Requirements for energy statistics in linked environmental-economic data sets

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Second meeting of the Oslo group on Energy statistics
New Delhi, India
5-7 February 2007

Abstract

Specific system characteristics which are required to combine energy and economic data in a coordinated system such as hybrid-accounts (also called NAMEA-accounts) are described in the first section. Experience at Statistics Norway with developing these types of accounts based on current statistical systems are then described and some of the difficulties encountered are presented. Some preliminary, aggregate results are shown with a description of future work planned. In the final section, uses of NAMEA-type data are shown with regards to developing decoupling indicators and decomposition analyses. In the conclusion some topics that would be relevant to consider in the further work of the Oslo Group are presented.

Introduction

Energy statistics and economic statistics have each been developed as independent statistical areas which are subject to their own conventions and classifications. Environmental accounting and specifically hybrid flow accounts, also known as "NAMEA[1] accounts" (System of Environmental and Economic Accounts (SEEA) 2003), combines two or more sets of data so that it is easier to see the links between the different types of data and also create a data set which can be the basis for more rigorous analyses. The starting point for NAMEA accounts is the national accounts and NAMEA accounts can also be considered as external satellite accounts to the national accounts. In NAMEA accounts, economic accounts are combined with physical flows such as energy, other materials and natural resources, and waste materials/pollution (also called "residuals") using a supply and use table format.

At Statistics Norway, air emissions data have been used to develop hybrid flow accounts (NAMEA-air). In order to do this we need to be sure that the air emissions data include and exclude the same units as the national accounts. Since the air emissions data rely heavily on energy statistics/balances/accounts it is necessary to ensure that the energy data used as a basis for the air emissions data conforms to the requirements of a NAMEA-system. In addition, creating NAMEA-energy accounts is also desirable. In the most recent NAMEA data collection exercise from Eurostat in September 2006, total energy use and energy use resulting in air emissions were part of the reporting tables. The demand for energy data that can be correctly combined with the national accounts is increasing but providing this data is not always that easy and the correspondence between these systems needs to be clear.

In this paper the requirements for hybrid or NAMEA-accounts are briefly presented, then some Norwegian experience with regards to establishing these types of accounts for energy is discussed and finally some examples of analyses or uses of NAMEA-type data are presented. The analyses use NAMEA-air emissions data since the NAMEA-energy dataset for Norway has not yet been fully established.

What are hybrid accounts (otherwise known as "NAMEA")?

Hybrid accounts or NAMEA-accounts use the supply and use tables of the national accounts as the starting point and expands these to include other physical and economic information. By using the national accounts framework and definitions, identifying what should be included and excluded in this system is already defined. The challenge is to fill in the picture with the appropriate information.

An important equality is that:

Supply = Use

Or more specifically, using national accounts terminology,

Domestic production + imports = Intermediate consumption + household final consumption + government final consumption + fixed capital formation + changes in inventories + exports

Supply and use tables have separate rows and columns for products and industries. It is products which are used for intermediate consumption, capital formation or exports but it is industries which use intermediate consumption, imports, and environmental resources and generate both value added and residuals. The term "residuals" is used to describe wastes of all types including emissions to air.

[1] NAMEA stands for National Accounting Matrix including Environmental Accounts.

Formally, residuals are the "incidental and undesired outputs from production and consumption processes that generally have no value (though the latter is not an absolute criterion). They may be collected, treated and temporarily stored within the economy but ultimately residuals are released to the environment." (SEEA-2003, page 69). In Table 1 a schematic diagram of a monetary supply and use table that has been extended to include environmental and energy data is presented. There are a number of different ways to set up these types of tables depending on the national accounts in a country and this is one possible example.

Table 1. Schematic diagram of a hybrid supply and use table. Monetary units in shaded areas in the middle and physical units (tonnes) in non-shaded areas wrapped around.

Use → ↓ Supply	Products (CPC)	Intermediate consumption by Industries (NACE/ISIC)	Consumption	Capital	Exports (ROW)	Residuals (Pollution)
Poducts (CPC)		(products used by industry and government)	Final Consumption (household final consumption)	Fixed capital formation (products converted to capital including changes in inventory)	Products exported	
Production by Industries (NACE/ISIC 2digit including government)	Domestic Production (products made by industry)					Residuals generated by industry and government
Consumption						Residuals (generated by households)
Capital						Residuals generated by capital
Imports (ROW)	Products imported					Residuals imported
Margins	Trade and transport margins					
Taxes less subsidies on products	Taxes less subsidies on products					
Value added		Value added by industry				
Monetary totals	Total products supplied	Total industry inputs	Total consumption by households	Total capital supplied	Total exports	
Natural resources		Naturally resources used by industry	Natural resources consumed by households		Natural resources exported	
Ecosystems inputs		Ecosystem inputs used by industry	Ecosystem inputs consumed by households		Ecosystem inputs exported	
Residuals		Residuals reabsorbed by industry		Residuals going to landfill	Residuals exported	
Other information		Employment ***Energy use in industry***	***Energy use by households***			

Source: Adapted from Table 4.1 SEEA-2003, page 137.
ISIC is the International Standard Industrial Classification of All Economic Activities; NACE is the Statistical Classification of Economic Activities in the European Community and is an abbreviation of the French title, Nomenclature statistique des activités économiques dans la Communauté européenne. This is the European version of ISIC. CPC is the Central Product Classification; ROW stands for the Rest Of the World

What are the requirements for data in a NAMEA system?

When developing a NAMEA data system, there are three particularly important system characteristics that need to be included. The first important system characteristic addresses the issue of which institutional units should be included and which ones should be excluded within the system boundaries. The second important system characteristic has to do with the groupings of the institutional units and the consistency of these groupings over time. The third important system characteristic has to do with assigning the different environmental, energy and economic components to the appropriate groups of institutional units.

It is important that the NAMEA statistics all are consistent with the official statistics published in the areas included in the NAMEA systems. It is important that the main figures from the NAMEA system can be fairly easily recognized and linked back to the main figures for the respective statistics.

And finally, reporting energy use to Eurostat as part of the biannual NAMEA reporting cycle began in the reporting made in 2006. For this reporting total energy use and energy use resulting in air emissions were to be reported at the two digit NACE level. Developing national systems to meet these reporting requirements are needed.

First system characteristic: Residence principle

The definition of the system boundaries and which institutional units should be included and excluded is based on the national accounts definition of resident institutional units. From the System of National Accounts handbook (SNA 1993) resident units are defined as follows:

> The accounts of the System are compiled for resident institutional units grouped into institutional sectors and sub-sectors… An institutional unit is said to be resident within the economic territory of a country when it maintains the centre of economic interest in that territory – that is, when it engages, or intends to engage, in economic activities or transactions on a significant scale either indefinitely or over a long period of time, usually interpreted as one year. As an aggregate measure of production, the GDP of a country is equal to the sum of the gross values added all of all resident institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs). This is not exactly the same as the sum of the gross values added of all productive activities taking place within the geographical boundaries of the national economy. Some of the production of a resident institutional unit may take place abroad – for example, the installation of some exported machinery or equipment or a consultancy project undertaken by a team of expert advisers working temporarily abroad. Conversely, some of the production taking place within the country may be attributable to foreign institutional units.
>
> (Part E. Concepts and Classifications, Section 4. National boundaries, SNA 1993, §1.28)

In practical terms this definition means that corrections need to be made for the activity of resident units in the rest of the world and the activity of non-resident units on the domestic territory. For the NAMEA air emissions data set, the following corrections should be made. Analogous corrections would also need to be made for a NAMEA energy data set.

Air emissions (or energy use) on national territory
- (+) Residents in the rest of the world
  - Road transport
  - Air transport
  - Water transport
- (-) Non-residents on domestic territory
  - Road transport

Air transport
Water transport
= Air emissions (or energy use) by resident units (i.e., the national accounts definition)

Some examples of the types of information that are necessary to include are listed below.

Residents in the rest of the world include activities such as:
- Bunkering abroad for ocean transport
- Fishing vessels abroad
- Tourists (households abroad) including purchasing fuel for vehicles
- National embassies abroad
- Lorries purchasing fuel abroad
- Aircraft bunkering abroad

Non-residents on domestic territory include activities such as:
- Bunkering of foreign ocean going vessels
- Foreign fishing vessels bunkering on national territory
- Tourism
- Foreign land transportation units purchasing fuel: lorries and households (tourists)
- Foreign aircraft bunkering on national territory
- Foreign embassies on national territory

Theoretically these are the types of activities that need to be adjusted for when adapting any kind of statistics which are based on national territory/geographic definitions and not an economic or national accounts definition of the country.

When trying to make these types of corrections or adjustments the data availability is often a limiting factor. The details available, for example, in the land transport statistics or the fuel purchases data does not always allow for the distinction between resident units and non-resident units operating on the domestic territory. Estimates for these figures can perhaps be made using transportation statistics and tourism statistics.

Given that these types of corrections need to be made in order to establish the NAMEA accounts, it is necessary to identify what are the most important corrections that should try to be estimated and included.

Some types of considerations can be more important than others depending on a country's geographic location and industry structure. For example if there is a large airport with a great deal of international air traffic, making corrections for foreign aircraft bunkering on national territory could be important. One country that is making these types of corrections for their air emissions NAMEA is the Netherlands because of the international air traffic in Schiphol.

If tourism is a very important and large industry in a country then making corrections for tourism could be important.

In Norway bunkering abroad for ocean transport is very important to include in the energy accounts. Norway has a large ocean-going fleet and the purchases of fuel abroad by these vessels are significant. Just the opposite type of problem exists for Luxembourg and sales of petrol (gasoline). Due to the low taxes on gasoline and diesel fuels, foreigners fill up their vehicles in Luxembourg even though they immediately drive out of the country and use the fuel and cause air emissions in their home countries. Corrections for bunkering abroad and other types of fuel purchases by foreign units can be substantial. This is often the area that needs to have a special focus.

Seldom is it possible to make corrections for activities of embassies with regards to emissions or energy use. These types of activities are usually negligible although technically these activities should be corrected for.

In all types of statistical work it is important to identify the area where the most gains will be obtained when trying to make adjustments and corrections.

Second system characteristic: Groupings of institutional units and consistency over time

Again, the definitions used by the system of national accounts are used for defining the groupings of the institutional units. More specifically this means the use of the ISIC (or NACE[2]) standard classifications of economic activities. It is very important that the same groupings are used in the two different statistical systems that are going to be combined. If the groupings are not the same, it then become necessary to aggregate the groupings until there can be an exact match between the two sets of data.

Sometimes the detail in the national accounts becomes the limiting factor whereas other times the detail of the groupings of the environmental or energy data are the limiting factors. Before the two sets of data can be linked together the aggregation levels must be consistent for the entire linked data set.

Another important factor is the consistency of these groupings of institutional units over time. Institutional units can change their industrial classification due to a number of different circumstances. Mergers, spin offs, and changes in main activity can all result in the reclassification of institutional units into different groups of economic activities. Maintaining a consistent time series within one set of statistics is challenge enough. When there are two or more linked statistical data sets, maintaining a consistent time series becomes even more challenging. When there is a major revision of a classification system, such as ISIC Rev. 4 and the corresponding NACE Rev. 2, the coordination task for NAMEA statistics is not non-trivial since the revision of all the data sets that contribute to the NAMEA statistics also need to be updated to the new classification system and consistent time series developed.

Third system characteristic: Attributing residuals/energy use to appropriate institutional units

Once the population of institutional units to be included in the NAMEA data set has been decided, then comes the challenge of attributing residuals or energy use to the appropriate group of institutional units.

The main principle used in this assignment process is that the institutional units that have the economic activity that is directly responsible for the energy use or residual generation are assigned the energy use or residual amounts. Thus pollution generated from electricity production should be attributed to electricity suppliers and not to the electricity consumers. The same would be the case for the use of energy carriers, those that use the energy (no matter what the purpose) need to attributed with that use.

The direct recording of residual flows and energy use is important for accurate and consistent connection of residual flows to material throughputs and economic transactions. The attribution of pollution or energy use to *final uses or products* should be considered as an analytical continuation of

[2] ISIC stands for International Standard Industrial Classification of All Economic Activities. NACE refers to the Statistical Classification of Economic Activities in the European Community and is an abbreviation of the French title, Nomenclature statistique des activités économiques dans la Communauté européenne.

NAMEA-accounting. This information is not obtainable directly out of the supply and use NAMEA data sets but needs to be converted to input-output tables which are then used for further analyses.

Consistency with official statistics

The NAMEA basically takes existing statistics and re-organizes the information so that it is consistent with the national accounts' breakdown by industry groupings. To make sure that the NAMEA statistics are consistent with the original statistics, it is often good to be able to check that especially the totals are the same in both the NAMEA and the original official statistics. If this is not the case, then it is often helpful to have bridge tables which can inform the user how it is possible to convert from one set of statistics to the other.

Eurostat reporting for NAMEA-energy

The Eurostat NAMEA Task Force proposed that energy use should be incorporated as part of the biannual NAMEA data reporting. In the 2006 NAMEA reporting tables figures for total energy consumption and emissions relevant energy use were to be reported at the two-digit NACE level for 1995-2004. See Appendix A for a general description of the data to be included in the reporting tables. The intention for reporting this type of data is to provide information which could be used to identify how economies are consuming energy with respect to their economic growth. This type of data can be used to identify if there is a decoupling of economic growth from energy use.

Converting energy data into NAMEA-energy data in Norway

There are two types of energy statistics produced by Statistics Norway regarding total energy figures; energy balances and energy accounts. The energy sources balance sheet and the energy accounts are based on different principles and definitions, for this reason some of the figures differ. It is important to consider which of the two presentations are the most relevant as determined by how the figures will be used. One should, however, avoid mixing figures from the two sets of statistics.

Two different approaches are used to compile the two different NAMEA tables for total energy consumption and emissions relevant energy consumption. The energy data source for the "emissions relevant energy use" is based on a special version of the energy accounts that covers energy consumption related to combustion of fuels and is specifically used in connection with the Norwegian emission model (see Hoem, 2006).

Energy balances and energy accounts

The energy sources balance sheet is based on international standards and is meant to be comparable to international statistics in this area. It monitors the flow of energy in Norway, irrespective of the nationality of the users. The balance sheet has a separate item for energy used for non-energy purposes (energy not used as fuel, but as input in industrial production). Regardless of this, all industrial consumption of coal and coke is considered as energy consumption because it is difficult to distinguish between raw material consumption and energy consumption. All energy used for transport purposes is also placed in a separate item in the balance, irrespective of user group. The energy balances basically use the geographic/territorial definition of Norway.

The energy accounts are based on the definitions in the national accounts, which is an economic definition of Norway where the residence principle is important. Energy used by Norwegian transport services and Norwegian tourists abroad are included, while energy consumed by foreign transport industries and tourists in Norway are excluded. Energy used for non-energy purposes is distributed by user group together with other types of energy consumption. Energy used for transport purposes is placed in the user group that actually uses it. The energy accounts should in principle be comparable to the national accounts because the sector classification and principle/definitions are approximately similar. However, there have been some discrepancies because different sources are used for quantity figures in the energy accounts and value figures in the national accounts.

In Norway, it is the energy accounts, and not the energy balances, that provide the starting point for developing the NAMEA-energy accounts since these are the official energy statistics that are closest to the definition of the national accounts.

Norwegian building blocks for the energy accounts and balances

The basis for the energy data at Statistics Norway that is published as official statistics is organized into the following five separate subsets of data (known as EDAT):

- Norwegian energy use outside of the energy sectors (resident units on domestic territory)
- Norwegian energy use outside Norway (resident units in rest of world)
- Foreigners' energy use in Norway (non-resident units on domestic territory)
- Energy use in the energy sectors (resident units on domestic territory)
- Consumption of energy raw materials in Norway (resident units on domestic territory)

Figure 1. Schematic diagram of the subsets of energy data and how they are combined into the existing energy balances and energy accounts

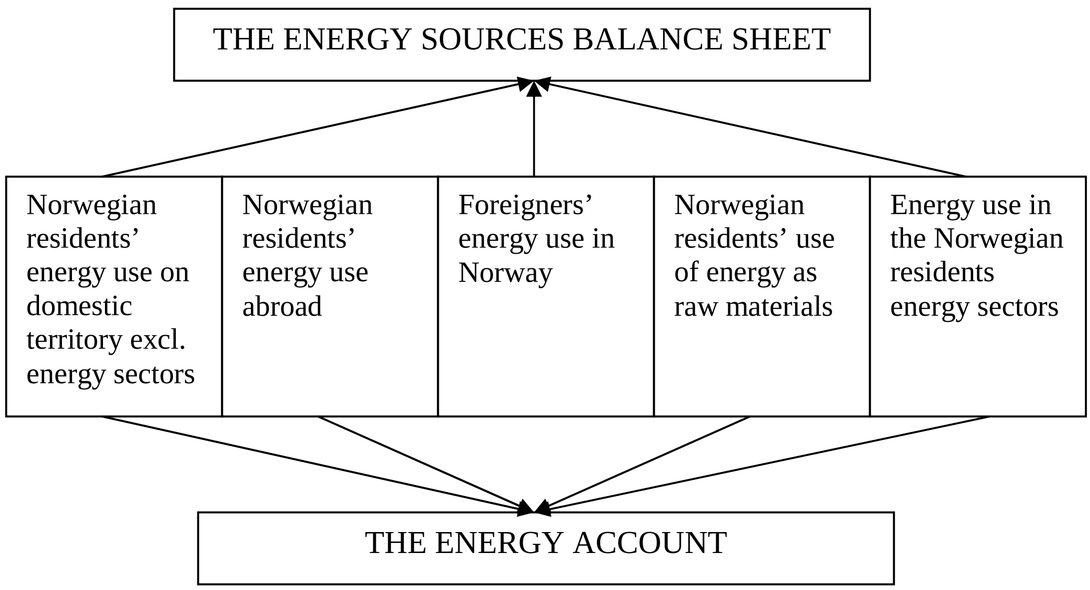


Figure 1 illustrates how the energy data at Statistics Norway is organized. By organizing the data in this way, it is possible to develop statistics according to different definitions and for different types of reporting and user groups.

To arrive at the energy balances, three of the five data sets are used. Excluded are the data for energy use by Norwegian residents abroad, as well as energy use in the energy sectors. To arrive at the energy accounts five of the six data sets are used, only foreigners' energy use in Norway (non-resident units on domestic territory) is excluded.

In addition, there are some other main differences between the energy balances and the energy accounts. The use of coal and coke is included in the energy balances regardless of the user. The energy sources balance sheet has a separate item for energy sources consumed for transportation purposes. The energy accounts place the consumption of all energy under the relevant consumer sector, regardless of whether the consumption refers to transportation, heating or processing.

For developing the NAMEA account for total energy consumption, the starting point is the data that are used for the energy accounts. The definition of the energy accounts follows that of the national accounts and should therefore equal the requirements in the NAMEA account for total energy consumption. In order to arrive at a NAMEA account for total energy consumption, the energy accounts need to be reorganized and classified slightly differently. This process is underway currently at Statistics Norway and some aggregated preliminary results are presented below.

Energy data in the Norwegian emission model.

Combustion of fossil fuels and biomass leads to emissions of greenhouse gases acidifying pollutants, NMVOC, particular matter, heavy metals, PAH and dioxins. Small amounts of NH_3 can also be emitted. In Norway a special version of the energy accounts covering energy consumption related to combustion of fuels is used when calculating emissions to air.

Fuel consumption figures in the Norwegian emissions model are, with only a few exceptions, taken from the Norwegian energy accounts. The energy accounts include energy carriers used as raw materials and reducing agents, which are subtracted in the data used to estimate emissions from combustion. Some emissions vary with the combustion technology; therefore a distribution between different sources is required. Total use of the different oil products is based on the Norwegian sales statistics for petroleum products. For other energy carriers, the total use of each energy carrier is determined by summing up reported/estimated consumption in the different sectors.

In order to compile emissions relevant energy use, the energy consumption data in the Norwegian emissions model “Kuben” (the “Cube”) form the basis for the input to the NAMEA-account (see Hoem, 2006).

However, not all energy use causing emissions to air will be covered using the energy-data in the Norwegian emissions model. For some major manufacturing plants (in particular offshore activities, refineries, gas terminals, cement industry, production of plastics, ammonia production), emissions of one or more compounds, reported to the Norwegian Pollution Control Authority from the plants, are used instead of calculating emissions on the basis of energy use figures for these manufacturing plants. In these cases, the energy consumption of the plants in question is subtracted from the total energy use before the general method is used to calculate the remaining emissions of the compound in question, in order to prevent double counting. For these manufacturing plants, the emissions factors from the Norwegian emissions model have to be used to calculate the energy use that corresponds to the emissions from these point sources reported to the Norwegian Pollution Control Authority.

Challenges in going from energy accounts to NAMEA accounts in Norway

At this time Statistics Norway has not yet fully developed the NAMEA-energy accounts as an official statistical area. We are currently working on developing these accounts.

A major portion of the work has already been accomplished since Statistics Norway publishes energy accounts which are according to the definitions for the national accounts. The energy accounts data sets are also developed using the industry groupings according to the NACE standard for the classification of economic activities. So much of the groundwork has already been established which facilitates the development of NAMEA accounts in Norway.

At this time the appropriate data sources for developing the main NAMEA accounts for total energy use and emissions relevant energy use has been identified. In essence the sources data that is used simply needs to be reorganized into the different detailed 2-digit NACE categories. Whenever the statistics are being developed based on existing data sets it is important to check that the reorganized information corresponds with the officially published data.

The sources to fill in the NAMEA table for total energy consumption is the 4 subsets of data from the EDAT (all in excel-format) that form the energy accounts (see figure 1). In this case, from the energy accounts data that is officially published, it is actually difficult to find the total energy use as the officially published tables are organised differently than the five separate subsets of data in the EDAT.

The source to fill in the NAMEA table for emissions relevant energy use is taken from the energy data specifically related to Norwegian emissions model. The variables from the Norwegian emissions model used to compile the NAMEA table for "emissions relevant energy use" are fuel types (energy carriers), industries and year. All data in the Norwegian emissions model are in SAS, and a SAS-program is under development in order to extract the data needed for NAMEA table for emissions relevant energy use. As there are no officially published statistics covering emissions relevant energy use, there are no other official sources with which to directly compare these data. Before reporting emissions relevant energy use by NACE 2 digit level, it will be necessary to discuss whether this kind of data can be published as official data at Statistics Norway.

The NAMEA energy use data reported to Eurostat is to be given in one uniform unit; Giga Joule. Although the energy accounts and the energy source balance sheet also are given in Peta Joule both in EDAT and in officially published tables, we cannot take advantage of these data in Peta Joule. We need to use the subsets in the EDAT in order to obtain detailed enough data required for the emissions relevant energy use as well for all data when it comes to the decoupling analysis, and the energy use data in the subsets are given in ktonnes, GWh or Sm^3. It is the same situation for the energy use data in the Norwegian emissions model.

Conversion factors for the energy content of each energy carrier is used to convert the consumption of the energy carriers to one uniform unit.

We are using the Eurostat reporting tables for NAMEA as a framework for development. In our opinion however these tables do not contain enough detail to be particularly useful for analytical work. We would like to be able to develop these types of tables in much more detail and not just total energy consumption and emissions relevant energy use. Our goal is to establish tables which include the energy consumption of industries (at the 2-digit NACE level) according to detailed types of energy carriers.

Once we have established the NAMEA energy accounts we also need to evaluate the results in light of the official energy statistics. One problem which may need to be discussed in further detail before NAMEA-energy can be established as official statistics is the sometimes large statistical discrepancies that exist in the energy statistics. At a highly aggregated level these statistical errors are not as important. However since NAMEA accounts need detailed industry level (such as the 2-digit NACE/ISIC) data which is then combined with detailed energy source data, these statistical errors can become important.

For some types of energy carriers, for example crude oil, natural gas and other gases and LPG, the statistical errors are significant in relation to intermediate consumption and household use. In 2004 the statistical error for petrol was approximately 25 per cent of intermediate consumption and household use. The same figure for coke was 23 per cent, for natural gas 19 percent and for other gases and LNG approximately 80 per cent. The issue of the quality of the NAMEA-energy data comes into question when such high levels of statistical error exist since such high levels of energy consumption cannot be linked to the industry responsible for this consumption. We do not know whether the statistical errors are linked to errors in the data material on the supply or the user side. These are some of the issues that need to be discussed further before detailed NAMEA energy accounts can be developed as official statistics, published with confidence and used in analyses.

Aggregated preliminary figures for NAMEA-energy accounts

Although all of the aggregation, statistical error, publication and quality issues have yet to be fully dealt with, some preliminary figures at an aggregated level have been developed using the energy accounts data at Statistics Norway. Table 2 presents these preliminary figures[3] as an example of the type of data set we are hoping to establish.

Based on the input data used to compile NAMEA total energy use we have organised this data in a Supply and Use Table. Table 4 explains the links between the variables in the NAMEA Supply and Use table with the variables in the officially published energy accounts data.

As mentioned before, the NAMEA total energy use accounts table would look different from the currently published energy accounts tables. Table 5 and Table 6 show the current official energy accounts tables. It is not easy initially to know which figures to check in order to know whether the figures compiled to the NAMEA total energy use accounts equals the officially published energy figures.

The main differences between the NAMEA way of organising the energy data and the way energy data is officially published by statistics Norway are:

- o NAMEA combines consumption figures for all industries together, while the officially published energy data differ between energy sectors and others, as well as between primary and secondary production within the energy sectors.
- o NAMEA shows detailed industry breakdown for consumption figures by NACE industries, which not necessarily are easily recognizable in the officially published energy figures although these figures are also published on a relative detailed industry level.

As seen in Table 3, supply of "Other gases and LPG" does not equal the use of these energy goods. This is due to conversions needed to calculate the different gases included in this energy group into one uniform energy unit. This means that for this energy group the normal method used to compile figures for NAMEA total energy use accounts is not preferable. Conversion factors for the gases included in "Other gases and LPG" are given from the EDAT.

Table 3 also includes economic information from the National Accounts. Since NAMEA accounts combine environmental and economic data, it is important that the information included about the quantity of energy produced or consumed is comparable to the similar information about energy produced or consumed in value. The first challenge is to define what energy-products in the national accounts that are equivalent to the energy-products included in the NAMEA energy accounts. A bridge table between the energy products of these two accounts should be developed. The next challenge is to check the comparability between the energy accounts and the national accounts. Although the energy accounts follow national accounts definitions, it is not given that the information included in these two sets of data is comparable. For example electricity use in GWh may not match with the economic consumption data from the national accounts.

[3] District heating and blast furnace gases are excluded from our calculations thus far.

Table 2: Total energy consumption according to NAMEA-definitions by NACE 2-digit. 2004

		Coal	Coke[1]	Fuel wood, wood waste, black liquor, waste	Crude oil	Natural gas	Other gases[2] and LPG	Petrol	Kerosene	Middle distillates	Heavy fuel oil[3]	Electricity
NACE 2-digit		1000 tonnes	1000 tonnes	1000 toe	1000 tonnes	Mill Sm3	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	GWh
	Grand total	**841**	**862**	**1 226**	**12 590**	**5 811**	**2 040**	**2 441**	**702**	**6 026**	**2 994**	**110 988**
	Total industries	**839**	**861**	**600**	**12 590**	**5 808**	**2 027**	**1 170**	**585**	**5 722**	**2 994**	**78 583**
	Total households	**2**	**1**	**626**	**0**	**3**	**13**	**1 271**	**116**	**304**	**0**	**32 405**
01	Agriculture, hunting and related service activities	0	0	2	0	7	2	5	1	114	1	1 959
02	Forestry, logging and related service activities	0	0	0	0	0	0	0	0	16	0	0
05	Fishing, fish farming and related service activities	0	0	0	0	0	0	4	0	471	4	136
10	Mining of coal and lignite; extraction of peat	0	0	0	0	0	0	0	0	0	0	35
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying	0	0	0	0	4 871	0	0	0	325	0	587
12	Mining of uranium and thorium ores	0	0	0	0	0	0	0	0	0	0	0
13	Mining of metal ores	0	0	0	0	2	0	0	0	6	3	175
14	Other mining and quarrying	0	0	0	0	1	1	0	0	48	0	299
15	Manufacture of food products and beverages	0	0	0	0	19	10	4	0	113	18	2 948
16	Manufacture of tobacco products	0	0	0	0	0	0	0	0	1	0	8
17	Manufacture of textiles	0	0	0	0	0	1	0	0	3	1	146
18	Manufacture of wearing apparel; dress; dyeing of fur	0	0	0	0	0	0	0	0	1	0	18
19	Tanning, dressing of leather; manufacture of luggage	0	0	0	0	0	0	0	0	1	0	8
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0	0	76	0	0	0	0	0	13	10	705
21	Manufacture of pulp, paper and paper products	0	0	273	0	10	11	0	0	13	147	6 373
22	Publishing, printing, reproduction of recorded media	0	0	0	0	0	3	1	0	1	0	380
23	Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	12 590	0	691	796	19	91	1 085	527
24	Manufacture of chemicals and chemical products	209	86	0	0	836	1 174	0	0	28	48	6 729
25	Manufacture of rubber and plastic products	0	0	0	0	1	1	0	0	7	0	363
26	Manufacture of other non-metallic mineral products	216	36	16	0	1	62	0	0	33	57	853
27	Manufacture of basic metals	321	611	5	0	32	28	0	0	31	0	29 303
28	Manufacture of fabricated metal products, except machinery and equipment	0	0	0	0	0	2	1	0	15	0	518
29	Manufacture of machinery and equipment n.e.c.	0	1	0	0	1	3	1	0	12	0	506
30	Manufacture of office machinery and computers	0	0	0	0	0	0	0	0	0	0	4
31	Manufacture of electrical machinery and apparatus n.e.c.	0	127	0	0	0	0	0	0	2	0	180
32	Manufacture of radio, television and communication equipment and apparatus	0	0	0	0	0	0	0	0	0	0	53
33	Manufacture of medical, precision and optical instruments, watches and clocks	0	0	0	0	0	0	0	0	1	0	79
34	Manufacture of motor vehicles, trailers and semi-trailers	0	0	0	0	0	1	0	0	4	0	241
35	Manufacture of other transport equipment	0	0	0	0	0	3	0	0	10	0	476
36	Manufacture of furniture; manufacturing n.e.c.	0	0	5	0	0	0	0	0	4	0	265

		Coal	Coke[1]	Fuel wood, wood waste, black liquor, waste	Crude oil	Natural gas	Other gases[2] and LPG	Petrol	Kerosene	Middle distillates	Heavy fuel oil[3]	Electricity
NACE 2-digit		1000 tonnes	1000 tonnes	1000 toe	1000 tonnes	Mill Sm3	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	1000 tonnes	GWh
37	Recycling	0	0	0	0	3	1	0	0	5	0	97
40	Electricity, gas, steam and hot water supply	27	0	214	0	7	1	1	0	33	1	1 926
41	Collection, purification and distribution of water	0	0	0	0	0	0	0	0	2	0	0
45	Construction	0	0	3	0	0	14	14	0	167	0	549
50-52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	0	0	0	0	2	1	35	0	101	0	4 679
55	Hotels and restaurants	0	0	0	0	0	4	4	0	11	0	1 464
60	Land transport; transport via pipelines	0	0	0	0	3	2	55	0	1 227	0	591
61	Water transport	0	0	0	0	8	0	0	0	2 545	1 616	10
62	Air transport	0	0	0	0	0	0	4	496	0	0	187
63	Supporting and auxiliary transport activities; activities of travel agencies	0	0	0	0	0	0	19	0	35	0	347
64	Post and telecommunications	0	0	0	0	0	0	79	0	6	0	350
65	Financial intermediation, except insurance and pension funding	0	0	0	0	0	0	35	1	9	0	305
66	Insurance and pension funding, except compulsory social security	0	0	0	0	0	0	0	0	0	0	0
67	Activities auxiliary to financial intermediation	0	0	0	0	0	0	0	0	0	0	0
70	Real estate activities	0	0	0	0	0	0	0	0	7	0	640
71	Renting of machinery and equipment without operator and of personal and household goods	0	0	0	0	0	0	1	0	8	0	102
72	Computer and related activities	0	0	0	0	0	0	4	0	0	0	0
73	Research and development	0	0	0	0	0	0	0	0	0	0	0
74	Other business activities	0	0	0	0	0	0	17	1	5	0	816
75	Public administration and defence; compulsory social security	0	0	3	0	0	0	1	60	50	0	2 722
80	Education	0	0	2	0	0	0	3	2	36	0	2 299
85	Health and social work	0	0	1	0	4	0	48	3	55	0	2 121
90	Sewage and refuse disposal, sanitation and similar activities	0	0	0	0	0	10	1	0	1	1	13
91	Activities of membership organization n.e.c.	0	0	0	0	0	0	0	0	9	0	1 412
92	Recreational, cultural and sporting activities	0	0	0	0	0	0	0	1	8	0	2 412
93	Other service activities	0	0	0	0	0	0	30	1	38	0	1 668
95	Activities of households as employers of domestic staff	0	0	0	0	0	0	0	0	0	0	0
	Household consumption	2	1	626	0	3	13	1 271	116	304	0	32 405

Table 3: Supply and use table for energy consumption according to NAMEA-accounts. 2004

SUT energy 2004	Coal	Coke[1]	Fuel wood, black liquor, waste	Crude oil	Natural gas	Other gases[2] and LPG	Petrol	Kerosene	Middle distillates [3]	Heavy fuel oil[4]	Electricity	National accounts
SUPPLY TABLE	*1 000 tonnes*	*1 000 tonnes*	*1 000 toe*	*1 000 tonnes*	*Mill Sm^3*	*1 000 toe*	*1 000 tonnes*	*1 000 tonnes*	*1 000 tonnes*	*1 000 tonnes*	*GWh*	*Mill nok*
a. Domestic production	2 904	173	1 194	138 732	83 204	6 944	11 961	670	6 329	1 913	110 671	162 353
b. Imports	766	810	32	501	0	345	551	264	805	1 422	15 309	13 313
c. Direct purchases abroad	0	0	0	0	0	0	27	124	1 943	1 355	0	7 715
d. Total supply (a+b+c)	**3 670**	**983**	**1 226**	**139 232**	**83 204**	**7 289**	**12 539**	**1 058**	**9 078**	**4 690**	**125 980**	**183 381**
USE TABLE												
e. Intermediate consumption	839	796	600	12 590	5 808	2 027	1 170	585	5 722	2 994	78 583	76 372
Agriculture, forestry and fishing	0	0	2	0	7	2	10	1	601	6	2 095	2 999
Mining and extraction	0	0	0	0	4 357	1	0	0	379	3	1 096	1 720
Manufacturing	812	861	375	12 590	1 421	1 992	806	19	387	1 366	50 779	20 511
Energy and water supply and construction	27	0	217	0	7	15	15	0	202	1	2 475	3 305
Wholesale, maintenance, hotels and restaurants	0	0	0	0	2	5	39	0	111	0	6 143	9 088
Transport	0	0	0	0	11	2	59	496	3 772	1 616	788	18 881
Services	0	0	0	0	0	0	156	2	68	0	2 551	9 617
Education, health and social work	0	0	0	0	0	0	83	7	87	1	5 611	3 276
General government	0	0	6	0	4	10	1	61	114	0	7 045	6 975
f. Inventory changes	15	-15	0	-152	0	-33	-104	19	-65	-16	0	10 528
g. Private households	2	1	626	0	3	13	1 271	116	304	0	32 405	48 008
h. Export	2 741	19	0	124 383	76 272	3 761	9 572	89	2 732	1 742	3 854	43 631
i. Losses in distribution	0	0	0	0	9	44	0	0	0	0	11 138	2 407
j. Foreign purchases in Norway	0	0	0	0	0	0	27	193	128	74	0	2 435
k. Total use (a+b+c+d+e+f)	**3 598**	**866**	**1 226**	**136 822**	**82 092**	**5 812**	**11 935**	**1 002**	**8 821**	**4 793**	**125 980**	**183 381**
l. Statistical differences	72	182	0	2 410	1 112	1 678	603	56	257	103	0	
m. Supply minus use incl. Statistical discrepancy	0	0	0	0	0	-200	0	0	0	0	0	

(1) Incl. Coke and petrol-coke
(2) Refinery gas, fuel gas and methane.
(3) Incl. autodiesel, marine gassoljer, tungdestillater og tungolje
(4) Incl. waste oil, paints and varnish etc.

Table 4: The linkage between NAMEA SUT and the officially published energy accounts statistics

NAMEA Supply and use tables (Report table 3: Supply and Use table for energy consumption according to NAMEA)	**Official published statistics by Statistics Norway (Report tables 5: Energy accounts. Extraction, conversion and use of energy goods[1] and 6: Energy accounts. Use of energy goods outside the energy sectors, by industry[2])**
SUPPLY	
a. Domestic production	Primary production + secondary production + other supply (production outside the energy sector)
b. Imports	Imports
c. Production abroad for Norwegian consumers.	Direct purchases abroad
d. Total supply (a+b+c)	
USE	
e. Intermediate consumption (equals NAMEA total energy use excl. HH consumption	Use outside the energy sectors + input in oil refineries + input in Thermal power plants + input in gas supply + input in Dual purpose power plants and district heating plants excl. HH consumption (Energy consumption in households[2]).
f. Inventory changes	Stocks
g. Private households	HH consumption (Energy consumption in households[2])
h. Export	Export
i. Losses in distribution	Registered losses
j. Foreign purchases in Norway	Foreign purchases in Norway
k. Total use (a+b+c+d+e+f)	
l. Statistical differences	Statistical differences
m. Supply minus use incl. Statistical discrepancy	

[1]http://www.ssb.no/english/subjects/01/03/10/energiregn_en/tab-2006-10-20-11-en.html
[2]http://www.ssb.no/energiregn_en/tab-2006-10-20-12-en.html

Table 5. Energy accounts. Extraction, conversion and use[1] of energy goods. 2004

	Coal	Coke[2]	Fuel wood, black liquor, waste	Crude oil	Natural gas	Other gases[3] and LPG	Petrol	Kero-sene	Middle distillates	Heavy fuel oil[4]	Electricity	District heating
	1000 tonnes		*1000 toe*	*1000 tonnes*	*Million Sm[3]*	*1000 toe*	*1000 tonnes*				*GWh*	
SUPPLY												
Coal mines												
Output	2 904	0	0	0	0	0	0	0	0	0	0	0
Input	0	0	0	0	0	0	0	0	0	0	-35	-1
Production of crude oil and natural gas												
Output	0	0	0	138 732	83 204	[5]6197	[6]7339	0	0	0	0	0
Input	0	0	0	0	[7]-4 871	0	0	0	[8]-313	0	-587	0
Hydroelectric power plants												
Output	0	0	0	0	0	0	0	0	0	0	109291	0
Input	0	0	0	0	0	0	-1	0	-5	0	-1266	0
Primary production	***2 904***	***0***	***0***	***138 732***	***78 333***	***6 197***	***7 338***	***0***	***-318***	***0***	***107 403***	***-1***
Imports	766	810	32	501	0	376	551	264	805	1 422	15 309	0
Exports	-2 741	-19	0	-124 383	-76 272	-4 099	-9 572	-89	-2 732	-1 742	-3 854	0
Direct purchases abroad	0	0	0	0	0	0	27	124	1 943	1 355	0	0
Foreign purchases in Norway	0	0	0	0	0	0	-27	-193	-128	-74	0	0
Stocks (+Decrease, -Increase)	-15	15	0	152	0	36	104	-19	65	16	0	0
Primary supply	***914***	***806***	***32***	***15 000***	***2 062***	***2 511***	***-1 579***	***88***	***-364***	***977***	***118 858***	***-1***
USE												
Energy Sectors												
Oil refineries												
Output	0	173	0	0	0	1 126	4 594	670	6 329	1 850	0	0
Input	0	0	0	-12 590	0	-722	-796	-19	-91	-1 085	-526	0
Thermal power plants												
Output	0	0	0	0	0	0	0	0	0	0	974	0
Input	0	0	-24	0	0	0	0	0	-8	0	-5	0
Gas supply												
Output	0	0	0	0	0	0	0	0	0	0	0	0
Input	0	0	0	0	-1	0	0	0	0	0	0	0
Dual purpose power plants & district heating plants												
Output	0	0	0	0	0	0	0	0	0	0	155	[9]2 947
Input	-27	0	-190	0	-6	-2	0	0	-20	-1	-655	-6
Other supply[10]	0	0	1 194	0	0	358	28	1	0	63	252	0
Registered losses	..	..	..	..	[11]-9	[12]-70	0	0	0	0	-11 138	-608
Statistical differences	-72	-182	0	-2 410	-1 112	-1 678	-603	-56	-257	103	0	0
Use outside the energy sectors	814	[13] 797	1 012	0	934	1 524	1 643	683	5 590	1 908	[14] 107 915	2 332
Domestic consumption[12]	814	797	1 012	0	934	1 524	1 616	559	3 381	380	107 915	2 332
Of which												
Non-energy purposes/reducing agents	679	779	0	0	687	979	0	0	11	23	0	0

[1]Also including energy goods used for non-energy purposes
[2]Including petrol coke.
[3]Refinery gas, fuel gas and methane.
[4]IIncluding waste oil, paint and varnish etc.
[5]Natural gas liquids
[6]Condensate
[7]Including gas terminals
[8]Including consumption by supply boats and in crude oil transport
[9]Including waste heat from manufacturing, 86 GWh.
[10]Production outside the energy sectors.
[11]Flaring outside the energy sectors
[12]Flaring of methane from waste disposals
[13]Of which 356 000 tonnes petrol coke
[14]Of which 4 322 GWh non-priority power
[15]Including Norwegian air transport abroad

Source: http://www.ssb.no/english/subjects/01/03/10/energiregn_en/tab-2006-10-20-11-en.html

Table 6. Energy accounts. Use of energy goods outside the energy sectors, by industry[1]. 2004

	Coal	Coke	Fuel wood, wood waste, black liquor, waste	Gas[2] and LPG	Petrol	Kerosene	Middle distillates	Heavy fuel oil[3]	Electricity
	1000 tonnes		*1000 toe*	*1000 toe*			*1000 tonnes*		*GWh*
TOTAL	***814***	***797***	***1 012***	***2 410***	***1 643***	***683***	***5 590***	***1 908***	***107 915***
Agriculture, forestry and fishing		**-**	**2**	**9**	**10**	**1**	**601**	**6**	**2 095**
Mining and quarrying	**-**	**-**	**0**	**3**	**0**	**0**	**54**	**3**	**474**
Manufacturing	**812**	**796**	**375**	**2 329**	**10**	**0**	**309**	**281**	**50 253**
Manufacture of food products	0	0	0	29	4	0	114	18	2 956
Manufacture of textiles, leather and leather products	0	0	0	1	0	0	5	1	172
Manufacture of wood products	0	0	76	0	0	0	13	10	705
Manufacture of paper and paper products	0	0	273	22	0	0	13	147	6 373
Printing, publishing etc.	0	0	0	3	1	0	1	0	380
Manufacture of industrial chemicals	209	86	0	2 109	0	0	19	47	6 482
Manufacture of chemical products and products of mineral oil, coal, rubber and plastic	0	0	0	4	0	0	15	1	611
Manufacture of cement and lime	125	3	16	5	0	0	1	29	228
Manufacture of other mineral products	92	33	0	68	0	0	32	28	626
Manufacture of iron and steel and ferro-alloys	383	388	5	13	0	0	11	0	6 693
Manufacture of primary aluminium	0	155	0	57	0	0	16	0	21 196
Manufacture of other metals	0	0	0	0	0	0	2	0	1 221
Water supply	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
Construction	**0**	**0**	**3**	**15**	**14**	**0**	**167**	**0**	**549**
Wholesale and retail trade, restaurants and hotels	**0**	**0**	**0**	**7**	**39**	**0**	**111**	**0**	**6 143**
Wholesale and retail trade	0	0	0	3	35	0	101	0	4 679
Operation of hotels and restaurants	0	0	0	4	4	0	11	0	1 464
Transport, storage and communication	**0**	**0**	**0**	**12**	**157**	**496**	**3 811**	**1 616**	**1 477**
Rail transport, scheduled bus transport etc.	0	0	0	2	0	0	122	0	591
Taxi	0	0	0	2	9	0	47	0	0
Other transport by road	0	0	0	0	46	0	1 059	0	0
International maritime transport	0	0	0	0	0	0	2 155	1 528	0
Coastal and inland water transport	0	0	0	7	0	0	390	88	10
Air transport	0	0	0	0	4	496	0	0	187
Services related to transport	0	0	0	0	19	0	33	0	338
Postal and telecommunication services	0	0	0	0	79	0	6	0	350
Financing, insurance and business services	**0**	**0**	**0**	**0**	**58**	**1**	**30**	**0**	**1 862**
Other private services	**0**	**0**	**0**	**0**	**83**	**7**	**87**	**1**	**5 611**
Public services	**0**	**0**	**6**	**16**	**1**	**61**	**114**	**0**	**7 045**
Public administration, excluding defence	0	0	3	0	1	0	6	0	2 022
Educational and research services	0	0	2	0	0	0	29	0	2 067
Medical and veterinary services, social care etc.	0	0	1	4	0	0	30	0	1 729
Other sectors of public administration	0	0	0	12	0	60	48	0	1 228
Private households	**2**	**1**	**626**	**18**	**1 271**	**116**	**304**	**0**	**32 405**

[1]Includes energy goods used for non-energy purposes. District heating is not included.
[2]Natural gas, fuel gas and methane
[3]Including waste oil, paint and varnish etc.
Source: http://www.ssb.no/energiregn_en/tab-2006-10-20-12-en.html

Uses of NAMEA-data sets

In the first half of this paper the requirements for establishing NAMEA data sets were described and some of the challenges in establishing the NAMEA for energy at Statistics Norway were presented. In this next section, some specific uses of NAMEA data sets are presented in order to illustrate the types of analyses that can be performed using these types of data sets. Industry profiles, decoupling analyses and index types of decomposition analysis can all be performed on NAMEA supply and use data sets. If environmental taxes are included as part of the NAMEA data sets it is possible to make analyses regarding the polluter pays principle.

If one converts the supply and use tables into input-output tables, additional types of analyses can be made. Supply and use tables are combined and by eliminating either the industry or product dimension, resulting in a single table showing both supply and demand according to a single classification. This type of table is known as an input-output table. There can be either product-by-product or industry-by-industry input-output tables.

Once input-output tables are established the methodologies associated with input-output analysis can be used. Also using these input-output tables as a basis, general equilibrium models including environmental components can also be developed.

In the following section some examples of decoupling and decomposition analysis are provided. Since the NAMEA-energy data has not yet been officially established at Statistics Norway, the data presented uses primarily the Norwegian NAMEA-air emissions data. Similar types of analyses would be able to be performed on NAMEA-energy type of data when they are established.

Decoupling

The OECD explains the general concept of decoupling as follows,

> The term "decoupling" has often been used to refer to breaking the link between "environmental bads" and "economic goods." In particular, it refers to the relative growth rates of a pressure on the environment and of an economically relevant variable to which it is causally linked.…
>
> Decoupling occurs when the growth rate of the environmentally relevant variable is less than that of its economic driving force (e.g. GDP) over a given period. In most cases, however, *absolute* changes in environmental pressures are also important. Hence the importance of distinguishing between *absolute and relative decoupling.* If the GDP displays positive growth, "absolute decoupling" is said to occur when the growth rate of the environmentally relevant variable is zero or negative — i.e. pressure on the environment is either stable or falling. "Relative decoupling" is said to occur when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of GDP. (OECD, 2002, page 5)

Decoupling can be investigated by putting two or more types of data together on a single graph and identifying how the growth rates are related. One prerequisite for this type of analysis is that the variables analysed are known to be causally linked.

Figure 2 shows relative decoupling for greenhouse gas emissions from value added in the manufacturing industry from 1994 until 2001 and from 2002 onwards it appears that conditions for absolute decoupling are being observed since air emissions are going down while value added is going up. The development of emission intensities (emissions per unit value added) can also be calculated and downward trends for this indicator would be evaluated as decoupling.

Figure 3 shows information for households. Since households do not have value added but rather consumption, the graph shows consumption, three types of air emissions, and household waste. For acidification and ozone precursors it appears that these types of emissions are decoupled from household consumption levels. Greenhouse gas emissions on the other hand only exhibit relative decoupling whereas household waste levels are increasing at an even higher rate than consumption. When this occurs, the term decoupling is not relevant.

Examples of decoupling figures for the manufacturing industry and households

Figure 2.

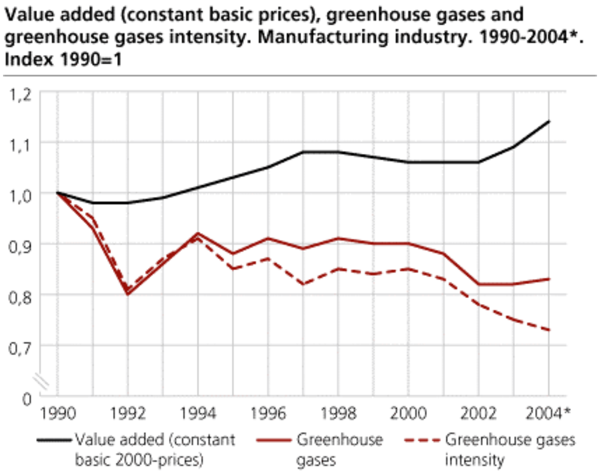
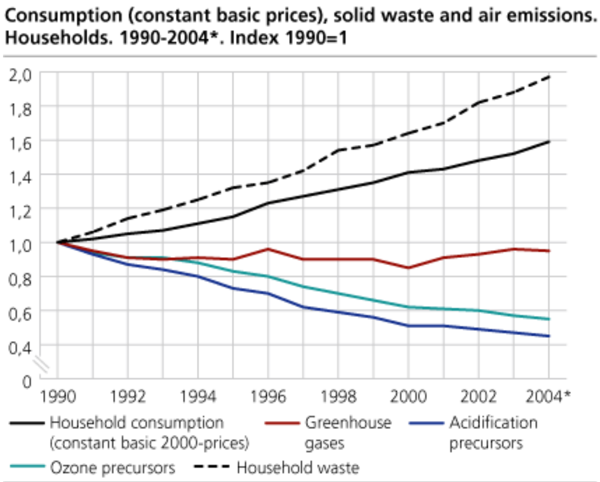


Figure 3.



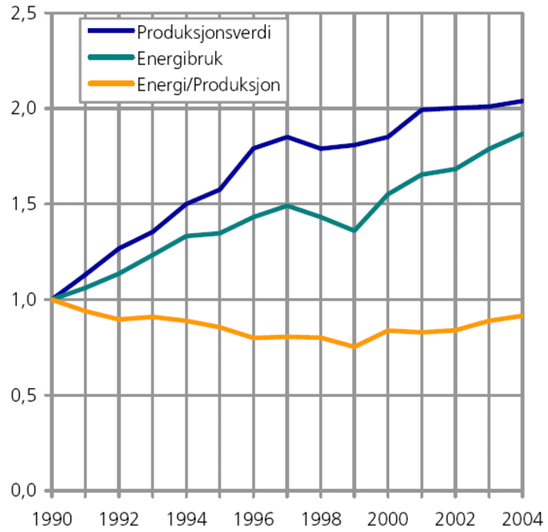
Source: Statistics Norway (http://www.ssb.no/english/subjects/09/01/nrmiljo_en/)

There are other economic and physical variables that can be used in this type of analysis, for example, production value, employment, energy use, and tonnes of materials produced. The main requirement for this type of analysis is that the two variables are causally related. Bøeng and Spilde (2006) discuss the development of energy indicators that show correspondence between energy consumption and economic activity in Norway. Indicators using energy consumption related to value added and energy consumption related to production value (output)[4] are discussed and evaluated in some depth.

Based on the analyses, most industries showed a more favourable development in their energy intensity indicators when energy consumption was combined with production value (output) instead of value added. For example, in the manufacturing industries, energy consumption per value of produced unit fell by 24 per cent from 1990 to 2004 whereas the consumption of energy per unit of value added only fell by 6 per cent. Figures 4 and 5 illustrate these differences for the oil and natural gas extraction industry and the transport via pipelines industry.

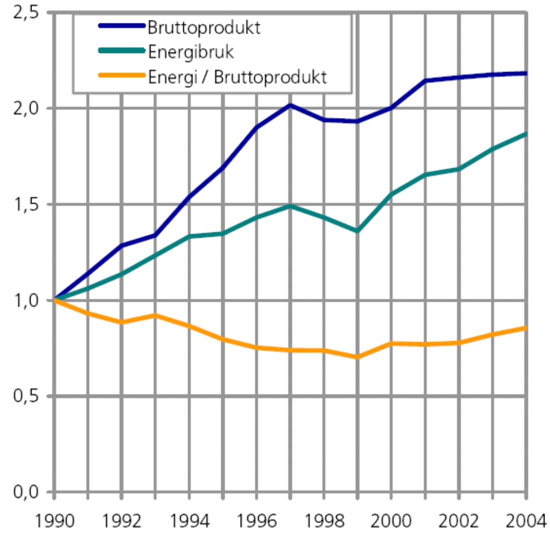
[4] The connection between production and value added is the following:
Output - intermediate consumption = value added

Figure 4. Energy use, production in 1995-basic prices and energy per produced unit for the oil and natural gas extraction industry and the transport via pipelines industry. (Index 1990 = 1)



Blue line (top) is production value
Green line (middle) is energy use
Yellow line (bottom) is energy use per unit of production value
Source: Bøeng and Spilde (2006)

Figure 5. Energy use, value added in 1995-basic prices and energy per unit value added for the oil and natural gas extraction industry and the transport via pipelinesindustry. (Index 1990 = 1)



Blue line (top) is value added
Green line (middle) is energy use
Yellow line (bottom) is energy use per unit value added

Total consumption of energy in the oil and natural gas extraction industry and the transport via pipelines industry in 2004 was 53 TWh which was an 87 per cent increase since 1990 (see green line in Figure 4.). The blue line in Figure 4 shows that the production values (in constant 1995-basic prices) in these industries has more than doubled during this same time period. This results in an 8 per cent decrease in the indicator energy consumption per production unit (production value).

The decrease can be partially explained by the increase in recycling of exhaust gases and steam from gas turbines located on the offshore platforms which results in more effective energy use. Between 2002 and 2004, Figure 4 shows an increase in the energy intensity (yellow line). This increase can be explained by the change in production patterns in the oil and gas extraction industry to higher levels of natural gas production which requires a higher level of energy use per unit produced.

Figure 5 shows the development in energy use with respect to value added (in constant 1995-basic prices) for the oil and natural gas extraction industry and the transport via pipelines industry from 1990 to 2004. Since the growth in value added during this period is even higher than the growth in production value over the same period, this results in a lower energy use per unit of value added.

The increase in value added for these industries between 1990 and 2004 was 118 per cent resulting in a decrease in the energy use per unit of value added of 14 per cent during this same period. The background for the strong increase in the value added in the oil industry was due to the fact that the intermediate consumption in constant prices increased less that the production value during the same period.

The operating surplus for establishments in the oil industry increased faster than the production value. The strong growth in this industry has also contributed to the 18 per cent national decrease in energy use per unit of value added since 1990.

One of the problems with using output (production values) is that these figures can be changed due simply to changes in the organisational structure in an industry where over time there is more specialized production especially when enterprises have been divided into several units. If parts of an enterprise are separated from an individual unit into several units, the combined output and intermediate consumption will usually increase, while the total value added is less effected by these types of organisational changes. For this reason, using value added may be a better choice.

Since Statistics Norway has responsibility for the Norwegian energy data and the emissions inventory, there is a good deal of understanding behind these statistics and why they might increase or decrease if there have been significant changes in certain enterprises or if new regulations or taxes have been introduced in specific industries. Also dramatic changes in the price of electricity can be the reason that some enterprises use more fuel oil instead of electricity, which is then reflected in the emissions. These dramatic changes can sometimes explain some of the changes observed, but there is no way that simple observation of the data set with all of the small changes that occur in the Norwegian economy can be accounted for without performing more detailed analyses.

For this reason an index-based decomposition analysis methodology was tested to try to find an appropriate but simple analysis methodology for quantifying some of the underlying factors influencing the patterns observed in the air emissions (and by extension the energy use once these statistics are established).

Decomposition

An index based methodology has been used to analyse the changes between 1990 and 2003 for three greenhouse gases (see Hass et al. 2005 for a more detailed methodology description). Although this data will be t-2 years, this is still more current than having to wait for the input-output tables from the national accounts (t-3 at the earliest) in order to do decomposition analyses using an I-O methodology.

The decomposition method used in this study is based on the model presented by Bruvoll and Medin (2000). Since this analysis is based on the NAMEA air data which only has air emissions and value added data, the energy use and population factors needed to be eliminated.

The total changes in emissions for a given period decomposed into the scale-, composition- and other technological changes components can be written as:

$$\overline{P}_t = \overline{S}_t + \overline{C}_t + \overline{T}_t$$

where

$$\overline{S}_t = P_0 * \left[\frac{Y_t}{Y_0}\right] \qquad S_t = \left[\frac{\overline{S}_t}{P_0}\right] * 100$$

$$\overline{C}_t = \sum_j P_{j0} * \left[\frac{Y_{jt}}{Y_{j0}} - \frac{Y_t}{Y_0}\right] \qquad C_t = \left[\frac{\overline{C}_t}{P_0}\right] * 100$$

$$\overline{T}_t = \sum_j P_{jt} - \left[P_{j0} * \frac{Y_{jt}}{Y_{j0}}\right] \qquad T_t = \left[\frac{\overline{T}_t}{P_0}\right] * 100$$

P = Pollution
S = Scale component
C = Composition component
T = Other technological changes component
Y = Production
t = Time
j = Sectors

The first trial calculations are focusing on greenhouse gas emissions for CO_2, CH_4 and N_2O between the two years 1990 to 2003 and focus first on the whole economy and then break down the results by aggregated industry groupings. By using the method described by Bruvoll and Medin (2000) we want to investigate whether it is possible to quantify three of the structural components that are responsible for the observed changes in the air emissions, i.e. the scale component, the composition component, and the technological changes component. In this study only CO_2-emissions, CH_4-emissions and N_20-emissions are included in the calculations for *total emissions of greenhouse gases (in CO_2-equivalents)*.

The scale component corresponds to the effect on air emissions from economic growth. Economic growth can be given as growth in output by kind of main activity, growth in value added by kind of main activity or growth in GDP per capita. Given constant emissions per unit produced, emissions will increase at the same rate as production.

The composition component reflects the impact on air emissions from the production structure. For example, if the most polluting sectors grow faster than average economic growth, the change in the composition component will be positive.

The other technological changes component corresponds to the effect on emissions to air from changes in factors such as energy efficiency and changes in the intermediate consumption of energy types within an industry, improvements in technology, etc. This component may also be influenced by changes such as the entry of taxes and regulations aiming at improving an air emissions problem.

The data sources that are used in this decomposition analysis are already published figures at Statistics Norway for air emissions and the annual and quarterly national accounts. The data used are based on the publication in April 2005 and covers the period from 1990 to 2003. These data are publicly available from the StatBank link associated with the NAMEA-air annual publication (see link in left column of webpage: http://www.ssb.no/english/subjects/09/01/nrmiljo_en/). The economic data used are gross value added and household consumption data in constant 1995-prices.

Norwegian greenhouse gas emissions decomposition results between 1990 and 2003

Between the years 1990 to 2003, total greenhouse gases increased by 11.5 percent or 6 736 544 tonnes CO_2-equivalents. Measured in CO_2-equivalents, the emissions of CO_2 form the major part of the total greenhouse gas emissions, with respectively 83.9 and 82.3 percent of total greenhouse gas emissions in 1990 and 2003. Of the three gases that are included in the calculation of *total emissions of greenhouse gases*, CH_4 is the only gas for which emissions have declined in the period from 1990 to 2003. For details, see Table 7.

Table 7. Emissions of greenhouse gases, CO_2, CH_4, N_2O. Tonnes CO_2-equivalents. Between 1990 and 2003

	CO_2	CH_4	N_20	Total
a) Emissions in 1990	48 188 768	5 179 639	5 172 032	58 540 439
b) Emissions in 2003	54 785 818	5 074 010	5 417 155	65 276 983
c) Changes in tonnes CO_2-equivalents, between 1990 and 2003	6 597 050	-105 629	245 123	6 736 544
d) Changes in percent, between 1990 and 2003	13.7	-2.0	4.7	11.5
e) Changes as percent of total greenhouse gas emissions from 1990	11.3	-0.2	0.4	11.5

Table 8 shows the changes in tonnes of greenhouse gas emissions from the three components. In other words, the changes shown in line c of Table 7 are decomposed into the associated three components. The calculations show that the three components effect the greenhouse gas emissions in different directions. Economic growth between 1990 and 2003 has contributed to an increase in emissions to air. Given no change in the composition component and the other technological changes component, the greenhouse gas emissions would have increased with 28.3 million tonnes CO_2-equivalents. However, the total greenhouse gas emissions "only" increased with 6.7 million tonnes CO_2-equivalents, given the negative effect on emissions from changes in the production structure and particularly the changes in the other technological changes component.

Table 8. Changes in greenhouse gas emissions broken down by the structural components. Tonnes CO_2-equivalents. Between1990 and 2003.

	CO_2	CH_4	N_20	Total
Scale component	23 307 142	2 505 201	2 501 523	28 313 866
Composition component	-2 154 554	-925 107	-1 025 544	-4 105 205
Other technological changes component	-14 555 539	-1 685 723	-1 230 856	-17 472 117
Sum (equals changes between 1990 and 2003)	6 597 050	-105 629	245 123	6 736 544

The decomposition analysis results shown in Table 8 are analysing the economy as a whole. Another way to present this information is to examine the data as a percent of total emissions. Table 9 presents the results from the decomposition analysis as a percentage of each emission type, i.e. the growth in greenhouse gas emissions between 1990 and 2003 is given in percentage and decomposed into the effect from the three decomposition components (i.e. Table 9, line d is explained).

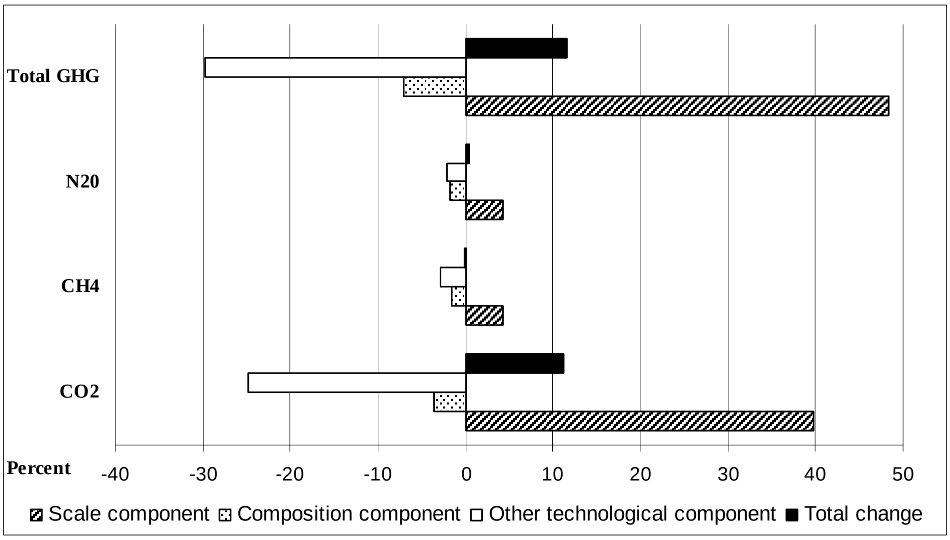
The scale component's share of total emissions of respectively CO_2, CH_4 and N_2O is equal for all emission types, indicating the growth in total gross value added in the period between 1990 and 2003. Given constant emissions per unit produced, emissions will increase at the same rate as gross value added. The scale component and the other technological changes component almost have the opposite effect on emissions: while economic growth leads to increases in greenhouse gas emissions, other technological changes lower greenhouse gas emissions. Although changes in production structures also lead to lower greenhouse gas emissions, the effect on emissions from an increase in economic activities lead to an overall increase in total greenhouse gas emissions.

Table 9. Changes in greenhouse gas emissions broken down by structural components (scale, composition and other technological changes). Percent. Between 1990 and 2003.

	CO_2	**CH_4**	**N_20**	**Total GHG**
Scale component	48.4	48.4	48.4	48.4
Composition component	-4.5	-17.9	-19.8	-7.0
Other technological changes component	-30.2	-32.5	-23.8	-29.8
Sum (equals changes in percent)	13.7	-2.0	4.7	11.5

This information is also shown in Figure 6. If the three components are added together for each of the emission types the total change for each emission type is obtained.

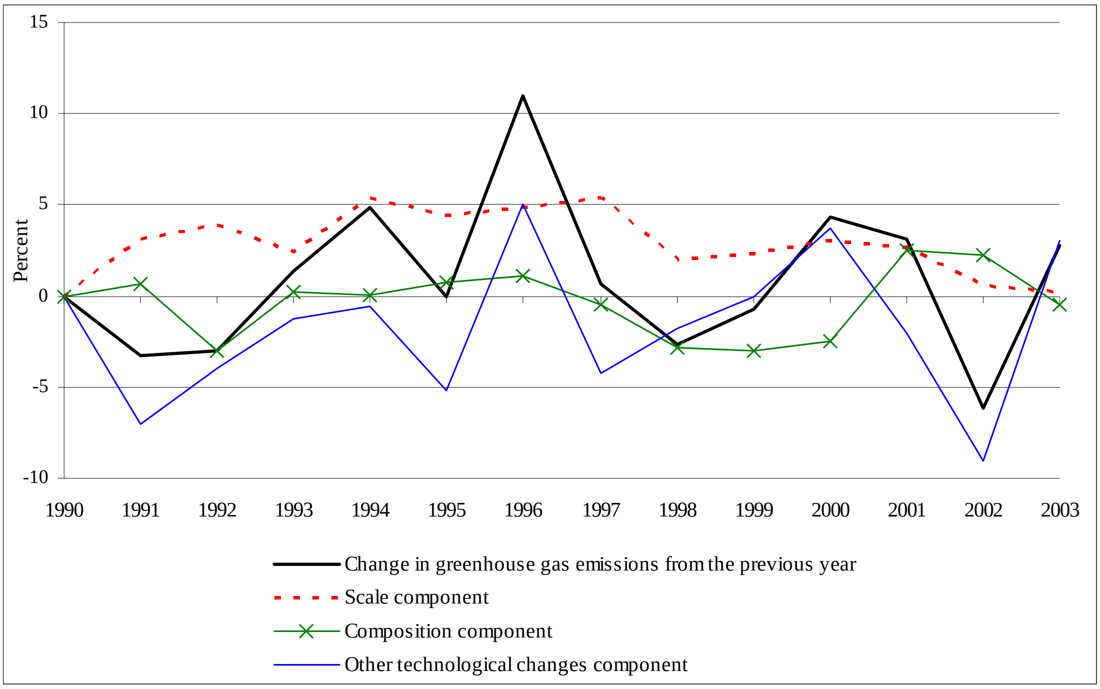
Figure 6. Changes in emissions broken down by structural components (scale, composition and other technological changes). Share of total. Per cent. Between 1990 and 2003.



Decomposition analysis for the Norwegian economy, 1990 - 2003 (time series)
In addition to the between two years analysis, we have also performed a decomposition analyses for each year during the whole time period, 1990 to 2003 using the whole Norwegian economy as the unit of analysis. These results are shown in Figure 7. This figure shows the per cent growth of greenhouse gas emissions from one year to the next (shown in the heavy black line) which is then the arithmetic sum of the three components, scale (broken red), composition (green with X) and other technical changes (smooth blue), shown in the figure as the other three lines.

From this time series analysis, the total change in greenhouse gas emissions from the previous year appears to be particularly influenced by the other technological changes component. Of course the scale and composition components do influence the pattern but the large variations observed in the total emissions appear to be strongly influenced by the variations shown in the third component, other technological changes. The time series also shows in which time periods the various components have the strongest effects. For example in 1993 and 1994 it was the scale component and not the composition or technology components that caused the increase in emissions. It is also interesting to note that the scale component has contributed positively to the growth in emissions during the whole time period whereas the other two components sometimes contribute positively and sometimes negatively to the emissions. This information can be combined with other information regarding the Norwegian economy, such as energy prices and rates of oil and natural gas extraction, to help us understand even more of the picture. This type of figure helps provide some better understanding regarding the changes over time rather than looking at the differences between two specific time periods.

Figure 7. Annual changes in greenhouse gas emissions broken down by the structural components. Per cent. 1990-2003.



In addition to looking at the Norwegian economy as a whole, it is also possible to use the NAMEA-air data to perform industry level analyses. This was done using aggregated industry groups and the results are presented in the next section.

Industry level decomposition analyses between 1990 and 2003

It is also possible to do decomposition analyses on an industry level using the NAMEA data. This data will be t-2 years but this is still more current than having to wait for the input-output tables from the national accounts (t-3 at the earliest) in order to do decomposition analyses using an I-O methodology.

This industry level analyses show wide variations between the different aggregated industry groups. Again the three components are able to be obtained from the available NAMEA-air data, scale, composition and other technological changes components.

The scale component reflects that the growth in the economy was not evenly distributed across the different industry groups and this in turn influences the emissions patterns. The scale component shows how the growth in the economy, measured as gross value added, would influence the growth in emissions if all other things are held constant.

The three industry groups that have the largest scale component effect for greenhouse gas emissions are the transportation industry, manufacturing and mining and extraction. Primary industries (i.e. agriculture, forestry and fishing), and households are the next largest contributors.

Table 10. Changes in emissions resulting from the scale component. Tonnes CO_2-equivalents. Between 1990 and 2003.

	CO_2	CH_4	N_20	Total GHG
Total	23 307 142	2 505 201	2 501 523	28 313 866
Agriculture, forestry and fishing	975 215	985 868	1 271 285	3 232 368
Mining and extraction	3 880 568	192 477	14 148	4 087 193
Manufacturing	5 446 638	179 839	1 019 606	6 646 083
Energy and water supply and construction	355 646	1 466	17 407	374 519
Wholesale, maintenance, hotels and restaurants	286 345	1 202	2 110	289 657
Transport	8 566 623	12 626	77 555	8 656 804
Services	390 324	3 192	3 870	397 385
Education, health and social work	307 200	1 661	19 078	327 939
General government	249 003	1 046 544	46 201	1 341 748
Household consumption	2 849 579	80 327	30 263	2 960 170

Table 11 shows the results of an industry level decomposition analysis for the composition component. The composition component describes the changes in the economic structure of the Norwegian economy. Some industries grew during this period while others did not. Even though the composition component in total contributes to reductions in greenhouse gas emissions (-4 105 205 tonnes CO_2-equivalents), the effect on emissions on an industry level varies.

Changes in the production structure between the different industries can be seen in this table. Increases are particularly seen in the mining and extraction industries which includes the extraction of oil and natural gas. Decreases are seen especially in the manufacturing industries and the transportation industry. Smaller decreases are seen in the energy water supply and construction industries and general government. Increases are seen in the services industries and household consumption. The combined effect of the changes in the production structure in the economy has meant an overall decrease in emissions if all other factors had been held constant. It is interesting to note that the changes observed due to the composition component go in the same direction for all three types of air emissions. This is different from what is observed with regards to the third component (which includes the effect of technology changes) when some of the emissions increase while others decrease in the same industry.

Table 11. Changes in emissions resulting from the composition component. Tonnes CO_2-equivalents. Between 1990 and 2003.

	CO_2	CH_4	N_20	Total GHG
Total	-2 154 554	-925 107	-1 025 544	-4 105 205
Agriculture, forestry and fishing	-39 687	-40 121	-51 736	-131 544
Mining and extraction	3 774 794	187 230	13 762	3 975 787
Manufacturing	-4 941 974	-163 176	-925 134	-6 030 284
Energy and water supply and construction	-313 841	-1 293	-15 361	-330 495
Wholesale, maintenance, hotels and restaurants	285 977	1 200	2 107	289 284
Transport	-1 026 535	-1 513	-9 293	-1 037 341
Services	165 673	1 355	1 642	168 670
Education, health and social work	-55 244	-299	-3 431	-58 974
General government	-217 590	-914 520	-40 372	-1 172 482
Household consumption	213 875	6 029	2 271	222 175

Table 12 shows the other technological changes component by industries. It is definitely this component that in the period between 1990 and 2003 draws down the total greenhouse gas emissions, especially the CO_2-emissions. In this study, the component “other technological changes” will to a large extent reflect the effect on pollution from more efficient utilisation of energy and from changes in the composition of energy types, i.e. changes in the intermediate consumption. This conclusion is drawn based on the study by Bruvoll and Medin (2000) and not from the current analysis since energy cannot be included using the NAMEA-air data. Bruvoll and Medin (2000) used detailed Norwegian energy data in addition to emissions, economic and population data for their analysis between 1980 and 1996. Their study showed that it was particularly the two effects of more efficient utilisation of energy and from changes in the composition of energy types that greatly influence the emissions levels. However since energy data is not being included in the current analysis it not possible to say anything definitive about changes in energy use. In this current study changes in energy use will also be included in this final component which also includes technology changes and efficiency improvements.

Table 12. Changes in emissions resulting from the other technological changes component. Tonnes CO_2-equivalents. Between 1990 and 2003.

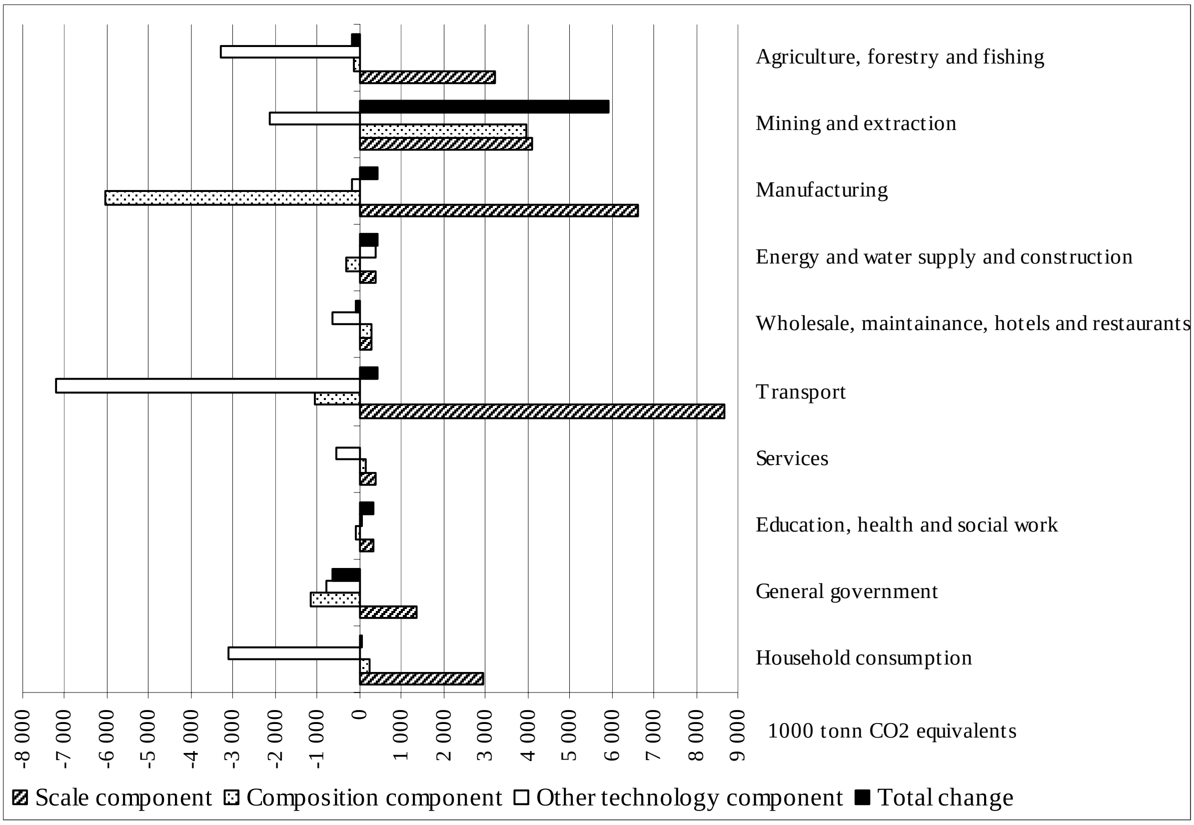
	CO_2	CH_4	N_2O	Total GHG
Total	-14 555 539	-1 685 723	-1 230 856	-17 472 117
Agriculture, forestry and fishing	-1 019 538	-989 487	-1 286 546	-3 295 571
Mining and extraction	-2 070 316	-51 460	-12 642	-2 134 418
Manufacturing	334 052	-78 788	-434 747	-179 484
Energy and water supply and construction	367 527	2 156	17 394	387 078
Wholesale, maintenance, hotels and restaurants	-670 762	-3 306	10 510	-663 558
Transport	-7 154 081	-8 691	-34 865	-7 197 637
Services	-584 302	-6 828	57 514	-533 616
Education, health and social work	40 614	-1 074	21 297	60 837
General government	-318 498	-490 966	10 287	-799 177
Household consumption	-3 480 234	-57 279	420 942	-3 116 570

The reductions in emissions from efficiency improvements in the utilisation of inputs (most likely energy) in the transport industries have strongly contributed to the relatively low increase in total greenhouse gas emissions from the transport sector. The emissions from the transport industries increased by 2 percent from 1990 to 2003, while these industries experienced a 43 percent growth in gross value added in the same period. But, also the efficiency improvements in intermediate consumption that occurred in primary industries (agriculture, forestry and fishing), the extraction industries and households have contributed to curbing the growth in emissions between 1990 and 2003.

For some industries, for example the mining and extraction industry, changes in the emissions are negative for all three of the different greenhouse gases being examined. On the other hand, for the manufacturing industry this component shows a positive direction for CO_2 emissions and negative directions for CH_4 and N_2O (all measured in CO_2-equivalents). It is not surprising that there would be mixed effects shown for the different types of emissions for the different industries since this final component includes all of the various changes that are not attributable to scale or composition.

In Figure 8 the effect on emissions from the three components, scale, composition and the other technical changes, for total greenhouse gas emissions is compared on an aggregated industry level. In the transport industry, *both* the production changes and the input efficiency have changed in a way that both components contribute to reduced greenhouse gas emissions. This effect can also be seen in the primary industries and the general government sector, but in a less significant way than for the transport industry.

Figure 8. Changes in emissions by components (scale, composition and other technological changes) by aggregated industries. 1000 tonnes CO_2-equivalents. Between 1990 and 2003.



Both the extraction industry and the manufacturing industry stand out from the other industries when looking at how these industries effect emissions. These two industry groups also differ from each other, although they both have had a higher growth in the gross value added than in greenhouse gas emissions in the period studied. While the composition effect contributes to a formidable increase in greenhouse gases from the extraction industries, it is more than neutralised by the formidable decrease in greenhouse gases from the manufacturing industries.

Industry level information helps to identify which industries influence the observed changes and which components are contributing the most to those industry level changes. These types of analyses help us to understand the changes from one period to another.

With regards to industry level analyses we have not yet tested whether the aggregation level for the industries influences the results. At this time we have used a 10 industry aggregation level in these calculations. It is possible for us to use the NAMEA-air data at its most detailed level with 45 industries to see if different results are obtained with less aggregation. Bruvoll and Medin (2000) performed a sensitivity analysis comparing results for industries aggregated into 8 groups vs. 125 groups (the most detailed industry level available for the data). They found that only small changes occurred in most of the components but that the process emissions component was the most sensitive to the aggregation level since it had the fewest decomposition factors.

Based on the sensitivity analysis of Bruvoll and Medin (2000), there may be some indication that in the current analysis, since there are only three components, the results may be influenced by the level of aggregation. This needs to be investigated in more detail before we start to include this type of analysis in our regular NAMEA-air publishing routines.

Conclusion and issues to consider

There is a demand for energy data that conforms to the definitions of the national accounts and that can be used to develop hybrid type/NAMEA-energy accounts. This type of data can be used for analyses which help to provide insights into developments in national economies. For the European countries there will be a need to report annual NAMEA-energy data to Eurostat in the future on most likely a biannual reporting schedule as part of the NAMEA-air emissions reporting tables.

In working towards the establishment of energy data which conform to the needs of a NAMEA-type data set, the conversion from established energy statistics needs to be clear. The terminology for energy data that conforms to the national accounts definitions also needs to be considered. At Statistics Norway there are two terms used, energy balances and energy accounts whereas Statistics Denmark uses energy statistics and energy accounts. Some type of clear terminology needs to be established.

Also the methodology for converting between the different types of energy statistics (energy balances, energy accounts, NAMEA-total energy use and NAMEA-air emissions relevant energy use) needs to be clarified. There is a need to develop bridge or conversion tables to help users understand how to go from one system to the other. This could also help to illustrate what the differences are, add additional quality checks into the statistical systems and indicate how to reconcile these differences (note that this is listed as one of the UNCEEA "issues").

In Norway, the energy produced by the hydroelectric power plants are included in the energy accounts but other types of emissions-free energy generation is not that easily identified in the main tables. Although Statistics Norway publishes figures for renewable energy generation (in units of 1000 t.o.e) from wind, solid biomass, biogas and liquid biogas, and industrial and municipal waste, perhaps these emission free energy carriers could be made more obvious in the standard statistical tables. These types of energy types need to be included in the NAMEA/hybrid accounts in a more obvious way.

With regards to the national accounts, correspondence information between the energy product groups and the product groups used in the national accounts also needs to be clear in order to obtain value added data included in the NAMEA-energy tables.

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NAMEA-energy reporting instructions from Eurostat NAMEA reporting tables

The questionnaire contains 2 data sheets to report data on energy use by industries and households:
-- Emission-relevant energy use
-- Total energy consumption

Emission-relevant energy use:

The purpose of this data sheet is to show the [amount of] energy used by resident units that is directly linked to air emissions reported in the previous 13 data sheets on air emissions. To that end, only the data related to the combustion of fuels causing air emissions are to be reported - i.e. combustion of primary energy forms (lignite, coal, natural gas, wood and other biofuels, peat, waste) and combustion of secondary energy forms (coal coke, coke gas and other gases, petroleum products such as fuel oil, diesel oil, motor gasoline, LPG, jet fuel and kerosene, and other petroleum products).

Excluded are:

- inputs of fuels that are transformed from one form into another (e.g. refining of crude oil into petroleum products, conversion of coal into coke);
- fuels used as raw materials, such as petroleum products in the chemical and plastics industries or wood for construction;
- changes in inventories of energy products.

For all these reasons, energy accounts for NAMEA are not the same as the traditional energy use table (in monetary units) available in national Accounts which record the total purchases of all energy products.

Total energy consumption:

This data sheet reports the total energy use for each industry and households. In addition to the combustion of fuels (as reported in the previous data sheet) it should include air-emission free energy forms and net balances:

- the use of primary electricity that is not based on fuel consumption, such as hydro (incl. pumped storage), nuclear, tidal, wave, geothermal, wind and solar electricity;
- other non-fuel related energy generated (any other form of energy production - steam and hot water and heat - that is not based on fuel combustion. For example, geothermal steam and hot water and heat from nuclear power plants or solar panels); and
- the net balance of purchased minus sold electricity, heat and hot water.