Miljøprojekt?

nr. xxx 2003

Prioritisation of product groups and product areas in the integrated product policy. Seminar-proceedings.

ANNE MERETE NIELSEN, KIM CHRISTIANSEN AND BO P. WEIDEMA

2.-0 LCA CONSULTANTS

1Introduction

This report contains the proceedings from a seminar held in Copenhagen on the10th of March 2003 including a résumé of the subsequent discussions. The purpose of the seminar was to provide inspiration for the detailed planning of the project “Prioritisation within the integrated product policy” by gaining experiences from Danish as well as foreign projects using input-output data for environmental assessment of products.

Where no author is stated, the summary has been put together by Anne Merete Nielsen, 2.-0 LCA consultants.

In environmental assessment of products, the terms direct and indirect environmental load are often used; however not always in the same way by different authors. The seminar made clear that these terms should be used with caution, if not avoided, since they can be understood in several ways. For example, the term “direct environmental load of a product” is used synonymously to environmental load caused by emissions in

4. the producing industry
5. the use process
6. the use process plus emissions from production of the electricity that is used in the use process

In this report we have avoided using the ambiguous terms wherever possible.

2Introduktion

Denne rapport indeholder resuméer af indlæggene fra et seminar, der blev afholdt i København 10. marts 2003 og resumé af den efterfølgende debat. Formålet med seminaret var at give inspiration til den detaljerede planlægning af projektet "Prioritisering af den integrerede produkt politik" ved at indsamle erfaringer fra danske såvel som udenlandske projekter, der har anvendt input-output data til miljøvurdering af produkter.

Når ingen anden forfatter er nævnt, er resuméet skrevet af Anne Merete Nielsen, 2.-0 LCA consultants.

Ved miljøvurdering af produkter bliver den totale miljøpåvirkning ofte opdelt i en "direkte" og en "indirekte" påvirkning. Denne opdeling foretages dog forskelligt af forskellige forfattere. På seminaret blev det klart, at disse begreber skal bruges med forsigtighed, hvis ikke ligefrem undgås, da de kan forstås på meget forskellige måder.
For eksempel blev udtrykket "produktets direkte miljøbelastning" på seminaret brugt til at dække miljøpåvirkninger foranlediget af emissioner i

4. den producerende industri
5. brugsprocessen
6. brugsprocessen plus emissioner fra produktion af den elektricitet, der bliver brugt i brugsprocessen

I denne rapport har vi så vidt muligt undgået at bruge disse udtryk.

3The ambitions of the Danish prioritisation project

BO WEIDEMA, 2.-0 LCA CONSULTANTS

This paper presents a model for prioritisation within the integrated product policy. The description of the model contains more precise technical details, but is relatively brief and therefore requires prior understanding of the fundamental concepts of environmental life cycle assessment and input-output analysis, such as presented in the Nielsen & Weidema (2001).

The model description serves as a specification of the model development during phase 2 of the project "Prioritisation within the integrated product policy" funded by the Danish Environmental Protection Agency.

3.1General description of the model

The model is an environmentally extended Input-Output table, also known as a NAMEA (National accounting matrices including environmental accounts) for the Danish domestic production and consumption, with the following improvements compared to the NAMEA already published by Statistics Denmark:

- more detailed description of the product use stage,
- more detailed description of the product disposal stage,
- more detailed description of industries at the level of product groups,
- improved description of imported products,
- improved description of environmental exchanges,
- including quantified uncertainties,
- including market sensitivity,
- including descriptions of environmental improvement potentials,
- made available in a standard LCA-software.

Each of these improvements is described in more detail below.

3.2More detailed description of the product use stage

The 73 processes (columns) of private consumption in the official Danish NAMEA (and the similar columns for public consumption) is already a good starting point for a specification of the use stage. To this, we can make the following improvements:

- Placing the already available NAMEA data for "Gas, Liquid fuel, District heating etc. and Gasoline and oil for use in vehicles" in their appropriate columns under "final use", adding the appropriate uncertainty.
- Disaggregating "final use" columns that currently contain an inappropriate aggregation of consumption activities for which separate emission data are available or are expected to become available during the project.

- Distributing consumption data (cell or column entries) over other "final use" columns, thereby linking related consumption activities (for example, the column electricity may be distributed over the other columns that contain the final uses to which electricity is applied).
- Aggregating columns when this leads to a simplification of the model without loss of important information in relation to the purpose of the project.

Possible sources of data and inspiration are:

- The experiences from our Dutch sister project, where 350 products and services were screened for direct emissions (Goedkoop et al. 2002),
- Dall & Toft (1996), where the consumption of 812 types of products was linked to 22 groups of household activities. The study was recently updated (Dall et al. 2002), this time based on the consumption statistics and including an ecotoxicological assessment of the use of household chemicals.
- The Dutch "life style" project (Nonhebel & Moll 2001) and the Perspektief study (Schmidt & Postma 2003).

3.3More detailed description of the product disposal stage

However, the link between monetary flows and physical flows is especially weak for wastes and scrap, due to their low value. Most often, waste services are paid for, while a few industries may have so valuable scrap products that they can be sold. All in all, the information in the NAMEA-matrices gives little information on how the activities and emissions from these industries are related to the products that cause the waste.

The modelling of the waste handling will therefore be improved by:

- Using data from the Danish "Information System for Waste and recycling" (ISAG), which includes a detailed inventory of hazardous waste and waste-import and export by OECD-code (from year 2001 the industrial waste is divided over 11 supplying sectors), to disaggregate the above-mentioned industries per waste type, with particular emphasis on isolating the waste types that involve important environmental effects.
- Adding emissions factors for each such disaggregated waste handling industry, based on data from available models for treatment of waste in life cycle assessment, with estimated uncertainties.
- Distributing use of waste treatment services in final use (cell or column entries in the NAMEA) over other "final use" columns, thereby linking waste treatment to the consumption activities creating the waste, again with a focus on fractions with important environmental effects.

3.4Description of industries at the level of product groups

The purpose of a more detailed description of industries is to reduce the problem that very different products from the same industry are assigned the same emission factors (environmental impact per DKK).

The selection of industries for more detailed description can be based on two criteria:

- high emission factors for a product group within the industry, or for the industry as such; also seen in the light of how product groups can best be delimited for regulatory measures,
- the reduction in uncertainty that can be achieved by subdivision of the industry into product groups, which depends on the quality of the available data for subdivision.

It is especially important to identify products or product groups with a high emission rate per DKK that "hide" within industries with a low emission rate, as else these may be overlooked.

The following data are needed to make a meaningful subdivision of an existing industry in the NAMEA:

- Environmental data of adequate quality for an identifiable product or product group within the industry. In this context, "adequate quality" implies a degree of completeness and validity, which is at least as good as that available for the whole industry via the NAMEA.
- The production value of the new product groups.
- The purchases and sales values per industry for the new product groups.

With this information, the production value and the environmental data can be subtracted from the similar data for the whole industry. The remaining part of the industry is then the residual, and can be named consequently, e.g. if creating a new sub-sector "Stainless steel" and subtracting it from the sector "Manufacture of basic ferrous metals" the residual sector can be named "Basic ferrous metals except stainless steel" (in national statistics, a residual is often signified by the abbreviation n.e.c. = "not elsewhere classified", which we may also use when appropriate).

Data sources for the above information are (in order of priority):

- The supply-use table from Statistics Denmark, which links the 130 industries in the NAMEA to 2859 product groups, can be used to identify sectors that require subdivision as well as information on production value and the trade between sub-sectors.
- A version of the supply-use tables with indication of physical quantities, which is very useful for linking to LCA data.
- A survey of Danish sector statistics performed as part of this project, with a view to assess their applicability for sector subdivision.
- The structure and arguments for specifying the 966 groups of industrial products from the project "Environmental prioritisation of industrial products (Miljøprioritering af industriprodukter)" (Hansen 1995).
- Life cycle data, i.e. data from life cycle assessments or LCA databases. It is important to be aware that life cycle data will often be less complete than NAMEA-data with respect to purchased inputs, which may call for combining the environmental part of life cycle data with NAMEA-data for some of the lesser inputs.
- Direct contacts to industry experts.
- Data from more detailed foreign NAMEAs (especially the American), duly corrected for use in Denmark.

3.5Improved description of imported products

In the official NAMEA, there are no separate environmental exchanges reported for imported products. In traditional Input-Output Analysis, the standard assumption is that a foreign production sector has the same emission factors (environmental exchange per DKK) as the corresponding Danish sector.

This assumption may be applied in an initial analysis, but will be replaced by more appropriate assumptions when possible.

As a prerequisite for such improvements, the geographical origin of the imported products must be identified, in terms of countries or country groups for which emission factors are available or can be estimated. Statistics Denmark can provide a breakdown of the imports on country groups.

The simplest improvement that can be made is to replace the Danish emission factors (for the imported products) by emission factors that are more representative for the foreign production sectors. Such emission factors can be obtained from foreign NAMEAs or other sources. This improvement can be done for selected, important products, or as a general procedure. For some production sectors, the available foreign data may be of so low quality that the standard assumption (to use Danish emission factors) may be preferable.

The next improvement option is to link the foreign NAMEAs directly to the Danish NAMEA. This will allow more detailed modelling, e.g. of improvement options, market sensitivities etc. The linking of the Danish NAMEA to two foreign NAMEAs is illustrated in figure 3.1.

DK domestic production	DK domestic consumption	DK exports	Emission factors and emissions	Danish NAMEA *3.5.0.0.0.0.1*
Imports to DK production	Imports to DK consumption	Imports to DK re-exported		

↓

DK domestic production	DK domestic consumption	(DK exports to country group 1)	(DK exports to country group 2)	Emission factors and emissions	Danish IO table linked to two country groups´ production IO tables
Imports to DK production from country group 1	Imports to DK consumption from country group 1	Production I/O of country group 1	(From country group 1 to country group 2)		
Imports to DK production from country group 2	Imports to DK production from country group 2	(From country group 2 to country group 1)	Production I/O of country group 2		

Figure 3.1. Linking of the Danish NAMEA to two foreign NAMEAs.

The parts in brackets may be left out in this project; for the Danish exports because this is of less importance to the problem studied; for the country-to-country tables because of lack of readily available data. In effect, the implicit assumption is that the foreign country groups are relatively self-contained economies (with little import and export). Correcting this assumption require substantial resources, so only the most important corrections will be made in this project.

3.6 Improved description of environmental exchanges

By placing the NAMEA data in a standard LCA-software (SimaPro 5.1), the calculation results can be coupled with any desired environmental assessment method, such as EDIP or Eco-indicator 99, and specific weighting factors can be associated with any of the environmental impact categories.

The official Danish NAMEA covers both energy related emissions and non-energy related emissions of CO_2, SO_2, NO_x, NH_3, NMVOC, CO, CH_4, and N_2O.

The Danish Institute of Local Government Studies (AKF) is currently performing a project "Environmental assessment of the Danish consumption pattern (Miljøvurdering af danskernes forbrugsmønster) for the Danish Social Science Research Council in which the environmental impact of 72 product groups are studied. The project links the 72 product groups to the 135-industry NAMEA and supplements the latter with further environmental data based on the CORINAIR database. From this project, data on VOCs, PAHs, CO and heavy metal emissions have been obtained.

For toxicity, the EDIP normalisation data show high importance of arsenic, lead, cadmium, cobber, mercury, chromium, zinc, PM_{10}, CO, pesticides, benzene, PAH, toluene, xylene, dioxins, tetrachloroethylene, and tetrachloromethane. Since the purpose of the EDIP normalisation is exactly to provide a "complete" reference value for the total toxic emissions in the context of LCA, it is seen as a natural starting point for this project to distribute these normalisation values over the originating industries. For very unhomogeneous industries (like the chemical industry), it may be necessary to allocate the emissions over the products (i.e. to subdivide the industry according to products with important emissions). Since the EDIP normalisation data may in practice be less complete than desired, we will in addition investigate which substances contribute significantly to the total toxicity values in the TRI-based score used in the American and Dutch NAMEAs, and investigate what industries these come from. If important substances are thereby identified (in addition to the ones in the EDIP data) - we will - starting with the substances that come out with the largest contributions - seek to obtain specific Danish and/or European emission data for inclusion in the NAMEA data used in this project.

The NAMEAs of Goedkoop et al. (2002) also cover road traffic noise and land use. For land use, the normalisation data in Weidema & Lindeijer (2001) will be distributed over the relevant production industries.

Other possible sources of data are:

- Eurostat's annual data on 48 environmental pressure indicators for the EU, which in some cases have a breakdown of the contribution from specific industries.
- OECD bi-annual compendium of environmental data. For EU countries data, collection is done jointly with Eurostat.
- The Dutch Pollutant Release and Transfer Register (PRTR) via the Data Warehouse Emission Registration (approximately 100 pollutants and 100 source categories).
- Data from mass flow analyses performed for the Danish EPA, which cover aluminium, brominated flame retardants, cadmium, chromium, copper, dichlormethane, trichlorethylene, tetrachlorethylene, dioxins, lead, mercury, nickel, phthalates, tin (organotin), and wood preservation agents.

- Other recent Danish EPA projects, a number of pre-projects to suggest action plans for selected sectors, as well as a number of cleaner technology reports.
- Foreign NAMEAs, e.g. EU (Eurostat), the American 485-sector and the Japanese 399-sector NAMEAs.

3.7 Including quantified uncertainties

For the prioritisation, it is an obvious advantage to have an expression of the uncertainty of the environmental impacts for each of the product groups.

The uncertainty in the NAMEA is mainly stemming from the implicit assumptions that:

- industries are homogeneous with respect to inputs from other industries and outputs to other industries (inputs and outputs per DKK),
- industries are homogeneous with respect to emission factors (emissions per DKK), and
- foreign industries have the same emission factors as the corresponding domestic industries.

Thus, the uncertainty can be reflected by a CV on each cell in the input output table and on each emission factor. Estimates of these CVs can be derived from aggregated tables where we have access to the underlying disaggregated tables.

3.8 Including market sensitivity

Using retrospective NAMEAs to answer prospective questions like the one we pose with this project: "What environmental measures will give the largest reductions in environmental impacts?", may lead to wrong results, since some of the processes included in the NAMEA may not be able to change their production capacities in response to market-based environmental measures. This problem can be overcome by adjusting the input-output relations to reflect the actual prospective market reactions.

Each industry is therefore analysed systematically for long-term production constraints. This means that for each industry or product group, it should be asked:

- Are there any regulatory or political constraints that determine the production output, so that this output cannot change in response to a change in demand?
- Does the sector have any co-products, the output of which cannot change in response to a change in demand, since it is determined by the demand for a determining product?
- Are there any long-term constraints in availability of raw materials, waste treatment capacity, or other necessary production factors?

For each constrained supplying industry or sub-industry, starting with the ones with the largest production value, the alternative most sensitive suppliers are identified (or in the case of input constraints, the most sensitive alternative consumption or treatment route). Details on procedures for identifying most sensitive suppliers can be found in Weidema (2003b).

A separate copy of the NAMEA, named “market based model”, is created. In this version of the NAMEA:

- For industry internal constraints (typical for homogeneous products such as electricity), the industry is divided in a constrained and a non-constrained part,
- The constrained supplies are transferred to the alternative non-constrained industry.
- The constrained outputs are added as separate products in new final use columns named “industry name (constrained supplies)”. Since a constrained industry is still relevant for non-market-based environmental measures, this new product shall take part in the prioritisation in the same way as any other product.
- The additional supply from the non-constrained supplying industry is matched by an identical reduction in the entry for that industry in a new column “Constraints adjustments”.

In this way, the total production volume and thus the total emissions of all sectors are kept constant, while making the model sensitive to life cycle simulations.

Besides the interactions described above, there may be other interactions between different industries and their products that should be taken into account when assessing the importance of different product groups. For example, a technology development in the one industry may lead to changes in consumption patterns affecting other industries indirectly. Also the product-oriented environmental measures may in themselves have indirect effects beyond the product group(s) that they target. It will be considered how such interactions and indirect effects can be identified and included in the analysis in a systematic way, while avoiding the introduction of additional bias and uncertainty.

3.9Descriptions of environmental improvement potentials

The standard NAMEA expresses the magnitude of the environmental exchanges from each sector, not the possible change (improvement potential) in these exchanges.

Therefore, the potentials for environmental improvements in the industries (internally and in the product lifecycles) will be assessed and described based on existing sector descriptions. Industries with a sufficient potential for environmental improvements will be divided into a BAT[*]-industry and a residual. This is entered into the “market based model”.

Two kinds of improvement potentials are to be described:

- industry internal improvement potentials, i.e. a reduction in emission factors
- lifecycle improvements, i.e. improvements that imply increased efficiency (reduced use of inputs) or substitution of inputs.

These two kind of improvements may be connected, but involves different changes in the NAMEA (change in emission factors and change in input flows).

---

[*] BAT = Best Available Technology

3.10 Questions following the presentation

Q - Mark Goedkoop: What if the time does not allow all the ambitions to be fulfilled? What is the required part?

A - Bo Weidema: All the described elements of the model will be addressed but level of detail of each element will depend on the available budget.

3.11 Literature

Dall O, Toft J. (1996). Miljøbelastningen ved familiens aktiviteter. København: Forbrugerstyrelsen. (Rapport 1996.1).

Dall O, Toft J, Andersen T T. (2002). Danske husholdningers miljøbelastning. København: Miljøstyrelsen. (Arbejdsrappport 13).

Goedkoop M J. (2003). Database Manual Dutch Input Output Database 95. PRé Consultants.

Goedkoop M J, Madsen J, Nijdam D S, Wilting H C. (2002). Environmental load from private Dutch consumption. In the Proceedings of the 5th Ecobalance Conference, Tsukuba.

Hansen E. (1995). Miljøprioritering af industriprodukter. Copenhagen: Danish Environmental Protection Agency. Miljøprojekt 281. http://www.mst.dk/udgiv/Publikationer/1995/87-7810-301-0/pdf/87-7810-301-0.PDF

Müller-Wenk R. (1999) Depletion of Abiotic Resources Weighted on the Base of "Virtual" Impacts of Lower Grade Deposits Used in Future. IWOE Discussion Paper no 57. St. Gallen: IWOE. (see also http://www.iwoe.unisg.ch/service).

Nonhebel S, Moll H C. (2003). Evaluation of options for reduction of greenhouse gas emissions by changes in household consumption patterns. Bilthoven: RIVM. (Report 410 200 059).

Nielsen A M, Weidema B P. (2001). Input/Output-Analysis - Shortcut to life cycle data? Proceedings of a workshop held in Copenhagen on the 29th of September 2000. Copenhagen: Danish Environmental Protection Agency. (Environmental Project 581). http://www.mst.dk/udgiv/publications/2001/87-7944-365-6/pdf/87-7944-366-4.pdf

Pedersen O G. (1999). Physical input-output tables for Denmark – Products and materials 1990, Air emissions 1992. Copenhagen: Statistics Denmark.

Schmidt T, Postma A D. (2003). Minder energiegebruik door een andere leefstijl? Project perspectief, december 1995-juni 1998, eindrapportage. Rotterdam: CEA, Bureau voor communicatie en advies over energie en milieu BV.

Schmidt K, Poulsen P B, Schmidt A. (2003). Model til udpegning af fremtidige indsatsområder for Program for renere produkter. København: Miljøstyrelsen. (p.t. only available as final draft).

Stranddorf H K, Hoffmann L, Schmidt A. (2003). Normalisation and weighting - update of selected impact categories. Technical report from the project: "LCA-metodeforbedring/metodeudvikling og konsensusskabelse, Delprojekt 4" København: Miljøstyrelsen. (p.t. only available as final draft).

Suh S, Huppes G. (2001). Environmental IOA of the Industrialised World - A project description. Pp. 69-75 in Nielsen & Weidema: Input/Output-Analysis - Shortcut to life cycle data? Proceedings of a workshop held in Copenhagen on the 29th of September 2000. Copenhagen: Danish Environmental Protection Agency. (Environmental Project 581). http://www.mst.dk/udgiv/publications/2001/87-7944-365-6/pdf/87-7944-366-4.pdf

Treloar, G.J. (1998). A Comprehensive Embodied Energy Analysis. Australia: Faculty of Science and Technology, Deakin University.

Weidema B P. (2000). Can resource depletion be omitted from environmental impact assessments? Poster presented at SETAC World congress, Brighton UK, May 2000

Weidema B P. (2003). Market information in life cycle assessments. Technical report from the project: "LCA-metodeforbedring/metodeudvikling og konsensusskabelse, Delprojekt 2: Systemafgrænsning" København: Miljøstyrelsen. (p.t. only available as final draft).

Weidema B P, Petersen E H, Øllgaard H, Frees N. (2003). Reducing uncertainty in LCI. Developing a data collection strategy. Technical report from the project: "LCA-metodeforbedring/metodeudvikling og konsensusskabelse, Delprojekt 2: Systemafgrænsning" København: Miljøstyrelsen. (p.t. only available as final draft).

4Selection of future effort areas in the Danish IPP - the pilot project

Anders Schmidt from dk-TEKNIK ENERGY & ENVIRONMENT presented the project "Model for identification of future fields of action within the program for cleaner products". This project was a pre-project for the current project "Prioritisation within the integrated product policy".

4.1Purpose and method

The purpose of the pilot project was to develop a preliminary model for screening/prioritisation of possible and relevant areas for future environmental efforts towards products and product groups in the Danish IPP. The model should be used to identify 3-5 relevant areas (lines of business or product groups) for product orientated environmental efforts in 2002.

The following procedure was applied:

1. Lines of business and commodities were coupled, and economic data for Danish supply was established.
2. All commodities were environmentally assessed, and the results were also weighed by economic importance.
3. The sub-lines of business producing commodities with a "high" ranking in step 2 were selected, taking the action potential into account as well as which lines of business had already been subject to IPP-efforts.

4.2Coupling of commodities and lines of business

The Danish supply was calculated from data in the commodity statistics from Statistics Denmark. Here information on the domestic productions, export and import, split up on a 2-digit combined nomenclature level (99 product groups in total, 4 omitted), was used. Export was omitted from the calculations, therefore little focus was on environmental impacts from products that mainly are being exported.

The size of the lines of business was quantified from data found in DB93, which is the Danish equivalent to NACE. This was done on the 3-digit code level which identifies 106 sub-lines of business with a production, and for 40 sublines of business within 4 general lines of business. The general lines of business are

- supply of electricity, gas water and heat
- building and construction
- trade (retail and wholesale)
- transportation

The lines of business and the commodities were coupled via data from Statistics Denmark.

4.3 Environmental assessment

The environmental data for the Danish productions was estimated from the American EIOLCA-database (EIOLCA.net, 2002).This has the implicit assumption that the US lines of business are comparable to Danish lines of business with respect to the products being produced within the line of business, and that the relative environmental impacts (that is the impacts per produced value unit) are the same in Denmark and the United States. Absolute impacts are not considered in the prioritisation

In EIOLCA 72 types of environmental indicators are quantified for 485 product groups. 8 indicators were chosen:

- Global warming potential
- SO_2
- NO_x
- Water consumption
- Toxic releases
- Energy consumption
- Consumption of copper
- Generation of hazardous waste

Data from the commodity statistics were matched to the EIOLCA by choosing all product groups in EIOLCA that matches the products within a given 2-digit CN-code. If more than six product groups were available in EIOLCA, 5-7 representative groups were chosen. For some product groups, none or imperfect matches were found, e.g. for fish, wool, nickel, lead and zinc.

4.4 Ranking procedure

Three criteria were applied for giving priority to the commodities

- Environmental importance

A commodity is given high priority if 3 out of 8 environmental indicators are rated as ”high”, i.e. belonging to the upper third in the ranking of the 95 commodities. 45 commodities were selected from this criteria.

- Combined environmental/economic importance

A commodity is given high priority if 3 out of 8 environmental indicators are rated as ”high”, i.e. belonging to the upper third in the ranking of the 95 product groups, when the impacts per produced value unit is multiplied with the Danish supply of the commodity. 34 commodities were selected from this criteria.

- Both approaches

Nineteen commodities with a "high" ranking by the two previous procedures were selected for further examination along with 3 commodities with high environmental priority and high export/low supply, in total 22. The selected groups were

- Fish
- Dairy products
- Salt, clay, stone, cement *
- Mineral fuels *
- Inorganic chemicals *
- Organic chemicals *
- Fertilizers *

- Paints, varnishes
- Cleaning products
- Glues, proteins, enzymes
- Misc. Chemical products *
- Rubber and rubber commodities *
- Plastics and plastic commodities
- Tricotage
- Commodities of stone, gypsum, etc *
- Glass and glassware
- Iron and steel *
- Commodities of iron and steel *
- Copper and copper commodities *
- Aluminium and aluminium commodities *
- Misc. Metal commodities *
- Locomotives *

Subsequently, groups without a ”*” were deselected because of previous or planned initiatives, leaving them being of minor interest in the current context.

4.5Reporting database

For the 14 final groups, the following information was entered in a database:

- Eco-labelling criteria? (Number of licenses in Denmark)
- Green purchasing guidelines?
- Product panel?
- Line of business initiatives under Programme for Cleaner Products?
- Environmental approval requested for the line of business?
- Line of business initiatives under Programme for environmental management?
- Number of EMAS- and ISO 14001 registrations
- Support from Programme for environmental competence?
- Number of companies (3-digit level) and employees

Further, the following elements were described

- Which product groups on 4-digit CN-code level are covered by the 2-digit level
- Percentage of overall supply, import/export in percentage of supply
- The relation of the product group to (sub)-lines of business
- Number of companies and employees within the line of business
- Environmental assessment
- Supply chain
    - Purchase of raw materials from other lines of business (raw materials statistics)
    - Import/export from/to other lines of business (foreign trade statistics

4.6Improvement of the model

Based on the pre-project, Anders Schmidt suggested that further work should remember to

- Verify basic assumptions and describe limitations
- Increase the level of detail with respect to the number of commodities (the Danish commodity statistics (2-digit level, 96 groups) were determining for the level of detail in the pilot project)
- Increase the level of detail by further exploitation of EIOLCA, e.g. to 200 product groups
- Increase the number of parameters used and their precision by
    - Calibration of EIOLCA with Danish environmental statistics
    - Extract and use more parameters from EIOLCA (e.g. ressource parameters)
    - Include consumption of chemicals (Product Registry)
    - Include generation of different types of waste (ISAG – registration, weight of production)
    - Include use and disposal phases based on LCA information or common knowledge.
- Include political and economical aspects in some ways?

4.7 Questions following the presentation

Q – José Potting: In the selection procedures, both impact pr. unit and total impact was used. In the latter case, where the production volume is included, there is a risk of giving high priority to a product group, just because it is not subdivided. For example, agriculture would come out high, but if it is subdivided into individual food items it could fall below other product groups.
A- Anders Schmidt: High production volume was only used to check bias in the selection. Food products were not included in the selection due to other initiatives being already taken, but would else have been given high priority.
A – Mariane Hounum: We are not prioritising individual products but product groups.
Q – Göran Finnveden: A similar procedure in Sweden ended up with electricity and buildings as top-scorers.

4.8 References

EIOLCA.net. (2002). Carnegie Mellon, Green Design Initiative. Database available at http://www.eiolca.net/.

Schmidt K, Poulsen P B, Schmidt A. (2003). Model til udpegning af fremtidige indsatsområder for Program for renere produkter. København: Miljøstyrelsen. (p.t. only available as final draft).

5 An integrated approach to analyse the impact of the Danish consumption. NAMEA and environmental effect index

Trine S. Jensen, from the National Environmental Research Institute, Department of Policy Analysis presented an integrated approach combining consumption of goods with environmental profiles into an environmental index. The integrated approach is used in the project "Environmental Assessment of the Danish consumption" (Wier et al, 2000), where it combines three methodologies

1. National Accounting Matrix including Environmental Accounts (NAMEA) and input-output analysis (linking products and environmental impacts)
2. Environmental index (aggregation of different environmental impact)
3. Data envelopment analysis (prioritisation of products with respect to environmental impact)

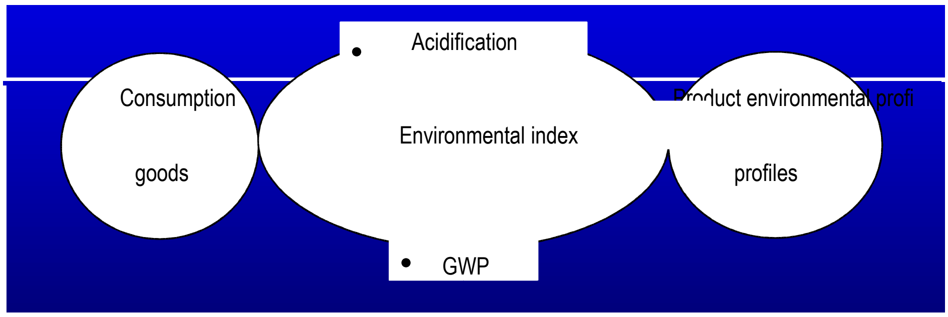
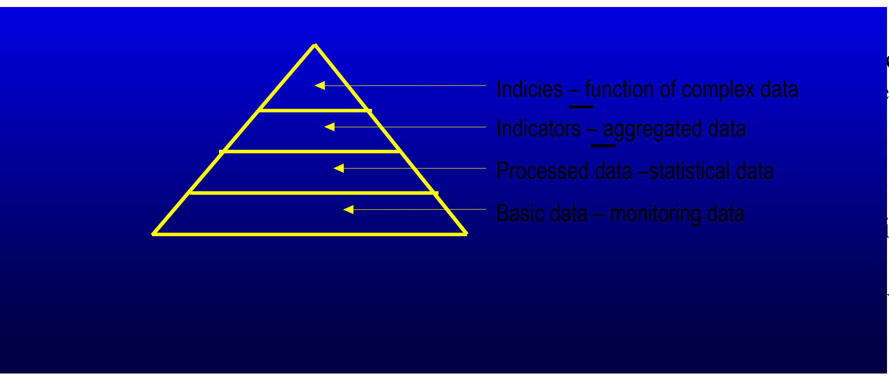


Figure 5.1: Outline of the integrated approach

5.1 Extension of NAMEA

NAMEA has been extended to include more environmental parameters as listed below:

- Material flow Accounts indicators with an industrial breakdown (DMI, direct material input, and TMR, total material requirement)



cal oxidation
ir photochemical oxidation potential (POCP))

, trichlormethane, methylbromid, HCFC's and
ial (ODP))

with greenhouse effect

(CFC113 and HFC's and their global warming potential (GWP))

- Industrial greenhouse gassees
  (HFC's, C3F8 and SF6 and their GWP)

- Priority metals (air emission)
  (Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn (kg))

- PAH (air emission)
  (benzo(a)pyrene, fluoranthene, benzo(b and k)fluorathene, benzo(ghi) perylene, indeno(1,2,3-cd)pyrene (kg))

- Waste accounts with an industrial breakdown based on a material balance principle (supplementary to the new information system for waste and recycling – (ISAG))

5.2General considerations

Indexing is a way of presenting data in an aggregated form that may otherwise be difficult to interpret. When individual indicators are aggregated into environmental indexes, it serves three purposes, which are simplification, quantification and communication.

Data aggregation can be illustrated by the information pyramid shown in figure 5.2. At the bottom you find the basic data, e.g. monitoring data. At the top of the information pyramid you find indexing of data, i.e. a complex function of the basic data. Statistical data is structuring of basic data. Selection of representative data or aggregation of statistical data is used as indicators.

Figure 5.2: The information pyramid.

Examples of aggregated indexes include

- Greenhouse effect index (GWP)
- Acidification index
- Ozone depletion index
- Photochemical oxidation index
- Air emission of hazardous chemicals index
- Groundwater pollution of pesticide index
- PVC consumption index

5.3Aggregation based on science or preferences

Scientific based environmental index are indexes, where environmental themes with equal environmental effects are weighed based on scientific knowledge of the relation between environmental load/pressure and effect. E.g. global warming potential index, acidification potential index and the ozone depletion potential index.

On the other hand, preference based environmental index are indexes, where environmental themes with different environmental effects are weighed based on subjective value setting. This is used to compare between non-comparable environmental parameters, e.g. aggregation of different thematic environmental indexes into one index. Preferenced based index can be used to set values of environmental goods, e.g. cultural landscapes, biodiversity, etc.

Examples of preference based methods are:
1) multiple criteria decision making methods, e.g. Distance to Target and the Analytic Hierarchy Process methods, or
2) economic cost based methods e.g. Cost Benefit Analysis or Cost Effectiveness Analysis.

The challenge for preference based environmental index is to reach a certain degree of consensus about the weight, so the index becomes widely accepted, and thus can be used for priority and target setting.

In the project presented at the beginning of this presentation the aim is among other, to extent the existing list of scientific based index. Further the aim is to evaluate the importance of using different preference bases weights on the ranking of consumption goods.

5.42.2 Aggregated index – for and against

Aggregated indexes have some clear advantages compared to individual indicators. The advantages include their power to present environmental issues to non-environmentalists and interpret complex data set. Because of this, they can be used as a tool for prioritisation. It may also be more relevant to set up targets for aggregated areas, rather than for individual emissions.

Against aggregated indexes speak that they have a tendency to focus on the environmental value of the index, instead of the environmental problem, and may be difficult to interpret. Therefore aggregated indexes must always be supplied with further information about how to interpret the index, how the index it put together and present the data behind along with the index.

5.5References

Wier M, Munksgaard J, Keiding H, Jensen TC; Bastrup-Birk, A; Gravgaard Pedersen O. (2000). Miljøvurdering af danskernes forbrugsmønster - metoder til rangordning og sammenvejning af forskelligartede miljøeffekter (projektbeskrivelse)

Christensen, N; Møller F (2001). Nationale og internationale miljøindikatorsystemer. Metodeovervejelser. Faglig rapport fra DMU, nr. 347.

6Addressing toxic impacts in IO-LCA - what are the problems and what can be done?

Michael Hauschild from the Institute of Product Development started by stating that a top-down approach definitely has its place in chemical LCA.

In conventional LCA with the bottom-up approach, u
pstream impacts are nearly completely ignored due to lack of data. This can lead to serious underestimations, because recent research on traditional LCA for chemicals indicates that the major chemical impact lies upstream, even for many "down the drain" chemicals.

Figures for total contribution to toxic impacts in Denmark is already inventorised as basis for the normalisation references for impact assessment of human toxicity and ecotoxicity in the EDIP method for LCIA. The challenge then is to allocate this sum correctly between the lines of business. This gives rise to two kinds of questions:

- Does the normalisation reference really reflect the level of the emissions of toxic substances in Denmark?
- How can this sum be allocated to the individual lines of business to best reflect the toxicity impacts arising from the individual products?

6.1The certainty of the normalisation reference

In EDIP97 (Wenzel et al., 1997), the normalisation reference was inventorised for the six impact categories addressing toxic impacts, which were three for ecotoxicity (water acute, water chronic, and soil) and three for human toxicity (air, water and soil).

The ambition was to estimate the figure within the right order of magnitude for 1990. Therefore only 10-20 most important activities and substances were included. However, the result for aquatic ecotoxicity was more or less confirmed by an update based on 1994 figures and following a different approach for some of the activities.

For human toxicity categories the uncertainty is much higher. It is certain, that the estimate is too low, because many activities were excluded from the study. But it is not certain that the most important emissions in the reference actually are the most important of the actual impact. Since the ambition with the normalisation references was to reach the right order of magnitude, the potential error is 90%, even if this ambition was actually succesful.

6.2Allocating toxic emissions to individual lines of business

Assuming the level of toxic emissions in Denmark is known, the next question arises: how can this sum be allocated to the different lines of business, which make up the total production in Denmark? In other words: how can we estimate how much of the total toxic emission comes from the textile industry, how much from agriculture etc.?

For energy-related impacts, the allocation can be based on the amount of MJ used by the different productions/activities. There are small differences between the impacts of fossil fuels, and some difference depending on preventive measures, but the uncertainty of this calculation seems to be reasonable.

For use of resources (incl. land-use), allocation based on the amount of product kg or m^2 also seem reasonable, even though there are significant differences according to scarcity. Furthermore, the number of different entities (resources or habitats) is limited.

Similarly, chemical–related impacts may be allocated based on the amount of kg. But here, there is a devastating difference according to substance properties, and furthermore the number of substances potentially contributing is extremely high (10-20.000 in products in Denmark). Additionally there are enormous differences in the emissions from single productions/activities according to preventive measures (cleaner production).

An alternative could be to allocate toxicity according to use of chemicals, measured as amount of import from chemical line of business. This approach has the disadvantage, that a chemical is not a chemical in the same way an energy carrier is an energy carrier. There are huge differences between the toxicity of different substances. Furthermore, "use" of a chemical is not the same as "emission", because the substance may stay in the product (perhaps waiting to be emitted at a later stage) or it may react to form a new chemical.

Process conditions are very important for emissions, and hence, the impact of the emission may depend considerably upon geographic location. Finally, some substances are formed in the processing, and are emitted without being used at all.

Facing all these obstacles, it is clear that allocation based on one single parameter is not enough. The lines of business must be studied further. A possible procedure could be to focus on the lines of business with highest chemical impact. These could be identified and ranked based on

- US EPA's TRI database
- perhaps Dutch industry sector emission figures
- perhaps further sources from Denmark

When limiting the number of lines of business, it will be possible to base the allocation on deeper knowledge on the type of chemicals used in the different lines of business.

6.3 Why not just forget the whole thing?

Before facing a task with so much uncertainty and so many details, it may be fruitful to stop and think, if the topic is worth the effort. Are the chemical impacts important at all? How much damage do they actually cause (and how much of it in developing economies? The common perception that chemicals form an important and largely unknown threat to human and ecosystem health may be a distorted picture, nonetheless it still influences society's priorities. Anyhow, *a precautionary approach says that chemical impacts must be included.* If chemical impacts are important, it will not make sense to rank the products without taking them into account. On the other hand, if chemical impacts are not important, it might be possible to take toxicity into account in a less time-consuming, more qualitative way?

6.4Questions following the presentation

Q – Bo Weidema: Maybe the product policy is not the best way of regulating chemicals?
A – Michael Hauschild: Lists of the most important chemicals regulated by the EU covers 10-50% of impacts; the 100.000's other chemicals are not addressed individually. Therefore, the product policy may still be used to address this general chemical "pressure".
Q – Mark Goedkoop: Would it be possible to test the practicability of different methods?
A – Michael Hauschild: Yes, good idea.
Q – Ole Dall: I am wondering how it can be that even for chemicals that are emitted fully in the use stage, the impacts up-stream can still be dominating?
A- Michael Hauschild: This is the experience from a case study within pulp and paper. It includes not only the production of the chemicals but all upstream emissions, using risk assessment estimation when data were not available.
Q – Trine Susanne Jensen: Maybe the product register data can be used?
A - Bo Weidema: This discussion will be continued in the afternoon (see chapter 14).

6.5References

Wenzel H, Hauschild M and Alting L. (1997). Environmental assessment of Products. Volume 1: Methodology, tools and case studies in product development. Kluwer Academic Press.

7Economic modelling of consumer behaviour

METTE WIER, THE DANISH INSTITUTE OF LOCAL GOVERNMENT STUDIES (AMTERNES OG KOMMUNERNES FORSKNINGSINSTITUT)

There are various ways of economic modelling of household behaviour linking household behaviour to the associated environmental consequences.

One traditional way of modelling describes the household as a production unit, producing e.g. meals, clean clothes, cleaning services etc. An example is shown in figure 7.1, focussing on washing clothes. The household applies inputs such as water, dirty clothes, electricity, laundry detergent, labour and a washing machine. The desirable output is clean clothes, and the undesirable outputs are dirt, waste water, and emissions related to energy consumption. The main point is that the quantity of the undesirable outputs is highly related to the production technology, i.e. the proportions in which the inputs are used. This has to do with various factors such as vintage of the washing machine, energy and water saving attributes of the washing machine, the content of the laundry detergent, and others.

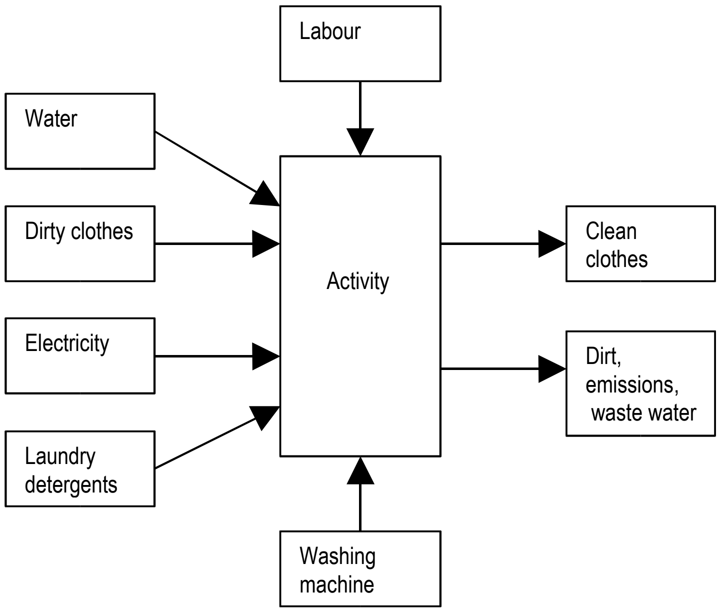
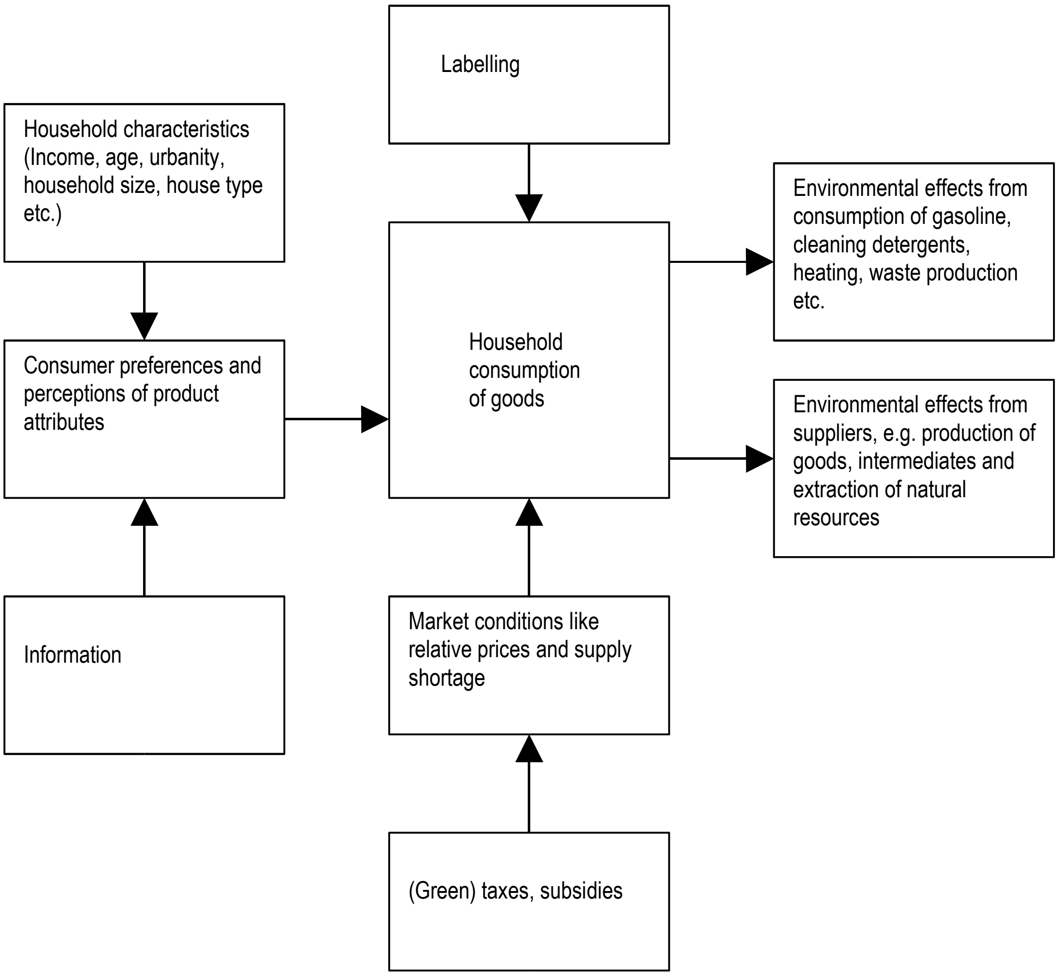


Figure 7.1. Household production model

Another more general – and widely applied – framework of economic household behaviour modelling is shown in figure 72. The figure shows the variables applied in the modelling and how they are assumed to influence consumption pattern. However, less often, environmental effects from the use stage and environmental effects from the supplying processes are included in the system. Environmental effects from the use stage are effects from consuming the goods in the household (e.g. private transportation, heating, etc). Environmental effects from the supplying processes are effects taking place in the production sectors in the economy when producing the consumption goods, e.g. producing furniture, clothes, foods etc. These effects can be linked to the economic flows by combining input-output tables, social accounting matrices (or household budget data) and the NAMEA system.

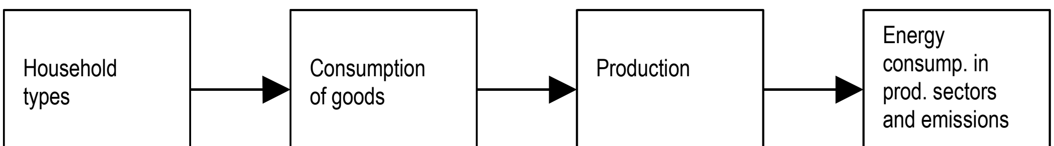
Figure 7.2. A modelling framework of household behaviour and environmental effects.

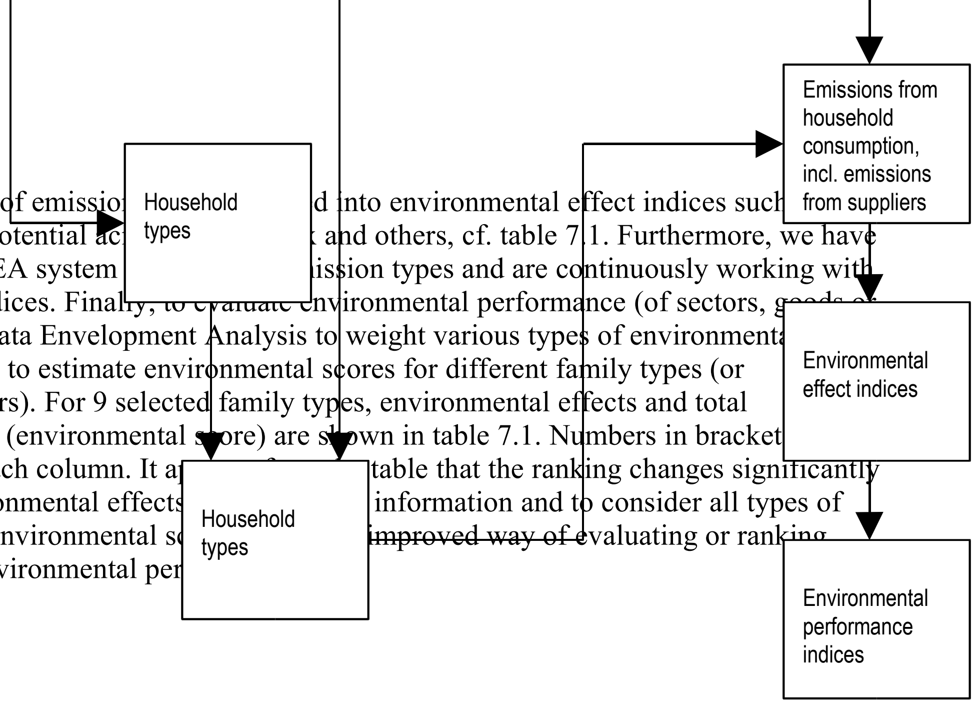
In an ongoing project taking place at AKF, funded by the Danish Social Science Council, we have developed a general integrated model linking household consumption of goods, production of goods, and various types of environmental effects from the use stages and the supplying processes. The model is developed in cooperation with Copenhagen University, National Environmental Research Institute, Energy Agency and Statistics Denmark.



In the model, we combine Danish household budget data with input-output tables and the NAMEA system, cf. figure 7.3. Using this approach, it is possible to compare the environmental profiles across sector, across goods, or even across household types.

Figure 7.3. The integrated model system.





In the model, various types of emissio[illegible]d into environmental effect indices such [illegible] global warming potential, potential ac[illegible]k and others, cf. table 7.1. Furthermore, we have extended the Danish NAMEA system [illegible]ission types and are continuously working with constructing new effect indices. Finally, to evaluate environmental performance (of sectors, goods or household types), we use Data Envelopment Analysis to weight various types of environmenta[illegible] together, making it possible to estimate environmental scores for different family types (or alternatively goods or sectors). For 9 selected family types, environmental effects and total environmental performance (environmental score) are shown in table 7.1. Numbers in bracket[illegible] the ranking, according to each column. It a[illegible] table that the ranking changes significantly depending on type of environmental effects[illegible] information and to consider all types of environmental effects, the environmental sc[illegible] improved way of evaluating or ranking households according to environmental per[illegible]

.1. The environmental scores for different family types.

	Potential acidification index	Photochemical oxidation index	Global warming potential index	Ozone depletion index	Water consumption	Total material requirement	Cadmium	Benzen(a)pyrene	Environ-mental performance score
	Mol/1000 DKK	g/1000 DKK	kg/1000 DKK	mg/1000 DKK	m3/1000 DKK	kg/1000 DKK	mg/1000 DKK	mg/1000 DKK	%
Low income									
Urban-flat	12 (2)	67 (2)	85 (3)	110 (8)	1.3 (7)	298 (2)	1.10 (9)	5.19 (9)	104 (4)
Urban –house	13 (7)	83 (4)	96 (6)	98 (3)	1.1 (6)	311 (5)	0.87 (1)	3.59 (2)	103 (5)
Rural-house	14 (8)	97 (8)	109 (9)	92 (1)	0.9 (2)	316 (6)	1.01 (7)	4.15 (6)	102 (6)
Middle income									
Urban-flat	12 (3)	81 (3)	83 (2)	111 (9)	1.4 (8)	302 (3)	0.95 (6)	4.43 (8)	98 (7)
Urban –house	13 (6)	92 (7)	94 (5)	102 (6)	1.0 (4)	321 (7)	0.89 (2)	3.58 (1)	97 (8)
Rural-house	14 (9)	111 (9)	108 (8)	101 (5)	1.1 (5)	344 (9)	0.95 (5)	3.90 (5)	94 (9)
High income									
Urban-flat	10 (1)	57 (1)	73 (1)	92 (2)	1.4 (9)	288 (1)	0.88 (3)	3.77 (4)	109 (3)
Urban –house	12 (4)	87 (6)	91 (4)	101 (4)	0.9 (3)	306 (4)	0.89 (4)	3.64 (3)	117 (1)
Rural-house	13 (5)	84 (5)	97 (7)	103 (7)	0.7 (1)	323 (8)	1.04 (8)	4.36 (7)	110 (2)

8Modelling of waste in IO-based analysis

OLE DALL, COWI A/S

All projects I have been involved in took offset in calculations based on physical materials/products - not value. The value based statistics do usually not count waste since it typically has no value. I will point out some sources for statistical information I have used dealing with waste.

8.1Waste in a LCA-perspective

• Important but difficult
It is obvious that if materials only are calculated as an input it will be wrong. For example is the metals for a car reused more than 90% and therefore the amount used per car is less than 10% of the input.

But it is on the other hand just about as difficult to make a waste handling model as to make a product assembly model. Every product has to be split in different materials and treatment methods. And the statistics are poor since waste often has low value.

• Time span between use and waste - accumulation
Another problem is that there often is a time span between production and waste phase for the products (f.ex. buildings which easily can be more than 100 years), which makes it very difficult to tell how the product is treated as waste. The solution could be to define production and disposal within same year even though that is wrong to - this at least solves the accumulation problem, but do not take in account the development in treatment method.

• The “value” of waste
To calculate "the value of waste" one need to know what the incineration or recycling actually saves. This is in some cases obvious if it saves primary materials, but can be more complicated by the development of new recycling processes. What are the savings of using rubber granulates from tyres as surface layer in sport arenas?

• Lack of data
Of course there is lack of data for splitting up the waste treatment of different methods as there is lack of LCA-data for different treatment methods. But it can possible be estimated in most cases.

8.2Projects

• Environmental burden of household activities (Dall and Toft, 1996) and (Miljøstyrelsen, 1996)
The project made LCA-screening for the use of 800 typical household products. The typical waste handling was specified for every material in all the products.

For every material there was specified an average treatment processes. For example the household waste was 87% incinerated and 13% deposited, and the energy recovery was calculated for the incinerated part.

• Environmental ranking of industrial products
The project took offset in the trade statistics and evaluated 900 groups of industrial products. The method was to split up the products in materials and for every material evaluate the energy use and the percent of material that was lost by use. There was used a default value for the loss of every material unless there was found a specific value for a product. The project database in access format provides a uniq information source for material composition off all kinds of products. The waste treatment method was not evaluated. The project was performed by Erik Hansen et. al. (Hansen, 1995).

• LCA-based indicators for waste and treatment
The main project and the methodology project aim to evaluate the waste treatment system in Denmark and have developed tree LCA-based indicators for calculation the savings by waste treatment. The indicators are saved energy, saved resources and saved deposition of waste which are obtained by incineration or reuse instead of deposition. The project takes offset in the Danish waste statistics (ISAG) and many other sources of information about the material content in the waste streams. This is reported for 27 types of materials, and the potentials for optimised waste handling is calculated for every material. The data for material contents and waste handling can be used to evaluate the waste treatment of the products in IO-based calculations (Miljøstyrelsen, 2002 and 2003).

• Possible instruments for increased recycling of hazardous waste
This was a project performed for The Danish environmental agency, and the aim was to evaluate the if the reuse of hazardous waste would increase if there was a deposition fee. The project was based on the EWC (European Waste Catalogue) registration categories for hazardous waste, which was used in combination with the ISAG-registration to point out which types of hazardous waste that already is reused and where there might be any potentials. The registration in EWC-categories is new in Denmark (first time in 1999) and is done together with the ISAG registration. The possibilities is that the EWC-statistics splits up the waste according to the business sector from where the waste origins.

The 3 main problems are:
1) that the registration method is new and therefore often gives inexact information on waste types
2) other materials than hazardous are only briefly registered and
3) the EWC-registration does not register treatment method.
The latter can partly be compensated since the Danish ISAG statistics have information about treatment, but on aggregated level for the both statistics (which are the public sources) the connection can only be made in coarse groups. (Miljøstyrelsen, finalised 200? - but not published yet!)

8.3Data for waste, weight and treatment

• Data for waste treatment in Denmark –ISAG gives:
- all primary and some secondary waste types
- waste fractions and main source
- not products, materials nor business line

• Metals

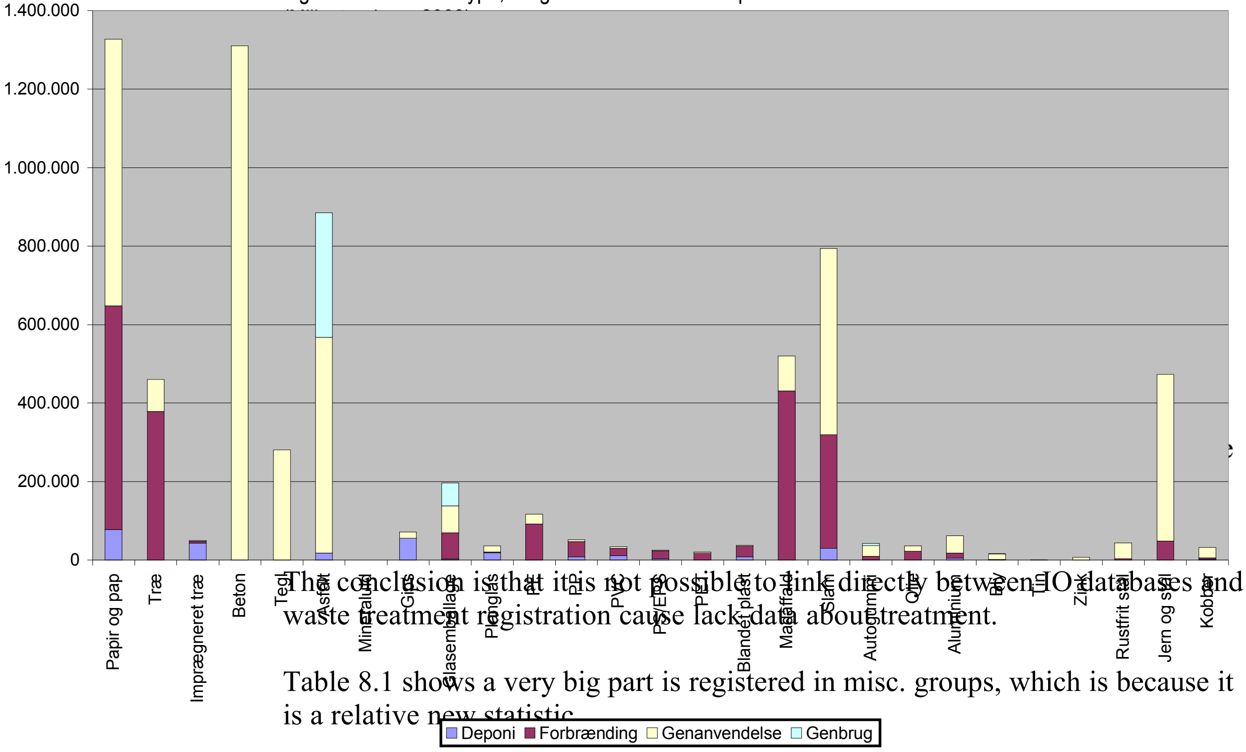
No detailed registration - all metals for reuse are registered as one group - and most iron missing as waste.

• Packaging
Not registered separately - the biggest problem is that packaging is included in IO statistics together with the main product, but has to be treated separately.

• Household waste
No separate registration of materials in ISAG, but good supplementary analysis.

• Actual treatment
Is registered in ISAG.

Figure 8.1: Waste - Type, weight and treatment The picture is from Indicators for Waste treatment



The conclusion is that it is not possible to link directly between IO databases and waste treatment registration cause lack data about treatment.

Table 8.1 shows a very big part is registered in misc. groups, which is because it is a relative new statistic.

Table 8.1: Groupings in European Waste Catalogue (EWC).

EAK	NAVN	Total (tons)	Reuse (tons)	Rest (tons)	Reuse (%)
13060100	Other oil waste, unspecified	34.705	29.516	5.189	85
13020200	Unchlored motor-, gear- and lubricant oils	37.852	34.425	3.427	91
13020300	Other motor-, gear- and lubricant oils	1.021		1.021	0
13010500	Unchlored emulsions	274		274	0
5010300	Sediment from tanks	78	16	62	21
12010700	Used, halogen-free cutting oil (not emulsions)	189	139	50	74
5010600	Sediment from maintenance of equipment	1.898	1.892	5	100
	Unspecified	586		586	
	SUM	**76.602**	**65.989**	**10.613**	**86**

8.5What to do?

- Need for individual evaluation of every product, material and treatment
- Is possible if common sense is used!

8.6References

Hansen, E. (1995). Miljøprojekt, 281. Miljøprioritering af industriprodukter

Dall, O og Toft, J. (1996), Miljøprojekt, 26. Kortlægning af miljøbelastningen ved en families aktiviteter.

Forbrugerstyrelsen, 1996. Miljøbelastningen ved familiens aktiviteter

Miljøstyrelsen, 200?. Virkemiddelanalyse for øget genanvendelse af farligt affald (endnu ikke udgivet)

Miljøstyrelsen, 2002. Miljøprojekt, 221. Affaldsindikatorer - metodeprojekt

Miljøstyrelsen, 2003. Ressourcebesparelser ved affaldsbehandlingen- (endnu ikke udgivet)

9Swedish experiences of prioritisation within the IPP

Göran Finnveden from the Swedish Defence Research Agency presented a project made for the Swedish EPA to prioritise the means within the integrated product policy.

The project was in many ways similar to “Prioritisation within the integrated product policy”, but had lower ambitions and lower budget. The aim of the project was twofold:
• to identify which product groups are most significant from an environmental viewpoint, and
•to discuss where in the lifecycle the environmental impacts chiefly arises.

An environmentally extended Input-Output analysis with data from the Swedish System of Environmental and Economic Accounts gave results for products and services going to final demand in Sweden (consumption, investments and export). The parameters under study were

- Energy use
- Air emissions ($C0_2$, $S0_2$ and NOx)
- Use of chemical products

Emissions from the use phase of fuels was added to the fuels. Waste management was not linked to product groups. Calculations were performed with approx 90 product groups/sectors. Results presented with approx 50 product groups/sectors.

To estimate the environmental impacts of imported goods, the foreign productions was assumed to have similar emission intensities as in Sweden. This typically underestimates CO_2 and SO_2-emissions but overestimates NOx (Statistics Sweden)

Two aggregation methods were applied:

- A “dangerous” approach where the aggregation was based on labelling of inherent properties, i.e. toxic, very toxic, harmful, corrosive or irritant.
- A “hazardous” approach where the aggregation is based on labelling of risks for chronic diseases.

Further a separation was made between fossil fuels and other chemical products.

The study showed that the largest environmental impacts came from the following product groups (the product groups are listed according to the median of the parameters):

- Petroleum products
- Electricity, gas, steam and hot water
- Buildings
- Wholesale and retail trade

- Property and real estate management
- Food products and beverages
- Land transportation

The study further showed that the highest intensities of environmental impacts came from the following product groups (again listed according to the median of the parameters):

- Petroleum products
- Sea transportation
- Fishing, aquaculture
- Electricity, gas, steam and hot water
- Metal and steel
- Air transportation
- Non-metallic mineral products (cement, glass)

9.1References

Palm, V., Looström Urban, H., Wadeskog, A. and Finnveden, G. (2002): Kunskap om produkters miljöpåverkan – vad ger dagens statistik? Naturvårdsverket Rapport 5231. (In Swedish with English summary). www.naturvardsverket.se

10Environmental load from private Dutch consumption

MARK J GOEDKOOP, JACOB MADSEN [1] ,DURK S NIJDAM[2,] AND DR. HARRY C WILTING [2]

[1] PRé Consultants; Plotterweg 12; 3821 BB Amersfoort; Netherlands; [2] RIVM; P.O.box 1; 3720 BA Bilthoven; Netherlands

Keywords: Input output databases, consumption, environmental load, monitoring

This paper describes an operational approach to determine the worldwide impacts from consumption in the Netherlands. An important innovation is the use of linked input output tables that cover the world wide trade and economy, albeit that the input output tables are rather coarse. The framework can also be used to improve input output datasets for other countries or regions, and can be the starting point of a worldwide LCA dataset to which each country can connect its own input output database.

Each economy has an economic input output table, that specifies the value of the purchases between sectors within the country and abroad (the imports), as well as the supplies to other sectors and the exports. Furthermore all other major costs and revenues are specified.

These tables have been used by several LCA experts to compile input output (I/O) databases (Joshi, 2000) for a general overview. Environmental data per sector is divided by the added value, resulting in an environmental load per unit of value. These ratio's can be used to link the environmental load to all supplies thorough the economy, enabling us to get a total environmental load of the outputs of all sectors.

10.1Towards a system of interconnected IO tables

A yet unsolved problem is how to deal with imports and exports. Traditionally LCA practitioners that used IO datasets have used the assumption that the environmental load per unit of added value for imports and exports are identical (Joshi, 2000). An apple in Europe has the same load as an apple in the USA. However, it is clear that there are some problems in assuming that the environmental load connected to an agricultural product produced in the EU has the same load as a product produced in developing countries. Some research indicates that, especially for trade with non OECD countries, the environmental load per unit of value is an order of magnitude higher compared to production in OECD countries (Goedkoop, 2000).

In a large economy such as the USA, the lack of specific data for imports may not be too relevant for most sectors, but when smaller, and more trade oriented economies are analyzed this may lead to significant distortions. This paper describes how we can link a national IO table to a set of three international IO tables that span the world economy. We believe that this approach can be generalized, so that other researchers can add their own National IO table.

10.1.1The environmental load from consumption

The dataset presented here is the result of a project commissioned by the Dutch government. The project originates from the desire to be able to trace the impacts of its policy on the environmental load of private consumption on a national level. For that purpose, a system has been developed that links consumer expenditure to the environmental load it creates. The intention is to update the system every 5 years and to monitor the trends.

10.1.2Direct and indirect environmental load

It is important to distinguish between direct and indirect environmental load caused by consumption.

- The direct environmental load is defined as the load that occurs after a product or service has been purchased by the consumer. IO databases cannot cover such load, they trace economic flows up to the point the consumer purchases the product.
- The indirect environmental load is the load that occurs before the product or service has been purchased. Basically this is the load produced by economic activities. This load can assessed in IO databases

This distinction can be clarified with a simple example. When the consumer purchases paint to decorate his own house, the *indirect* environmental load is the load associated with the production of the paint, the packaging and the distribution, The *direct* environmental load is the load that comes from the emission of solvents. The direct environmental load is *not* the same as the “use phase” in LCA. For instance electricity consumption is regarded as indirect, the consumer purchases the electricity. Similarly, the production of fuels for a private car is regarded as indirect load but the exhaust gasses from the car is regarded as direct environmental load.

This distinction seems slightly artificial, it is however very useful, as the indirect environmental load can be well covered with environmental input output tables

10.1.3Consumption patterns

In most countries a detailed analysis of consumer expenditure is available. Such a statistic specifies average expenditure by consumers over a large range of products and services. For this project we used the data from the Central bureau of Statistics (CBS, 1997). on expenditure over 350 products and services. Some products occur several times in the list. For instance car use for recreation and car use for shopping are kept separate.

The products and services can be analyzed for the direct environmental load. To determine the indirect environmental load a link was made to 105 industrial sectors as defined in the Dutch economic input output table. As we will see these Dutch sectors are also linked to input output tables in other parts of the world.

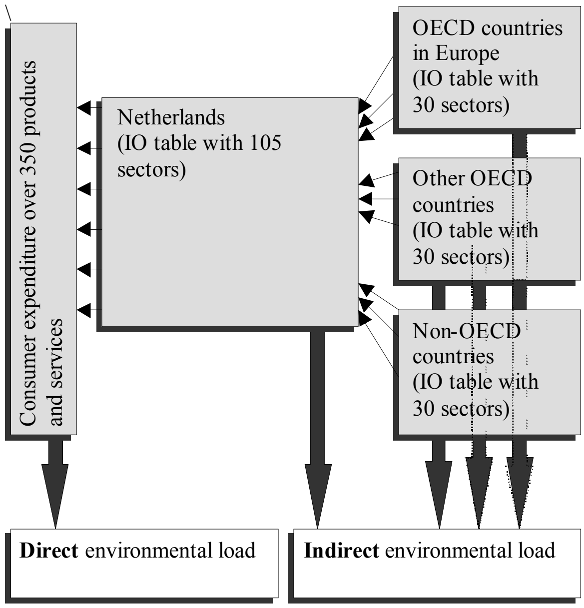


Figure 10. 1 Overview of the financial flows throughout the economies to the Dutch consumption pattern.

10.1.4 Selection of elementary flows

The Dutch government specified a list of 20 elementary flows or "stressors". These are:

- Emissions of CO2, CO, CH4, NOx, SOx, N2O, HFC's/ HCFC's, non methane VOC, benzene, PAHs, heavy metals, nitrogen, phosphate, PM10 (dust),
- Land use, water consumption, wood use, fish extraction, use of pesticides.
- Truck, Car and Moped kilometers, especially to assess the nuisance caused by noise

10.1.5 Direct environmental load

The 350 products and services have been screened to determine if they result in any direct environmental load. About 20% of these have a direct environmental load. LCA databases and other sources are used to determine the direct environmental load. An analysis showed that the major contributions to the direct environmental load are associated with (top 5 only, in descending order):

1. Car driving for work and recreation
2. Gardening (fertilizer and pesticides)
3. Wood and Coal, used in fireplaces and old stoves
4. Heating
5. Cleaning

Of course this ranking also depends on weighting across impact categories, here equal weights were used of all elementary flows (emissions, resource use etc.)

10.1.6Indirect environmental load in the Netherlands

The Dutch input output matrix has 105 sectors. The National “emission registry” system maintains a detailed data inventory for industrial activities. This database has been used to run queries that produce datasheets per sector. Significant amounts of work were needed to convert the data to a format that is consistent with the definition of the stressors and the sectors. For a number of stressors, such as land use, other data sources needed to be used.

10.1.7Indirect load outside the Netherlands

The “rest of the world” is split up into three regions:

1. OECD countries in Europe
2. Other OECD countries
3. Non OECD countries

For each of these regions, thirty sectors were defined that were taken from the DIMITRI and EDGAR database ((Wilting et al., 2001 and Olivier, 1996). These databases already have data on Energy use, CO_2, NO_x and SO_x per country and per sector, so it is relatively easy to create datasets for these stressors per region. To cover the other stressors a wide range of sources has been consulted. In order to focus the efforts, an analysis was made using the GTAP database to identify which countries or regions contribute most to an industrial activity. The focus was to find data for these countries and regions first, and extrapolate this data over the whole region. Of course the data collection was not complete, and often extrapolations have had an important influence.

10.1.8Connecting the IO tables

The use of different sector definitions for the Netherlands (105 sectors) and the three regions that cover the rest of the world (30 sectors each) requires a conversion routine. This routine has been established in the following way, see figures 10.1 and 10.2:

- An aggregation table has been constructed that specifies which of the 105 Dutch sectors can be aggregated to one of the 30 international sectors.
- Each Dutch sector has 105 domestic purchases and 105 imports. The 105 imports were converted into 30 imports using the aggregation table.
- Dutch trade statistics have been used to determine which share of each import comes from region 1, 2 and 3. Competing and non competing imports have been treated in the same way. Also here a 30 sector aggregation has been used.

In figure 10.2 a schematic overview of the procedure is given

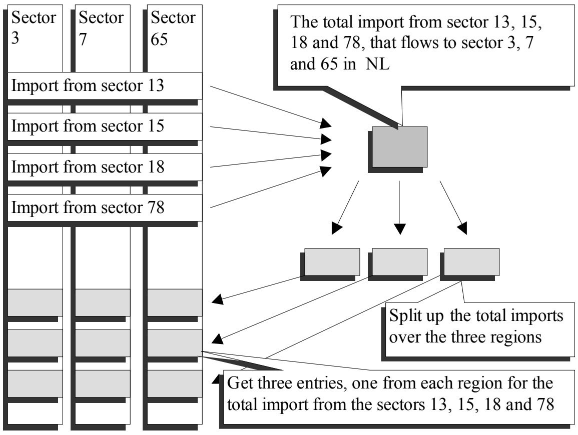


Figure 10.2: Overview of how we can replace data on import in the 105 sector definition to imports in the 30 sector definition, specifying the three regions

So far flows between the three world regions (see figure 10.1) have not yet been implemented, but in principle sufficient data is available to link these flows too.

10.2 Some results

The results of the procedures described above can be summarized in a few graphs. First we analyze the relative share of the different "consumption domains" to a selected set of impact category indicators. A domain is defined as a group of purchases. Instead of the individual emission an aggregation has been made, mostly using the CML 2001 impact assessment method (Guinée et al., 2001).

Figure 10.3 shows that for most impact categories food plays a dominant role in the consumption patterns. Recreation and working expenditure are quite heavily dominated by expenditure on car transport. This shows that the use of cars is also an important contribution to the load.

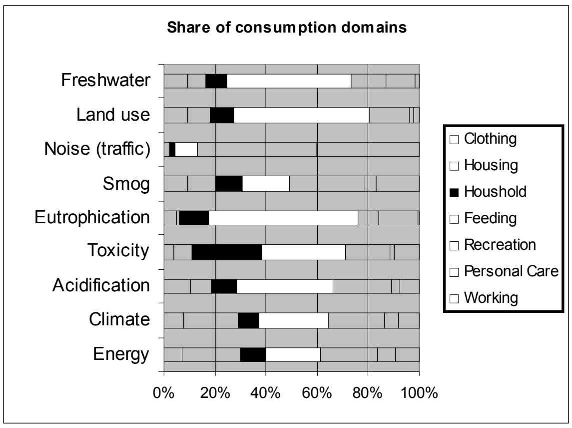


Figure 10.3: Share of the consumption domains over the environmental impact categories (direct and indirect, all regions).

Another result is the analysis of the direct versus the indirect environmental load. This shows that especially road noise is associated with direct environmental load. This is partly a distortion due to the fact that truck kilometers and car kilometers are considered to have the same impact. Indirect load is dominant in most other impact categories.

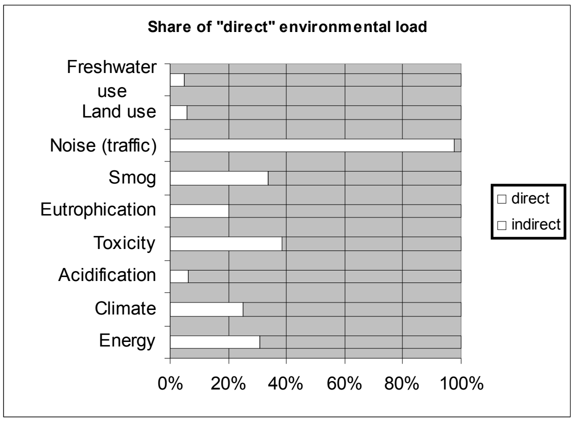


Figure 10.4: Share of the "direct" environmental load, caused by the consumer, in relation to the indirect load that is caused by economic activities (all regions).

Another view is obtained when we analyze the relative contribution of the load from the regions. Here we can see that the Non OECD have a relatively high contribution, especially in land-use and acidification. This is remarkable, as the value of the imports of this region is relatively modest. The Netherlands get 66% of the imports from Europe and only 17% from the Non OECD countries. The contribution of toxic emissions within the Netherlands is remarkably high. One explanation is that the share of direct consumption of household (which occurs always in the Netherlands) is high for toxicity.

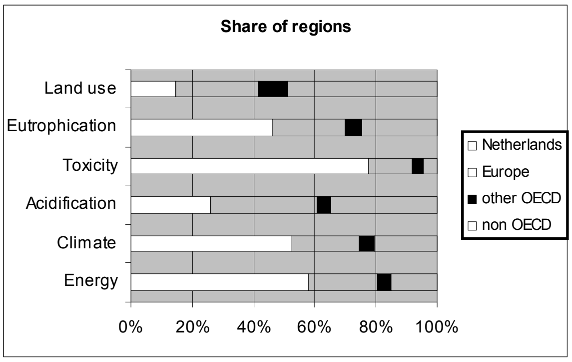


Figure 10.5: Share of the regions total environmental load (direct and indirect)

These results allow us to get an insight into the dominant and less dominant issues related to private consumption. For instance it seems that many LCA studies are focusing on products within the household consumption domain, while this study shows that this is an important domain. There are other consumption domains that are much more important to focus on. Especially the environmental load related to the food productionchain seems to deserve more attention.

10.3Use of the connected IO tables in LCA

The environmental load that is associated with imports is quite significant for a relatively small economy. The importance of the imports from the non OECD countries is much more important than the trade volume with these countries suggests. This either indicates that the prices for these products are much too low, or that the pollution in the non OECD countries is significantly higher, compared to OECD countries. Clearly the assumption used in IO based LCA databases that the imports can be dealt with by assuming the environmental load per unit of value for imports is the same as for the domestic production, can lead to significant errors for smaller economies as the Dutch.

With the insights and framework developed in this project we think we can offer a more or less generic solution for the LCA communities that are interested in modeling I/O databases for smaller and trade intensive economies. The three IO tables for the world regions are available for anyone that wants to link their economy to. Of course we must consider some important limitations:

- A 30 by 30 sectors I/O dataset has a limited specificity; for instance all metals come from the sector base metals, and thus we cannot distinguish between steel and copper or gold.
- It has been very hard to get relevant data for the three regions. Often data had to be extrapolated from one or just a few (important) countries to the whole region.
- Only data for 20 stressors (elementary flows) have been collected.
- Most of the data is for 1995 (this the requested base year by the commissioner)

In spite of these limitations, we believe it is valuable to experiment further with this approach, and start to join forces to link all I/O LCA database in order to develop and improve a word-wide IO data network.

10.4Questions after the presentation

Q – José Potting: Have these data been added to the SimaPro software? Is it possible to link to process data for hybrid analysis?
A – Mark Goedkoop: Yes, but be aware that resources are not included.
Q – Greg Norris: How will the information be used?
A – MG: It is intended as a tool for assessing the environmental policies for the coming 5 years; then the data should be updated. The use (and the update) will depend on government priorities.

10.5References

CBS. (1997). Budgetonderzoek 1995, microbestand, Centraal Bureau voor de Statistiek, Voorburg / Heerlen 1997.

Goedkoop, M.J.; Reducing environmental pressure by less use of materials; Ministry VROM, the Hague, 2000, see also www.pre.nl/download/default.htm

GTAP database, Center for Global Trade analysis, Purdue University, www.gtap.agecon.purdue.edu/

Guinée, J.B.; et al. Life Cycle Assessment, an operational guide to the ISO standards, Final report, CML, Leiden 2001.

Joshi, S.; Product Environmental Life-Cycle Assessment Using Input-output Techniques, Journal od Industrial Ecology, Volume 3, nr 2&3, 2000

Olivier, J.G.J et al. Description of EDGAR 2.0. RIVM report 771060002, Bilthoven the Netherlands 1996; a recent version 3.0, can be accessed on www.rivm.nl/ieweb/ieweb/index.html?databases/edgar.html.

Wilting, H.C. et. Al. Dimitri 1.0 : Beschrijving en toepassing van een dynamisch input-output model (*Dimitri 1.0 : Description and application of a Dynamic* *input-output model, in Dutch)*, RIVM report 778001 005, Bilthoven, the Netherlands, 2001, see www.rivm.nl/bibliotheek/rapporten/778001005.pdf

11A critical discussion about the need and implications of hybrid approaches in environmental analysis of product systems.

Henk Moll from IVEM presented some methodological considerations based on research on the energy and environmental impacts of consumption.

At IVEM methodologies are developed and studies are done to analyse the energy flows in the economic system by Energy Input-Output Analysis (IOEA). Here the energy use and greenhouse gas emissions attributed to consumption are determined by a hybrid approach, where input-output analysis is combined with conventional process analysis. The research is performed in the context of the Dutch research program on Global Air Pollution and Climate Change. The goals of the research are

- Description and analysis
- Scenario based projections
- Assessment of improvement potentials

11.1Environmental analysis of the economic system, economic sectors and product systems

At a large scale we find economic systems, such as countries or states. In an economic system there is a production, which can be measured as the gross domestic production (GDP). The unit of the GDP is money per year, e.g. $ per year, or DKK per year.

The system has an environmental load (EL), which can be measured in physical units, according to the parameters addressed. Use of energy can be measured in J per year, use of resources as well as emissions can be measured in t per year, etc.

For an economic system, environmental intensity (EI) can be an indicator of environmental performance. EI can be defined as

EI = EL/GDP

At a smaller scale, we find economic sectors, such as different lines of business. The production of an economic sector can be measured as the value added of sector (VA_s). The unit is money per year, and the environmental load of the sector (EL_s) is measured in physical units, similar to GDP and EL of economic systems.

For an economic sector, environmental intensity of the sector (EI_s) can be an indicator of environmental performance. EI_s can be defined as

$$EI_s = EL_s / VA_s$$

For each product the environmental load from a producing sector can be calculated as the value added by the producer multiplied with the environmental intensity of the producing sector.

However, to estimate the total environmental load of a product, the environmental load of the suppliers should be added, as well as the load of later processes in the product chain (retail, use in households, disposal etc.)

$EL_{total} = EL_{producing\ sector} + EL_{supplying\ sectors} + EL_{later\ processes}$

The total environmental intensity of a product can then be defined as

$EI_{total} = EL_{total}/\text{consumer price}$

11.2From environmental input-output analysis (EIOA) to hybrid analysis

The input-output tables put together in individual countries by the bureaus of national statistic provides information on the contribution of different economic sectors to produce a product or deliver a service. Combining these data with environmental loads for each sector, the $EL_{supplying\ sectors}$ of a product can be calculated.

Two problems related to energy arise in such an approach

- The same service may have different price. For example the price of natural gas and electricity depends upon in what line of business the energy is used.
- Energy carriers have different prices (GJ/Euro) because of other differences in quality.

A fruitful solution to these problems can be to include some process analysis. By process analysis energy requirement for energy (ERE) values are calculated. These ERE values can be used to attribute the use of energy carriers and conversion energy losses to the sector consuming the energy carriers.

Two similar problems are related to materials

- The same material has different prices
- slightly differing materials have different prices (kg/Euro) because of other differences in quality

A solution to these problems can be to include some process analysis with regard to material production. Calculation resuults of gross energy requirement values (GER) for material production can be used to attribute the use of materials and conversion losses to the sectors consuming the materials.

Three problems are related to the data-structure, where production is divided into different sectors (lines of business)

- The different lines of business are inhomogeneous with regard to input consumption
- The production processes (and thus environmental load) of the different lines of business are inhomogeneous
- The products output of a line of business is inhomogeneous

A solution to these problems can be to include some process analysis to develop a founded subdivision into more homogeneous subsectors with more homogeneous sector outputs.

11.3 Discussion and conclusion

Input-output analysis is based on the assumption that the (sub)sectors are relatively homogeneous with regard to sector inputs and outputs. EIOA uses economic allocation as principle to attribute environmental loads to sectors, products and services.

Hybrid analysis, where knowledge from process analysis is added to the EIOA, may produce improvements in cases that the assumption above are problematic. Hybrid analysis may also be used to give insight in the inherent uncertainties of EIOA.

Potential drawbacks of hybrid analysis may be, that they add work and complexity to the studies. And if precautions are not taken, there is a risk of counting some inputs and outputs double.

Therefore it is advisable to start with some casestudies to explore the potential and to adresssome problematic sectors for EIOA.

11.4 References

Nonhebel S, Moll H C (2001). Evaluation of Options for Reduction of Greenhouse Gas Emissions by Changes in Household Consumption Patterns. Dutch National Research Programme on Global Air Pollution and Climate Change. Report no.: 410 200 059.

Wilting H. (1996). An energy perspective on economic activities. Ph. D. thesis, University of Groningen.

12 Prioritisation and Benefit Estimation for Potential US EPA Investments in Life Cycle Assessment

Greg Norris from 2.-0 LCA consultants presented an Value-of-Information approach to prioritise and estimate benefits of future research. The approach had been used in a project from the US EPA.

Although not always dealt with explicitly, estimates of uncertainty is a part of all decision making. We assume that increased information will increase the probability of the right choice, i.e. the choice leading to the largest benefits. The information is gathered through research. Estimates on uncertainty can be used to prioritise the research, getting as much benefit from the effort as possible.

12.1 The value-of-information approach

The value of a new study depends upon how much it can be assumed to reduce the uncertainty of the choice, and how big values may be influenced. This can be illustrated through the following example of a value-of-information analysis:

When doing research

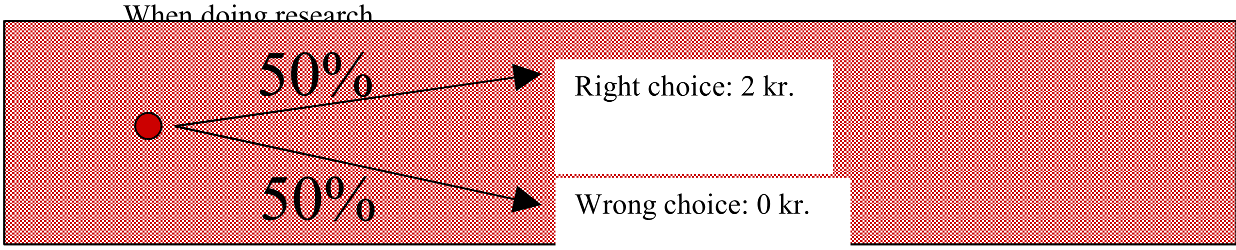


Figure 12.1. The decision making situation.

Figure 12.1 illustrates the situation where a decision maker faces a choice between two alternatives. Without further information, there is a 50 % chance he/she will choose either, giving an expected result of 1 kr. Information that would improve chances to 75% right and 25% wrong would give an expected result of 1,5 kr. This information would then be worth 0,5 kr to the decisionmaker.

More generic it can be said, that the value of information equals the expected result with information *minus* the expected result without information

When applying this approach to efforts which will benefit a wider range of studies, such as research to refine LCA data or methods, the value can be estimated through estimates of the damage due to imperfect method or data:

$$D = \text{Damage}_{\text{due to LCA imperfection}} = \text{Damage}_{\text{choices made}} - \text{Damage}_{\text{best available choices}}$$

The value of the research is then:

$$\text{Value of Research} = D_{\text{pre-research}} - D_{\text{post-research}}$$

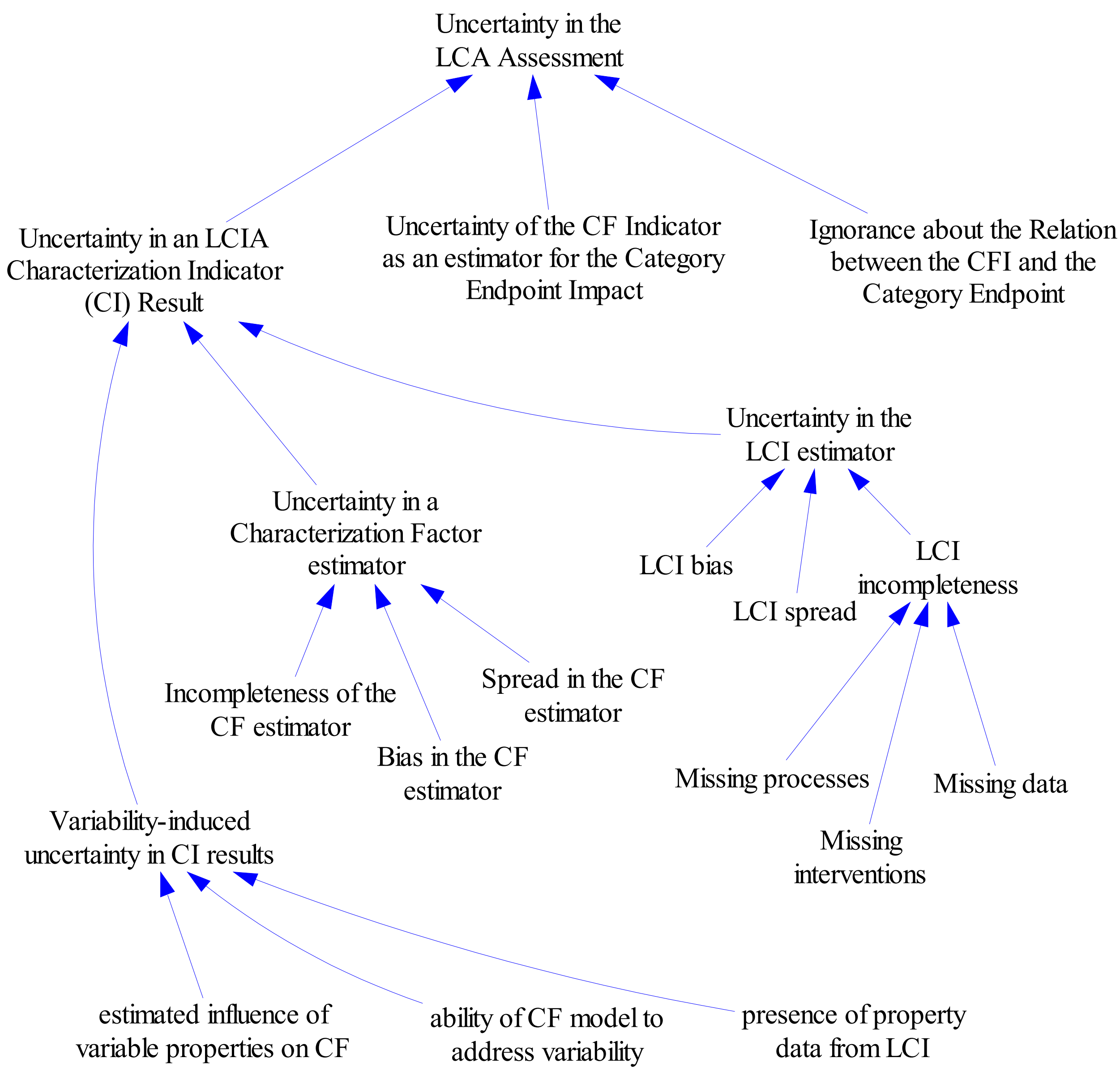
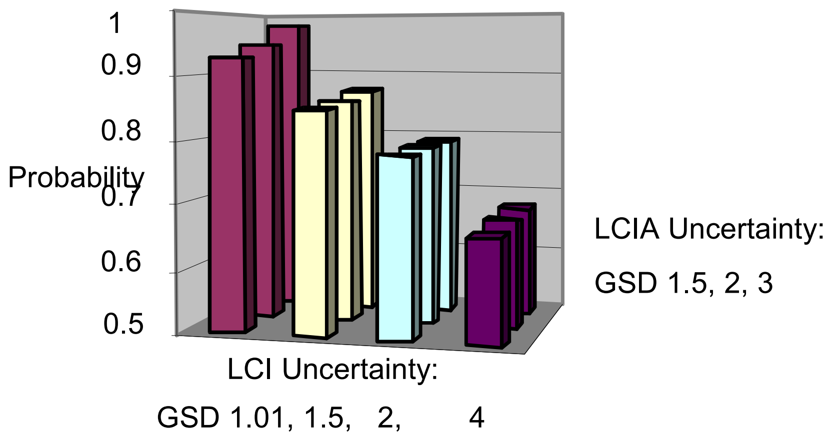


Figure 12.2: Sources of uncertainty.

However, the sources of uncertainty are manifold, as shown in figure 12.2. The next task is therefore to identify the parameters where an increase in certainty will lead to the highest proposition power, i.e. probability of making the right choices.

In figure 12.3 is shown an estimate of the changes in probability of correct choice, with different levels of uncertainty for two parameter: the inventory data (LCI) and the impact assessment methodology (LCIA). It can be seen that increases in the certainty of available data will give more benefits than increases in the certainty of the impact assessment methodology.

Figure 12.3. Probability of correct choice as function of LCI and LCIA uncertainty.



12.3 Main findings

Reducing LCI uncertainty is “Job # 1”, because reduction in this uncertainty will lead to the highest benefits. When LCI data are reasonably uncertain, gains from LCIA refinement will be very slight. The other way around it is good news, that the influence of inevitable LCIA uncertainty is not too strong on the usability of the result.

It is possible to estimate value of research that reduces LCI and LCIA uncertainty. To this task, IO-LCA data are very useful.

13 Use of Accumulative Structural Path Analysis for U.S. Economy

SANGWON SUH, CENTRE OF ENVIRONMENTAL SCIENCE (CML), LEIDEN UNIVERSITY

Keywords: ASPA; LCA; IOA; IPP

The method and application of Accumulative Structural Path Analysis (ASPA) are presented. Together with other analytical tools ASPA helps understanding the structure of complex supply-chain and identifying important blocks of or individuals of supply paths in a product system. ASPA is an extension of Structural Path Analysis (SPA), which uses scalar decomposition of Leontief inverse, while ASPA uses both inverse itself and its decomposition into scalars. A computer program routine is designed to apply the algorithm for large input-output systems and LCA systems such as U.S. input-output table (500×500) or ETH 96 database (1200×1200). The routine is utilized for greenhouse gas emissions in U.S. as an example, although use of aggregated indicators is rather straightforward. Finally its envisaged possible area of application for Integrated Product Policy (IPP) is shortly discussed.

13.1 Introduction

There are variety of quantitative analytical tools that can be used to gain insights into a complex supply-chain, and help highlighting priority areas of further improvements. An analytical tool can tell only about a single aspect of the whole system and thus, in many cases, combinations of different tools are desirable to understand the overall aspects of the system better, while different sets of tools can be considered depending on the objectives of the study.

In the field of Life Cycle Assessment (LCA) such tools include, but not limited to, contribution analysis, perturbation analysis, uncertainty analysis and key-issue analysis (for reviews see Heijungs & Suh, 2003 and Heijungs et al., 2003). These tools are used to investigate a part of the whole supply-chain, namely a product system that fulfils certain functional unit. In the field of input-output analysis, analytical tools has been developed from a slightly different perspective, as they are focused more on the general characteristics of macro-level system than a functional-unit based product system. Analytical tools such as key linkage analysis and field of influence studies are the examples that reflects the macro-level views (see eg. Rasmussen, 1956 and Hazari, 1970).

The most comprehensive form of the key linkage analysis is perhaps the Structural Path Analysis (SPA) (see Defourny & Thorbecke, 1984 and Treloar, 1997). SPA was developed originally for national accounts system, and it identifies the most important commodity flow paths in a system using a power series form of an inverse. Accumulative Structural Path Analysis (ASPA) is an extension of SPA designed to identify not only individual paths but also aggregated blocks of supply-chain and their accumulative impacts.

In this brief paper the method and application of SPA and ASPA are presented. Current paper contains some results of ASPA applied to U.S. environmental input-output table and ETH database, and its envisaged possible area of application for Integrated Product Policy (IPP) is also briefly discussed.

13.2 Method

13.2.1 Linear supply-chain network

For the sake of simplicity, supply-chain network is explained here using notations and nomenclatures of LCA system, while extending it into input-output system or hybrid input-output LCA system is rather trivial (Heijungs & Suh, 2003). Consider a standard inventory problem,

(1) $$\tilde{\mathbf{A}}\mathbf{s} = \mathbf{f},$$

where $\tilde{\mathbf{A}}$ is an LCA technology matrix, **s** is a scaling factor and **f** is the final demand where functional unit is located. For non-singular $\tilde{\mathbf{A}}$,

(2) $$\mathbf{s} = \tilde{\mathbf{A}}^{-1}\mathbf{f}.$$

Let **B** shows environmental intervention by each process, then the environmental intervention to fulfil the functional unit, **f** is calculated by

(3) $$\mathbf{b} = \mathbf{B}\mathbf{s}.$$

By letting **C** a set of characterisation factors,

(4) $$\mathbf{c} = \mathbf{C}\mathbf{b}.$$

Using (2) and (3), (4) becomes

(5) $$\mathbf{c} = \mathbf{C}\mathbf{B}\tilde{\mathbf{A}}^{-1}\mathbf{f},$$

13.2.2 Contribution analysis

Contribution analysis is one of the most frequently used analytical tools in LCA. Let us diagonalize **s** in (2). Then **b** in (3) and **c** in (4) and (5) becomes an environmental intervention×processes and an impact category×process matrix, respectively. Then $(\mathbf{b})_{ij}$ and $(\mathbf{c})_{ij}$ shows the contribution by *j*th process in *i*th intervention and the contribution by *j*th process in *i*th impact category, respectively.

The result of a contribution analysis shows, when aggregated by processes throughout the upstream and downstream, which process contributes how much. Then the overall environmental impacts can be reduced basically in two ways: by reducing the environmental intervention from the largest contributors and/or by reducing the amount of the process output used in the product system. For instance, the total environmental impacts of the product system can be significantly reduced by reducing the amount of environmental impacts by the largest contributor through eg. adding pollution abatement equipments. Note here that, using only the contribution analysis, the latter strategy may not be as easy as the first strategy. Efforts to reduce the amount of input from the largest contributor to the main process of the product system, for instance, may have negligible influence in the overall results, especially when the use of such input occurs in the upstream processes. The latter strategy requires information on the commodity flows in a supply-chain and their environmental impacts, which is not immediately eminent from the contribution analysis. Especially when the system become complex and large, a tool is necessary to systematically acquire such information.

13.2.3Structural Path Analysis

In order to investigate the individual commodity paths, an inverse should be decomposed into parts. An inverse of an LCA technology matrix can be expanded as a power series[1],

(6) $$\mathbf{A}^{-1} = \mathbf{I} + (\mathbf{I} - \mathbf{A}) + (\mathbf{I} - \mathbf{A})^2 + (\mathbf{I} - \mathbf{A})^3 + \cdots,$$

or

(7) $$\widetilde{\mathbf{A}}^{-1} = \mathbf{I} + \overline{\mathbf{A}} + \overline{\mathbf{A}}^2 + \overline{\mathbf{A}}^3 + \cdots,$$

where $\overline{\mathbf{A}} = (\mathbf{I} - \mathbf{A})$.

Combining (7) with equation (5) yields

(8) $$\mathbf{c} = \mathbf{CB}(\mathbf{I} + \overline{\mathbf{A}} + \overline{\mathbf{A}}^2 + \overline{\mathbf{A}}^3 + \cdots)\mathbf{f},$$

and especially the characterized result of impact *k* due to a unit output of commodity *j* is decomposed in scalar by

(9) $$^{j}c_k = \sum_i c_{ki} b_{ij} + \sum_i \sum_l c_{ki} b_{il} \bar{a}_{lj} + \sum_i \sum_l \sum_m c_{ki} b_{il} \bar{a}_{lm} \bar{a}_{mj} + \cdots,$$

for all *i*, *l*, *m*, … Note that each permutation of indices, *l*, *m*… in each term in (9) represents a specific input path required to meet a unit final demand of *j*.[2] A second-order of upstream path, $\sum_i c_{3i} b_{i1} \bar{a}_{14} \bar{a}_{43}$, for example, shows the amount of the third environmental impact generated by the first commodity to produce fourth commodity to meet the unit final demand on the third commodity, which is set for the functional unit.

With complete decomposition of an inverse shown in (9), structural path analysis allows us to locate the key paths throughout the system that contribute significant environmental impacts. Here we define 'the most important paths' in the way that the most important first order path (product *p* to process *q*) in environmental impact *k* is defined by

---

[1] Input-output technology matrix automatically fulfils sufficient condition to have a power series form for its inverse by the way how they are constructed. However, LCA technology matrix does not necessarily fulfil the sufficient condition. The necessary-sufficient condition for a non-singular matrix to have a power series form for its inverse is to have its eigenvalue within the modular of unity. It is shown that, however, LCA technology matrix can always be transformed to have a power series form without affecting the result (see Suh (2001a)).

[2] We need another condition to be fulfilled, which is, here, assumed to be satisfied. For details on the conditions for a polynomial expansion of an inverse to show individual commodity path see Suh (2001a).

$$\sum_i c_{ki} b_{ip} \bar{a}_{pq} = \max_{l,j} \sum_i c_{ki} b_{il} \bar{a}_{lj} \quad (10)$$

which means that the flow of product p to process q causes the biggest environmental impact for impact category k as a single order path of commodity flow. Similarly, the most important nth order path, $(\overbrace{p, q, r, \cdots x}^{n-1})$ can be defined as

$$\sum_i c_{ki} b_{ip} \overbrace{\bar{a}_{pq} \bar{a}_{qr} \cdots \bar{a}_{wx}}^{n-1} = \max_{j,l,m,..,o} \sum_i c_{ki} b_{il} \overbrace{\bar{a}_{lj} \bar{a}_{jm} \cdots \bar{a}_{no}}^{n-1} \quad (11)$$

The most important paths in each order represent the most important packets of given length in the supply-chain in the system. In general, as the length of the supply-chain increases the impact is decreased, since the 'contents' of far-upstream inputs in the final products are generally smaller than that of near-upstream inputs.

Although SPA pinpoints individual commodity paths and their contributions to the overall impacts, it is still not clear how much overall environmental impacts are connected to the quantity of certain commodities use by the up/downstream processes. That's because, first, SPA only takes direct environmental impacts of a process and its contents in the overall results into accounts without considering their indirect impacts from that process and on upwards, and, second, each individual path may have negligible impacts while their sum through an intermediate upstream product is significant.

13.2.4Accumulative Structural Path Analysis

Accumulative Structural Path Analysis takes both direct and indirect impacts into account. It identifies the bottlenecks in a supply-chain through which major environmental problems in a product system take place.

As an alternative to (9) using elements of inverse matrix, the characterized result of impact k due to a unit output of commodity j is decomposed in more compact form of scalar quantities by

$$^{j}c_k = \sum_i c_{ki} b_{ij} + \sum_i \sum_l c_{ki} b_{il} \tilde{a}_{lj} \, , \quad (12)$$

where $(\tilde{a})_{ij} = \tilde{\mathbf{A}} = \mathbf{A}^{-1}$. Or equivalently by

$$^{j}c_k = \sum_i c_{ki} b_{ij} + \sum_i \sum_l c_{ki} b_{il} \bar{a}_{lj} + \sum_i \sum_l \sum_m c_{ki} b_{il} \bar{a}_{lm} \tilde{a}_{mj} \, , \quad (13)$$

which is now expanded up to the third term. Likewise the equation (13) can be further expanded infinite times, while the number of terms being finite (*cf.* (9)). Note that each of index l in (12), $\sum_i c_{ki} b_{il} \tilde{a}_{lj}$ shows the direct and indirect impact on the kth environmental impact category by the first order input path to the jth product including all upstream indirect impacts stemming from the lth input.

13.3Application

13.3.1Data and Calculation

U.S. input-output table (500×500) and preliminary environmental data for the year 1998 is used, which has been compiled as an update of Missing Inventory Estimation Tool (MIET) 2.0 (Suh, 2001b and Suh & Huppes, 2002). In addition ETH database (1200×1200) is used to test applicability for larger matrices (Frischknecht et al., 1996). These data are transformed and imported into MatLab 6.0, and using a routine is coded for contribution analysis, SPA and ASPA these systems are analyzed.

13.3.2Performance

A difficulty in implementing the SPA and ASPA for lager system is that the number of paths that are to be assessed increases exponentially as the number of inputs and the order of upstream become larger. Suppose $n \times n$ square matrix. Assuming that each process has inputs of all commodities, the number of input paths established at the second order of upstream become n^2. Since for each second order of upstream path they have n number of third order upstream inputs, the number of upstream paths up to third order become n^3 and so on. If the size of matrix become $2n \times 2n$, the second order of upstream paths become $4n^2$ and third does $8n^3$ and so on. In case of the ETH database, the number of paths up to the third order becomes 1.7E9, and that to the 10^{th}, which is set as a default maximum order in current routine, it amounts to 6.2E30. Evaluating such number of paths within reasonable time required certain cut-off mechanism in the routine. Current routine does not calculate paths do not contribute more than 1% of the total of a product system. This cut-off mechanism maintains evaluating a product system in 0.5 - 5 seconds so that the entire 1200 system can be evaluated within less than an hours.

13.3.3Results

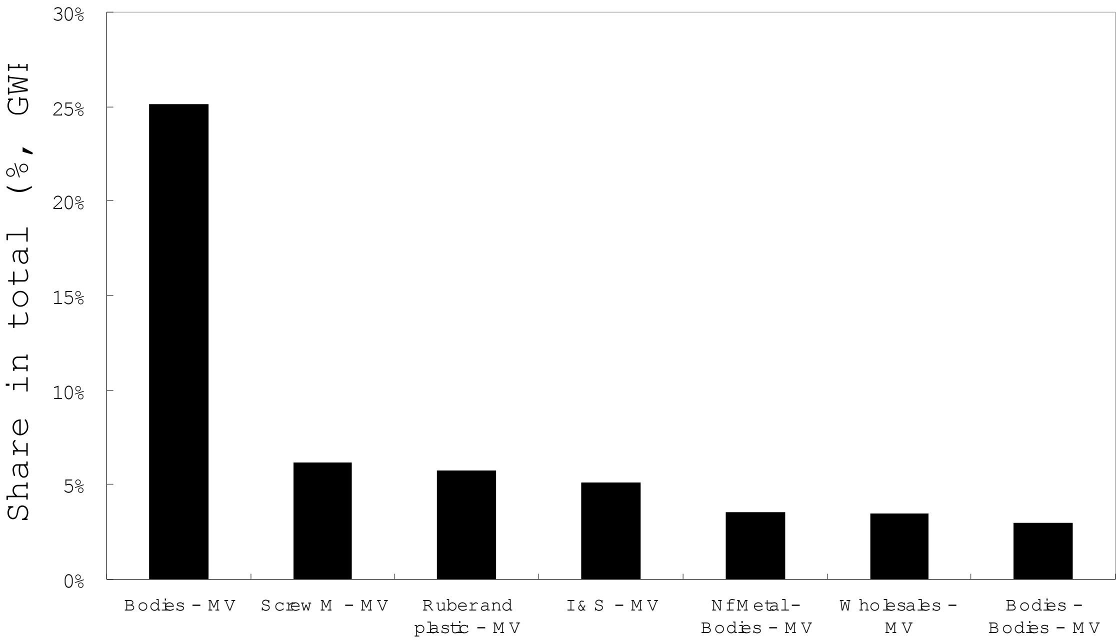


Figure 13.1: ASPA of Motor Vehicles (Cradle to gate only – w/o use and disposal). MV: Motor Vehicle, Bodies: Motor Vehicle Bodies, Screw M: Screw machine products and stampings, Rubber and plastic: Rubber and plastic products, I&S: Iron and steel, Nf Metal: Non-ferrous metal, Wholesales: Wholesales service.

Figure 13.1 shows the ASPA results of U.S. Motor Vehicles in terms of greenhouse gas emission (cradle to gate only). The result shows that Bodies to the Motor vehicle and upwards inputs from bodies contribute around 25% of the total global warming impact of motor vehicle. Comparison with 5th and 7th column, which shows the second order of upstream, namely non-ferrous metal to bodies to motor vehicle and bodies to bodies (intra-industry transaction) to motor vehicle only contribute less than 8% of 25%, it is expected that the direct emissions from manufacturing of motor vehicle body would be significant.

13.4Discussions

Analyzing a product system for identification of important supply-chain or improvement of data quality often requires combination of tools. Together with key issue identification method, which pinpoints the contribution of uncertainty in an overall product system, contribution analysis, SPA and ASPA could provide more rigid definition of important sectors for IPP. Such a combination of analytical tools are expected to 1) gain overall insight into the product systems, and facilitate 2) a systematic method in prioritizing important product in entire supply-chain, 3) a scanning tool for locating the largest uncertainty contributor and to enhancing the data quality.

13.5References

Defourny J., Thorbecke E. 1984: Structural path analysis and multiplier decomposition within a social accounting matrix framework, Economic Journal 94, 111-136.

Frischknecht, R., P. Hofstetter, I. Knoepfel, E. Walder, R. Dones & E. Zollinger. 1996: Ökoinventare für Energiesysteme. Grundlagen für den ökologischen Vergleich von Energiesystemen und den Einbezug von Energiesystemen in Ökobilanzen für die Schweiz. 3. Auflage. ETH, Zürich.

Heijungs R., Suh S. 2003: The Computational Structure of Life Cycle Assessment, Kluwer Academic Publisher, Dordrecht, the Netherlands.

Heijungs R., Suh S., Klijn R. 2003: Numerical approaches to life cycle interpretation:
The case of the Ecoinvent database, CML Working Paper, CML, Leiden University, the Netherlands.

Suh S. 2001a: Note on power series expansion for a system with mixed measures, CML Working Paper, CML, Leiden University, the Netherlands (currently adopted in Suh S., 2003: Linear Systems in Industrial Ecology, *in prep*.).

Suh S. 2001b: Missing Inventory Estimation Tool (MIET) 2.0. User's guide, http://www.leidenuniv.nl/cml/ssp/software/miet. CML, Leiden University, The Netherlands.

Suh S. and Huppes G. 2002: Missing Inventory Estimation Tool using extended Input-Output Analysis. International Journal of Life Cycle Assessment 7 (3). 134-140.

Suh S, Lenzen M, Treloar GJ, Hondo H, Horvath A, Huppes G, Jolliet O, Klann U, Krewitt W, Moriguchi Y, Munksgaard J, Norris G. 2002: System boundary selection in Life Cycle Inventories using hybrid approaches, submitted to Environmental Science & Technology.

14Discussion

14.1Questions raised

The afternoon discussion was structured according to the topics raised by the participants.

The topics fell in two groups:

- Issues regarding the purpose and scope of the Danish prioritisation project
    - The overall objectives and target group
    - Temporal aspects
- Issues regarding the technical aspects of the prioritisation model and procedures
    - Consumption phase
    - Import assumptions
    - Impact assessment and environmental data
    - Extrapolation of data
    - Reuse, recycling and waste treatment
    - Model openness to future developments
    - Inclusion of LCA data
    - Improvement potentials

14.2The overall objectives and target group

Q: Are you looking at total impacts or relative impacts?

The key objective of the project is to give advice on what product groups will benefit the most from being targeted by the Danish environmental product policy. We will therefore look both at products that in themselves have a large environmental impact per monetary unit, as well as product groups that have such a large volume in the Danish production or consumption that their overall environmental impact is large.

Q: Do the project look at activities, products or materials?
Q: How do you define product groups?

Bo Weidema: Our starting point is the final demand as expressed in the Danish input-output table. This means private consumption, public consumption, as well as exports. The Danish input-output table has already a quite disaggregated record of private and public consumption (on 72+35 rows), but not necessarily disaggregations that are relevant in the context of household activities. Therefore, the project will reallocate these final consumption columns into new processes, which better reflect consumption activities, i.e. products that are used together, such as shoes and shoe polish. However, the database will be transparent, so that it will still be possible to analyse the component products (here: shoes and shoe polish) as separate products.

Ole Dall: An advice is that the product groups should be easy to communicate, i.e. they must be meaningful for the target group.

Bo Weidema: One should be careful not to fix the product groups too rigidly. For example, the pre-project identified locomotives as an important product group, while most consumers would regard locomotives as not a product, but as a part of the activity “transport”. However, if locomotives are an important export commodity, this may merit that it should enter into the prioritisation as a separate product group.

José Potting: Implementation of measures will also differ between private consumption and products for export, etc.

Bo Weidema: To help the Danish EPA, we need to have a flexible approach to measures and instruments. It is no problem to keep the database open, so that household activities can be disaggregated into products.

Mark Goedkoop: It is OK to keep the database transparent but it is important to know something about the needs of the target groups to be able to present the trade-offs in a meaningful way.

Bo Weidema: The target group will be involved during the project, to ensure this.

14.3Temporal aspects

Q: What is the time horizon of the project?

Bo Weidema: The decisions we shall support are only within the next 5 years. So we do not intend to make scenario analyses or similar. The reference year for which we have the input-output table is 1999. This implies that we look at products that are traded in 1999, but this may include products that were produced in earlier years, and products that may have a lifetime much longer. If we have a steady state economy, this would not give any problem. However, for products where the market is not saturated (e.g. mobile phones or similar new electronic equipment), it may be necessary to make adjustments so that our data takes into account the changes in stock in the consumption stage. In the same way, it may be necessary to adjust the waste treatment to reflect the waste treatment of the products traded, rather that the waste treatment of historical products.

Mark Goedkoop: In the Dutch project, we found waste handling to be of less significance; so I would advice not to spend too much time on detailed modelling of this.

Göran Finnveden: This may be because relevant emissions from the waste handling are not included? If emissions from landfills are integrated over long time, they may be important.

Mette Wier: How will you include efficiency improvements, which may differ between sectors?

Bo Weidema: Beyond what I mentioned before, we do not intend to include this.

Mariane Hounum: Although there may be sector differences, it is unlikely that differences in speed of efficiency improvements will change the ranking between sectors?! Mette Wier agreed.

14.4 Consumption phase

Mette Wier: Activity areas in consumption will be influenced by changes in commodity supply and options. What are potential improvements of change in commodity mix?

Bo Weidema: I hope to coordinate this project closely with the AKF project that has more focus on household activity areas and interactions.

Kim Christiansen: A mix of measures and instruments are needed. It is not likely that we can identify one measure that will be most efficient for a specific product group. Improvements from a consumer point of view is very limited by a few key decisions in a consumer's lifetime: Choices of housing, job, family structure etc., and major changes in behaviour will require dramatic incentives or long-term planning.

Mariane Hounum: The typical approach in DK is working with the industrial sector organisations, which leaves relatively little room for including improvements in the consumption patterns.

14.5 Import assumptions

Q: When you link to foreign input-output tables, how do you know where a product really comes from? A product imported from Germany may just recently have been imported to Germany from Egypt?

Bo Weidema: However, it may be a problem that the foreign tables are not themselves linked to each other, i.e. you make an implicit assumption that these economies are closed, which may be true for Europe and USA, but less so for the non-industrialised countries.

Sangwon Suh: Re-export is typically taken care of in the input-output tables. You may also model a homogenous world market, i.e. that all exporters take equal part in all imports.

Henk Moll: Experience from a Ph.D. study showed large differences between Dutch data and data at larger regional level. But at a certain level (e.g. Europe), an assumption of closed economy is not so problematic.

Michael Hauscild: Many metals and agricultural products come from outside Europe.

Bo Weidema: We don't have to select one single approach, but for each product group choose the most appropriate approach: We can use foreign data for some product groups while sticking to the standard import assumption (that foreign production equals Danish production of the same commodity) for others.

Göran Finnveden: Obviously you must look for product groups were you don't have a national production.

Mark Goedkoop: Avoid "the more you know the worse it gets," when you have detailed data for one country (e.g. USA), and nothing for another.

Bo Weidema: We intend to ensure a "level playing field" for all products. This means that we will need to estimate data where they are missing.

14.6 Impact assessment and environmental data

Mette Wier: Expert view and consumers view on what is an important problem may differ. How will you approach this?

Bo Weidema: there may be some situations where you will need to include issues that the experts do not find so important, e.g. toxicity. Some issues may be regarded as more important because they involve a risk, and consumers are risk-aversive. Voluntary exposure to hazards (traffic) may also be regarded as more acceptable than involuntary (pesticides in food).

Q: Maybe you will not need weighting and thereby the conflict in perceptions?

Bo Weidema: As we deal with the entire economy, trade-offs are inescapable, also because we need to prioritise our data collection.

Q: But could you not stick to the traditional LCA approach with a limited number of impact categories that are not weighted?

Bo Weidema: This will still be too many for the decision makers.

Mariane Hounum: Some aggregation will be needed in the political and administrative communication. Experts are not agreeing on priorities. We need to take into account the public perception.

Mark Goedkoop: Results may be quite equal between different impact assessment methods.

Bo Weidema: This may be because the size of the product group is the determining parameter, not the impact categories.

Sangwon Suh: A US study on the different LCIA weighting methods showed high degree of correlation. Not needed to solve the weighting problem in this study. It is more important to assess robustness of results of the study.

Michael Hauschild: If impact categories are correlated, they may be reduced to fewer categories, using selected representative impact categories.

Bo Weidema: A reason for the lack of difference between methods may also be because the current LCAs and impact assessment methods exclude a lot of important parameters.

Trine Susanne Jensen: Would like the study to include different weighting methods.

Bo Weidema: As we will use SimaPro as presentation software, it will not be any problem to use (and even add) different impact assessment methods as required.

Michael Hauschild: Chemicals must be included, but how? It might be useful to check the product register. Maybe select indicator chemicals. Use common sense also.

Greg Norris: An option is to analyse the American Toxic Release Inventory (TRI), using Edgar Hertwhich's Human Toxicity Potential to weigh toxicity between chemicals (as in the USEPA's TRACI model), thus allowing identification of substances that contribute most to the total toxicity score, and then to analyse for what sectors contribute to these. However, the TRI is incomplete due to lack of reporting in some sectors and from some companies.

For a sub-set of chemicals (air pollutants) more data is available in the National Toxics Inventory (NTI). Comparison show lower air impacts from TRI than for NTI (more data, more detailed specification).

Göran Finnveden: If you use indicator chemicals, you will have to use different weighting methods. Don't anticipate obtaining a full picture of the impacts of chemicals. In the Swedish study, the input (consumption) of chemicals was used to set priorities, e.g. by comparing to normalisation data. Product registers are only found in the Nordic countries and there are differences between them.

Michael Hauschild: Using the product register data, estimates of emissions may be made. QSAR for maybe 40.000 chemicals and database combining them to risk-sentences are available. And risk sentences can be translated into semi-quantitative toxicity scores.

Kim Christiansen: A study with the Danish product register used "classified" data to identify sectors with high impacts from chemicals for substitution assessment some 10 years ago, so it might be possible to run another priority setting. Several rankings are available from the last 15-20 years.

José Potting: The emission registration database in the Netherlands could also be useful.

Mark Goedkoop: For our project, the Dutch EPA made list of chemicals to include, i.e. we did not have to make our own priorities.

Anders Schmidt: I highly recommend checking with the product register. You can use the EURAM scoring system.

Sangwon Suh: I recommend starting with output side from industrial sectors. Emissions are a function of technology as well as regulatory level and more specific assessments will be needed (if resources are available).

14.7 Extrapolations

Bo Weidema: When is it meaningful to extrapolate environmental data from one country to another? There are a number of procedures to minimise the error when extrapolating, such as taking into account differences in regulatory issues, sector composition etc. But it appears that we have so good data for Denmark, that these extrapolations may only be relevant for imported products, i.e. to extrapolate between foreign countries.

Michael Hauschild: In the Danish methodology project, dk-TEKNIK tested different extrapolation methods. The experiences from this exercise may be useful.

14.8 Reuse, recycling and waste treatment

Q: How to deal with raw material acquisition today, for products that will be used for the next 100 years?

Michael Hauschild: In the old prioritisation project, COWI looked at losses based on assumed recycling rates.

Q: When is a material lost?

Bo Weidema: Most material will not be lost, but will be available in the waste in concentrations that will be of interest for future extraction efforts. In the UNEP/SETAC initiative we have suggested that a material is irretrievably lost when its concentration falls below the level at which it will be available in nature as a result of natural or accelerated re-deposition. This is likely to differ from material to material, but an approximation may be a concentration 10 times the average crust concentration, which is very similar to the value that Bengt Steen originally suggested in the EPS system. Another question is what technology will be applied to mine such future low-concentrated sources, at that time in the future where this may become relevant. Müller-Wenk's analyses has shown that the environmental effect of such future mining is not likely to be significant, compared to the overall environmental impact.

Lone Lykke Nielsen: Questions whether we have the necessary knowledge on concentrations in landfills and incineration slags.

Mariane Hounum: I would like to advocate for initiatives that keep the materials in the business flow, so that we will not need future mining in waste deposits.

Mark Goedkoop: In our LCA's we don't assume optimistic future scenarios. We regard materials in the landfills as materials lost.

Bo Weidema: If mining efficiency is increasing, we may never need to use landfill deposits.

Göran Finnveden: I agree with Mark Goedkoop on the uncertainties of waste management scenarios. It is very important to take the time horizon into consideration.

Michael Hauschild: It should be no problem to use technology forecasts.

Per Nielsen: Another practical problem – what is recycling rates of components?

Mark Goedkoop: That is not important.

Bo Weidema: You may just use average recycling rates.

Kim Christiansen: In the old COWI prioritisation project, there are some fairly good estimates of material losses based on waste indicators and recycling and treatment options at the product level and using the top-down approach of IOA. Also both waste flows and technologies are reasonable fixed.

Lone Lykke Nielsen: Maybe you are to optimistic on the data availability for specific waste flows.

Ole Dall: I agree that it is possible to estimate waste treatment scenarios of the different product groups.

Anders Schmidt: How many radios are sent for recycling? Coppers in cables are different from copper contacts in electrical products.

José Potting: Data can be available from industry sector organisations. They supplied many data for the Dutch studies.

Bo Weidema: I conclude that data on concentrations in waste treatment flows might be available. Using average recycling rates, it may be assumed that recycling is mainly from the largest contributing flows, and the rest can then be assumed deposited.

Michael Hauscild: A model for emissions from slag deposits as determined by technology and waste product type is available. Not using a long-term perspective, but assuming a stable phase. Similar models for distribution from incinerators and landfills (also non-controlled) are available for Denmark. The crucial question is whether there will be also long-term emissions from landfills. I doubt that environmental emissions from waste treatment are important. Maybe only methane is important. It must be enough to estimate the emissions the next 100 years.

Göran Finnveden: I am not so sure – slags from mines are major sources of heavy metals. Also emissions from household waste landfills to surface water might be a problem.

Ole Dall: If you use the EDIP method for resource assessment, then it becomes very important to determine how much of the resource is deposited and how much is really lost. If energy becomes less of a problem in the future, it is not a problem to extract materials from waste deposits.

Mariane Hounum: Emissions from landfills is not important in a 100 years perspective. Waste treatment is a problem in other contexts. In the context of IO-LCA, assessment of resource loss may also be less important.

Michael Hauschild: Just record the amount deposited. But it is possible to do a toxicity assessment. In foreseeable future there will be no emissions. In non-foreseeable future recycling might be applied.

Mark Goedkoop: Are we only talking about waste products in Denmark? Waste from Danish consumption will be treated in Denmark. For exported products, uncontrolled incineration and landfilling in developing countries, landfill fires etc. will be relevant.

Bo Weidema: Exports are included. Whatever Danish product policy can influence. Waste handling abroad can be estimated. We will use Danish data and adjust where relevant.

14.9Model openness to future developments

Q: I find it important that future developments are not locked out by choice of software for the project.

Bo Weidema: All modelling will be transparent and kept in Excel spreadsheets. It will then be transferred to different other software for calculation and presentation (MatLab, Analytica and SimaPro). Thus, there should be no problem in expanding and improving both data and methodology later.

14.10LCA data

Q: Can LCA data be integrated with the input-output data?

Bo Weidema: If LCA data of adequate quality is available, these can be used to subdivide an industry. For example, very high quality LCA-data on steel production are available from the International Iron and Steel Institute. However, even these data are not very complete when it comes to upstream flows, so it may be necessary to combine such data with input-output data for upstream exchanges. Also because of confidentiality it may be impossible to include these data directly in the model, but they may be used for verification.

Mariane Hounum: The EDIP database is being updated. It is growing in size and quality. Textile, wood and furniture, and electronics added; updates on paper, plastic, and glass; steel in progress. If it is finished in time, it can be made available to the prioritisation project.

14.11 Improvement potentials

Bo Weidema: We plan to use in priority BREFs (BAT-notes) and MARKAL-MATTER sector studies to identify improvement potentials, because these sources have a higher degree of internal consistency, since they cover more sectors with the same methodology. However, also other sources of data may be included. We look only 5 years into the future, so new technology will not be included.

José Potting: Other improvement options than technical may be relevant, e.g. consumer behaviour.

Bo Weidema: Yes, we will look at the experiences from the Danish and Dutch household studies. However, radical changes and changes that involve excessive costs will not be included, for the said reason.

Henk Moll: The MARKAL-MATTER sector studies covers only technical aspects, not social.

14.12 End of workshop

Bo Weidema thanked the participants, especially the foreigners who travelled far for a one-day seminar, for their valuable contributions.

14.13 References

Palm V, Urban H L, Wadeskog A, Finnveden G, Moberg Å (2002). Kunskap om produkters miljöpverkan – vad ger dagens statistik? Naturvårdsverket, Rapport 5231, juli 2002. www.naturvardsverket.se.

Nonhebel S, Moll H C (2001). Evaluation of Options for Reduction of Greenhouse Gas Emissions by Changes in Household Consumption Patterns. Dutch National Research Programme on Global Air Pollution and Climate Change. Report no.: 410 200 059.

15Annex A. Seminar programme.

15.0.0.0.1Prioritisation of product groups and product areas
in the integrated product policy

- Invitational Expert Seminar -

10th March 2003, Copenhagen

Location: Ascot Hotel, Studiestræde 61 - DK-1554 København V Copenhagen

8.30 Welcome and coffee

8.45 *Bo Weidema:* The ambitions of the Danish prioritisation project

9.15 Minipresentations from advisory expert board:

<u>The Danish starting point</u>
Anders Schmidt: Experiences from the pre-project
Trine Susanne Jensen: An integrated approach to analyse the impact of the Danish comsumption -NAMEA and environmental effect indices
Michael Hauschild: Estimating toxic emissions from the different sectors
Mette Wier: Modelling of the consumer-phase
Ole Dall: Modelling of the waste-phase

<u>Experiences from foreign Input-Output projects</u>
Göran Finnveden: Swedish experiences of prioritisation within the integrated product policy
Mark Goedkoop/Jacob Madsen: The Dutch I/O project - The Effects of Dutch Production and Consumption on the Environment in the Netherlands and Abroad
Henk Moll: A critical discussion about the need and implications of hybrid approaches in environmental analysis of product systems.
Greg Norris: The American experiences with IO, and how to include uncertainties
Sangwon Suh: Use of Accumulated Structural Path Analysis (ASPA) for U.S. economy - a way to assess the importance of a supply chain

12.00 Lunch

13.00 Discussion:

- The amount of sectors in the Danish NAMEA
  - Which sectors have an appropriate level of details for prioritisation between product groups?
  - Which sectors are most important to split up?
  - When splitting up sectors: which procedures should be followed?

- Assigning environmental data to the sectors
  - Which sources and procedures are best for estimating emissions from different sectors?
  - How to ensure consistency?
  - When is extrapolation meaningful?

- How can use and waste phases best be modelled?
  - What level of detail is necessary?
  - Which sources exist?

- Foreign import
  - Which imports are most important to follow in a detailed way?
  - How to maximise relevance of information: when whould import be linked to a rough (highly aggregated) NAMEA from the right geographic location, and when should it be linked to a detailed NAMEA from the wrong geographic location?

- Usability of the final prioritisation-tool
  - How shall we handle the indirect effects?

16.30 End of workshop

16Annex B. List of participants

		Institution	Adress 1	Adress 2	Tel.	@
Mette	Boye	Danish Consumer Council	Fiolstræde 17	DK - 1017 København K	+ 45 7741 7736	mb@fbr.dk
Kim	Christiansen	2.-0 LCA consultants	Borgergade 6, 1.	DK - 1300 København K	+ 45 333 22 8 55	kc@lca-net.com
Ole	Dall	COWI	Havneparken 1	DK- 7100 Vejle	+45 76 42 64 00	OLD@COWI.DK
John	Egholm Jensen	Danish EPA	Strandgade 29	DK - 1401 København K	+45 32 66 01 00	jeje@mst.dk
Göran	Finnveden	Swedish Defence Res. Ag.	PO Box 2142	SE - 103 14 Stockholm	+46 8 402 38 27	finnveden@fms.ecology.su.se
Mark	Goedkoop	PRé consultants bv	Plotterweg 12	NL - 3821 BB Amersfoort	+31 33 4555022	Goedkoop@pre.nl
Michael	Hauschild	Tech. Univ. of Denmark	DTU – Building 424	DK - 2800 Kgs. Lyngby	+45 45 25 4664	mic@ipl.dtu.dk
Mariane T	Hounum	Danish EPA	Strandgade 29	DK - 1401 København K	+45 32 66 01 00	MTH@MST.DK
Trine S	Jensen	NERI	Frederiksborgvej 399	DK - 4000 Roskilde	+45 4630 1831	tsj@dmu.dk
Susanne	Kofoed	Danish Agricult. Council	Axeltorv 3	DK - 1609 København V	+ 45 3339 4264	sko@landbrug.dk
Jens Brøbech	Legarth	Rambøll a/s	Bredevej 2	DK - 2830 Virum	+45 4598 8854	jrl@ramboll.dk
Lone	Lykke Nielsen	Danish EPA	Strandgade 29	DK - 1401 København K	+45 32 66 01 82	LLN@MST.DK
Jacob	Madsen	PRé consultants bv	Plotterweg 12	NL - 3821 BB Amersfoort	+31 33 4555022	madsen@pre.nl
Henk	Moll	University of Groningen	Postbus 72	NL - 9700 AB Groningen	+ 31 50 3634 607	H.C.Moll@fwn.rug.nl
Per H.	Nielsen	2.-0 LCA consultants	Borgergade 6, 1.	DK - 1300 København K	+ 45 333 22 8 51	pn@lca-net.com
Anne Merete	Nielsen	2.-0 LCA consultants	Borgergade 6, 1.	DK - 1300 København K	+ 45 333 22 8 52	amn@lca-net.com
Gregory A.	Norris	2.-0 LCA consultants	147 Bauneg Hill Rd	US -Maine 03906	+ 1 207 676 7640	gan@lca-net.com
Jose	Potting	University of Groningen	Postbus 72	NL - 9700 AB Groningen	+31 50 3634 605	j.potting@fwn.rug.nl
Anders	Schmidt	dk-TEKNIK	Gladsaxe Møllevej 15	DK - 2860 Søborg	+45 39 555 917	aschmidt@dk-teknik.dk
Sangwon	Suh	University of Leiden	PO.Box 9518	NL - 2300 RA Leiden	+31 71 5277477	suh@cml.leidenuniv.nl
Bo	Weidema	2.-0 LCA consultants	Borgergade 6, 1.	DK - 1300 København K	+ 45 333 22 8 22	bow@lca-net.com
Mette	Wier	Inst. of local gov.studies	Nyropsgade 37	DK - 1602 København V	+ 45 33 11 0300	MW@akf.dk