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Environmental Pressure Information System (EPIS) for the household sector in Norway

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Abstract

Surveying the mass flows in different environmentally important systems is a field that gets increasing international attention. Statistics Norway has been engaged in Eurostat's work with the Environmental Pressure Information Systems (EPIS). The objective of Eurostat's EPIS project is to provide a tool for the compilation and modelling of timely data on environmental pressures arising from different economic activities.

The purpose of this report is to provide information on the environmental pressure arising from the households in Norway, using the EPIS methodology. This methodology shows which processes that are important for the environment. Due to the mass balance approach the study can also be used to identify weaknesses in statistics. Lacks of data and areas with very uncertain data are discovered, and can give an indication about which areas that shall be prioritised in order to reduce the uncertainty in the environmental statistics and for coverage of the knowledge gaps.

The mass flow per capita has increased with 124 kg in the inflow and 102 kg in the outflow during the studied period. That gives relative changes too small to be statistically significant for showing changes in the total mass flow per capita. But there have been evident relative changes in the flows for some input and output categories between the two studied years. Household water is the category with the highest influence on the size of the mass flow. Inflow of air constitutes the second highest mass inflow, followed by energy commodities, and thereafter food and beverages inflow and other material inflow that are at about the same size. The outflow of CO_2 and gaseous H_2O are the most important mass outflows after the household sewage.

This study concludes that among the existing environmental statistics in Norway that should be improved is data for the waste water sector, so that water emissions can be traced to their sources. For the waste sector, newer, annual, and more complete data sets are wished. The field with the highest uncertainty, that gives rise to the highest difference in the mass balance, is however the inflow of materials in the households.

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1. Introduction

1.1 Background

The EPIS (Environmental Pressure Information System) project in Eurostat started in 1994. EPIS related activities have, in addition to in Norway, also taken place in Austria, Finland, Germany, Spain, Sweden and the United Kingdom. The objective of Eurostat's EPIS project is to provide a tool for the compilation and modelling of timely data on environmental pressures arising from different economic activities. The EPIS methodology can create indicators for this pressure. The goal is to collect data in a format that gives a connection between environmental pressure and economic activity. This approach increases the possibility for integration of environmental questions to economic decision-making. The approach also gives a deeper insight in the flows of key materials and diffuse pollution.

EPIS is developed due to a need for regular data for environmental pressure from human activities. It gives a good integration of the environmental and the economic development, facilitates for preventive goals for protection of the environment and a sound use of resources and a better usage of material and energy.

The core of EPIS is a matrix of 100-150 high pressure processes in Europe, selected by an expert group. The prioritisation of processes is made on the basis of the estimated pressures: if at least one type of pressure resulting from all processes of the same type is quantitatively remarkable (more than 5% or only more than 1% of the national total), it will be included in the high pressure processes (Eurostat 2000).

The EPIS approach takes as its starting point the conventional material balance approach; the inputs of materials and energy to one process are in balance with the system accumulation and the outputs of products and residuals arising from the same process in a given time period.

In the study of the results of the input-output analysis, it is important to keep in mind the effects of the different lifetimes for the commodity groups in the households. Environmental effects may occur several years after the inventory year. A change in the input can give a delayed change in the output due to the products' lifetime in the household. A change in the storage volume can also give a change in the output volume that is not reflected in the input volume.

Earlier EPIS projects in Norway are fulfilled for the pulp and paper industry (Rypdal *et al.* 2000a) and for the Norwegian offshore oil and gas production (Rypdal *et al.* 1999). A study of how to account for use of chemicals in EPIS has also been made (Rypdal *et al.* 2000b). While EPIS projects have earlier been made for different industrial processes, this report concentrate on the household sector. The household includes high pressure activities, and is an important consumer of resources.

1.2 Project objectives

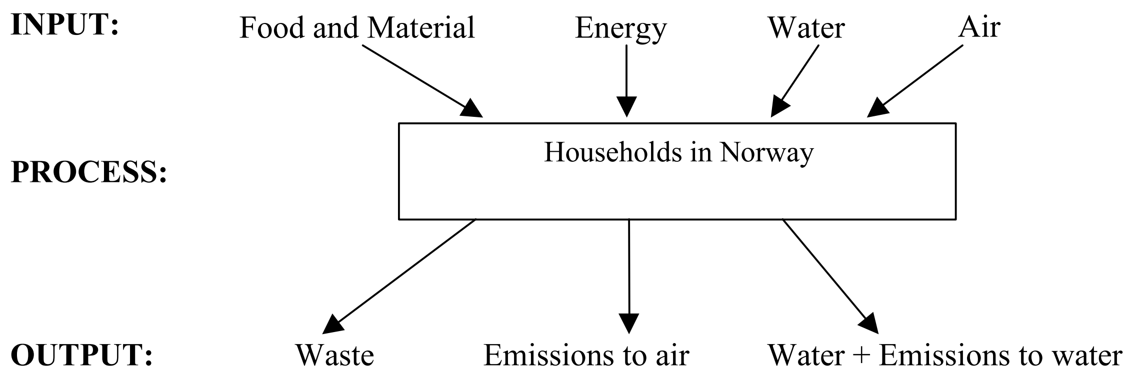
The aim of this study is to establish an EPIS database for the Norwegian household sector. The EPIS coefficients given in the final result are meant to be included in an EPIS database in Eurostat, e.g. for use in countries that lack data. The coefficients can be used as a base for sustainability indicators for the selected activities. This study is also meant to be a base for a subsequent study, where the results will be compared with the NOREEA system. The data will be based on available statistics. The result may be used for comparisons with other countries as well as for improvements of the inputs to the NOREEA system.

The approach aims to improve our knowledge of how materials are used in the households in order to have information to enhance the efficient use of resources. The household sector was chosen as study field because it is an important consumer of resources. The report can also be used as a base for a material flow analysis over the whole country. EPIS studies can frequently also be used to identify weaknesses in statistics due to its mass-balance approach.

2. Methodology

The EPIS approach relies on a material flow approach. An estimation is made of the input into the households expressed in physical units, relative to the output. The main input categories are food and material, energy, air and water, and the main output categories are emissions to air, waste water and waste (Puolamaa 1999a).

Figure 1. Flowchart for the studied system "Norwegian households"



Included in the system boundary for the studied system are all the households inside of the Norwegian national territory. In the conception "household" is in addition to the dwellings and gardens and the activities there, also cars, snow scooters and cabins included. Waste water is defined as the sewage entering the municipal water system from the households, which means that sewage sludge is included in the output category waste water. In this study also the CO_2-emissions from renewable energy resources (wood) are included in order to account for all mass. The pressure that arise from the use of commodities are included, but only in the latest step in the chain. The commodities are only included as a mass flow and not as a source to indirect emissions. Services are not included, neither are the material and energy consumption that arise due to service consumption.

As a reference to which all numerical data on inflows and outflows are presented the coefficient unit weight per capita are chosen, for example the amount of water used by one person in Norway, or the quantity of CO_2-emissions generated per person. This choice facilitates the comparisons between different years and countries. The primary aim with the EPIS coefficient unit is to create a relevant, representative reference to which in- and outflows of the studied system, within the system boundaries, are related and quantified. Normally, the EPIS coefficients are given in the unit weight/tonnes product (tP), but in the household sector there is no obvious product.

The aim has been to study the material flow in the latest possible year with updated data. Data are mainly based on the year 1999 when nothing else is mentioned. As a basis for comparison also the data for 1992 are included.

The actual years the population in Norway was 4.29 million (1992) and 4.46 million (1999), and the numbers of households were 1.98 million (1992) and 2.05 million (1998) (SN 2001a). The increase in the population between the two studied years is 176 000, which means a 4% increase of the population in the seven year period.

3. Nomenclature, Definitions and Data sources

With regard to the compilation of EPIS, standardized classifications and coding systems are used when they are available (Table 1).

Table 1. Classifications and other codes used in the EPIS database

Subject	Classification or codification
Countries	EU + EEA
Activities	NACE
Processes	PRODCOM, (NOSE-P, SNAP)
Production technologies	to be developed
Env. management technologies	to be developed
Raw materials, operating substances, products	PRODCOM, CPA, CN
Fuels	SIRENE, CORINAIR/NAPFUE
Waste water	Process and cooling water
Waste materials	Actual label, aggregated EWC, EWC
Pollutants	CAS, aggregated pollutants

Source: Puolamaa (1999a).

In the Norwegian statistics not all of these codes are used, but for some categories (activities and processes) the Norwegian codes can be translated to the international ones, see Table 2.

NACE is the EU standard statistical nomenclature for economic activities. NACE-activities of interest for this project are (Puolamaa 1999b, Eurostat 1998):

NACE 100 Household consumption
- NACE 100.1 Household consumption for transport
- NACE 100.2 Household consumption for heating
- NACE 100.3 Household consumption n.e.c. (other final consumption)

NOSE Process List (NOSE-P) indicates core processes causing pressures to air, water and land inside the actual NACE group. NOSE-P codes of main relevance for these NACE-activities are:

- NACE 100.1 Household consumption for transport

NOSE-P
201.01 Passenger cars
201.02 Light duty vehicles <3.5 t
201.03 Heavy duty vehicles >3.5 t and buses
201.04 Mopeds and motorcycles <50 cm^3
201.05 Motorcycles >50 cm^3
201.07 Automobile tyre and brake wear
202.03 Maritime activities
202.05 Other mobile sources and machinery

- NACE 100.2 Household consumption for heating

NOSE-P
101 Combustion processes

- NACE 100.3 Household consumption n.e.c.

NOSE-P
107.01 Paint application
107.04 Other use of solvents and related activities
113.01 Household consumption and similar processes
113.02 Gardening

In the Norwegian Emission Inventory a code system is used for the different emission sources that can be translated to the nomenclature of SNAP. SNAP is an established standard for air emission data at international level. SNAP is a precursor to NOSE-P and includes almost the same processes, which makes the conversion to NOSE-P codes easy. The correspondence between actual process codes is given in Table 2.

Table 2. Table over the correspondence between three process code systems

The Norwegian Emission Inventory	SNAP	NOSE-P
04 Boilers	02 02 Residential plants	101 Combustion processes (production of heat and electricity)
05 Small stoves	02 02 Residential plants	
06 Passenger cars, M1	07 01 Passenger cars	201.01 Passenger cars
07 Duty vehicles, N1	07 02 Light duty vehicles < 3.5 t	201.02 Light duty vehicles < 3.5 t
08 Heavy duty vehicles	07 03 Heavy duty vehicles >3.5 t and buses	201.03 Heavy duty vehicles >3.5 t and buses
09 Motorcycles	07 05 Motorcycles > 50 cm^3	201.05 Motorcycles > 50 cm^3
10 Mopeds	07 04 Mopeds and motorcycles < 50 cm^3	201.04 Mopeds and motorcycles < 50 cm^3
15 Two-stroke boats	08 04 Maritime activities	202.03 Maritime activities
16 Four-stroke boats	08 04 Maritime activities	202.03 Maritime activities
18 Motorised equipment (four stroke)	08 09 Household and gardening	202.05 Other mobile sources and machinery
24 Evaporation	06 01 Paint application, 06 04 Other use of solvents and related activities	107.01 Paint application, 107.04 Other use of solvents and related activities
31 Other combustion	02 02 Residential plants	101 Combustion processes (production of heat and electricity)
33 Snow scooter	08 10 Other off-road	202.05 Other mobile sources and machinery
34 Wear	07 07 Automobile tyre and brake wear	201.07 Automobile tyre and brake wear

Table 3 summarises the main data sources for the material flow calculations in this EPIS project.

Table 3. Data sources for the EPIS material flow characteristics

Subject	Main source
Activities	The Norwegian Emission Model, Statistics Norway
Processes	The Norwegian Emission Model, Statistics Norway
Raw materials, operating substances, products	The Survey of Consumer Expenditure, Statistics Norway
Fuels and energy	National Energy statistics, Statistics Norway
Emissions to air	The Norwegian Emission Model, Statistics Norway
Waste water	Waste water treatment statistics, Statistics Norway
Waste materials	Waste statistics, Statistics Norway

4. Input

4.1 Energy

Statistics Norway (SN) gives energy data for the sector private households in the annual energy accounts. The energy account is based on data partly from SN and partly from other institutions. Internal statistics that are used, are among other things the manufacturing statistics, the electricity statistics, the sales statistics for petroleum products, the refinery statistics, the district heating statistics, the external trade statistics and the national accounts. Data from the Norwegian Petroleum Directorate and Norsas are some of the external sources that are used.

The energy fuels used for transport are included in this section and not in the material section. Heating and transport are the two main activities in the households that consume energy. The transport sector represents ca. 19% of the total household energy consumption.

Table 4. Use of energy commodities in the Norwegian households. 1992 and 1999. ktonnes and kg per capita

Energy commodity	1992, ktonnes	1999, ktonnes	1992, kg per capita	1999, kg per capita
Total	**3 074**	**3 320**	**717**	**744**
Coal	4.7	2.8	1.1	0.6
Coal coke	1.5	1.3	0.4	0.3
Wood	1 156	1 417	270	317
Liquefied petroleum gas	2.5	4.0	0.6	0.9
Gasoline	1 324	1 252	309	281
Kerosene	140	144	32.6	32.3
Middle distillates, total	223	250	52.0	56.1
- Autodiesel	60	101	14.0	22.7
- Fuel oil (light)	144	135	33.5	30.2
-Heavy distillate	19	14	4.5	3.1
Heavy fuel oil	0.1	-	0.03	-

Source: SN 2001d + calculations

The change in energy use (oils and fuelwood) over the seven years is 8%, which is a higher increase than the population growth. The energy use per capita has increased with 27 kg (3.8%).

The usage of electricity does not contribute to any material flows into the households and is consequently not included in the mass balance. The electricity consumption constitutes about ¾ of the Norwegian households' residential energy consumption, which makes Norway special with a lower energy mass flow per capita than is typical in other countries.

4.2 Air

Oxygen is consumed by the combustion of fossil fuels both for the formation of CO_2 and for the formation of H_2O from the hydrogen in the hydrocarbons. The amount of oxygen needed for the formation of CO_2 can be determined approximately from the CO_2 emission. 1 kg hydrogen demands 8 kg O_2 for combustion, and all gaseous and liquid fuels have been assumed pure carbohydrates in the calculations. Taking these two chemical processes into account the oxygen consumption by the combustion of fossil fuels reaches 5.82 million tonnes in 1992 and 5.68 million tonnes in 1999. Oxygen consumed during the combustion of wood was 1.26 million tonnes in 1992 and 1.55 million tonnes in 1999.

The mass value of the O_2 input must be reduced though, due to the double counting of the carbon by oxidisation of CO, VOC, CH_4 and dust to CO_2 after the combustion. The emission of NO_X from the combustion does just partly originate from the fuels, but mostly from the atmosphere. The same is the fact for N_2O and the nitrogen part of the NH_3. Here we assume that everything comes from the atmosphere. This means an extra mass inflow of O_2 and N_2 into the system.

The human respiratory process is also an important source of emission of CO_2 and consumption of oxygen in the households[1]. The amount of O_2 entering the body is ca 250 ml/minute and the amount of CO_2 leaving the body is ca 200 ml/minute (Vander *et al.* 1994). This means a consumption of 0.75 million tonnes O_2 in 1992 and 0.78 million tonnes O_2 in 1999, and an emission of 0.82 million tonnes CO_2 in 1992 and 0.86 million tonnes CO_2 in 1999.

4.3 Materials

The EPIS categories raw materials and operating substances are for households defined as food and beverages and other materials entering the households. Statistics Norway is regularly carrying out a Survey of Consumers Expenditure where detailed data for the consumption of different commodity groups are given (SN 1996, SN 2000e). These reports give the consumption in monetary units, except for food and beverages where the consumption also is given in mass units. Factors for recalculation to weight are, when possible, taken from the external trade statistics, preferably values from the export statistics where transport costs are not included (SN 1999a, SN 2000f). Some product prices were not available from the external trade statistics, and in these cases approximations have been made. The consumption of tobacco is given by SFT (The Norwegian Pollution Control Authority). For cars and motorcycles data from OFV (2001) have been used to get the number of vehicles. Inflow of cars into the Norwegian households is estimated to be equal with the number of first-time registered new and imported secondhand cars the actual year. This approximation is justified by the fact that almost all personal cars end up in the households seen over a longer time span.

For food and beverages average data for 1997-1999 have been used, and for tobacco data for 1999 have been used. For the other commodity groups the expenditures are an average of the expenditures in 1997-1999, calculated with the 1999-prices. The CPI (Consumer Price Index) is used for the recalculations to 1999 prices. For the year 1992 the Survey of Consumers Expenditure 1992-1994 is used, and a conversion to 1999 prices has been made using the CPI (SN 2001c).

[1] While this is not relevant for a pollution accounting, as the net emissions are zero, it is important for the mass balance when carbon in food is included.

Table 5. Material inflow into the household sector in Norway. 1992 and 1999. ktonnes, kg per capita and NOK per capita

Commodity group	ktonnes		kg per capita			NOK per capita	
	1992	1999	1992	1999	Change 92-99 %	1992, (1999 prices)	1999
TOTAL	**4 758**	**5 522**	**1 110**	**1 238**	**11**	**49 085**	**61 913**
Food, beverages and tobacco	**2 539**	**2 580**	**592**	**578**	**-2**	**18 192**	**18 436**
Flour, meal and bakery products	326	333	76	75	-2	1 601	1 944
Meat and meat products	201	206	47	46	-1	3 415	3 189
Fish and fish products	83	80	19	18	-7	972	942
Milk, cream, cheese and eggs	675	581	157	130	-17	2 775	2 455
Edible oils and fats	59	55	14	12	-10	407	351
Vegetables, fruits, berries, potatoes and potato products	698	721	163	162	-1	2 522	2 274
Sugar, chocolate and sugar confectionery	45	40	11	9	-18	890	1 459
Other food products	77	114	18	26	44	1 179	748
Non-alcoholic beverages	261	323	61	72	18	1 340	1 572
Alcoholic beverages	107	123	25	28	11	1 522	1 926
Tobacco	6	4	1.4	0.9	-35	1 569	1 574
Other materials	**2 192**	**2 803**	**511**	**628**	**23**	**30 894**	**43 477**
Clothes	73	80	17	18	5	5 519	5 852
Footwear	16	19	3.7	4.2	12	1 043	1 057
Dwelling maintenance material	901	1169	210	262	25	2 209	3 365
Furniture, furnishings, textiles	147	167	34	38	10	3 217	3 544
Household equipment etc.	489	603	114	135	18	3 218	3 745
Medicines and health care products	19	25	4.5	5.7	26	975	2 686
Transport vehicles	76	122	18	27	54	5 921	12 872
Transport equipment for maintenance	28	30	6.5	6.7	4	905	921
Audio-visual equipment	30	51	7.1	12	62	2 190	3 015
Other recreational equipment	50	82	12	18	58	1 587	2 012
Newspapers, books and writing materials	201	247	47	55	18	2 073	2 304
Articles for personal care and other personal goods	162	208	38	47	23	2 036	2 106

Source: SN 1996, SN 2000e + calculations

The data for the inflow of food and beverages, which constitute approximately half of the total material inflow, are of good quality. The mass approximations for the other product groups have a higher uncertainty level, due to the conversion from value to mass unit. There is a big uncertainty in the figures for dwelling maintenance material, which is a very large group, with big influence on the net sum. The absolute increase in the consumption between 1992 and 1999 is 764 ktonnes, which corresponds to a percentage increase of 16%. The percentage increase per capita is 11%.

4.4 Water

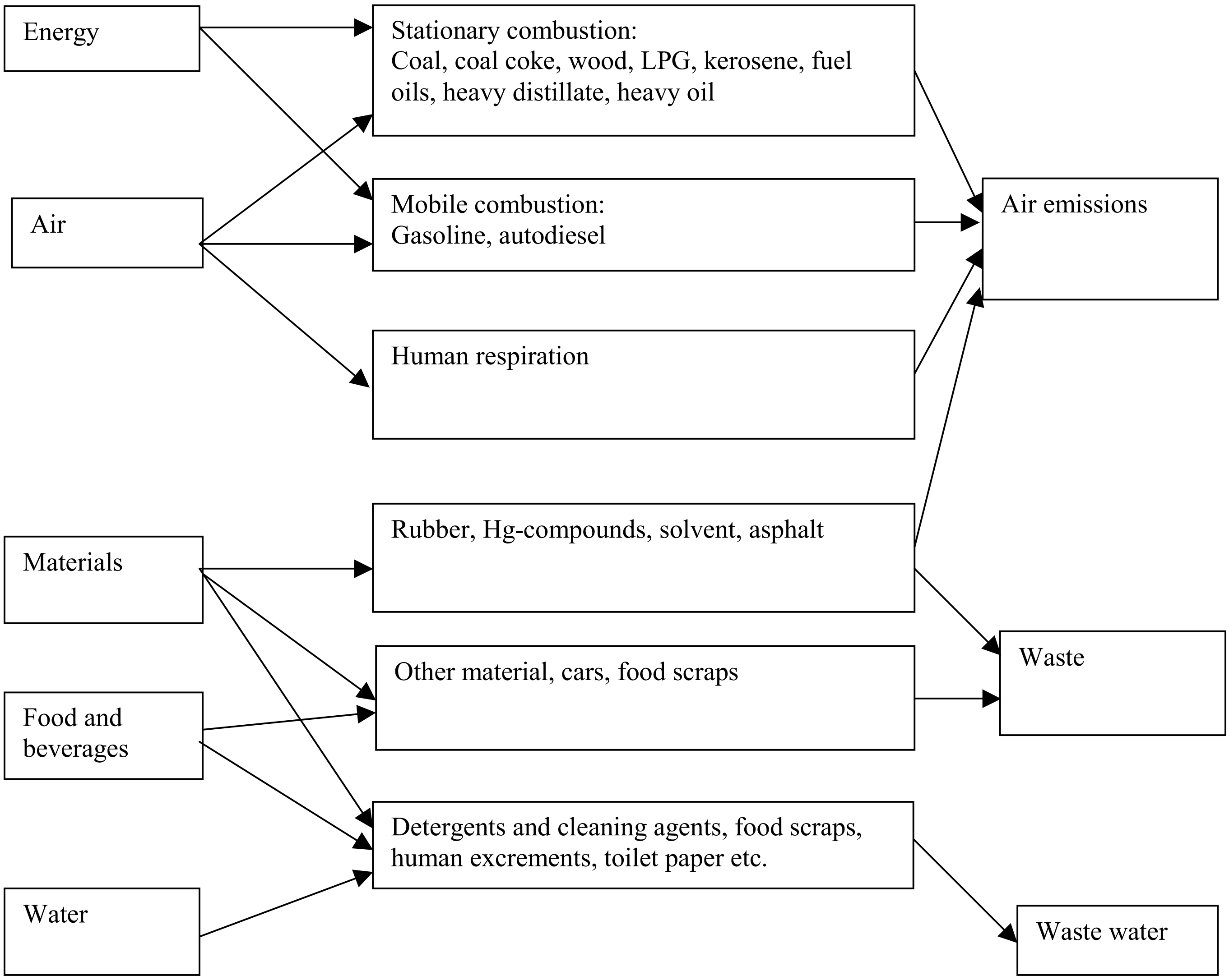
The National Institute of Public Health collects data from the Norwegian water works (SN 2000d). The Norwegian water works supply about 89 per cent of the Norwegian population with water. The remaining 11 per cent of the population are supplied by smaller water works or take water from their own wells, rivers and lakes. The households are accountable for a consumption of 38% (1996) of the total consumption of water from the water works. It is assumed that more than one third of the water is lost between the water work and the consumer, but taking that and the self supplied households into account, the consumption of the households is found to be 309 million m^3 (SN 2000d). That corresponds to 308 million tonnes of water. With the assumption that the consumption per capita is the same for 1992 and 1999, the water consumption in 1992 was 296 million tonnes of water.

5. Processes

5.1 Processes in the household sector

The household sector includes several processes. In Figure 2, an attempt to trace the main inputs and outputs to different processes in the households has been made.

Figure 2. Material flow characteristics for the households in Norway.



The energy consumed in the households goes to stationary combustion (81%), and to combustion in the transport sector (19%). This energy ends up mainly as air emission. A small amount of the air emission (0.6%), has its origin from material use in the households (rubber, Hg-compounds etc.).

The water is in the process step being contaminated with waste products from the other input categories, mainly from the food and beverages input category. The mass amount of this contamination is approximated to correspond to the sewage sludge. But in reality the contamination is bigger because parts of the mass are leaving as air emissions (CH_4, CO_2 etc.) during the processes in the waste water treatment plants.

5.2 Lifetimes for different material categories in the households

Possible differences between the input and the output can origin from the changes in the mass storage in the households between different years. These fluctuations in the storage mass are very difficult to measure. Water and energy are more or less going straight through the households, with a very short process time. The time that different material categories stay in the households before they leave in the form of waste or emission varies a lot between different commodity groups. Food mostly has a lifetime of days while for example furniture can have a lifetime on many decades.

Division for Environmental Statistics in Statistics Norway has estimated the lifetimes for some commodity groups in the waste accounts for Norway (Skullerud and Stave 2000). Different commodity groups are by lifetime analyses given a higher and a lower assumed lifetime (Table 6).

Table 6. Estimated higher and lower lifetimes for different products in the Norwegian households.

Commodity groups	Lifetimes, year	
	lower	higher
Commodities of plastic	3	10
Sanitary/household	5	10
Carpets	5	10
Shoes etc.	1	5
Machines and tools	10	30
Cars	8	15
Motorcycles	8	15
Bicycles	8	15
Perambulators	8	15
Boats	15	20
Instruments and apparatus, not electric	5	25
Watches and clocks, not electric	5	25
Music instruments, not electric	5	25
Furniture	10	20
Tools and sport articles, not electric	3	10
Electric and electronic products	0	30

Source: Skullerud and Stave (2000).

6. Output

6.1 Air emissions

Emission quantities for all the main air emission types are estimated in the Norwegian emission model (Flugsrud *et al.* 2000), where they also can be connected to their source. The data includes stationary emission (mainly from heating), process emission, and mobile emission (from transport).

Table 7. Air emissions from private households in Norway. 1992 and 1999. Tonnes

	1992	1999	Change 92-99
	Tonnes	Tonnes	%
CO_2 (fossil)	4 196 659	4 336 137	3.3
CO_2 (wood)[1, 2]	1 733 582	2 124 752	22.6
CO_2 (human respiration)[2]	824 275	858 026	4.1
CH_4	8 594	9 566	11.3
N_2O	315	1 087	245.2
SO_2	2 003	1 263	-36.9
NO_X	36 584	20 961	-42.7
NH_3	278	1 110	298.9
NMVOC	78 751	61 513	-21.9
CO	546 359	408 219	-25.3
Particulates	14 599	16 335	11.9
Pb	91	0.2	-99.7
Cd	0.2	0.2	19.3
Hg	0.2	0.2	5.2
PAH-Total	66	75	13.6
PAH-4	3.4	3.9	15.7
PAH-6	11	12	12.4

[1]Emission factor: 1.5. (Emission factor given in Flugsrud *et al.* (2000): 1.8, Water content 18%).

[2]Renewable, not included in ordinary statistics.

Source: Emission inventory from Statistics Norway.

Table 8. Air emissions from private households in Norway. 1992 and 1999. kg per capita

	kg per capita		Change 92-99
	1992	1999	%
CO_2 (fossil)	979.1	971.8	0.2
CO_2 (wood)[1, 2]	404.4	476.2	18.8
CO_2 (human respiration)[2]	192.3	192.3	0.9
CH_4	2.0	2.1	7.9
N_2O	0.073	0.24	234.7
SO_2	0.47	0.28	-38.9
NO_X	8.5	4.7	-44.5
NH_3	0.065	0.25	286.7
NMVOC	18.4	13.8	-24.3
CO	127.5	91.5	-27.6
Particulates	3.4	3.7	8.5
Pb	0.021	0.0001	-99.7
Cd	0.000036	0.000041	15.7
Hg	0.000041	0.000042	2.0
PAH-Total	0.015	0.017	10.2
PAH-4	0.00079	0.00088	12.2
PAH-6	0.0026	0.0028	9.0

[1]Emission factor: 1.5. (Emission factor given in Flugsrud *et al.* (2000): 1.8, Water content 18%).

[2]Renewable, not included in ordinary statistics.

Source: Emission inventory from Statistics Norway.

The value of the CO_2 emission from the Norwegian emission inventory has been reduced, due to the double counting of the carbon by oxidisation of CO, VOC, CH_4 and dust to CO_2 after the combustion. The size of the reduction has been calculated based upon the carbon content in the compounds. Standard for reporting CO_2 is based on total carbon.

Gaseous H_2O is also emitted in the processes. Wood has a water content on 18% and coal a water content on 10%[2] that end up as gaseous H_2O. When the hydrocarbons in the fossil fuels are combusted, the hydrogen reacts with atmospheric oxygen and oxidizes to water. We have also assumed that hydrogen and oxygen in the wood cellulose are released as gaseous H_2O in the combustion process, which means that the mass of H_2O emissions originating from wood is almost 60% of the weight of the wood. The total amounts of H_2O emissions from different fuels are 2.87 million tonnes H_2O in 1992 and 2.97 million tonnes H_2O in 1999. The human body also has a loss of gaseous water by evaporation from the skin and the respiratory passageways of 900 ml H_2O per day and person (Vander *et al.* 1994).

6.2 Waste

Almost all the household waste is treated or administered in the municipal waste system. The Division for Environmental Statistics, Statistics Norway, has calculated the total generated amount of waste for some waste categories in a waste account (SN 2000a). A waste account is based on the principle of a material balance between annual waste generation and the waste disposal each year. Two different methods have been used to estimate waste quantities, the "supply of goods method" and the "waste statistics method". A problem with the waste account is that it does not yet give a full overview of all the waste product groups generated in the households, and there is also lack of data for recent years.

[2] Pers. comm. Gisle Haakonsen, Division for Environmental Statistics, Statistics Norway (2001).

Therefore, the waste amount for the households is also complementary calculated with another method based on a sorting analysis from 1997 (Heie 1998). The sorting analysis is a study that was made for quantifying the different waste groups on landfills. The percentage weight distribution for the different waste groups combined with the total amount of household waste for the years 1992 and 1998 (SN 2000c), are used to estimate the amount for the different waste groups.

Table 9. Waste from private households in Norway. 1992. Tonnes

	Waste accounts[2]	weight-%, sorting analysis -97	Weight based on sorting analysis	Recycled[3]
Total	..	100.0	1 012 192	86 363
Paper and cardboard	421 202	33.0	334 521	56 600
Plastic	160 467	8.2	83 387	143
Park and garden waste	..	2.3	22 953	-
Wet organic waste	288 765[1]	27.9	282 023	1 088
Wood waste	79 553	2.0	19 955	561
Glass	54 419	3.6	36 494	10 865
Metals	111 097	4.6	46 505	6 643
Textiles		5.4	54 671	1 121
Hazardous waste	..	0.1	925	-
Other	..	12.9	130 758	9 342

[1]In wet organic compound food waste and park- and garden waste are included.

[2] Source: SN (2000a).

[3]Source: SN (2000b).

Table 10. Waste from private households in Norway. 1999. Tonnes

	Waste accounts[2]	weight-%, sorting analysis -97	Weight based on sorting analysis	Recycled[3]
Total	..	100.0	1 396 674	524 156
Paper and cardboard	..	33.0	461 589	247 133
Plastic	..	8.2	115 061	3 077
Park and garden waste	..	2.3	31 672	52 459
Wet organic waste	420 000[1]	27.9	389 150	84 331
Wood waste	..	2.0	27 535	58 125
Glass	55 131	3.6	50 356	28 432
Metals	..	4.6	64 170	36 271
Textiles		5.4	75 438	7 810
Hazardous waste	..	0.1	1 276	-
Other	..	12.9	180 427	6 518

[1]In wet organic compound food waste and park- and garden waste are included.

[2] Source: SN (2000a). Data for 1998.

[3]Source: SN (2000b).

A source of error with the usage of the percentage weight distribution from the sorting analysis is that this sorting analysis does not include bulky refuse (furniture, larger objects). The bulky refuse has another distribution, for example it does not contain any wet organic waste. The bulky refuse is included in the total sum that the percentage distribution is applied to, though. The amount of the bulky refuse is roughly estimated to ca. 270 000 tonnes in 1998 and 250 000 tonnes in 1992[3].

The total sum of household waste used in the calculations shall include the amount of total waste generated. But it is actually different from the total sum in the waste account, because scrapped cars and private combustion of paper in ovens etc. are not included in the municipal waste statistics, but in the waste account. In the EPIS material flow characteristics the waste amounts given using the sorting analysis are used, though, due to a more complete data set.

In section 6.2.1 an estimate of the amount of waste consisting of scrapped cars is made. A further development of the report could be to make estimates for the other product groups not included in the municipal waste statistics, as toilet paper, fire paper and holiday boats.

6.2.1 Cars

Waste consisting of scrapped cars is not included in the municipal statistic, but we see it as a part of the waste from the Norwegian households, and therefore we have made calculations for this mass flow. In 1992, 53 741 cars were left for scrap, and in 1999 the number was 83 613. It was not possible to find an average weight for the scrapped cars, so therefore we have used the average weight for new cars in 1995 in the calculations. The average weight for new cars in 1995 was 1155 kg/car[4].

6.2.2 Hazardous waste

The total amount of hazardous waste that is treated in Norway was 113 989 tonnes in 1992 (Norsas 1998) and 252 300 tonnes in 1998 (Norsas 2000). Only a minor part of the total amount of hazardous waste that is generated in Norway has its origin in the households, though. The amount of hazardous waste from the households has been estimated to 4 kg/ habitant or 10.3 kg/ household (NRF 2000).

Table 11. Categories and amounts of hazardous waste from Norwegian households.

Category	Amount / household and year
Waste oil	3 litres
Oil filter	0.2 kg
Paint, glue, varnish	6 kg
Solvents	0.9 kg
Detergents	0.3 kg
Plant protection agents	0.1 kg
Photo chemicals	0.04 kg
Hobby chemicals	0.04 kg
Fluorescent lamp tubes	0.6 piece

Source: NRF and Norsas (1998).

Not included in Table 11 are batteries, oil changed on a garage, and EE-waste (electric and electronic). The hazardous waste that is generated in the households is assumed to be of minor signification in the EPIS mass balance.

[3] Pers. comm. Øystein Skullerud, Division for Environmental Statistics, Statistics Norway (2001).
[4] Pers. comm. OFV, Opplysningsrådet for Veitrafikken.

6.3 Waste water

The quality of the data on waste water from the households is quite low and there are major data lacks in this field. Some quite rough assumptions have been made to fill in the data gaps. Data for water emissions from the household sector are poor, but there are data for the emissions from the total waste water system.

A calculation of all the water going through the waste water plants in Norway has been made based on data from SESAM for 1999. SESAM is a database for collection of physical and economical data used by Statistics Norway and SFT (the Norwegian Pollution Control Authority). Not all the plants have reported how much waste water they are treating per year, but based on those who have reported, a factor for treated waste water on 155 m^3/personal unit/year is calculated[5]. The number of personal units connected to waste water plants is from SESAM-data counted to be 5.35 million in 1999. This gives a total amount of waste water in 1999 on 828 million m^3.

The amounts of waste water from the households are just a fraction of the water coming into the waste water treatment plants. To get a rough estimate of the household part of the waste water we have divided the amount of water going into the households with the total amount of waste water. This calculation gives that ca 37 % of the waste water consists of household sewage. This percentage is used for calculating the emissions originating in the households and the household part of the sludge.

The approximation is made that the amount of waste water originating in the households is the same as the amount of water from the water works supplying the households, plus the household part of the total sludge weight, (approximated to 37%, see discussion above). This approximation should be acceptable, and means for Norway 308 million tonnes sewage in 1999 and 296 million tonnes in 1992. Lawn sprinkling might be a source of error of importance for this approximation, but no calculation has been made of this here.

Data for the emissions from the total waste water sector and from the household sector are given in Table 12.

Table 12. Emissions of phosphorus and nitrogen from the total waste water sector and the household sector in Norway. 1999. Tonnes and kg per capita

	Total waste water sector[1]		Household sector	
	P	N	P	N
Total	1 298.4	17 694	484.3	6 600
Emission from waste water plant	836.4	13 494	312.0	5 033
Leaks from pipes	119.5	901	44.6	336
Spread settlements	342.5	3 299	127.8	1 231
Emission per capita, (kg)	0.29	3.98	0,11	1.48

[1]Source: Mork *et al.* (2000).

In 1992, the emissions of phosphorus and nitrogen from waste water treatment plants were respectively 574 and 11 410 tonnes, which gives an emission of 214 tonnes phosphorus and 4 256 tonnes nitrogen from the household sector, using the approximation of 37%.

[5] Pers. comm. Svein Erik Stave, Division for Environmental Statistics, Statistics Norway (2001).

A large fraction of the contaminants in the sewage ends up in the sewage sludge that is a residual product from waste water treatment plants. The sewage sludge has in this study been defined as part of the waste water category and not the waste category, because the waste water plants are not included in the studied system. In 1999, 103 900 tonnes dry weight sewage sludge was utilised as nutrient on agricultural areas and for other purposes. In 1992, 80 000 tonnes sludge was registered taken care of. Also in the calculation of the emissions from the sewage sludge the approximation of 37% coming from the household sector has been used.

Table 13. Contents in sewage sludge from the waste water plants and the household sector in Norway. 1999. Tonnes

		Total sludge[1]	Household sludge
Heavy metals:	Cd	0.11	0.04
	Cr	3.05	1.14
	Cu	24.76	9.24
	Hg	0.09	0.03
	Ni	1.56	0.58
	Pb	2.94	1.10
	Zn	35.07	13.08
Other matters:	Organic substance	64 970	24 234
	Kjeldahl-N	2 930	1 093
	Ammonium-N	320	119
	Total P	1 680	627
	K	180	67
	Ca	3 430	1 279

[1]Source: Mork *et al.* (2000).

7. Summary and conclusions

In the final material flow characteristic tables, Table 14 - Table 16, the coefficients and differences are given for the three main NACE-activities, which are estimated to cover all the main environmentally important activities in the households. In Table 17 a total material flow characteristics for the whole household sector is shown.

Table 14. Material flow characteristics for NACE 100.1; Household consumption for transport. Norway. 1992 and 1999

	1992 kg/capita	**1999** kg/capita
Input		
Materials		
Transport vehicles	17.8	27.3
Materials for maintenance	6.5	6.7
Energy carriers		
Gasoline	308.9	280.5
Autodiesel	14.0	22.7
Air		
O_2 (fossil combustion)	735.4	690.8
O_2 (fossil, hydrogen)	376.9	353.0
O_2 (incomplete combustion)	-87.9	-54.2
N_2 and O_2 for NO_X, N_2O and NH_3	8.3	9.8
Output		
Waste		
scrapped cars	14.5	21.6
Air emissions		
SO_2	0.22	0.075
CO_2 (fossil)	1011.2	949.9
CO	99.7	59.1
CO_2 red. due to CO, VOC, CH_4	-203.7	-124.0
NO_X	8.16	4.30
Pb	0.021	0.000031
Dust	0.52	0.36
VOC	15.0	9.83
CH_4	0.54	0.43
N_2O	0.052	0.22
NH_3	0.065	0.25
Minor substances	0.00074	0.00048
H_2O (gaseous, H in fuel)	424.0	397.2
Difference (input-output)	**9.6**	**17.4**

Table 15. Material flow characteristics for NACE 100.2 Household consumption for heating. Norway. 1992 and 1999

	1992 kg/capita	1999 kg/capita
Input		
Energy carriers		
Coal	1.1	0.6
Coal coke	0.35	0.3
Wood	269.6	317.5
LPG	0.58	0.9
Kerosene	32.6	32.3
Fuel oil	33.5	30.2
Special distillate	4.49	3.1
Heavy oil	0.03	..
Air		
O_2 (fossil comb.)	166.4	154.6
O_2 (fossil, hydrogen)	78.8	73.8
O_2 (wood comb.)	294.1	346.3
O_2 (incomplete combustion)	-27.7	-32.2
N_2 and O_2 for NO_X and N_2O	0.39	0.42
Output		
Air emissions		
SO_2	0.25	0.21
CO_2 (fossil)	228.9	212.6
CO_2 (wood)	404.4	476.2
CO	27.7	32.4
CO_2 red. due to CO, VOC, CH_4	-61.7	-71.8
NO_X	0.37	0.39
Dust	2.9	3.3
VOC	1.9	2.2
CH_4	1.5	1.7
N_2O	0.021	0.024
PAH-Total	0.011	0.012
Heavy metals	0.000083	0.000093
H_2O (gaseous, combustion)	48.6	57.2
H_2O (gaseous, carbohydrates)	109.2	128.6
H_2O (gaseous, H in fuel)	88.7	83.0
Waste		
Ashes[6]	1.3	1.6
Difference (input-output)	**0.29**	**0.20**

[6] The quantity of wood ashes is 0.5 % of the total amount of wood combusted, Pers. comm. Edvard Karlsvik, SINTEF (2001).

Table 16. Material flow characteristics for NACE 100.3 Household consumption n.e.c. (other final consumption). Norway. 1992 and 1999

	1992 kg/capita	**1999** kg/capita
Input		
Materials		
Food and beverages	590.8	578.3
Other materials	488.4	594.1
Water		
Household water	69 043	69 043
Air		
O_2 (solvents etc.)	3.2	3.7
O_2 (human respiration)	174.8	174.8
Output		
Waste water		
Household sewage	69 049	69 051
Tot-N	0.99	1.48
Tot-P	0.050	0.11
Heavy metals	..	0.005
Waste		
Park- and garden waste	5.35	7.10
Other household waste	230.8	305.9
Hazardous waste of household waste	..	4.0
Air emissions		
CO_2 (evaporation of solvents etc.)	4.4	5.15
CO_2 (human respiration)	192.3	192.3
VOC	1.465	1.72
PAH-Total	0.0041	0.0040
Hg	9.5	5.2
H_2O (gaseous, human)	0.25	0.25
Difference (input-output)	**815.7**	**829.8**

Table 17. Total material flow characteristics for the households. Norway. 1992 and 1999

	NACE	1992 kg/capita	1999 kg/capita	Change 92-99 Absolute, kg/capita	Change 92-99 Relative, %
Input					
Energy carriers					
Stationary combustion	100.2	342	385	43	12.4
Mobile combustion	100.1	323	303	-20	-6.1
Materials					
Food and beverages	100.3	591	578	-13	-2.1
Transport materials	100.1	24	34	10	40.0
Other materials	100.3	488	594	106	21.6
Water					
Household water	100.3	69 043	69 043	0	0.0
Air					
O_2 and N_2 (heating combustion)	100.2	512	543	31	6.0
O_2 and N_2 (transport combustion)	100.1	1033	999	-33	-3.2
O_2 (solvents etc.)	100.3	3.2	3.7	0.5	17.2
O_2 (human respiration)	100.3	175	175	0	0.0
Output					
Waste water					
Household sewage	100.3	69 049	69 051	2	0.0
Waste					
Scrapped cars	100.1	14	22	7	49.5
Ashes	100.2	1.3	1.6	0.2	17.7
Other household waste	100.3	236	313	77	32.6
Air emissions					
CO_2 (transport)	100.1	808	826	18	2.3
CO_2 (heating)	100.2	572	617	45	7.9
CO_2 (human respiration)	100.3	192	192	0	0.0
CO_2 (evaporation of solvents etc.)	100.3	4.4	5.1	0.8	17.2
Other air emissions (transport)	100.1	124	75	-50	-40.0
Other air emissions (heating)	100.2	35	40	6	16.2
Other air emissions (household consumption)	100.3	1.5	1.7	0.3	17.1
H_2O (transport)	100.1	424	397	-27	-6.3
H_2O (heating)	100.2	246	269	22	9.0
H_2O (human)	100.3	0.25	0.25	0	0.0
Difference (input-output)		**826**	**847**	**22**	**2.6**
Difference NACE 100.1		9.6	17	7.8	81.6
Difference NACE 100.2		0.3	0.2	-0.09	-30.1
Difference NACE 100.3		816	830	14	1.7

As seen in Table 17, the total difference between the input and the output in the household sector is 0.83 tonnes per capita in 1992 and 0.85 tonnes per capita in 1999. The difference has increased with 2.6% over the seven years. The mass flow per capita has increased with 124 kg in the inflow and 102 kg in the outflow during the studied period, which gives relative changes too small to be statistically significant for showing changes in the total mass flow per capita. But there have been evident changes in the flows for some input and output categories. The input mass flow of food and beverages has decreased with 13 kg/capita (2.1%) between the two years. This is explained with the fact that people eat more outside the home, in restaurants and the like, which is outside the system boundary. The material inflow has increased with 10 kg/capita (40 %) for transport material and 106 kg/capita (21.6%) for other material. This can be seen in relation to the fact that between 1992 and 1999, the average income after tax for the Norwegian households has increased by 40 800 NOK or 16.9%, measured in 1999 prices (SN 2001b). Household water is the category with the highest influence on the size of the mass flow, but it only contributes with a difference in the size order of 7-9 kg/capita. Inflow of air constitutes the second highest mass inflow, followed by energy commodities, and thereafter food and beverages inflow and other material inflow that are at about the same size. The outflow of CO_2 and gaseous H_2O are the most important mass flows after the household sewage. For all the emissions there have been increases or stability in the mass outflow, except for emissions from the transport sector, where all the major air emissions except CO_2 have decreased.

The differences between input and output in the activity "Household consumption for transport" (Table 14) are quite small, but increasing. The differences can be explained with fluctuations in the car stock and uncertainty in the data. Both the inflow of new cars and other vehicles and the outflow of scrapped cars have increased considerably these seven years. For the activity "Household consumption for heating" (Table 15) the difference is less than a half-kilo per capita for both years, with a decreasing difference. In the material flow characteristics for the NACE activity "Household consumption n.e.c." (Table 16) there are considerable differences for both years, but the percentage change in difference between the two years is small. This is the activity with the biggest material flow, mainly because of the large quantity of water passing through the households. But the household water does not contribute appreciably to the difference. The input category "Other materials" seems to be estimated too high, compared to the output category "Other household waste" where most of the materials are supposed to end. One explanation might be that the material inflow has been given a too high value in the recalculation from monetary unit to weight. It can also be an accumulation of materials in the households.

The boundary between the different activities seems unsure, which can be one explanation for the difference in the separate tables. The household sector is also a difficult sector to draw the system boundaries for. For example, the outflow of park- and garden waste is included, but it is a difficult task to include the inflow of gardening in the material balance.

Some of the coefficients shown in the material flow tables must consequently be considered as quite uncertain, due to the considerable differences between the input and the output values.

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