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Comparisons between two Calculation Methods: LCA using EPIS-data and Input-Output Analysis using Norway's NAMEA-Air Data

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Abstract:
In recent years there has been a great deal of work done for calculating the environmental profiles for different products. In the environmental profiles, both the direct and the indirect emissions that arise in the production chain for the studied product are included. In this study, two different methods for calculating the direct and the indirect emissions are compared, Life Cycle Assessments (LCA) and Input-Output (IO) analyses. The data used for the comparing example is EPIS (Environmental Pressure Information System)-data in the LCA and Norway's NAMEA (National Accounting Matrix including Environmental Accounts)-air data, NOREEA (Norwegian Economic and Environmental Accounts)-data, in the IO analysis. The usage of EPIS-data as a complement to NOREEA-data in the IO analysis is also discussed. Methodological differences in the two calculation methods and in the data sets used are examined.

In an example, the direct and the indirect air emissions arising from the consumption of the products books, newspapers and writing materials in the Norwegian households are studied. The results for the two calculation methods appear to be quite different for the air emissions of CH_4, CO_2, N_2O, NO_x and SO_2. But the differences can mainly be explained by methodological differences between the two methods and different system boundaries for the data sets used.

Britta Hoem, Kristine Erlandsen and Tone Smith have prepared this report. Other contributors are Kristin Rypdal, Julie Hass and Knut Ø. Sørensen.

Keywords: EPIS, NAMEA, LCA, Input-Output Analysis.

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1 Background

This is the second report in the Eurostat financed project "Environmental Pressure Information System" under contract OJ No. C 284. The aim with this project is to study potential applications of the EPIS data and to study links to accounting systems like NOREEA (Norwegian Economic and Environmental Accounts).

The first part of this project resulted in an EPIS report over the Norwegian households (Hoem 2001). The purpose of that report was to provide information on the environmental pressures arising from the households in Norway, using the EPIS methodology. Due to the mass balance approach it can also be used to identify weaknesses in the statistics. Other aims with the report were to make comparisons with other countries as well as improve the input to the NOREEA system.

This report is presenting LCA (Life Cycle Assessment) and Input-Output (IO) analysis using the air emissions data in NOREEA, two different methods for calculating the environmental pressure connected to related product group. The methods will be compared and an example will be shown for comparisons of the two methods. The products considered here are books, newspapers and writing materials consumed by Norwegian households. The main aim with this report is to test the EPIS database with respect to applications in LCA. The assessment will cover emissions to air, emissions to water, and waste as far as the data allows. Comparisons of output with indirect air emissions calculated from the NOREEA system are made. Advantages and disadvantages with the two approaches are discussed.

In this report, the possibilities to use the EPIS data as input to the NOREEA system will also be discussed. One of the most important weaknesses with the NOREEA system is that indirect emissions only cover the emissions arising in Norway from Norwegian production. In a complete EPIS-database there could exist country-specific emissions for all the producing countries. It could be a possibility to use EPIS-data together with input-output calculations using NOREEA data for adding the indirect emissions from products that are produced in other countries, but imported and used in Norway.

2 Life Cycle Assessment (LCA)

2.1 The methodology of LCA

Life Cycle Assessment is an established method for analysing and assessing the environmental impact of a material, product or service throughout its entire life cycle. A product is followed "from-cradle-to-grave", i.e. from raw material acquisition, through production, use and waste disposal. The methodology for LCA is specified in the international standards ISO 14040-43.

The assessment is made by a compilation of an inventory of relevant inflows and outflows of material and energy use in a product system, an evaluation of the potential environmental effects associated with these inflows and outflows and interpretation of the results from the inventory and evaluation phases in relation to the goal definition for the study.

The creation of an LCA goes through four main phases (Tillman and Baumann 1995):
- Goal definition and scoping phase
- Inventory analysis
- Impact assessment (classification and characterization, weighting)
- Improvement assessment/ Interpretation

2.1.1 Goal definition and scoping

In this phase, the purpose of the study and the intended use of the study is clearly stated. This is an important phase in the work, to make the assessment transparent and comparable with other studies. In scoping, the extent of the study is defined, including system boundaries and level of detail. Data requirements and data quality goals are to be considered. In this phase, the functional unit is also decided. The functional unit is a measure of the performance of the system under study, and is used as a basis for calculation. All the data in the assessment are related to the functional unit.

2.1.2 Inventory analysis

In the inventory analysis a flow model is constructed. A collection of data for the inputs to the system in terms of raw materials and energy, and of the outputs in terms of emissions to air, emissions to water, and solid waste are made for all the activities inside the system boundaries. When the data collection is finished, the mass flow in the different activities are calculated in relation to the functional unit, and thereafter the environmental burdens of the whole system are calculated. The result table from the inventory analysis contains the LCI-data (Life Cycle Inventory-data).

A more detailed description of the system boundaries is part of this phase, where the boundaries in relation to natural systems, geographical area and time are defined. Boundaries in relation to other products' life cycles must also be defined, for example an allocation (distribution of the environmental burdens) must be made if the studied process results in more than one product.

2.1.3 Impact assessment

The impact assessment comprises three sub-phases, classification, characterization and weighting. *Classification* means that the data from the inventory analysis are grouped into a number of impact categories, such as global warming, acidification, etc. In the *characterization*, quantification is made of the contribution to the impact categories of the various resource usages and pollutant emissions. The *weighting* step is a valuation of the different environmental effects using values from the social sciences (Tillman and Baumann 1999).

2.1.4 Improvement assessment
In the improvement assessment, options for reducing the environmental impact of a system are identified and evaluated.

2.2 Data sources and data quality

2.2.1 Data sources
For Life Cycle Assessments data are needed to give the environmental influence from all the activities inside the system boundaries. The principal rule is that specific data shall preferably be used. "Specific data" means internal company statistics, i.e. data that comes directly from the company that produces the actual product or service. This requires companies to provide this type of information, but some times certain information is confidential and hence difficult to obtain. Often there is also a big effort needed from the company to find all the requisite information.

Often general data has to be used. Considerable work is in progress to create LCA-databases for important materials, substances and energy supply systems (Swedish Environmental Protection Agency 1996). Other data can be found in the literature, e.g. earlier made LCA-reports and environmental reports, interviews with experts or branch organisations, or legislations regarding permitted emissions.

2.2.2 Data quality and data uncertainty
It is important to have in mind the age of the data when literature is used as data source. Data should preferably represent the mean data for the actual year. Other factors influencing the data quality are level of technology development and for which geographical area they are valid. It is often more difficult to obtain input data for production in countries outside the Nordic countries.

A general cut-off rule for the LCA methodology with regards to accepted information loss is that the data gaps in the inventory shall not correspond to a contribution that exceeds one per cent to any of the environmental impact categories. Another rule is that the sum of the contribution to the environmental impact from processes described with general data must not exceed 10 per cent of the total contribution to any environmental impact category (The Swedish Environmental Management Council 1999). The cut-off criteria can be used for an uncertainty analysis of the LCA-results.

3 NOREEA - input/output matrices

3.1 What is NOREEA?

NOREEA is a co-operative project between the Division for Environmental Statistics and the Division for National Accounts in Statistics Norway. The project aims at connecting the environmental data or accounts with the national accounts supply and use matrix and thereby producing a set of data from which the relationships between economic activity and environmental issues can be described and analysed. NOREEA includes, among other things, the Norwegian NAMEA-air tables.

The NAMEA-air matrix consists of two sub matrices, one including data from the national accounts and one including figures from the emission accounts or other types of environmental accounts, such as solid waste. The two matrices are integrated, so along one row it is possible to find both the production value from one economic sector and the emissions produced by this sector. Emissions from households are included in the row that also shows household consumption.

De Haan and Keuning (1996) describe a national accounting matrix that has served as a standard for similar efforts in many European countries. A slightly modified NAMEA-matrix has been used to develop the NAMEA-air matrices in the NOREEA-system. At the moment, emissions to air are the best environmental parameter that is linked to the national accounts in Norway. Solid waste matrices are being developed (Hass and Sørensen, 2002 forthcoming), however, the coverage and detail are not as good as the air tables. Future plans include expanding the system to cover data on wastewater and improve the solid waste system (SN 1998).

The definitions that determine which emissions to include and exclude in the standard air emissions calculations reported to UNFCCC for example, are close to the concept of "emissions on the national territory". Whereas the national accounts focus is on actual emissions arising from the national economy or economic units that are resident in the national territory.

The difference between emissions on the national territory and emissions of the national economy is mainly determined by emissions from mobile sources, and in particular air, water and land transport (NACE 60-62). The major adjustments needed are additions of emissions by units resident in the rest of the world and deductions of emissions by non-resident units on the national territory. For Norway the emissions from ocean transport arising from the international bunkering of ships and the emissions for international air transport need to be included since these are considered "economic units resident in the rest of the world." Emissions arising from these two main activities account for the majority of the adjustments. The emissions from air transport of foreign companies in Norway are excluded from the NAMEA-air emissions since these emissions arise from "non-resident units operating on the national territory."

3.2 Environmental profiles for economic sectors

One interesting type of information that is produced by the NOREEA-system is environmental profiles for economic sectors. For each NACE group, profiles that put together information about the sector's direct air emissions, energy use, turnover, number of employees, green taxes paid, or any other information that is available either in the national accounts or in emission accounts, can be produced. To produce time series with this kind of data /profiles is a goal in the future. Such time series will provide useful information about how the sectors' emissions or share of total national emissions develop in comparison with for example the sectors' share of green taxes paid. This kind of data is also interesting in analysing "de-coupling" of environmental pressure from economic growth.

Emissions in some sectors are closely related to production activity in the sector, an example is the transport sector. In other sectors, such as some service sectors, emissions may be more closely linked to heating, own transport, etc. without a direct connection to the services and products that are produced. The fact that the emissions linked to the economic activity in the sectors differ considerably means that environmental efficiency in the various sectors cannot automatically be compared.

3.3 Environmental profiles for products - indirect emissions

In this project and in this report, we are interested in the environmental profiles for a product, which also can be calculated using the NOREEA-matrices. The national accounts system is constructed to show the interactions between different sectors in the economy. Using input-output tables, it shows what products that are used as inputs in different sectors and also what kind of products that are produced in the different sectors.

To produce more paper, one needs more timber, more machines, more transport. And the producers of machines, transport etc. will also need deliverances from other sectors, and all these will need more paper etc. Input-output tables are constructed to keep track of all these deliverances, and to handle how all sectors in the economy in this way are related to one another. By using the information in the input-output tables and combining them with emission data for the same sectors and products, one can calculate the indirect environmental effects that will be the result of increased production of inputs or the environmental effects connected to the production of a product before it reaches the consumer. Input-output tables might therefore be used to study the effect of public regulations, as they might show the effect in all sectors of the economy of for example green taxes. This aim differs from the purpose of LCA, which is mainly to decide how polluting a product is (Brekke 1998).

3.4 Data sources

The data used in NOREEA are partly derived from the national accounts and partly from the emission accounts and the energy accounts from Statistics Norway. These accounts are relatively coordinated when it concerns definitions and classifications (Hass and Sørensen 1998). Sources and methods for the National Accounts are described in "National Accounts 1992-1999, Production, uses and employment" (Statistics Norway 2001). The emission data is based upon the Norwegian Emission Inventory, and covers emissions to air. Documentation of methodology is found in Flugsrud *et al.* (2000). The emission model has been developed by Statistics Norway in co-operation with the Norwegian Pollution Control Authority (SFT), which has provided information regarding the parameters in the emission model and emission data for a number of large companies.

4 EPIS-data used in a Life Cycle Assessment and together with input-output calculations using NOREEA data

In this section we will study the possibilities of using the EPIS-data as input in an LCA and as a complement to NOREEA data in input-output calculations.

The goal with the EPIS model is to collect data in a format that gives a connection between environmental pressure and economic activity. The core of EPIS is a matrix of 100-150 high-pressure processes in Europe, selected by an expert group. The output of the EPIS-reports prepared in different countries shall be included in the EPIS-database in EUROSTAT. EUROSTAT intends to issue the technology database manual in early 2002, and validated EPIS-data is expected in 2005[1].

In the EPIS model the environmental pressure data are linked to different economic activities classified in NACE-groups. NACE is the EU standard statistical nomenclature for industrial classification of economic activities. Inside the actual NACE group the core processes causing pressures to air, water and land are mainly classified by PRODCOM. PRODCOM is a European wide product classification system. EPIS-data is not as directly linked to a product as the Life Cycle Inventory (LCI)-data, and the connection to NACE-groups makes it more natural to use EPIS-data in a NOREEA context. But often one economic activity with a specified NACE-number give rise to one or several clearly defined products, which gives a connection between the two models. In EPIS the studied products are defined with PRODCOM-codes. An LCA is less restricted, it can study principally any product or service if only the functional unit and the system boundaries are defined and clearly documented. An LCA includes all indirect emissions in earlier steps of the life chain. EPIS is only studying emissions arising from one activity in one life chain step, and corresponds by that to the LCI-data that is found for the different activities in the life cycle inventory before they are calculated to a result for the whole life chain phase, (f. ex. the production phase or the use phase).

EPIS data accounts for the inflow of material, energy, water and air and the outflow of waste, emissions to air, emissions to water, and water. LCI data accounts for the inflow of natural resources and energy use, and data for the outflow of emissions to air, emissions to water, waste, and secondary products (by-products). 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. For LCI-data there is no focus on the mass balance between the in- and outflows. LCI-data only concentrate on the mass flows that influence the environment. EPIS-data is so far mainly collected for the production phase, not for the use phase or the waste disposal phase in a product's life cycle. EPIS-data has often the country borders as geographical boundary, and is by that more general than LCI-data, that often concentrates on one company's production.

The conclusion is that EPIS data can be used in Life Cycle Assessments under some constraints. The main difference between EPIS- and LCI-data are the starting points in NACE-groups vs. products. Another important difference is the respective concentration on mass balance (EPIS) vs. environmentally important flows (LCA). If EPIS-data is going to be used in LCA, it is of main importance that the same system boundaries and the same functional unit are being used. This demands good access to EPIS-data. The access to satisfyingly documented EPIS-data from the EPIS database, for a great variety and number of NACE-groups/products still lies some years ahead. The EPIS-database can be used as a database for general data on a national level and the database can also give country specific data for the country where the inflow material in reality is produced. EPIS-data can be used to construct an LCA if data for the main activities of the life chain of the product is available. Data must be available for activities as many life-chain steps as the contribution from the excluded activities to the total emissions becomes so limited that they can be neglected. EPIS-data can

[1] Pers. comm. Dietmar Koch, EUROSTAT.

also be used to fill data gaps for activities that contribute to the studied system. Allocations must be treated the same way for the EPIS-data and the LCA, and EPIS-data must have good documentation, where data gaps, assumptions and system boundaries comes to hand. Re-scaling to functional unit must be done. The studied unit that the emissions are given in, are for EPIS "unit/tonne product" and for LCI "unit/functional unit". The functional unit is often the studied product, so recalculation to a mutual unit can be easy.

In section 6.1 an attempt to perform an LCA by using EPIS-data has been made for the product groups books, newspapers and writing material.

One of the aims of the project was to consider whether EPIS-data could be used as a supplement to NOREEA-data in the IO analysis to fill in the lack of emission data related to imported products.

A problem of using EPIS-data in IO analyses is that it is difficult to identify the part that is imported in every step in the production chain. This identification must be done for every semi-process in the life-chain, and it is also important that the division between the processes is correctly made to avoid double counting. For example, if we study the paper consumption in the households, first the imported part of this product group must be found. But parts of the Norwegian produced paper used in the household are produced from imported pulp and with the help of other imported operating substances etc. For every step backwards in the chain it becomes more and more difficult to keep track of the imported part that ends up in the household consumption. It might also be a problem to find satisfying EPIS-data for the actual country that the input categories are imported from. Another alternative could be to use other countries' NAMEA-data for the import, if they are available at the product level.

Heinze (1999) claims that there is a methodological problem using EPIS-data as a complement to NAMEA-data. The argument is that EPIS-data does not allow the calculation of cumulative emissions that needs data on pressures according to the production sectors. Heinze also meant that EPIS-data, when following the production steps for the selected products, does not include all the environmental pressures arising in an economic sector, due to its focus on mass flows and not monetary flows. It would therefore be necessary to add estimations of energy flows that were not taken into account due to the EPIS-technique to make them joinable with the NAMEA-data in the input-output model.

We find that there may be some substance in these arguments, but that it does not prevent the possibility to estimate NOREEA-data with starting-point in given EPIS-data. Concerning the fact that EPIS-data does not calculate indirect emissions, the same arguments can be used as for the use of EPIS-data in an LCA; EPIS-data must be available for all significant activities in the life-chain in order to be applicable.

5 The difference between LCA and IO analysis using NOREEA-data

Life Cycle Assessments and IO analyses with NOREEA-data have a lot in common. Both techniques count the environmental influences that arise from one product, but with quite different methods. Both methods try to catch the indirect environmental effects that arise in earlier stages as a result of the production of a certain product, but LCA does not have the same coupling to different economic sectors and cannot describe the interplay between them as the NOREEA-matrices can. The IO model links the emissions in a much stronger way to economical values and uses the reference unit "emissions of actual substance per NOK" in the calculations. The IO-calculations are based on monetary production, whereas LCA is based on physical production.

To compare the two methods we have to study what are included inside the system boundaries for each of them. Important differences between the two methods are that the IO model includes all the product's life-cycle stages backwards into infinity, whereas an LCA of practical reasons has to demarcate how many stages it is possible to follow. There is also a difference in the level of details. The NOREEA-matrices are limited to the production classification that is used in the economic models. LCA is not limited to any product classification at all, which means that it is possible to specify the product flows in much more detail. The detail level in the IO model is less than in LCA, even if it now is possible to establish NOREEA-matrices with up to 1000 different products. The system boundaries in the IO model are clearly defined by the production classification system. The system boundaries in an LCA are more uncertain, because they are much more flexible and the standard of their definition is dependent of the LCA-constructor's capacity. The higher detail level and freer system boundary definition in an LCA can have a negative influence on the comparability between different systems (Brekke 1998).

NOREEA-data used in the IO model gives more limited system boundaries than in LCA; in the present situation this method only shows air emissions, and only emissions that arise in the production phase of the products life cycle. This means that the life cycle perspective of the study to a large extent disappears. A big disadvantage with the IO model is also that this system only includes what happens inside the Norwegian borders, and not the emissions that arise associated to foreign trade. This results in the limitation that we only get good environmental profiles for the products that are produced in Norway. In chapter 4 we have discussed the possibilities to solve this problem by using land specific EPIS-data from the EPIS-database, for estimating the emissions that arise in other countries for the studied products.

6 Examples and comparisons

6.1 An LCA for paper production and consumption in the Norwegian households

6.1.1 The construction of an LCA for paper production using EPIS-data

This section does not produce a complete LCA, because important parts of the life cycle and emission types are excluded in the studied system. But the LCA-methodology is used on the data, and for simplicity, the studied system and the results will from now on be called an LCA.

In this section, an attempt is made to construct an LCA over the paper production in Norway by using EPIS-data. This example is based on data from the report "Environmental Pressure Information System (EPIS) for the Pulp and Paper Industry in Norway", Rypdal and Tornsjø (2000). The data can be seen in the Material flow characteristics in Table 6 - Table 8 in Appendix 1. The EPIS-report gives the main output emissions to water, emissions to air, and waste. To get a life cycle perspective on the paper production, we need LCI-data for the input categories. In Table 6 - Table 8, data is given for the environmental impact from the production of mechanical and chemical pulp and for the paper production in the paper mills, taken from Rypdal and Tornsjø (2000).

The functional unit for this LCA is 1 tonne of paper produced in Norwegian paper mills. The EPIS-data used in the study is mainly from 1997. Data for the use of raw material in 1997 has been estimated, based on data for 1993 (Rypdal and Tornsjø 2000).

Included inside the system boundaries for this LCA with enclosed environmental impact are the activities paper production, production of mechanical pulp and production of chemical pulp. This is not a complete LCA; it does not include any impact and improvement assessment, and is only a compilation of LCI-data for the production phase of the life cycle for the paper. Not included in the analysis are the environmental impact from the use phase and the waste phase. The emissions arising from the production waste are also outside the system boundaries for this LCA. Probably the main emissions in the life cycle for paper arise in the production phase, and it is also the production phase that is relevant to compare with the results for the IO model. For NOREEA-data used in the IO model, the emissions are arising in the life-cycle phase when the households have consumed the paper not included, but the emissions arising from production waste are included in the account, in contrast to in the LCA.

When it comes to the input of raw materials, the emissions from the production of "Mechanical and chemical pulp" can be found in the Appendix 1, Table 7 and Table 8. The distribution between the production of chemical and mechanical pulp are given in the PRODCOM-database[2]. Of the amount of pulp produced in Norway, ca. 84 per cent is chemical processed and ca 16 per cent mechanical processed. The majority of the Norwegian production of mechanical pulp is integrated with the production of paper. For the production of mechanical pulp, 11 per cent are calculated to come from the non-integrated plants and 89 per cent from the integrated plants. The EPIS-data for the pulp production activities have been rescaled to the functional unit and have together with the data for paper production in the paper mills been included in the resulting LCI-data.

For the input category "Waste paper and board" no indirect emissions shall be included because it is recycled materials. Excluded due to data gaps are the activities for the production of the energy carriers and the production of the input category "Operating substances".

[2] PRODCOM-data for the year 2000. PRODCOM is an international product classification system. This classification gives the correspondence between the product's code and the economic sector in which the product normally is produced.

Table 1. Inventory result for an LCA for paper production, with the functional unit 1 tonne of paper

INPUT	kg/functional unit
Energy carriers	
Wood, residues and black liquor	407.3
Fuel oils[1]	238.76
Other	
Process heat	
Electric power	
Raw materials and operating substances	
Raw materials for mechanical production	86.15
Raw materials for chemical production	969.6078
Waste paper and board	723.1032
Oxygen	:
Operating substances	177.82
Water	
Process water	> 90969
Cooling water	..
OUTPUT	..
Product	1000
Waste water	
COD	45.06
BOD	..
tot-N + tot P	0.152
Suspended matter	1.84
Suspended organic matter	5.6792
Metals	6.2
Waste (total)	108.143
Air emissions	
SO_2	1.92
Nox	1.44
CO_2	761.5
CH_4	0.118
CO	0.161
N_2O	0.0344
NMVOC	0.0976
Pb	0.00015
Cd	5.61E-06
Dust	0.178
H_2S	:

Data not available .. Not for publication :

[1] Include heating oil, heavy distillate and heavy oil.

Source: Rypdal and Tornsjø (2000) + calculations

In an LCA only fossil CO_2 shall be included, because the CO_2 emissions with non-fossil origin are supposed to be taken up by the biomass to the same extent as it is emitted. Data for how large a fraction of the emissions that has fossil origin is missing in the EPIS-data. But if we assume that the major part of the CO_2 emissions comes from the energy carriers, we can see that ca. 37 per cent of the energy carriers are fossil, indicating that the value for the net CO_2 emissions in reality should be lower. In the NOREEA-matrices only fossil CO_2 emissions are included.

Some data are missing in the LCA calculations due to confidentiality rules, as f. ex. factors for the emission of H_2S and the use of other energy carriers.

In Section 2.2.2, some cut-off criteria for an LCA are presented. We try these criteria on the LCI-data for the production phase in Table 1. One cut-off criterion is that the data gaps in the inventory shall not correspond to a contribution that exceeds one per cent to any of the environmental impact categories. This is a matter of judgment, but here we have assumed that if an exclusion of some processes contributes to less than one per cent of the total material flow, this criterion is fulfilled. This analysis passes this criterion if the input categories *raw materials for mechanical/chemical pulp production* can be defined as "followed from the cradle". If the activities *production of the energy carriers used*, and *production of operating substances* is seen as excluded processes, they only represent ca 0.88 per cent of the mass inflow. Some of the EPIS-data are confidential or unknown though, and it is possible that these data could change the result for this criterion.

Another criterion is that the sum of the contribution to the environmental impact from processes described with general data should not exceed 10 per cent of the total contribution to any environmental impact category. This criterion is difficult to implement here, because in this EPIS-report the studied product is general, "1 tonne of paper produced in Norway", which makes it correct to use general data for the paper production in Norway. For some coefficients, factors from a Swedish EPIS-report have been used.

To make this LCA more complete, data to fill in the data gaps has to be found. One possible data source for electricity is the report "Inventory of Life Cycle Data for Hydroelectricity Produced and Distributed in Norway" (STØ 1998a), and data for fuel oils might be found in "Life cycle inventory of Norwegian energy carriers, oil and gas" (STØ 1998b). There are several potential sources of LCI-data. The more specified the data are for the studied system, the better. But if general data has to be used due to data gaps, the EPIS-database is one possible source. There also exist LCI-databases where general data for different industries can be found. One example is the Swedish LCI-database developed by CPM (Centre for Environmental Assessment of Product and Material Systems) at Chalmers University of Technology in Göteborg (http://www.cpm.chalmers.se/).

6.1.2 The emissions from the consumption of the product groups books, newspapers and writing materials in the households

To make this LCI-data for air emissions comparable with the NOREEA-data, the results for the functional unit "1 tonne of paper" in Table 1 have been recalculated to be representative for all the households in Norway. For doing this recalculation, we have to find the total consumption in all the households in Norway for 1993 and 1997. We also only want the data for the paper product groups "Books, newspapers and writing materials". In these calculations, the rough estimation has been made that the direct and indirect emissions from 1 tonne of paper are equal to the emissions from 1 tonne of the product groups "Books, newspapers and writing materials". From the Consumer Survey comes a value on the consumption of the product group "Books, Newspaper and periodicals, various publications and paper products" in NOK. The values per household are in current prices 4041 NOK in 1993 and 4999 NOK in 1997 per year (SN 1996, SN 2000). As a factor for recalculation to get the amount in tonnes, is the weight/price-ratio given in the import statistics for SITC-group 892 and 642 in 1997, used (SN 1999). This gives a total consumption in the actual product categories of 242 066 tonnes in 1993 and 305 364 tonnes in 1997 for the Norwegian households. The resulting air emissions after these recalculations are shown in Table 2.

Table 2. Direct and indirect air emission data for the consumption of the product groups "books, newspapers and writing materials" in the Norwegian households. Tonnes per year

Emission component	1993	1997
SO_2	465	587
NO_x	348	440
CO_2	184 335	232 537
CH_4	28.6	36.1
CO	39.0	49.2
N_2O	8.32	10.5
NMVOC	23.6	29.8
Pb	0.0364	0.046
Cd	0.0014	0.0017
Dust	43.0	54.3
H_2S	:	:

Data not available .. Not for publication :

Source: Calculated from LCI-data in Table 1.

The simplification in these calculations is coarse, because environmental impact from the life chain steps between that the paper comes from paper mills and the refined paper products reach the households, are not included in the LCA.

6.2 Total emissions connected to household consumption of books, newspapers and writing materials calculated with the IO model using NOREEA-data

The Division for National Accounts, Statistics Norway, has calculated total emissions to air resulting from final deliveries of books, newspapers and writing materials to household consumption. The focus of the analysis is on *household consumption* as the economic sector and its consumption of the products *books* (61631), *newspapesr, weekly magazines and periodicals etc*. (61632) and *writing materials* (61633)[3].

The main objective of the calculations is to track all emissions to air caused by household consumption of books, newspapers etc. and writing materials. Not only the direct emissions from using these products, but also the (indirect) emissions resulting from the production process.

The total production by industries can be seen as their production of goods and services for intermediate production, for final deliveries and for export. Combining this total production by industries with statistics showing direct emissions to air by industries, results in a set of direct emission coefficients. The direct emission coefficients show the industries' total emission produced (tonnes) by each amount (million kroner) of production produced.

The direct coefficients show the emissions directly related to the production activities of each of the industries. Books and newspapers are produced by graphical industries, and the direct coefficients of this industry give us the emission related to this final part of the process. However, in this process they use paper etc, which is produced in other industries. We want to sum up all emissions that are related to all the stages of the production chain ending with the finished books and newspapers etc. The IO model can do the job to relate the consumption to all emissions created at the various stages in the production chain, not only from the final producer.

Based on the National Accounts, a matrix of industry *x* industry deliveries of intermediate production is produced, showing each industry's total deliveries to the other industries. From this matrix we derive

[3] The classification of individual consumption by purpose is based on the one presented in SNA 1993 and ESA 1995 (COICOP - Classification Of Individual COnsumption by Purpose). COICOP is now revised.

an IO-table, showing IO-coefficients. The IO-coefficients tell us the change required by the whole economy if one industry is increasing its final deliveries. In this analysis we are focusing on final deliveries to household consumption. We find the total production by industries resulting from final deliveries to household consumption by multiplying the IO-table with a matrix of final deliveries to household consumption.

Finally, multiplying the total production by industries resulting from final deliveries to household consumption with the direct emission coefficients, we find the total emissions to air resulting from final deliveries to household consumption.

Using this method for calculating the total emissions to air resulting from final deliveries to household consumption, has its limitations. First, both the direct emission coefficients and the IO-coefficients are constant and independent of changes in production level. Secondly, only intermediate deliveries and emissions from domestic production are included.

In Table 3 and Table 4, results from the calculations are shown. The tables show the emissions of the main emission components, and also the total emission of greenhouse gases calculated into one value using Global Warming Potentials (GWP_{100}), and emission of acid forming gases calculated into one value using Potential Acid Equivalents (PAE).

Table 3. Direct and indirect air emissions from the Norwegian households in 1993 using NOREEA-data. Tonnes

1993	CH_4	CO_2	N_2O	CO_2-equivalents	NOx	NH_3	SO_2	Acid equivalents
Household total	**151 250**	**5 038 720**	**6 168**	**10 127 000**	**44 626**	**14 536**	**6 269**	**2 021**
Studied product groups total	1 033	40 455	18	68 000	246	11	83	9
Books	243	9560	4	16 000	58	3	19	2
Newspapers, periodicals etc.	715	28233	12	47 000	170	8	55	6
Writing materials	75	2662	1	5 000	18	1	8	1

Source: Section for National accounting, Statistics Norway.

Table 4. Direct and indirect air emissions from the Norwegian households in 1997 using NOREEA-data. Tonnes

1997	CH_4	CO_2	N_2O	CO_2-equivalents	NOx	NH_3	SO_2	Acid equivalents
Household total	**159 311**	**5 651 244**	**6 392**	**10 978 000**	**49 888**	**16 025**	**5 692**	**2 205**
Studied product groups total	1 100	57 082	25	88 000	314	21	121	12
Books	227	11 690	5	18 000	65	4	24	2
Newspapers, periodicals etc.	805	41 459	18	64 000	229	16	86	9
Writing materials	68	3 933	1	6 000	21	1	10	1

Source: Section for National accounting, Statistics Norway.

6.3 Comparisons between the results for the LCA and the IO model using NOREEA-data

In Table 5, the results for the air emissions for the LCA in Table 2 and for the IO model in Table 3 and Table 4 are compiled for comparison.

Table 5. Comparisons between the two method's calculated direct and indirect air emissions from production of books, newspapers and writing materials used in the households in Norway. Tonnes

	1993				1997			
	LCA	IO model	Difference		LCA	IO-model	Difference	
			Absolute	Relative			Absolute	Relative
CO_2	184 335	40 455	-143 880	-356 %	232 537	57 082	-175 455	-307 %
CH_4	29	1 033	1 004	97 %	36	1 100	1 064	97 %
N_2O	8	18	9	53 %	10	25	15	58 %
NO_X	348	246	-103	-42 %	440	314	-125	-40 %
SO_2	465	83	-382	-463 %	587	121	-466	-384 %

Table 5 shows that the results for the two methods differ considerably for all the studied air emission components. Especially for the two greenhouse gases CH_4 and CO_2 the absolute differences are remarkable. In this LCA, CH_4 emissions from the production waste in landfills are not included, but these emissions are included in the IO model, which can be one explanation for this difference. Using data for waste categories for the pulp and paper industry from Rypdal and Tornsjø (2000) and CH_4 emission factors from SFT (1996), gives CH_4 emissions of ca. 4 000-5 000 tonnes from the landfills. For CO_2, one reason for difference is that this LCA includes all the CO_2 emissions while the IO model only includes the emissions with fossil origin. Only 37 per cent of the energy sources are from fossil fuels in the LCA. If we assume that the fossil fraction of the CO_2 emissions is equivalent, we get CO_2 emissions at ca. 68 000 in 1993 and ca. 86 000 in 1997, which is more in the same size as the values for the IO model.

The NO_X emissions mainly arise from transport activities. For LCA, the transport emissions arising after the paper has left the paper mills are not included, and for the IO-calculations, some emissions are lost that take place outside the Norwegian borders, so the results are expected to differ. For SO_2, almost all emissions arise in production processes by the pulp production. One explanation for the low value for the IO model can be found in the import statistics. Emissions from the production of imported paper are not included in the IO model. In the national economic statistics we can find the imported fraction for the product groups books, newspapers and writing materials consumed in the households. This fraction is about 13 per cent in 1993 and 9 per cent in 1997. For earlier life cycle steps in the production chain for the paper products, we have no data for the imported fraction that ends up in the households. But we can find the fractions for paper and pulp imported to Norway. Assuming that these fractions are the same for the pulp and paper ending up in the households, we get SO_2 emissions for the IO model at about 130 tonnes in 1993 and 190 tonnes in 1997. But these numbers are very uncertain, also because no work has been done to try to define more in detail what kind of paper and pulp that ends up in the households, and they are only meant as a way to show the dimensions of the import fraction's influence on the size of the emissions.

The relative difference between the two methods is both positive and negative, which makes it difficult to draw a conclusion regarding the causes of the differences. But some systematic errors due to the differences in the two methods are expected. The NOREEA results are expected to be *smaller* because emissions connected to import are not included. But on the other hand the NOREEA results are expected to be *larger* because emissions connected to transport and production waste are included in more steps in this method. The results are also expected to differ, due to the simplification made in the LCA where we equalize the emissions for paper production and the production of the product groups "books, newspapers and writing materials".

In Figure 1, the system boundaries for the two methods used in the example is drawn. In this figure it is clearly shown that the studied systems are not really comparable. One of the most important differences between the two methods that is not fully shown in the figure, is that NOREEA does not include the air emissions that arise by the production of imported paper products used in the Norwegian households. This is included in the LCA though, but with the assumption that the emissions by the production of the actual paper products are the same in the exporting countries as they should have been in Norway by corresponding domestic production. To find the imported part for all the steps in the life chain, and thereafter find satisfying LCI-data from the exporting countries, would be difficult.

Figure 1. A sketch of the life cycle of the product group "Books, newspapers and writing materials". The system boundaries for the LCA are marked with a dot line (smaller box) and the system boundaries for the NOREEA-system is marked with a broken line

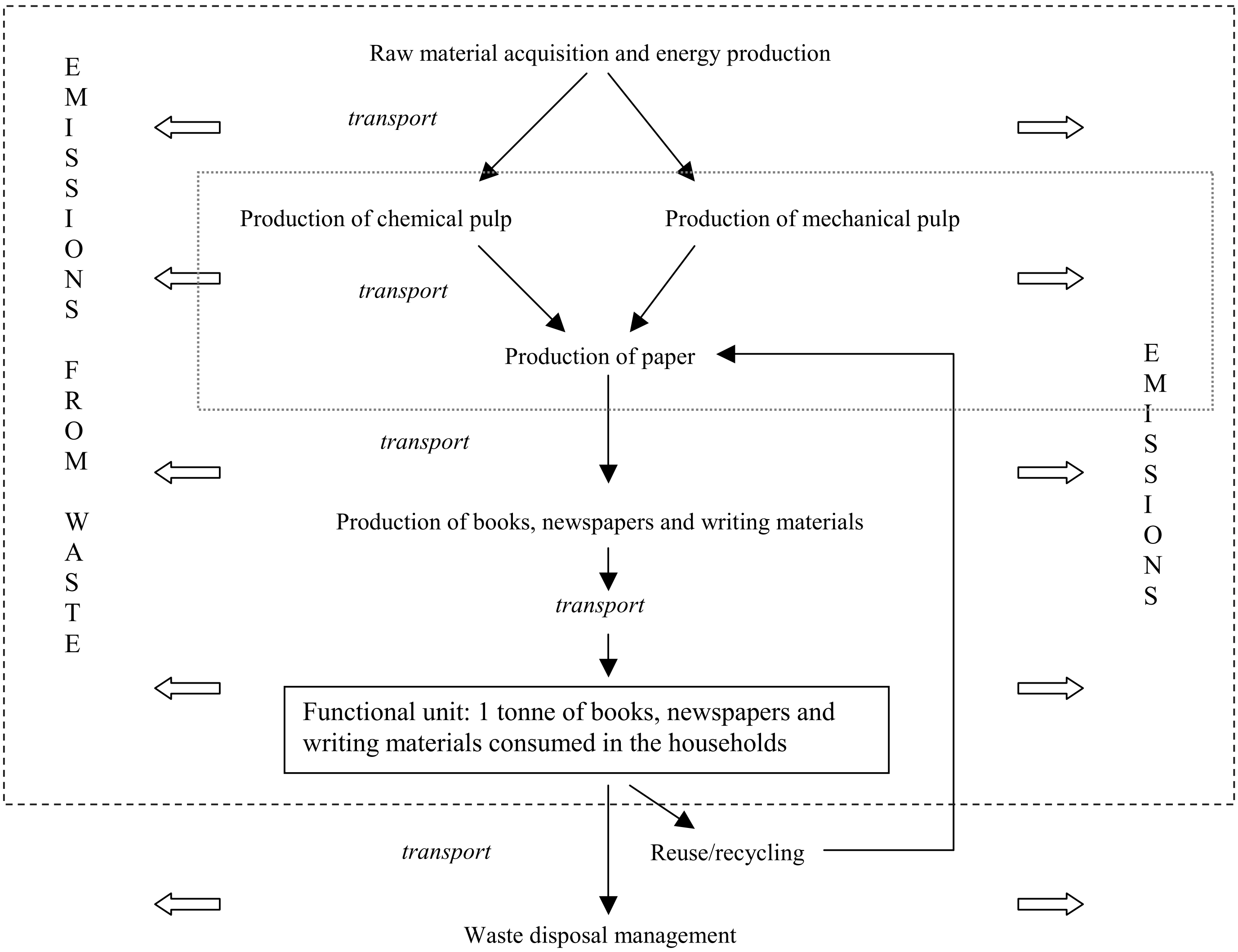

Figure 1 shows that only a small part of the life cycle can be compared, and only specifically air emissions in the production phase, so the life cycle perspective is mainly lost. It is also important to have in mind that this example is not an entirely appropriate comparison between the two techniques for counting environmental influence, because the LCA here constructed has concentrated on using EPIS-data and not the best available LCI-data.

7 Conclusions

Generally speaking, the main differences between LCA- and IO-analyses concern the level of detail of the product and the system boundaries that is analysed. In an LCA-analysis there are possibilities for a high degree of detail, whereas IO-analyses are restricted to the product classifications that exists in the economic matrix. On the other hand, an IO-analysis includes all related life-cycle stages back into infinity, whereas an LCA out of practical reasons has to limit the stages included in the analysis.

To do a more complete comparison of the two methods, a concrete analysis was carried out. In the LCA-analysis EPIS-data were used, and in the OI-analysis data from NOREEA-matrices were used. The analyses were restricted to compare air emissions. The products considered were books, newspapers and writing materials consumed by Norwegian households. These products were chosen because we expected that they were to a large degree produced domestically. Since the IO-method only captures product-related emissions from inside the Norwegian borders, we would get a better comparison of the methods if the problem of "imported emissions" were minimised.

Despite this choice of products in the analysis, the results from the two methods differed considerably. These differences are due to weaknesses in both the methods and the data used. When the differences between to methods differ as much as in our analysis, we consider it to be an important sign that no method alone shows the whole picture of the issue that is being analysed. Until the weaknesses in the methods have been addressed more carefully, our recommendation is to use complementary methods in analysing the environmental pressure arising from specific products.

References

Brekke, K. A. (1998): Om metoder for beregning av miljøprofil for ulike varer, og hva vi trenger det til, (About methods for calculation of environmental profiles, and what we need them for). Notater 98/97, Statistics Norway.

de Haan, M. and S.J. Keuning (1996): Taking the environment into account: the NAMEA approach, *Review of Income and Wealth* **42**, 2, 131-148.

Flugsrud, K., E. Gjerald, G. Haakonsen, S. Holtskog, H. Høie, K. Rypdal, B. Tornsjø and F. Weidemann (2000): *The Norwegian Emission Inventory,* Reports 2000/1, Statistics Norway.

Hass, J. and K.Ø. Sørensen (1998): Environmental profiles and benchmarking of Norwegian industries, *Economic survey* 1/98, 28-37, Statistics Norway.

Hass, J. and K.Ø. Sørensen (2002, forthcoming): NOREEA-project Phase 3: Final report to Eurostat.

Heinze A. (1999): Setting objectives and selecting the means of representing environmental pressures, Methodological comparison between the MEFIS and the EPIS, Eurostat meeting of 25-26 January, Doc. IES/99/5.5A.

Hoem, B. (2001): Environmental Pressure Information System (EPIS) for the household sector in Norway, Documents 2001/12, Statistics Norway.

Rypdal K. and B. Tornsjø (2000): Environmental Pressure Information System (EPIS) for the Pulp and Paper Industry in Norway, Documents 2000/3, Statistics Norway.

SFT (1996): *Utslipp ved håndtering av kommunalt avfall* (Emissions from treatment of municipal solid waste), Report 96:16, the Norwegian Pollution Control Authority.

Statistics Norway (1996): *Forbruksundersøkelsen 1992-1994* (Survey of Consumer Expenditure 1992-1994), Official Statistics of Norway NOS C 317.

Statistics Norway (1998): *Natural resources and the environment 1998*, Statistical Analyses 26, ISBN 82-537-4544-3.

Statistics Norway (1999): External trade 1997, http://www.ssb.no/muh/mu1997

Statistics Norway (2000): Survey of Consumers Expenditure 1997-1999, http://www.ssb.no/emner/05/02/fbu/tab-2000-12-18-01.html

Statistics Norway (2001): *National Accounts 1992-1999 Production, Uses and Employment.* Official Statistics of Norway, NOS C 632, ISBN 82-537-4875-2

STØ (1998a): Inventory of Life Cycle Data for Hydroelectricity Produced and Distributed in Norway, OR.58.98, Oestfold Research Foundation.

STØ (1998b): Life cycle inventory of Norwegian energy carriers, oil and gas, OR.52.98, Oestfold Research Foundation.

Swedish Environmental Protection Agency (1996): *Vägledning för livscykelanalyser LCA* (Guidance for Life Cycle Assessments LCA), Report 4537, Stockholm, Sweden.

The Swedish Environmental Management Council (1999): Bestämmelser för Certifierade Miljövaredeklarationer, EPD: Svensk tillämpning av ISO TR 14025 Typ III Miljödeklarationer (Requirements for Environmental product declarations, EDP: Swedish application of ISO TR 14025 Typ III Environmental declarations), MSR 1999:1

Tillman, A. M. and H. Baumann (1995): *General description of life cycle assessment methodology.* Report 1995:5. Dept. of Technical Environmental Planning, Chalmers University of Technology, Göteborg, Sweden.

Tillman, A. M. and H. Baumann (1999): *The hitchhiker's guide to LCA.* Dept. of Technical Environmental Planning, Chalmers University of Technology, Göteborg, Sweden.

Appendix 1

Data tables from the report "Environmental Pressure Information System (EPIS) for the Pulp and Paper Industry in Norway", Rypdal and Tornsjø (2000).

Table 6. Material flow characteristics for paper production

INPUT	Unit	Value	Value, kg/tP
Energy carriers			
Fuel oils[1]	GJ/tP	6.8	164
Other	GJ/tP	1.7	
Process heat	GJ/tP		
Electric power	GJ/tP	6.4	
Raw materials and operating substances			
Mechanical and chemical pulp	kg/tP		565
Waste paper and board	kg/tP		693
Operating substances	kg/tP		67
Water			
Process water[2]	m^3/tP	> 45	> 45 000
Cooling water	kg/tP		..
OUTPUT			..
Product	tP	1	1 000
Waste water			
Process water[2]	m^3/tP	45	45 000
Cooling water	kg/tP		..
COD	kg/tP		12
BOD	kg/tP		..
tot-N	kg/tP		0.1
tot-P	kg/tP		0.01
Suspended matter	kg/tP		1.7
Suspended organic matter	kg/tP		3.6
Metals	kg/tP		6.2
Waste (total)[2]	kg/tP		50
Production waste	kg/tP		..
Hazardous waste	kg/tP		..
Sludge	kg/tP		..
Waste from energy production	kg/tP		..
Air emissions			
SO_2	kg/tP		1.3
NO_x	kg/tP		0.7
CO_2	kg/tP		523
CH_4	kg/tP		0.02
N_2O	kg/tP		0.005
NMVOC	kg/tP		0.06
Pb	kg/tP		0.0001
Cd	kg/tP		0.000002
Dust	kg/tP		0.1
Difference input-output			-110

[1]Include heating oil, distillate and heavy oil.

[2]Factors from a Swedish EPIS work.

Table 7. Material flow characteristics for mechanical pulp production

INPUT	Unit	Value	Value, kg/tP
Energy carriers (non-integrated)			
Wood and residues	GJ/tP	1	62
Fuel oils[1]	GJ/tP	3.1	77
Other	GJ/tP	:	
Process heat	GJ/tP	:	
Electric power	GJ/tP	6.3	
Energy carriers (integrated)			
Wood and residues	GJ/tP	2.1	135
Fuel oils[1]	GJ/tP	1.4	35
Other	GJ/tP	0.2	
Process heat[2]	GJ/tP	(2.3)	
Electric power	GJ/tP	10.2	
Raw materials and operating substances			
Raw materials	m^3/tP (non-integrated)	2.1	1 037
	m^3/tP (integrated)	1.9	943
Pulp, waste paper and board[3]	kg/tP (integrated)		333
Operating substances	kg/tP (non-integrated)		44
	kg/tP (integrated, pulp/paper)		33
Water			
Process water[4]	m^3/tP (TMP/newsprint)	>15	> 15 000
Cooling water	kg/tP		
OUTPUT			
Product	tP	1	1 000
Byproduct	kg/tP		-
Wastewater			
Process water[4]	m^3/tP (integrated)	15	15 000
Cooling water	kg/tP		..
COD	kg/tP (non-integrated)		40
	kg/tP (integrated)		32
BOD	kg/tP		..
tot-N	kg/tP (non-integrated)		0.66
	kg/tP (integrated)		0.27
tot-P	kg/tP (non-integrated)		0.08
	kg/tP (integrated)		0.04
Suspended organic matter	kg/tP (integrated)		2
Suspended dry matter	kg/tP (non-integrated)		5.7
	kg/tP (integrated)		1
Waste			
Waste (total)[4]	kg/tP (non-integrated)		128
Waste (total)[4]	kg/tP (integrated)		117
Production waste	kg/tP		..
Hazardous waste	kg/tP		..
Sludge	kg/tP		..
Waste from energy production	kg/tP		..

Air emissions	kg/tP		
SO_2	kg/tP (non-integrated)		0.92
	kg/tP (integrated)		0.53
NO_x	kg/tP (non-integrated)		0.43
	kg/tP (integrated)		0.29
CO_2	kg/tP (non-integrated)		246
	kg/tP (integrated)		109
CH_4	kg/tP (non-integrated)		0.02
	kg/tP (integrated)		0.04
N_2O	kg/tP (non-integrated)		0.01
	kg/tP (integrated)		0.01
CO	kg/tP (non-integrated)		1
	kg/tP (integrated)		1.7
NMVOC	kg/tP (non-integrated)		0.1
	kg/tP (integrated)		0.16
Pb	kg/tP (non-integrated)		0.00007
	kg/tP (integrated)		0.00003
Cd	kg/tP (non-integrated)		0.00001
	kg/tP (integrated)		0.00002
Dust	kg/tP (non-integrated)		0.09
	kg/tP (integrated)		0.07
Difference input - output	non-integrated		-203
	integrated		216

Data not available .. Not for publication :

[1]Include: heating oil, heavy distillate, heavy oil and coal.

[2]Double counting of fuel.

[3]Include kaolin.

[4]Swedish factors.

Table 8. Material flow characteristics for chemical pulp production

INPUT	Unit	Value	Value, kg/tP
Energy carriers			
Wood, residues and black liquor	GJ/tP	11.8	834
Fuel oils[1]	GJ/tP	6.1	150
Other	GJ/tP	:	
Process heat	GJ/tP	..	
Electric power	GJ/tP	5.2	
Raw materials and operating substances			
Raw materials	m^3/tP	4.1	2 043
Operating substances	kg/tP		227
Oxygen	m^3/tP	:	
Water			
Process water [2]	m^3/tP	> 94	> 94 000
Cooling water	kg/tP		..
OUTPUT			
Product	tP	1	1 000
By-product			
24.14	kg/tP		16
Waste water			
Process water [2]	m^3/tP	94 (bleached)	94 000
Cooling water	kg/tP		..
COD	kg/tP		63.4
BOD	kg/tP		..
tot-N+tot P	kg/tP		0.2
Suspended organic matter	kg/tP		4.0
Waste			
Total waste [2]	kg/tP		100
Production waste	kg/tP		..
Hazardous waste	kg/tP		..
Sludge	kg/tP		..
Waste from energy production	kg/tP		..
Air emissions	kg/tP		
SO_2	kg/tP		1.2
NO_x	kg/tP		1.5
CO_2	kg/tP		479
CH_4	kg/tP		0.2
N_2O	kg/tP		0.06
CO	kg/tP		0.03
NMVOC	kg/tP		0.05
Pb	kg/tP		0.0001
Cd	kg/tP		0.000004
Dust	kg/tP		0.15
H_2S			:
Difference input-output			1 588

[1] Include heating oil, heavy distillate and heavy oil.

[2] Factor from a Swedish EPIS-work.

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