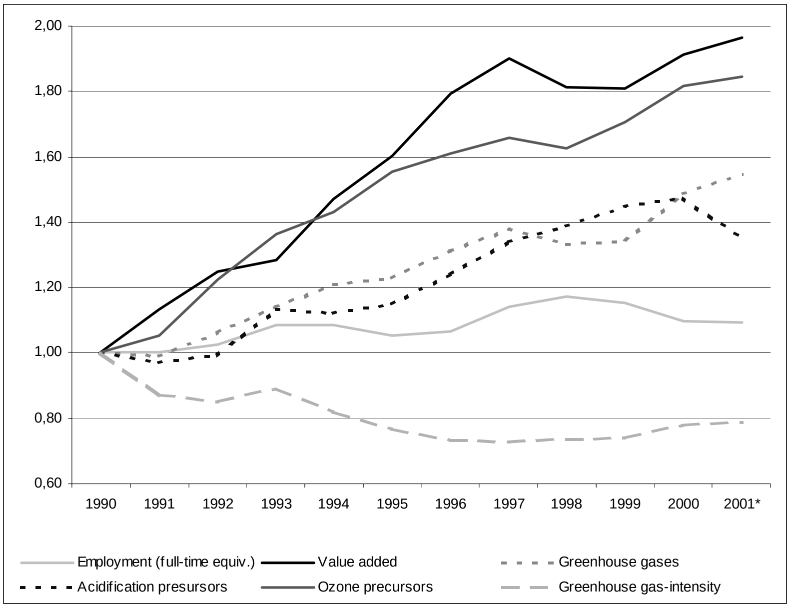
Source: National Accounts and Environmental Accounts, Statistics Norway.

In addition to looking at Norway as a whole, the NAMEA hybrid accounts allow for the examination of trends at more detailed industry levels. In the next section of this paper the following sectors are examined in more detail: Mining and Quarrying (including extraction of crude petroleum and natural gas), Manufacturing, Services (including wholesale, maintenance, hotels and restaurants) and Households.

Economic, air emission and greenhouse gas intensity trends for Mining and Quarrying (including extraction of crude petroleum and natural gas)

The Mining and Quarrying industry, which includes the extraction of crude petroleum and natural gas (NACE Section C, divisions 10-14), is a major part of the Norwegian economy and it is also very important in terms of Norway's air emissions. From 1990 to 2001 the value added of this industry has increased 96% and on average accounts for approximately 13% of total value added in Norway. This is a very important industry in Norway but it is also, unfortunately, pollution intensive. The industry's long-term focus on reducing emissions of both greenhouse gases and acidification gases has been encouraged and required by the Norwegian authorities. The results of these efforts can be seen in the divergent trends of these two types of emissions in comparison with the trend in value added for this industry (see Figure 5).

Figure 5. **Economic, air emission and greenhouse gas intensity trends for Mining and Quarrying (incl. extraction of crude petroleum and natural gas), 1990-2001* (Index 1990 = 1)**[1]



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

Source: National Accounts and Environmental Accounts, Statistics Norway.

There has been a large decrease of SO_2 emissions for this industry between 1990 and 2001; however, there has been an increase in NO_x emissions that at least partially counteract these SO_2 reductions when these are combined into acidification precursors. The growth in use of natural gas for production of electricity on oil platforms contributes to these increased NO_x emissions. In 2001 there has been a major reduction in flaring of natural gas offshore which has led to lower NO_X emissions and which helps explain the sudden drop in the acidification precursors' trend from 2000 to 2001.

The increase in the use of gas turbines for electricity production offshore has also led to increased CO_2 emissions although this has been partially offset by a reduction in flaring (the burning of excess natural gas without energy recovery).

On the other hand, the relatively recent focus of authorities and of the industry on tropospheric ozone precursors, in particular non-methane volatile organics (NMVOCs), has only started to show some positive results. More than 50% of Norway's NMVOC emissions come from evaporation during loading and storing of crude oil offshore. The slight reductions seen in the trend for the ozone precursors in 2001 are due to lower oil production that leads to smaller amounts of crude oil being loaded offshore and the fact that recovery facilities for vapours released during loading have been installed at certain facilities. Even with these improvements, further reductions are necessary if Norway shall meet the emission target set in the Gothenburg Protocol for NMVOCs, 195 000 tons in 2010 (target excludes ocean transport).

The greenhouse gas intensity indicator shows that the trend indicating improvement appears to be reversing. Initially this indicator shows an improvement but, by 1996 this appears to have stalled and since 1999 this indicator has reversed and shows that the situation is actually worsening.

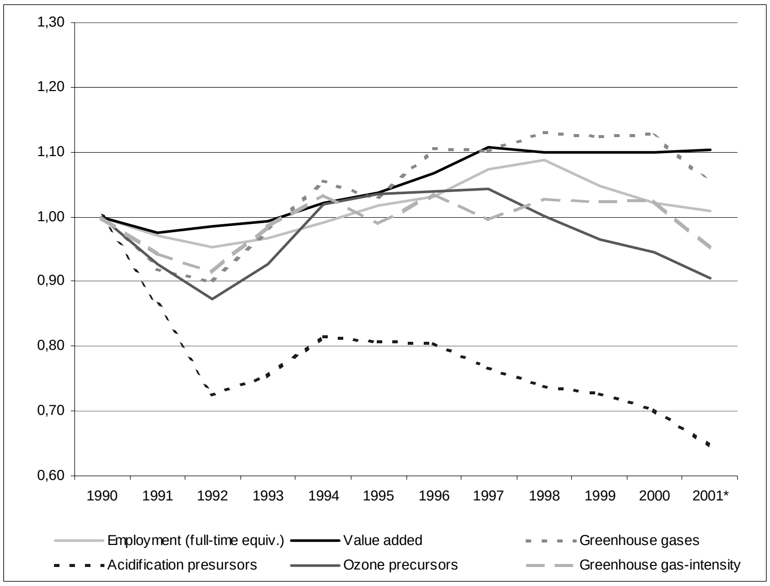
Economic, air emission and greenhouse gas intensity trends for Manufacturing

For well over 15 years the Norwegian authorities have focused on the reduction of acidification emissions from the Manufacturing industry (NACE Section D, Divisions 15-37). The results of this focus can clearly be seen in the downward sloping line for acidification emissions in Figure 6.

On the other hand, the manufacturing industry has been exempt from one of the mechanisms to encourage the reduction of greenhouse gases, specifically the CO_2-taxes on fossil fuels when used in production processes. The trend for greenhouse gas emissions has, in general, increased more than the increases in value added. As the enterprises in the Manufacturing industry become part of the Norwegian greenhouse gas emissions trading system in the next few years, there are expectations that the trends for these gases will also start to go down.

In the later part of the period, value added in the manufacturing industry has levelled out and employment has gone down. This is primarily due to the ferro-alloys industry being in a recession which has consequently reduced production levels.

Figure 6. **Economic, air emission and greenhouse gas intensity trends for Manufacturing, 1990-2001* (Index 1990 = 1)**[1]



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

Source: National Accounts and Environmental Accounts, Statistics Norway.

Bruvoll and Medin (2000) found that in contrast to all other sectors, the pulp and paper products industry actually had an increase in energy intensity (total energy use in relation to total production). Since they found that for CO_2 emissions, decreased energy intensity was the most important cause for decoupling of economic growth from emissions, the increase in energy intensity for the pulp and paper products industry means that decoupling is not yet in evidence in this case. The variation in the greenhouse gas intensity indicator from 91 to 104% also shows that there is no consistent decoupling in the manufacturing industries as a whole.

Preliminary figures for 2001 show a marked reduction for all emission types in the manufacturing industry. This is primarily due to lower production levels in general in 2001 and in particular to closures in the metals industry. Also in 2000 one of Norway's three oil refineries closed which also means lower emissions levels. Although the greenhouse gases in these figures only include CO_2, CH_4, and N_2O, the national figures reported under the Kyoto protocol show that there has been a major reduction in emissions of SF_6 in 2001 due to the closure of an enterprise engaged in the primary production of magnesium.

Economic, air emission and greenhouse gas intensity trends for services[4]

From 1990 to 2001 the services industries have contributed more and more to the Norwegian economy, measured in value added, than has the manufacturing industry. The services industry accounted for 34% of total value added in 1990, increasing to 40% in 2001. Whereas, the manufacturing industry provided 15.5% of total value added in 1990 and only 11.7% in 2001. The services industry in 2001 had employment (measured in full-time equivalents) of 2.3 times the employment in the manufacturing industry.

During this time period, Norway has been undergoing some changes in the structure of its economy as manufacturing becomes less dominant and the services industries become more important. These general trends are also important to the air emissions profile for the country. In 2000, the services industries contributed only 2% of total greenhouse gas emissions, 1% of acidification emissions and 2.5% of tropospheric ozone precursors.

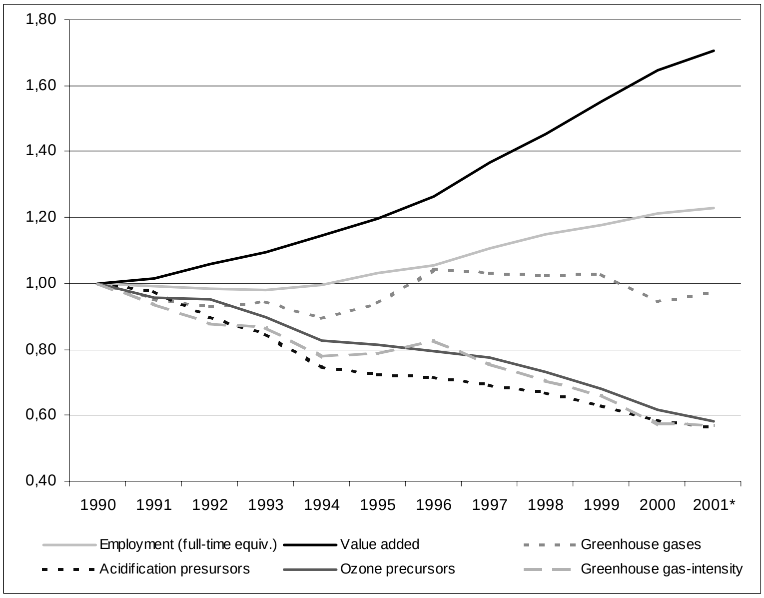
The trends look particularly consistent and good for acidification precursors and tropospheric ozone precursors with overall reductions of more than 40% over the whole time period (see Figure 7). The changes in greenhouse gas emissions, on the other hand, are relatively small. The greenhouse gas intensity indicator shows a more than 40% improvement, but this may be a bit misleading since this is due primarily to the growth in value added since there has been little change in the greenhouse gas emissions.

The reductions in the acidification and ozone precursors are primarily from mobile sources, which for this group of industries is transportation related. Included in the "services" is also NACE Section G, wholesale and retail trade. Technological improvements to vehicles during the time period 1990-2001 have meant that there have been substantial reductions in certain emissions, specifically NO_x, CO, NMVOC. The reductions in these emissions have counter-acted the increases of N_2O and NH_3 due to the increase in the number of vehicles with catalytic converters. Emissions of CO_2 have not changed to any great degree since the gains in technology have been offset by increases in activity. The reduction in the sulphur content of fuels has lead to lower levels of SO_2 emissions. The reduction of sulphur content in fuels has been a major policy focus of the

4. Includes business services (NACE Section K), Financial intermediation (Section J), hotels and restaurants (Section H), wholesale and retail trade (Section G), supporting activities for transport (Division 63) and post and telecommunications (Division 64).

Norwegian authorities and the reductions in the fuel content has led to lower emission levels of SO_2.

Figure 7. **Economic, air emission and greenhouse gas intensity trends for Services, 1990-2001* (Index 1990 = 1)**[1, 2]



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

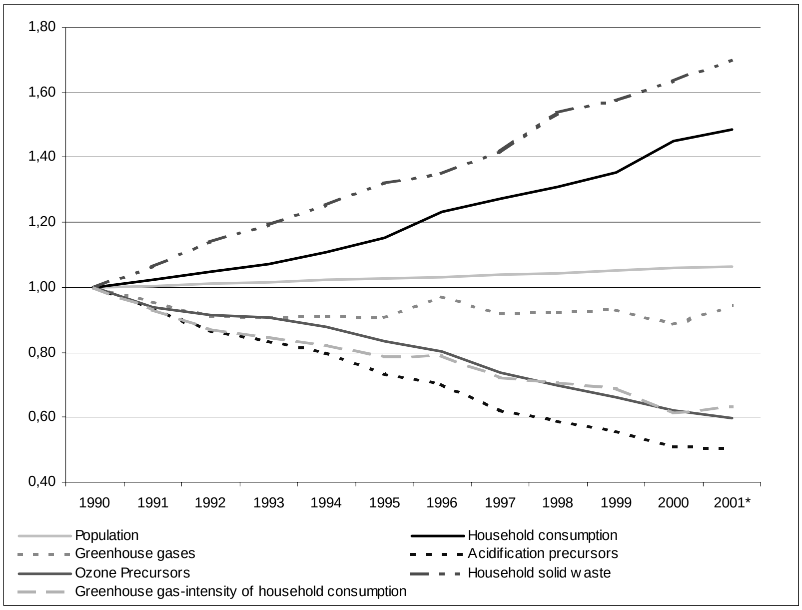
2. Includes business services (NACE Section K), Financial intermediation (Section J), hotels and restaurants (Section H), wholesale and retail trade (Section G), supporting activities for transport (Division 63) and post and telecommunications (Division 64).

Source: National Accounts and Environmental Accounts, Statistics Norway.

Economic, air emission, solid waste and greenhouse gas intensity trends for Households

Household activities also contribute to air pollution creation mostly from transportation and heating. There has been more than a 19% increase in private vehicle ownership and use (1.8 million in 1990 to 2.1 million in 2001) which has resulted in increased kilometres driven and an increase in air emissions from private vehicles. The average age of private vehicles is currently 10.2 years. Although the age of vehicles continues to increase there is an increasing number of vehicles with catalytic converters. Vehicles with catalytic converters and that use lead-free gasoline (petrol) have led to drastic reductions in lead emissions but these vehicles have a more mixed effect on other types of air emissions. In particular, NO_x emissions have been reduced however, N_2O (nitrous oxide) emissions have increased due to catalytic converters. During this time period there has been an increase in the use of diesel cars which have higher emissions of CO and CO_2 than cars using petrol (gasoline). Again, the technological improvements in the vehicles used by households have reduced some types of air emissions, but these improvements are however, partially offset by an increase in the kilometres driven by households.

Figure 8. **Consumption, air emission and greenhouse gas intensity trends for Households, 1990-2001* (Index 1990 = 1)**[1]



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

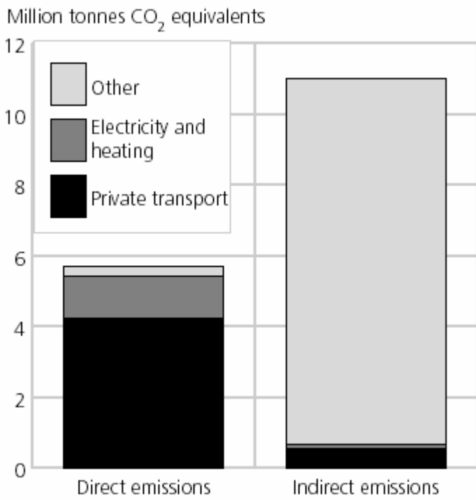
Source: National Accounts and Environmental Accounts, Statistics Norway.

Household consumption is used as the most relevant economic indicator for households. Household consumption has increased 49% from 1990 to 2001. Only household waste has increased more (70%) during this period.

The NAMEA-accounts only have direct emissions for households; however, by using input-output (I-O) analyses it is possible to identify some of the indirect emissions corresponding to Norwegian household consumption. In Figure 9, the direct and indirect greenhouse gas emissions for households are shown. The left-hand bar in figure 9 shows the 1997 direct greenhouse gas emissions (in CO_2-equivalents) from households, as can be obtained from the NAMEA-accounts. The right-hand bar shows the results from the I-O analysis.

These results show that household consumption of Norwegian-produced products resulted in substantial emissions, nearly twice that of direct emissions. Eighty per cent of the indirect emissions are connected to deliveries of foodstuffs, beverages and tobacco, transport services and housing, electricity and fuel. This analysis only captures the emissions from products that are produced in Norway and consumed by Norwegian households. The emissions connected to all of the imported products that are purchased by Norwegian households are not captured in this type of analysis. There are many products that are imported into Norway for household consumption; therefore, these results only provide a portion of the picture connected to indirect emissions from household consumption.

Figure 9. **Direct and indirect Norwegian household emissions of greenhouse gases, 1997**



Source: National Accounts and Environmental Accounts, Statistics Norway.
Reference: Statistics Norway (2001): Natural resources and the Environment 2001, pp. 210-212.

The results from a Swedish study (Wadeskog 2000) were similar in terms of which products were responsible for the majority of indirect emissions. In the Swedish case, the same product groups accounted for 82% of CO_2 emissions in 1995. However, in the Swedish study, the indirect CO_2 emissions were about the same as the direct emissions, whereas the indirect emissions were nearly twice the direct emissions for Norwegian households. This is probably due to the high level of hydroelectricity production in Norway and the high use of electricity for household heating in Norway.

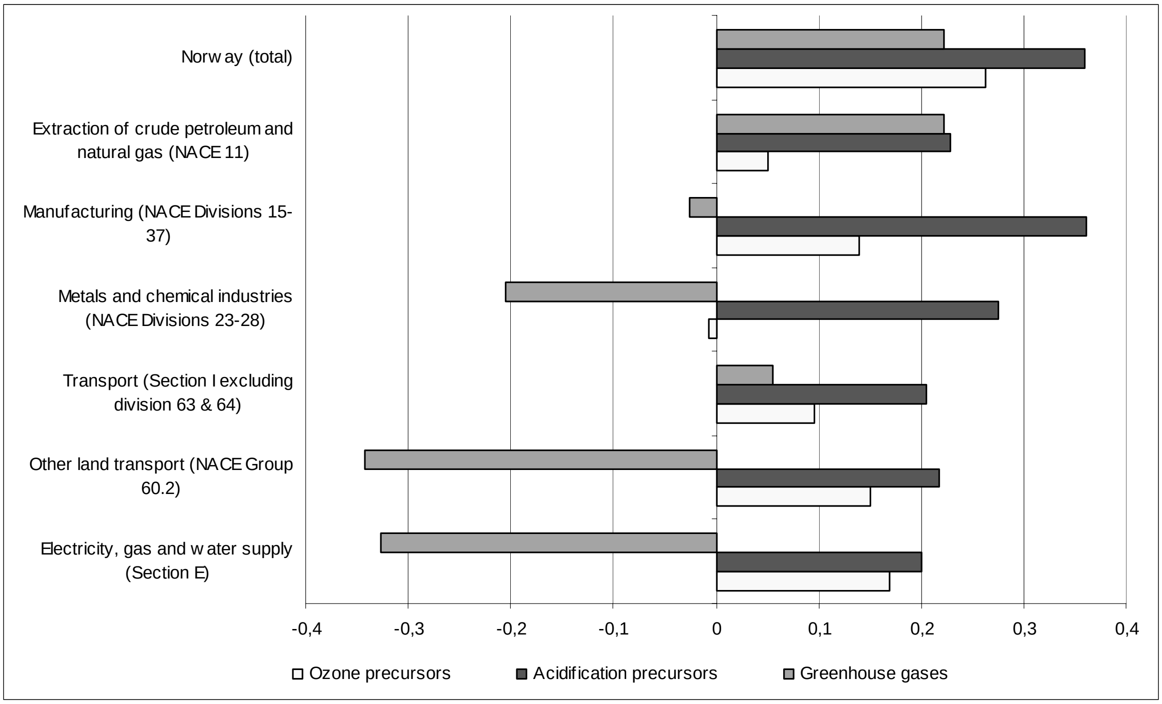
Decoupling factors

Economic activities are often the driving forces that result in increasing environmental pressures. The OECD (2002) has developed the calculation of decoupling factors to give an indication of the degree to which environmental pressures and economic forces are interacting (see Appendix A for calculation information for decoupling factors).

A positive number for the decoupling factor means that the environmental pressure relative to the economic pressure is less in the last period than in the first. This also indicates that there has been a positive environmental development with respect to the economic development. If the increase or reduction in the value added over the period is the same as that in the air emissions, this will result in a decoupling factor equal to zero.

Figure 10 presents decoupling factors for Norway and selected sectors. These factors were calculated using data from 1990 and 2000. Data for 2001 was not used since these are only preliminary figures.

Figure 10. **Decoupling factors[1] for Norway and selected sectors (between 1990 and 2000)**



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

Source: National Accounts and Environmental Accounts, Statistics Norway.

For Norway as a whole (including ocean transport), decoupling of the economic growth from all three aggregate types of air emissions appears to be occurring, although this decoupling is rather weak at between 0.2 and 0.4. This is also true for the extraction of crude petroleum and natural gas (NACE 11) but the decoupling for ozone precursors is only very slightly positive.

The manufacturing industries show a stronger decoupling for acidification precursors but for greenhouse gases, this is negative, indicating that the change in greenhouse gas emissions is greater than the change in value added. Negative results are obtained for the metals and chemical industries (NACE Divisions 23-28) with respect to greenhouse gases and ozone precursors. There has been a positive development with respect to acidification emissions in these industries.

For transportation as a whole, including ocean transport, there has been weak decoupling for all three aggregate types of emissions. However, if NACE Group 60.2 (Other land transport) is examined by itself, there is a very strong negative decoupling result with respect to greenhouse gases. This is due to increases in N_2O emissions from vehicles that have catalytic converters and the large increase in activity in land transport in recent years that has over-shadowed the technological improvements related to greenhouse gases. On the other hand, the technological advances and reductions in the content of sulphur in fuels have exceeded the growth in activity in relation to emissions leading to acidification (SO_2, NO_x and NH_3) and the same for tropospheric ozone precursors, but to a lesser degree.

And finally, NACE Section E, Electricity, gas and water supply, also shows a negative result with respect to greenhouse gases. There are very low air emissions from this NACE section due to the predominance of hydropower for the production of electricity and the high use of electricity for heating in Norway. In the past ten years there has been a greater use of energy recovery often from waste incineration which has been used specifically for heating. This has resulted in an increase in the air emissions from steam and hot water supply (NACE 40.30). These slight emission increases have then resulted in a strongly negative decoupling for this section. This is an example of when this decoupling factor may be misunderstood if the reasons for the change and the magnitudes of the change are not examined in more detail.

Norwegian policy evaluation

In the previous sections, the results of Norwegian air pollution policies have been pointed out when it has been possible to identify that these policies have been instrumental in the trend development. There are so many different factors and complex interactions occurring that it is not always possible to isolate the policy factors from the technology, energy efficiency, energy mix, economic and other factors. But having industry based data is necessary in order that analyses, such as input-output and decomposition analyses, can be performed.

An intimate knowledge of the changes in the emissions profiles in each industry is needed to be able to understand the trends, as well as analyses of the total data set to be able to identify the major factors that are influencing the developments over time.

In general, the time series NAMEA data has been used to show that the long term focus of the Norwegian authorities on acidification precursor emissions has shown results in all sectors and especially in the manufacturing sector. The situation with regards to greenhouse gases is mixed. The extraction industry appears to be making some progress but that appears to be reaching diminishing returns in the most recent years and there is little progress to point to in the manufacturing industries in this area. One area of great effectiveness is in the area of reduction in lead emissions. A thorough analysis of Norwegian environmental policy through 1995 is presented in an analysis paper from the Ministry of the Environment (NOU 1995:4 only in Norwegian) and a recent evaluation and comparison of economic instruments in Nordic environmental policy was made by the Working Group on Environment and Economics under the auspices the Nordic Council of Ministers (2002).

Nordic hybrid accounts (NAMEA) comparison

The Nordic NAMEA systems (Norway, Denmark, Sweden and Finland) are structurally very similar although there are some differences with regards to the specific set up of the national accounts input-output table and also where certain types of emissions are shown, such as ocean transport emissions and emissions from landfills (Hass and Skarborg 2000).

To evaluate whether the different NAMEA-systems in the Nordic countries are comparable a study was made of the following six different industries: Agriculture (NACE 01), Manufacture of pulp, paper and paper products (NACE 21), Manufacture of chemicals and chemical products (NACE 24), Manufacture of basic metals (NACE 27), Electricity, gas, steam and hot water supply (NACE 40), and the Transportation sector (NACE 60, 61, 62). See Hass and Skarborg (2000) for the full report. These different industries were chosen because they were of particular importance to the emissions profiles of all four countries.

A number of specific issues needed to be addressed and adjustments made before a comparison could be made with any confidence. Some of these issues were emissions from ocean transport, CO_2 emissions from biofuels, how imports and exports were handled, aggregation issues with regards to the definition of industry groups, allocation differences with respect to emissions, consistency of the time series of data, potential double counting with respect to calculating total energy use and emissions from landfills.

Once these issues were evaluated and the data sets adjusted, a comparison of the different industries in each country was attempted. Some explanations for why there were differences between the countries were also proposed.

Understanding observed differences

Although the Nordic economies are similar in many ways, when comparing environmental and economic variables it becomes clear that the industries have different compositions and different emission intensities. The reasons behind these observed differences can be due to differences in the structure of the industries or it can be differences between the types of activities that are included in the industries. The following two examples illustrate these two different reasons.

Structural differences

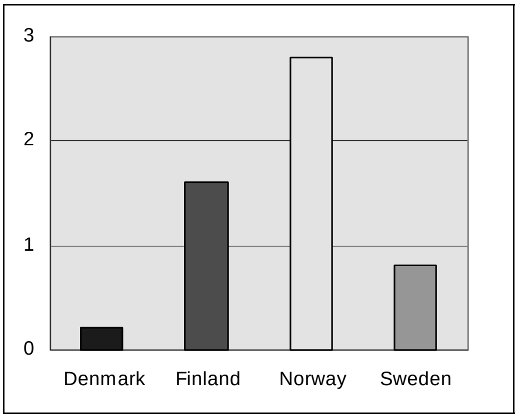
Structural differences help to explain the differences between the greenhouse gas intensities in NACE Division 24, Manufacture of Chemicals and chemical products, between Norway and Denmark. Figure 11 shows the greenhouse gas intensities for the four different Nordic countries. Norway has very high emissions per value added when compared to Denmark. This difference can be explained primarily by examining the types of enterprises and production activities that are predominant in the two countries in this NACE division.

In Norway, the emissions from this industry are arising primarily from the manufacture of basic chemicals and agro-chemical products. The production of these types of products results in relatively high levels of air emissions relative to value added.

In Denmark, on the other hand, there is a larger proportion of the value added in this division coming from pharmaceutical enterprises than in Norway. The pharmaceutical enterprises have much lower levels of air emissions and higher levels of value added; this combination makes the Danish chemicals industry appear more efficient, whereas, the reason is due primarily to the structure of the two industries in the different countries and the two very different types of production activities that are classified within the same division.

More detailed levels of industry categories were examined but either the emissions data or the economic data were not available or it did not make sense to break down the categories into smaller groupings due to the high level of integration between enterprises in the different categories.

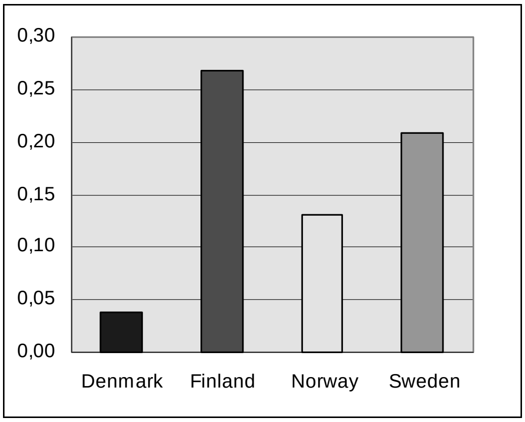
Figure 11. **Greenhouse gas intensities for NACE 24 (Manufacture of chemicals and chemical products) for Denmark, Finland, Norway and Sweden. CO_2-equivalents tons per value added in 1995 ECU**



1. Greenhouse gas calculations include only CO2, CH4 and N_2O.

Source: Hass and Skarborg (2000), p. 40, Figure 28.

Figure 12. **Acidification intensities for NACE 21 (Manufacture of pulp, paper and paper products) for Denmark, Finland, Norway and Sweden. mPAE per value added in 1995 ECU**



1. Greenhouse gas calculations include only CO_2, CH_4 and N_2O.

Source: Hass and Skarborg (2000), p. 38, Figure 24.

Differences in activities included

The manufacture of pulp, paper and paper products (NACE 21) is very important to Finland, Sweden and Norway and to a lesser degree to Denmark. This industry has a relatively high level of integration between pulp and paper manufacturing making it impractical to look at more detailed NACE groups since it would be very difficult to develop good economic information for the separate activities. In terms of value added, Finland’s industry is the largest of the four, with Sweden a close second.

From Figure 12 it appears that Finland is much less efficient (higher emissions per value added) than Sweden and Norway. This result was a little unexpected since size advantages were expected to be seen for the Finnish industry which would lead to more efficient production systems. However, upon closer examination of the activities included in the Finnish enterprises, it is common that these enterprises own and operate their own power producing plants instead of purchasing power from others. This means that the emissions associated with their secondary activity of power production is also included in this NACE category. This can account for the high emissions intensity in Finland.

On the other hand, some of the differences are due to different types of industrial processes since much of the emissions from this industry are process related. This can be an indication that the processes in Sweden and Norway are more emissions efficient but it is difficult to make this conclusion with any certainty due to the differences regarding the emissions included in the different NACE divisions in the different countries.

Improvements needed for international comparisons

Hybrid accounts have been most widely used in national contexts and the focus has been placed on consistency over time for the national systems. These accounts have proved to be very useful for trend analyses and other types of analyses since tools that are used for predominantly economic analyses, such as input-output analyses, can now be used with the hybrid data. Consistency between the data sets over time at the national level is of primary importance when attempting these types of analyses.

When international comparisons are going to be made, then additional requirements for the data sets need to be met. Although NAMEA accounting systems are being developed in many countries, NAMEA is not yet a harmonized system. This means that there is still a great deal of freedom for countries to include or exclude information according to their own definitions. This freedom makes it difficult to make comparisons between countries since there can be different definitions and there is uncertainty whether you are comparing the exact same things. Further work needs to be done before the NAMEA (hybrid) accounts can be used with confidence in international comparison work.

Conclusions

Having coordinated economic and environmental data will allow for greater consistency in the development of national indicators. It will also provide additional opportunities for analyses to understand the different factors influencing the changes in the environmental profiles of Norwegian industries. The Norwegian Ministry of the Environment has been supportive of the development of these accounts and is interested in using the data more extensively in their policy development and analyses.

The Norwegian hybrid accounts are planned for annual publication (in May) and were established as official statistics in 2002. When the accounts were published in 2002 great interest was shown in the results which resulted in several newspaper articles and an interview on the main evening news of the national television station.

The NAMEA systems in the Nordic countries are similar and provide a rich set of data for analyses and comparisons. Some of the country-specific ways of presenting the data make it difficult to use the data without checking that certain types of information are treated in similar ways. Once these differences are adjusted for, the NAMEA systems do allow for some interesting comparisons to make. Understanding the differences between the countries needs intricate knowledge of both the structure of the industries in the countries and the way that the NAMEAs are developed.

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Appendix A: Conversion factors

The following provides conversion factors and calculation examples of environmental themes and decoupling factors.

Decoupling factors are calculated based on OECD's definition (OECD 2002):

Decoupling factor = 1 – decoupling ratio

where the decoupling ratio is defined as:

$$decoupling\ ratio = \frac{\left[\dfrac{Environmental\ \mathrm{Pr}essure_{\ last\ period}}{Driving\ Force_{\ last\ period}}\right]}{\left[\dfrac{Environmental\ \mathrm{Pr}essure_{\ first\ period}}{Driving\ Force_{\ first\ period}}\right]}$$

In this paper the environmental pressure was air emissions and the driving force was value added (in constant 1995-basic prices).

Calculation of environmental themes

There is some debate whether it is appropriate to aggregate various types of air emissions into a single entity or theme. This is of particular interest since the Kyoto protocol has established this type of calculation for greenhouse gases using the GWP conversion factors (Godal and Fuglestvedt 2000; Fuglestvedt, *et al.* 2000). In this report, emissions types have been aggregated into three themes to be able to include more information in the calculations.

Greenhouse theme

Type of emissions	Amount of emissions (tons)	*	Conversion factor (GWP)	=	CO_2-equivalents (tons)
CO_2	11 388 060	*	1	=	11 388 060
CH_4	31 686	*	21	=	665 406
N_2O	99	*	310	=	30 690
			Sum		12 084 156

In order to calculate the greenhouse theme, the emissions for each of the compounds that contribute to that theme and the corresponding conversion factors are needed. Each of the emission types are multiplied by the Global Warming Potential (GWP) conversion factor and then added together to give a total. The following is an example using Norwegian data for NACE 11 Crude petroleum and natural gas extraction industry for 2000. This calculation shows that the oil and gas extraction industry (NACE 11) in Norway had emissions of 12.1 million tons CO_2-equivalents in 2000. This calculation only includes the three greenhouse gases, CO_2, CH_4 and N_2O whereas the official method for calculating this theme in Norway is to include all of the greenhouse gases included in the Kyoto agreement. All of these gases and their corresponding conversion factors are listed in the table at the end of this section. The calculation example above would need to be extended to include all of the different gases and not just the three shown in the example for reporting according to the Kyoto Protocol.

Acidification theme

Type of emissions	Amount of emissions (tons)	*	Conversion factor	=	Potential Acid Equivalent (tons PAE)
NOx	59 741	*	1/46	=	1 299
SO2	632	*	1/32	=	20
NH3	0	*	1/17	=	0
			Sum		1 318

The Norwegian emissions data for the three gases that contribute to acidification are reported in tons and this calculation results in tons PAE. The emissions are multiplied by the conversion factors to give potential acid equivalents (PAE) for each emission type. The sum of these values is the acidification potential emissions from the Norwegian crude petroleum and natural gas extraction industry (NACE 11) for 2000.

Tropospheric Ozone Precursors theme

Type of emissions	Amount of emissions (tons)	*	Conversion factor	=	Tropospheric Ozone Forming Potentials (tons TOFP)
NOx	59 741	*	1.22	=	72 884
NMVOC	234 877		1		234 877
CO	7 713	*	0.11	=	848
CH4	31 686	*	0.014	=	444
			Sum		309 053

The Norwegian emissions data for the four gases that contribute to the formation of tropospheric ozone are reported in tons and this calculation results in tons TOFP. The emissions are multiplied by the conversion factors to give tropospheric ozone forming potentials for each emission type. The sum of these values is the ozone precursor emissions from the Norwegian crude petroleum and natural gas extraction industry (NACE 11) for 2000.

Summary table with theme conversion factors

The following table provides the conversion factors for calculating the three environmental themes: greenhouse effect, acidification and tropospheric ozone precursors.

Compound	Conversion factor to CO_2-equivalents using Global Warming Potentials (GWP)* for **Greenhouse theme** – (100 year GWPs)
CO_2	1
CH_4	21
N_2O	310
HFC-23	11 700
HFC-32	650
HFC-125	2 800
HFC-134	1 300
HFC-143	3 800
HFC-152	140
HFC-227	2 900
C_3F_8 (PFC-218)	7 000
CF_4 (PFC-14)	6 500
C_2F_6 (PFC-116)	9 200
SF_6	23 900

*These values are based on atmospheric research and models and the values may change in the future. These are the values published by the IPCC (1995). The IPCC (1989) values were revised upwards. For example, in 1989, the GWP for CH_4 was 11 and the GWP for N_2O was 270.

These values are also published in Statistics Norway's annual publication, "Natural Resources and the Environment" in Appendix Table C1.

Compound	Conversion factor to Potential Acid Equivalent (PAE/kg)** for **Acidification theme**
NO_x	1/46
SO_2	1/32
NH_3	1/17

**Assumes complete dissociation. This is not likely under normal conditions but these values provide an upper estimate.

Compound	Conversion factor to Troposheric Ozone Forming Potentials (TOFP) for **Ozone precursors theme**
NO_x	1.22
NMVOC	1
CO	0.11
CH_4	0.014

Appendix B: Norwegian NAMEA data

Table B-1:

Value added, employment and greenhouse gas, acidification and ozone precursor emissions according to industry groups. 2000.

Table B-2:

Norway's total value added, employment and air emissions (according to components). 1990-2001*

Additional data is available in *StatBank*, the database available on Statistics Norway's website.

Table B-1. **Value added, employment and greenhouse gas, acidification and ozone precursor emissions according to industry groups, 2000**[1, 8]

	Total gross value added[2]	Employment (full-time equivalent persons)	Carbon dioxide, CO_2	Methane, CH_4	Nitrous oxide, N_2O	Greenhouse gases emissions[4]	Nitrogen oxides, NOx	Ammonia NH_3	Sulphur dioxide, SO_2	Acidification precursors[5]	Non-methane volatile organic carbons, NMVOC	Carbon monoxide, CO	Tropospheric ozone precursors[6]
	Million NOK (1995-constant basic prices)	1 000 full-time equiv.	1 000 tons	Tons	Tons	Tons CO_2-equivalents	Tons	Tons	Tons	Tons acid-equivalents	Tons	Tons	Tons NMVOC-equivalents
Totals	991 710	*1 974.5*	*55 016*	*332 966*	*18 245*	*67 664 258*	*513 312*	*25 437*	*83 421*	*15 262*	*377 760*	*581 460*	*1 072 622*
Agriculture, forestry and fishing	**25 586**	**79.3**	**1 970**	**99 332**	**9 592**	**7 029 005**	**37 129**	**23 216**	**1 069**	**2 206**	**3 852**	**21 191**	**52 871**
Agriculture and hunting	10 845	58.3	506	99 212	9 538	5 546 648	5 313	23 215	190	1 487	2 341	13 389	11 684
Forestry and logging	5 333	5.1	48	13	18	53 521	715	0	19	16	763	1 232	1 771
Fishing	4 455	13.1	1 404	104	35	1 417 058	30 989	0	855	700	724	6 410	39 237
Fish farming	4 953	2.8	11	2	1	11 777	113	1	4	3	24	159	179
Mining and extraction	**133 023**	**26.4**	**11 942**	**32 219**	**138**	**12 661 730**	**68 855**	**0**	**945**	**1 526**	**235 731**	**8 906**	**321 165**
Mining and quarrying	2 118	3.9	159	346	37	177 500	1 495	0	121	36	249	412	2 124
Oil and gas extraction	127 206	15.4	11 388	31 686	99	12 084 156	59 741	0	632	1 318	234 877	7 713	309 052
Service activities incidental to oil and gas extraction	3 699	7.1	395	187	3	400 074	7 619	0	193	172	605	782	9 989
Manufacturing	**117 761**	**281.4**	**13 456**	**28 513**	**5 781**	**15 847 217**	**24 548**	**558**	**20 240**	**1 199**	**32 416**	**47 484**	**67 987**
Fish and fish products	3 714	11.6	213	8	2	213 884	463	0	406	23	34	120	612
Meat and dairy products	4 023	15.9	95	4	3	96 011	346	1	43	9	56	259	507
Other food products	10 191	17.1	162	6	3	162 968	284	1	131	10	858	251	1 232
Beverages and tobacco	2 082	6.1	85	2	1	85 386	86	1	36	3	69	164	192
Textiles, wearing apparel, leather	1 855	7.3	26	1	1	26 147	37	0	31	2	331	72	385
Wood and wood products	4 948	15.2	57	15 751	33	398 322	635	0	220	21	2 143	6 884	3 896
Pulp, paper and paper products	8 388	9.4	340	11 629	87	611 067	1 635	0	1 527	83	388	3 515	2 932
Publishing, printing, reproduction	9 753	31.2	44	3	2	45 068	52	2	2	1	5 922	281	6 016
Refined petroleum products, chemical and mineral products	10 629	22.3	4 006	109	30	4 017 618	6 943	1	3 557	262	16 407	520	24 937
Basic chemicals	7 303	8.0	3 112	959	5 602	4 868 362	5 116	547	5 685	321	1 655	32 764	11 515
Basic metals	12 115	14.4	5 023	14	6	5 025 125	8 166	0	8 468	442	1 941	1 157	12 031
Machinery and other equipment n.e.c	28 024	75.1	198	10	5	199 704	338	3	92	10	1 039	641	1 522
Building and repairing of ships	3 504	13.0	26	1	1	26 005	188	0	11	4	595	82	833
Oil platforms and modules	6 901	19.9	15	1	0	14 834	33	0	4	1	5	22	47
Furniture and other manufacturing n.e.c	4 331	14.9	55	12	4	56 715	227	1	28	6	972	753	1 332
Energy and water supply and construction	**63 219**	**144.8**	**984**	**200**	**177**	**1 043 406**	**7 323**	**17**	**853**	**187**	**11 040**	**5 976**	**20 634**
Production and distribution of electricity	24 945	16.0	34	3	4	35 215	206	2	12	5	58	340	348
Water, steam etc	381	0.3	263	143	28	274 620	1 107	0	643	44	471	664	1 897
Construction	37 893	128.5	687	55	145	733 571	6 010	16	197	138	10 510	4 972	18 390
Wholesale, maintenance, hotels and restaurants	**151 043**	**324.3**	**482**	**79**	**45**	**498 077**	**1 702**	**41**	**152**	**44**	**4 700**	**6 804**	**7 525**
Wholesale and retail trade, maintenance and repair of vehicles	134 846	270.9	434	70	41	448 240	1 590	36	132	41	4 608	6 138	7 224
Hotels and restaurants	16 197	53.4	48	9	4	49 836	112	4	21	3	92	666	301
Transport	**55 880**	**119.3**	**19 612**	**1 317**	**636**	**19 837 017**	**347 323**	**77**	**58 799**	**9 392**	**18 723**	**39 885**	**446 863**
Transport via pipelines	12 999	0.7	14	5	0	14 102	37	0	0	1	1	10	48
Railways and trams	1 977	8.1	53	3	18	59 090	726	0	24	17	62	172	967
Other land transport	15 237	46.5	3 119	193	195	3 184 028	21 937	77	319	491	4 791	20 607	33 823
Air transport	5 071	12.7	1 443	33	46	1 458 103	4 992	0	165	114	2 116	5 444	8 805
Ocean transport	18 143	43.6	13 512	976	340	13 637 413	288 172	0	56 783	8 039	10 186	12 308	363 123
Inland water and costal transport	2 453	7.7	1 471	107	37	1 484 281	31 460	0	1 508	731	1 567	1 344	40 097
Services	**240 472**	**312.1**	**783**	**237**	**174**	**842 213**	**4 125**	**184**	**124**	**104**	**10 913**	**28 680**	**19 105**
Supporting activities for transport	16 046	27.7	183	32	21	190 511	1 593	20	56	38	6 363	3 255	8 664
Post and telecommunications	29 146	38.5	325	124	95	357 227	1 414	103	21	37	2 106	15 882	5 581

	Total gross value added[2]	Employment (full-time equivalent persons)	Carbon dioxide, CO_2	Methane, CH_4	Nitrous oxide, N_2O	Greenhouse gases emissions[4]	Nitrogen oxides, NOx	Ammonia NH_3	Sulphur dioxide, SO_2	Acidification precursors[5]	Non-methane volatile organic carbons, NMVOC	Carbon monoxide, CO	Tropospheric ozone precursors[6]
	Million NOK (1995-constant basic prices)	1 000 full-time equiv.	1 000 tons	Tons	Tons	Tons CO_2-equivalents	Tons	Tons	Tons	Tons acid-equivalents	Tons	Tons	Tons NMVOC-equivalents
Financial intermediation	44 908	45.1	142	50	36	153 889	518	39	23	14	792	5 984	2 083
Dwelling services (households)[7]	59 601	1.2	.	.	.	.	.	.	.	.	.	.	.
Business services etc	90 771	199.6	133	31	22	140 585	600	22	23	15	1 652	3 559	2 776
Education, health and social work	**154 536**	**533.2**	**613**	**146**	**202**	**678 444**	**1 432**	**85**	**237**	**44**	**3 358**	**13 407**	**6 583**
Education	46 139	149.2	87	14	5	88 627	115	4	47	4	98	714	316
Health and social services	79 264	309.9	291	76	166	344 421	747	49	96	22	2 562	7 687	4 319
Other social and personal services	29 133	74.1	235	55	31	245 396	571	32	94	17	699	5 007	1 947
General government	**55 479**	**153.7**	**268**	**162 786**	**355**	**3 797 109**	**1 933**	**2**	**95**	**45**	**798**	**752**	**5 518**
Public administration and defense	33 911	99.0	186	14	6	188 335	1 805	1	75	42	776	645	3 049
Water, wastewater and waste, local gov	4 235	3.3	72	162 770	349	3 598 409	116	0	14	3	15	56	2 442
Other service activities, local gov	17 333	51.4	10	2	0	10 364	11	0	6	0	7	51	26
Consumption													
Household consumption	554 023[3]	.	4 904	8 138	1 144	5 430 041	18 940	1 257	908	514	56 229	408 374	124 371

1. NAMEA-values use the National Accounts definition of Norwegian activity, not a geographic definition of Norwegian territory as is used for reporting to the Kyoto protocol and other international air emissions reporting systems.

2. Total gross value added is the sum of value added for the different kind of activities including chaining discrepancies and without the corrections that are needed for calculating GNP (Gross National Product).

3. Household consumption is not included in the calculation for total value added.

4. Greenhouse gases calculations include only CO_2, CH_4 and N_2O.

5. Acidification precursor calculations include NO_x, SO_2 and NH_3 emissions.

6. Ozone precursor calculations include NO_x, NMVOC, CO and CH_4 emissions.

7. Emissions for dwelling services are included in emissions from household consumption.

8. Last updated: 20 March 2003.

Table B-2. **Norway's total value added, employment and air emissions (according to components), 1990-2001*[1]**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001*
Economic data												
Total gross value added. Million NOK (constant 1995 basic prices)[2]	691 942	713 379	741 269	758 900	799 594	835 001	875 834	922 636	940 806	962 604	991 710	1 010 634
Employment. 1000 full-time equivalent persons	1 778.7	1 757.3	1 748.7	1 756.2	1 779.5	1 816.5	1 851.9	1 906.8	1 953.5	1 967.1	1 974.3	1 983.4
Emissions to air												
Greenhouse gases												
Carbon dioxide – CO_2. 1000 tons	48 638	46 038	45 507	45 913	48 208	48 308	54 571	55 091	53 219	52 302	55 016	55 399
Methane – CH_4. Tons	307 312	311 774	315 763	321 822	325 917	328 657	332 637	335 074	329 645	327 562	332 966	333 435
Nitrous oxide – N_20. Tons	18 087	17 544	15 328	16 468	16 796	17 057	17 142	16 957	17 832	18 510	18 245	18 318
Acidification precursors												
Sulphur dioxide – SO_2. Tons	141 953	141 539	124 361	114 314	113 979	95 974	116 729	116 212	89 814	77 099	83 421	91 567
Nitrogen oxides – NO_x. Tons	500 283	470 935	441 913	424 256	436 025	433 720	508 257	516 539	486 884	460 002	513 312	508 554
Ammonia – NH_3. Tons	22 589	22 953	24 540	24 283	24 568	26 081	26 538	25 982	25 905	25 481	25 437	24 639
Ozone precursors (also NO_x and CH_4)												
Non-methane volatile organic carbons – NMVOC. Tons	304 640	303 164	330 358	345 602	360 338	375 396	382 032	379 001	362 963	366 115	377 760	386 037
Carbon monoxide – CO. Tons	880 178	811 933	789 622	791 365	777 085	744 951	720 519	684 053	644 085	609 175	581 460	560 887
Heavy metals												
Arsenic – As. Kg	4 416	4 316	4 188	4 215	4 708	3 985	4 444	4 192	4 379	4 223	3 680	3 352
Lead – Pb. Kg	188 359	145 058	127 943	87 730	24 544	22 655	11 451	10 727	10 248	9 123	8 208	7 266
Cadmium – Cd. Kg	1 878	1 806	1 783	1 826	1 386	1 205	1 307	1 316	1 333	1 144	943	908
Copper – Cu. Kg	23 115	20 242	20 431	20 297	18 923	19 665	20 237	20 656	21 387	21 408	20 475	20 771
Chromium – Cr. Kg	15 747	15 694	15 361	14 753	14 260	13 818	14 703	15 441	14 315	13 357	11 522	9 702
Mercury – Hg. Kg	2 236	2 104	1 899	1 539	1 622	1 519	1 688	1 680	1 546	1 543	1 502	1 444
Particulates												
PM10. Tons	73	67	64	70	71	70	73	77	70	67	69	67
PM2.5. Tons	61	56	53	59	61	60	63	66	61	58	59	57
Other emissions												
Polycyclic organic hydrocarbons-PAH-4. Tons	15	14	13	14	14	14	14	14	14	13	14	15
Dioxins. Mg	146 538	113 376	109 778	107 476	106 800	83 235	66 469	58 138	49 519	52 455	51 071	50 596

1. Last updated 20 March 2003.

2. Total gross value added is the sum of value added for the different kind of activities including chaining discrepancies and without the corrections that are needed for calculating GNP (Gross National Product).

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