Measuring the environmental impact of products

CPM's experiences of tools, methods and the provision of information

Report 5349

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Foreword

The availability of credible, life cycle-based knowledge and information about the environmental performance of products to various parties is a key issue in terms of the ability to implement an environment-oriented product policy. For the Swedish Environmental Protection Agency, this is an important part of work towards environment-friendly production and consumption in a life cycle perspective.

Since its inception in 1996, the Competence Centre for Environmental Assessment of Product and Material Systems (CPM) at Chalmers University of Technology has worked to produce knowledge and information about the environmental performance of products from a life cycle perspective together with parties including a number of companies. The Swedish Environmental Protection Agency believes that it is now appropriate to review CPM's work so far, and has asked CPM to summarise and analyse its experiences with regard to knowledge and information about the environmental impact of products, and these are presented in this report. The assignment has included identifying gaps and limitations, potential for development, a possible link to environmental quality objectives and proposals of collaboration between various parties to improve the flows of knowledge and information regarding the environmental impact of products.

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The authors alone are responsible for the content of the report, and it cannot therefore be considered to represent the views of the Swedish Environmental Protection Agency.

Stockholm, March 2003
Swedish Environmental Protection Agency

Contents

Summary

This report summarises CPM's (Competence Centre for Environmental Assessment of Product and Material Systems) work on product-related environmental assessment since the beginning of 1996 by means of interviews with CPM representatives and studies of CPM-related reports. The knowledge and information on the environmental impact of products that exists within CPM is presented by means of companies explaining their environmental work in collaboration with CPM. There is then a description of tools used in industry for the quantitative assessment of the environmental performance of products, the development of methodology as well as understanding and communicating quantitative information for the assessment of the environmental performance of products based on the content of CPM's project reports. The sources of data and information that have been built up, explored or used within the CPM are also listed. A reservation is made for the possibility that certain people, reports or activities within the operation might have been overlooked in this report. The knowledge gaps and limitations in the acquisition and provision of information that CPM companies have identified relate to the life cycle assessment (system assessment) as a tool for a product-related environmental assessment, the cost and quality of life cycle inventory data, support for data communication, inspiration for dynamic problem-solving and a development of CPM collaboration.

One way of using CPM's results to provide guidance towards Swedish environmental quality objectives is exemplified in this report through a case study. There is also a suggested collaborative model, partly to improve flows of knowledge and information between various parties in Sweden, but mainly as the best way of achieving a means of providing information for use by decision-makers so that they can guide industrial systems towards a dynamic definition of sustainability. CPM emphasises that a decision-maker needs information on all three subsystems: *the technical system*, *the environmental impact* and *weighting*. There are major deficiencies above all in the co-ordination of information on environmental impact.

The collaborative model is based on knowledge and experiences developed and summarised at the environmental informatics area within CPM. In 2001 this area became an independent administrative part of the Chalmers unit Industrial Environmental Informatics (IMI), which further develops knowledge and experiences of quantitative life cycle impact assessment, the structure and exploitation of databases, data quality control, data exchange (formats and standards), models and strategies for data acquisition, integration of information systems together with networks and trade.

1 *Introduction*

This contains a description of the purpose, scope and method of the study as well as its background, starting with the EU's integrated product policy, the Swedish environmental quality objectives and CPM's role and organisation. See also the report's foreword. The introduction also contains an explanation of core terms used in the study and instructions to the reader on how the report can be read.

1.1 The purpose, scope and method of the study

The purpose of this study is to describe the most important experiences within CPM from its inception n 1996 until the present day with regard to knowledge and information on the environmental impact of products. The report presents various kinds of information that are used and an explanation of how it is used. The knowledge and procedure within CPM is linked to the Swedish environmental quality objectives. Any gaps and limitations relating to knowledge and procedures are identified, and suggestions are made as to how collaboration between various parties in society might be structured in future in order to best produce information for various decision-makers.

This study is based mainly on written material and interviews. The CPM reports published since the beginning in 1996 and that have been used in this study are listed in appendix 2. Other related reports may be found in the reference chapter. Interviews have also been conducted, with both current and former company members (see the foreword for people involved). The interview questions are listed in 3.

The CPM companies represent various different sectors, e.g. the motor industry, forestry and the electronic industry, as well as various parties in the product chain, e.g. the raw materials and processing industry as well as end producers.

1.2 Background

Sweden is a part of Europe, and in order for there to be good conditions for a healthy market and effective environmental work in Sweden, we must all take this into account when planning our work. Within the European Union a decision has been made to have a life cycle perspective of the environmental performance of products. This decision supports Swedish environmental work and contributes towards compliance with environmental quality objectives. Below is a brief description of the EU's integrated product policy and the Swedish environmental objectives, with reference to other sources of information if you wish to find out more. There is also a description of CPM's organisation, business activity and history.

1.2.1 IPP – EU's integrated product policy

In 2001 the European Commission presented a so-called Integrated Product Policy (IPP) with regard to the environmental performance of products. The IPP initiative is described in a Green Paper produced by the European Commission. The purpose of IPP is to improve the environmental performance of products throughout a product's entire life cycle. Products are understood to mean both goods and services. The overall objectives of IPP work are:[1]

- To stimulate demand for environment-friendly products by offering customers easily accessible, credible information

- To stimulate company management to make products environment-friendly, by such means as generating flows of life cycle information and supporting product development, as well as developing standards for environmental work
- To apply the pricing mechanism to develop the market for environment-friendly products, by such means as extending producer liability and eco-labelling of products

IPP is an important strategy in environmental work in both Sweden and the EU. The Commission is currently working on producing a communiqué on IPP during the spring of 2003, as a development and clarification of the Green Paper. In 2002 the Swedish Environmental Protection Agency announced a governmental assignment to further develop the integrated product policy.

For more information about IPP, see, for example, the Swedish Environmental Protection Agency's website: www.naturvardsverket.se/samhälle&miljömål/IPP or the Green Paper on integrated product policy[2]. This and a lot of other material can be downloaded and read from the EU's web pages about IPP: http://europa.eu.int/comm/environment/ipp.

1.2.2 Sweden's environmental quality objectives

In 1999 fifteen environmental quality objectives were adopted by the Swedish parliament, to serve as guidelines for future action in the environmental field by state-owned parties and other parties in society. The objectives describe the properties that Sweden's natural, environmental and cultural resources must have in order for society to be able to develop in an ecologically sustainable way. The overall objective is to be able to pass a society without major environmental problems on to the next generation, i.e. in 20 years, in 2020.

Three action strategies have been adopted by parliament, and the aim is that when combined these will contribute towards the environmental quality objectives being achieved within the prescribed time. These are the efficiency strategy, the cycle strategy and the resource management strategy. The efficiency strategy relates to the efficient use of energy and transport operations, the cycle strategy to the achieve a closed, toxin-free material cycle and a low-resource cycle, and the resource management strategy involves taking care of our resources in the form of land, water and the populated environment.

Sweden's fifteen environmental objectives are listed together with associated interim targets in appendix 1. More information about the environmental objectives may be found, for example, at the official Environmental Objective portal http://www.miljomal.nu/

1.2.3 CPM – Competence Centre for Environmental Assessment of Product and Material Systems

CPM is the Competence Centre for Environmental Assessment of Product and Material Systems, and is a competence centre at Chalmers University of Technology, initiated by NUTEK (now VINNOVA). It was established in 1996, since when it has formed the hub of one of Sweden's largest and most important ICA networks. The main purpose of CPM's business is to:

– Prevent and reduce the environmental impact of products
– Collect and support Swedish competence for sustainable product development on an international level
– Provide relevant methods and support for the implementation of environmental aspects in decision-making with regard to products and material for industry and society

CPM is financed in equal parts by three parties, Chalmers University of Technology, VINNOVA – Swedish Agency for Innovation Systems (formerly NUTEK), and its industrial members:

1. ABB *(CPM members from the beginning, i.e. stages 1-3)*
2. Akzo Nobel *(stages 1-3)*
3. Avesta Sheffield *(stage 2)*
4. Bombardier Transportation *(stage 3)*
5. Cementa AB *(stages 2, 3)*
6. Duni *(stages 2, 3)*
7. Electrolux *(stages 1, 2)*
8. Ericsson *(stages 1, 2)*
9. Holmen (formerly MoDo) *(stages 1, 2)*
10. ITT Flygt *(stage 3)*
11. Perstorp AB *(stage 1, 2)*
12. SAAB Automobile AB *(stages 1-3)*
13. SCA Hygiene Products *(stages 1-3)*
14. Stora Enso *(stages 1-3)*
15. Telia *(stage 1)*
16. Vattenfall AB *(stages 1-3)*
17. AB Volvo *(stages 1-3)*
18. Volvo Car Corporation *(stages 1-3)*

CPM has been through three stages since 1996. In stage one, between 1996 and 1998, they developed systems to give a structure and method to LCA data management, and built up the national, reviewed LCI database SPINE@CPM. This work was based to a large extent on the knowledge and networks established in the period up until 1995 when the LCA data format SPINE was developed[3 4]. In a first international assessment of all competence centres at Chalmers University of Technology, CPM's work is summarised as being extremely important, with good support from both industry and academia.[5] Stage two, from 1998 to 2001, aimed to develop the best methods available for LCA, highlighting important method selections, etc. A comprehensive international assessment of CPM in 2000 summarised the business and laid the foundation for stage three.[6 7] Stage three will last until 2004, and one important task during this period is to introduce the results of development and test work into reality, i.e. to adapt the results into financial contexts and to focus on functionality and value.

Within CPM work takes place on research, applied research and special assignments that are appropriate for a competence centre, e.g. participation in ISO standardisation. At the time of writing a discussion is under way on how, in practical terms, CPM can reinforce its collaboration with Chalmers' new initiative in the environmental field, Chalmers Environmental Initiative (CEI), in order to establish itself as a committed player in international contexts. In various projects, both CEI and CPM are already collaborating with both national and international institutes and universities, companies and authorities, etc.

Work being undertaken on product-related environmental assessment within each company in the CPM consortium affects project proposals and project work within CPM, by way of company representatives contributing their experiences, problems, ideas, etc. Research is being conducted in companies within the framework of the projects, and researchers from Chalmers University of Technology are involved in questions and problems that companies are encountering. In this way research and development within CPM is being directed towards solutions that are actually required by the companies.

At the same time, independent research work is being undertaken at Chalmers University of Technology, which has other sources that enable it to achieve the relevance and applicability for questions and results that are so important, e.g. other project partners outside the sphere of CPM, such as the EU, authorities, individual companies, institutes, consultants, etc. This activity is important to CPM members, as this is one way of bringing new knowledge and experience into the consortium.

1.3 Core terms in the study

This chapter contains explanations of the most important terms in this study: quantitative life cycle impact assessment, life cycle perspective and life cycle assessment.

1.3.1 Quantitative life cycle impact assessment

Examples of results from a quantitative life cycle impact assessment are the degree of recyclability, kilograms of CO_2 equivalents that contribute to the greenhouse effect, or cubic metres of the natural environment required for an emission of a toxic substance not to have a negative impact. These results consist of raw figures, not qualitative environmental statements in the form of TYPE I labelling, policy documents or summary product data sheets. It is important to emphasise that the quantitative life cycle impact assessment is not limited in environmental work, as many claim. The best environmental work is achieved when quantitative and qualitative values are linked together. This methodology is currently being developed at the Industrial Environmental Informatics department at Chalmers University of Technology, in collaboration with CPM.

In brief, this methodology means that a quantitative life cycle impact assessment of a product is based on an environmental policy, i.e. a description of the company's approach, in which environmental work plays an all-embracing role. The policy defines what is meant by the "environment" together with the overall objectives for environmental work.

The policy is then used to identify the environmental indicators, i.e. the things in the environmental that the company is concerned about and wants to improve in its environmental work, e.g. fish stocks or air quality. Without making the policy concrete in this way, it is impossible to quantify and measure any changes in environmental impact.

To be able to conduct a quantitative life cycle impact assessment, you must then move one stage further and quantify the indicator. Fish stocks can be measured as "the number of dead fish in the lake" or air quality as "the concentration of sulphur dioxide and nitrogen dioxide in the air".

Finally, the result of the life cycle impact assessment must be linked back to the environmental policy and objectives, so that the company can draw conclusions on the product's positive or negative environmental impact based on its original position.

1.3.2 Life cycle perspective and life cycle assessment

In this study, the life cycle perspective means an all-embracing view of the environmental impact of a product, from receipt of raw materials, through the refining processes and final manufacture, to the utilisation phase and recycling, reuse or waste management for a product. This all-embracing view balances responsibility for local, momentary environmental impact with the impact further up and down the product chain over a longer period of time.

The life cycle assessment, LCA, refers in this study to a method-based analytical tool, a well-established technique that is used to conduct quantitative life cycle impact assessments from a life cycle perspective. A standardised procedure for this LCA technique is described in ISO 14040 Principles and framework for life cycle assessment (LCA)[8], ISO 14041 Life Cycle Inventory (LCI)[9], ISO 14 042 Life Cycle Impact Assessment (LCIA)[10] and ISO 14 043 Life Cycle Interpretation[11].

LCA consists of two elements, the life cycle inventory and the life cycle impact assessment. In the life cycle inventory you define the objective and the scope of the LCA study, you model the product system, gather data for all elements and perform the LCI calculation, in which all flows into and out of the system are allocated per functional unit. The life cycle impact assessment aims to examine a product system's impact on the environment by first of all identifying indicators in the environment, i.e. the things in the environment that you are concerned about and want to improve in your environmental work, and then linking these to the LCI result with the aid of models for environmental impact and subsequent weighting.

1.4 Notes on reading the report

The introduction provides a background description of the report by introducing the environmental work within Sweden and Europe that is relevant to the report, and describing CPM's role since it started in 1996. The introduction also defines the purpose, scope and method of the study, together with a presentation of the core terms used in the study.

The work of CPM companies on quantitative life cycle impact assessment, their view of the collaboration within CPM and future needs are described in chapters

2. CPM companies' work on product-related environmental assessment,

3.1 Benefits of CPM collaboration and

4. Knowledge gaps and limitations in information acquisition and provision.

The project reports published since CPM started in 1996 are divided into four groups, reflecting the chapter headings

3.2 Industrially applied tools for the quantitative life cycle impact assessment of products,

3.3 Development of methodology for the quantitative life cycle impact assessment of products,

3.4 Understanding and communicating quantitative information for the life cycle impact assessment of products and

3.5 Sources of data and information.

Conclusions and suggestions for the future are presented in

5. One way of using CPM's results to provide guidance towards Swedish environmental quality objectives,

6. Collaboration between various parties in the future to improve flows of knowledge and information.

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1 EU Institutions press releases, Commission adapts green paper on integrated product policy, Brussels, 2001-02-08

2 COM (2001) 68, Brussels 2001-02-07

3 Carlson R, Design and Implementation of a Database for use in the Life Cycle Inventory Stage of Environmental Life Cycle Assessment, 1994

4 Steen B, Carlson R, Löfgren G, SPINE, A relational database structure for life cycle assessment, 1995

5 NUTEK, First International Evaluation Group 3 (7 centers), October 1997

6 CPM, Report to internal evaluation group, October 2000, Internal CPM report

7 Baras J S et al., Competence Centers Programme, Second, Mid-Term, International Evaluation, November-December 2000, VINNOVA Information VI 2001:5

8 ISO 14040, Environmental Management – Life Cycle Assessment – Principles and framework, International Organization of Standardization, 1998

9 ISO 14041, Environmental Management – Life Cycle Assessment – Goal and Scope Definition and Inventory Analysis, International Organization of Standardization, 1998

10 ISO 14042, Environmental Management – Life Cycle Assessment – Life Cycle Impact Assessment, International Organization of Standardization, 1999

11 ISO 14043, Environmental Management – Life Cycle Assessment – Life Cycle Interpretation, International Organization of Standardization, 2000

2 *CPM companies' work on product-related environmental assessment*

This chapter summaries the tools used by companies in their work on product-related environmental assessment. In this context the term "tool" has the very general meaning "facility to aid the decision-making process" in a quantitative life cycle impact assessment. According to the CPM companies, it is principally customer requirements and statutory requirements that form the basis of this environmental work.

LCA is the tool used within virtually all CPM member companies to acquire and impart knowledge of products' environmental impact, although the area of application varies between companies. A summary of this work is presented below. Other tools, i.e. also those that apply the LCA perspective in a more general sense, that are used at companies to acquire and impart knowledge of products' environmental impact, are also presented in this chapter.

2.1 Life Cycle Assessment

An LCA is applied to map out precisely or in general terms the environmental impact of components and materials, i.e. to increase knowledge of the products within the company. It is also used as a tool in research and development work on new products and functions, to take into account the product's or function's life cycle impact. One example is to continuously compare the environmental impact of new products with old ones using an LCA, in order to maintain control of product development and life cycle impact.

An LCA can also be a tool to identify the most important environmental aspects for a company, in accordance with the ISO 14 001 and EMAS environmental systems, and to identify where the most effective improvements can be implemented. The results from an LCA can also be used as references to indicate improvements in environmental work. Other results that an LAC can provide include identification of which dismantling manuals need to be produced for a product.

The LCA result for a product can be issued together with other information, e.g. from an Environmental Risk Assessment (ERA), to customers, who in turn then compile environmental information about the product for the end customer. By conducting an LCA for products, you can also communicate certified and other environmental product declarations (EPD – Environmental Product Declaration) directly to end customers. Product data sheets, environmental fact sheets, so-called paper profiles (a kind of simple environmental product declaration produced in a Nordic collaboration applied within the forestry industry), manuals, instruction manuals or other customer documentation are all means of communication aimed at customers. These can describe what a product is good for, how to use it, etc., and here you can include general environmental information based on, for example, an LCA. Other external forms of communication describing a product's environmental impact that companies have mentioned include feedback to suppliers involved in environmental work, annual reports, brochures, information to trade journals, news agencies, the EU and participation at trade fairs, etc.

2.2 Other tools that are useful in a life cycle perspective

There are tools that offer support in various ways for environment-friendly product development. The construction and design of a product is thus adapted for reuse, recycling and many other environmental considerations (DfR - Design for Recycling, DfE - Design for Environment). LCA is one such tool, and another is the labelling of components or materials to show the customer how it is to be maintained, disposed of, etc. Environmental Effect Analyses (EEA, or E-FMEA – Environmental - Failure Mode Effect Analysis) are qualitative assessments of LCA-related and environmental aspects that are conducted at an early stage in development projects together with product developers, buyers, etc. in certain CPM companies. These analyses might, for example, lead to the identification of problem areas in which more detailed LCAs have to be conducted. Chemical lists and restricted lists with various limitations, e.g. bans on the use of certain chemicals and materials, information on a planned phasing out of these and instances when substitute methods should be applied are all commonly used tools in work on the life cycle impact of products. As well as trying to investigate whether a chemical or material is included in a restricted list, many companies also conduct a risk assessment and classification of chemicals and materials that are not included in the lists. This environmental and risk assessment is often based on confidential information from the supplier. Other work with chemicals includes external communication in the form of safety sheets or safety data sheets, i.e. the legal requirements to provide recipients of products subject to the Swedish National Chemical Inspectorate's regulations with up-to-date safety data sheets in accordance with these regulations.

Environmental reporting is something that all businesses with an obligation to obtain a permit must produce, in order to fulfil the legal requirements in Sweden. The EU also plays an important role in this area, as it defines legal environmental requirements such as the European End-Of-Life Vehicle Directive, which controls the motor industry's producer liability for used products. End-Of-Life Vehicle Management is a collaboration within the motor industry in Europe that has been created to satisfy these legal requirements, by such means as creating shared material databases.

Collaboration on research and testing takes place between CPM companies and their customers, e.g. to produce system solutions for a specific application, to make sure that the product is used efficiently, to avoid sub-optimisation of the environmental impact by creating system borders in their studies that are too tight, etc. Benchmarking between products is another way of analysing the life cycle impact of products.

3 *Knowledge and information about the environmental impact of products within CPM*

Section 3.1 below contains a summary of the value perceived by member companies that CPM represents for their work on product-related environmental assessment. The summary is based on interviews with company representatives. The foreword contains a list of the people who were interviewed.

The other sections, 3.2-3.5, are summaries of CPM reports written since the beginning in 1996 up to and including 2002. All projects undertaken within CPM have been concluded with some form of CPM report. In total over 50 reports have been published under the direction of CPM. The report summaries are divided into four sections, based on the differences in information processing and knowledge of products' environmental impact that are most relevant for the report. The various areas are:

- tools used in industry,
- development of methods,
- understanding and communication of quantitative information and
- sources of data and information for quantitative life cycle impact assessment of products.

A scientific summary of CPM's activities between 1999 and 2000 is contained in the "Scientific report 99 03 01 – 00 02 29"[12].

3.1 Benefits of CPM collaboration

The single most important result of CPM's work so far is definitely the national, reviewed LCI database SPINE@CPM. SPINE@CPM is an important source of LCI data for companies, and tools relating to the database, e.g. the data documentation tool SPINE@CPM Data Tool, are used by many member companies. They consider that the SPINE tools provide a systematic aid to environmental work and contribute towards greater credibility, as the structure enables work to be transparent. It is important, for example, for the external communication of product's environmental impact via environmental product declarations (EPD), and also when certifying environmental management systems, etc. Staff at companies are trained internally or at CPM to master these tools and to learn the theory behind them.

According to the companies, one very important task of CPM is the quality assurance of information and methods for the quantitative assessment of products' environmental impact. As the university is an independent party, this reinforces the credibility of all environmental work. Quality-assured information is provided by the national LCI database SPINE@CPM, which currently contains around 500 reviewed data sets. Quality assurance is based on CPM's data quality criteria[13], which where drawn up jointly in the CPM consortium in connection with the creation of the database and the SPINE data format, which then contributed towards the standardisation of the ISO/TS 14 048 LCI data documentation format. Quality-assured methods mean validated methods that have been scientifically produced, such as the EPS assessment instrument, which is used in LCAs. LCA technology has also been developed and standardised with the aid of CPM's research and experience.

CPM is at the forefront of research in the field of environmental system analysis and industrial environmental informatics. This means that CPM is a major source of knowledge for the companies. They see benefits in being involved on research work, as they can obtain the results more quickly and be involved in influencing its direction. They can also be involved, for instance, by sponsoring industrial doctoral candidates, and this raises competence levels within the company.

CPM also acts as a sounding board and a forum for discussing and initiating project ideas, identifying problems and finding solutions. CPM is the hub in an LCA network that is important to member companies. A company often has only one or a few people working on LCA-related tasks, so it can be beneficial to get ideas and support from other companies and organisations on such matters. CPM companies emphasise the value of sharing experiences among proactive companies with similar conditions and problems in the environmental field.

CPM is also necessary to support the companies' external activities, dialogue with authorities, the EU, UNEP (United Nations Environment Programme) and other research and political forums. CPM's work involves gaining international acceptance for research results, for example ISO standardisation, which contributes towards increase utilisation and value for all members.

CPM is also an important bridge between academia and industry. Both parties need one another in order to create scientifically accepted, efficient environmental work. CPM thus plays an important role, helping to produce simple tools that everyone can use in their environmental work, i.e. translating research results into practice. By the same token, industry contributes with information on which problems are relevant, etc. This mutual need should encourage collaboration to a greater extent than is the case in Sweden at present.

3.2 Industrially applied tools for the quantitative life cycle impact assessment of products

The CPM projects that deal directly with testing various tools to assess life cycle impact in industry are summarised in the section below, based on CPM reports published since the start in 1996. The reports deal with the application of LCA in product development and in communicating a product's life cycle impact to the professional buyer and the private customer.

3.2.3 LCA in product development

A study was conducted in 1999 to integrate the environmental aspects into concept selection in product development at Saab Automobile AB.[14] They also wanted to create a joint platform and uniform procedure for assessing environmental aspects in all stages of product development. In the study they identified six indicators that they could use to assess life cycle impact during concept selection and in the subsequent stages of product development. The result led to the product's life cycle impact being discussed to a greater extent than before, both in the actual development work and in connection with decision-making. The study also gave rise to suggestions for a further development of the tool.

In 2001 CPM collaborated with IVF Industrial Research and Development Corporation to develop a much simplified LCA tool for the electronic industry, which, besides being simple, contains transparent, documented and structured LCA information for PCBs.[15] The method used to build up the information system that supports this web-based tool can easily be applied to other industries or products. The tool is aimed mainly at product developers, as well as others involved in the supply chain, and aims to generate interest in environmental aspects of product development and LCA as a tool to assess the life cycle impact of a product. IVF Industrial Research and

Development Corporation was a project partner, and is responsible for publication of the tool: layout, user support, marketing, etc. The tool has not yet been published.

A couple of LCAs were conducted within CPM in 1999, with the aim of comparing the life cycle impact of products and functions. One of these compares the environmental impact of a videoconference versus a physical meeting [16], and the other highlights the environmental and financial consequences of selling functions instead of products [17]. According to the summaries of the two assessments, the LCA tool worked satisfactorily in comparing and assessing life cycle impact.

3.2.4 LCA-based environmental product declarations

During stage 1 of CPM, CPM and the Gothenburg Research Institute (GRI) at the Gothenburg School of Economics and Commercial Law were given the task of evaluating and further developing a manual for the calculation of LCA-based environmental product declarations that had been produced by IVL Swedish Environmental Research Institute.[18] The evaluation highlights how an LCA that is to form the basis of a third party-certified environmental product declaration should be produced with regard to viability, acceptance, clarity and generality. In the project they also drew up recommendations for the structure of Type III environmental information for professional buyers.[19] [20] The advice given to improve the understanding of Type III information was to focus on training the buyers and to simplify the information.

In 1999 CPM was involved in producing a manual for reviewing LCAs, with reference to EPD, together with bodies including Chalmers Industriteknik (CIT), IVL Swedish Environmental Research Institute (IVL), Svenska Material- och Mekanstandard (SMS) and AB Svenska Miljöstyrningsrådet.[21] This work forms the basis of specifications for the reviewing procedure in the Swedish EPD system. The review methodology is based partly on that developed within CPM.

In 2001 two studies were conducted dealing with the communication of product-related environmental information. Both studies emphasise the importance of those who provide and those who request environmental information understanding one another. One study is aimed at private customers[22] and the other at professional customers and buyers[23].

An interview survey was conducted among private customers regarding the information on a product's life cycle impact that customers would like, compared to what they are offered in the form of environmental product declarations. The survey aimed to find a way of communicating LCA-based information to private consumers in a simple, informative way. The result of the survey shows that consumers believe that it is difficult for them to assess the environmental impact on the basis of the quantitative life cycle impact information provided for a product. There is not enough time, and they have no clear references and/or knowledge of the subject. Depending on which type of product group was studied, there were different opinions of which kind of communication worked best. Eco-labels/logotypes with a credible background in the form of a control body, etc. were desirable in some cases, environmental product declarations in others, etc.

The second study was based on group meetings with representatives of industry and authorities in Denmark, Sweden and Norway, and in-depth interviews with representatives from marketing, purchasing and environmental departments. Procedures suggested to create a common basis for understanding information about a product's life cycle impact in this study were to invest in activities that bring professional customers and buyers closer to producers and data providers, and also to invest resources in describing the information needs of the customer before formulating the product-specific or sector-specific requirements. Such activities might include targeted information campaigns for the various user groups about the Nordic EPD system, LCA methodology and its application, together with close collaboration with industry to develop Product-Specific Rules (PSR) for a product group.

3.3 Development of methodology for the quantitative life cycle impact assessment of products

The CPM projects that aim directly to develop methodology for life cycle impact assessment tools in industry are summarised in the section below, based on CPM reports published since the start in 1996. The reports deal mainly with methodology for the life cycle inventory (LCI) and the life cycle impact assessment (LCIA), although there was also information about the integration of decision-making processes for environmental work within a company.

3.3.1 Life Cycle Inventory

During 2001 a licentiate's dissertation was presented on the modelling and simulation of processes in the Life Cycle Inventory (LCI) to support potential product and process development options, for application in the field of cement manufacture.[24] A model was developed to simulate various product and process options, and to generate information about potential environmental, product and financial performance. At about the same time a closely-related report was written, although this was more about the mathematical methods of modelling and simulation in an LCI.[25] One of the conclusions of this study was that very little has been done in the field of LCA method development, for example no literature was been found on this subject within the framework of this study. The LCA technique as applied by ISO and other sources does not take into account simulations in LCI. It can be interpreted that LCI calculations involve finding an acceptable, linear solution for the problem. The report suggests how it might be possible to simplify and improve modelling and simulation in LCI.

A doctoral thesis from 1998, which was partly financed by CPM, dealt with the life cycle analysis in the building industry.[26] It contains both case studies and a development of methods. A licentiate's dissertation in the same area was completed in 1999, in which the author concentrated on the differences in the production phase and the utilisation phase.[27] In 1999 the next doctoral thesis was produced, dealing with system expansion and allocation in the field of LCA, with regard to the processing of waste paper.[28] In 2001 a study was conducted, which produced recommendations on how metal recycling should be modelled in an LCA, based on existing methods and depending on the purpose of the study.[29]

3.3.2 Life Cycle Impact Assessment

EPS (Environmental Priority System in product development) is a tool that was initially developed in a small project at Volvo in 1989, for the purpose of enabling them to produce a quick, rough estimate of the environmental impact of a product in the product development phase. The EPS system has then been further developed and also become known as an assessment tool for LCI results.[30] The systematic approach for using EPS in product development is documented in two reports, one describing the general characteristics of the system[31] and one describing the models and the data content in the method [32].

One indicator that can be found in the EPS system is Years Of Lost Lives (YOLL). A CPM project that was conducted during 2000-2001 aimed to model the contribution from the processes in the nuclear fuel cycle for environmental impact in accordance with the YOLL indicator. The report confirms that this impact is negligible compared to the equivalent effects of natural radiation [33].

A general summary of the various weighting methods for LCA was produced at CPM in 1998[34]. A licentiate's dissertation was produced in 2000 by the same author, who on this occasion investigated how weighting methods are used and perceived in practice [35]. Some of the conclusions were that there is a need to use more different methods to cover decision-makers view of the world, and that aggregated results from weighting methods were difficult to understand and use.

A CPM report from a study conducted in 2001 presents ways of identifying significant environmental aspects and indicators for assessing the life cycle impact [36]. The author offers several tips on which questions are significant in this work, e.g. how do we define the environment and how can we see whether it is getting better or worse?

Two linked CPM reports have been written on how one might estimate the environmental impact of land use in an LCA, one being published in 1998[37] and the other in 2002[38]. The latter suggested a method of including land use in an LCA, and discussed the advantages and disadvantages of the method. It is based to some extent on the results of the first report. Indicators presented to represent the land quality are the ecosystem's productivity (production of biomass) and biodiversity (presence of species from the Swedish 'red list' of threatened species [39]). Reference levels are suggested, and an evaluation of Sweden is presented.

In 2001 a study was produced that investigated the availability of metals in the earth's crust, in order to be able to quantify and evaluate resource extraction in an assessment of life cycle impact.[40] It presents opportunities to produce rare metal concentrate from the bedrock and other kinds of minerals than are currently considered to be accepted mineral resources.

3.3.3 Integration of decision-making processes

During CPM's first stage, CPM contributed towards a disputation entitled "Life Cycle Assessment and Decision Making" by way of CPM companies being included in case studies.[41] The result showed structural differences in how LCAs were used at companies, that LCAs served to teach rather than support decisions, and that the introduction of LCAs depended to a great extent on an LCA contractor.

In 2001 a thesis was produced at CPM based on the integration of decision-making processes for environmental work in a company.[42] The essay introduced a model for an integrated environmental management system and the implementation of an environmental strategy. Pitfalls were discussed, as were the importance of well-defined indicators, the link between economy and ecology, and the design of the environmental management system.

3.4 Understanding and communicating quantitative information for the life cycle impact assessment of products

In 1993 the development of SPINE was initiated through a thesis [43] at Chalmers University of Technology, and this continued between 1994 and 1995 in a Nordic project, with many participants from industry and various research organisations. The result was published in 1995 in the report entitled "SPINE, A relational database structure for life cycle assessment"[44], and this was a contributory catalyst to the launch of CPM in 1996.

The SPINE system has since been developed in many different ways, while still retaining its original basic aim and core. Industrial applications have indicated important areas of research, and research has made it possible to have more detailed modelling and systematisation. Although all work on system development and data processing at CPM is actually related, CPM decided in this report to present work on SPINE under the six headings Database structure and exploitation, Data quality control, Data exchange, formats and standards, Models and strategies for data acquisition, Integration of information systems and Networks and trade. This breakdown is based on sorting work on CPM reports published since CPM started in 1996. Data and information sources are listed separately in the next chapter.

3.4.1 Database structure and exploitation

The creation of the quality-reviewed LCI database SPINE@CPM started in the wide-ranging project entitled Establishing CPM's database in connection with the formation of CPM in 1996, which ran until the end of 1997. The overall aim of this project was to increase the availability, usefulness and quality of LCA data.[45 46] This involved creating a physical database for LCA data, developing criteria for data quality requirements, collecting and documenting data, publishing certain data for the public, developing and managing the database's conceptual data model SPINE and working to standardise an LCA data documentation format. The results of the project include 174 well-documented data sets, models for data reviewing and documentation, technical systems to support data administration, documentation and reviewing, protected Internet publication of data, participation in a proposal for a new ISO 14040 standard relating to LCA data documentation format. [47] In CPM's stage 2, from 1998 to 2001, there was a continuation project that aimed to add to the content of the database.[48] In the course of this project a further 272 reviewed data sets were acquired for SPINE@CPM, and 271 non-reviewed ones for the SPINE@by-pass database (used only for training and experimentation). Data came from CPM companies, students producing theses as well as specific data acquisition projects, and was reviewed and published by CPM. A final report summarises CPM's business management of the data business during stage 2.[49] At present SPINE@CPM contains just 500 data sets, see appendix 4.

During 2001 the three methods of assessing life cycle impact, EPS – Environmental Priority System for product design[50 51], EDIP – Environmental Design of Industrial Products[52 53] and Eco-indicator '99[54], were interpreted and implemented in the WWL-CAW (World Wide LCA Workshop) tool according to the SPINE model.[55] All three methods are now available free of charge on the Internet.[56] A manual for documenting methods of assessing life cycle impact according to SPINE, e.g. in WWLCAW, has been produced at the Industrial Environmental Informatics unit at Chalmers University of Technology.[57]

CPM was involved, and financed the application to the EU project OMNIITOX (Operational Models aNd Information tools for Industrial applications of eco/TOXicological impact assessments), which will be completed in 2004.[58] The results of the OMNIITOX project include an OMNIITOX tool that will contain physical, chemical and toxicological data on substances and information about their toxicological effect on people and the natural environment in the form of characterisation models and factors. It will also include an information portal for risk assessment (ERA – Environmental Risk Assessment).

3.4.2 Data quality control

Within the framework of CPM's database project Establishing CPM's database, during 1996 the Data quality sub-project was undertaken, with the aim of achieving agreement within CPM on the definition of data quality, in order to form the basis for the data quality requirements in the SPINE@CPM database.[59] One of the conclusions was that the requirement for data quality varies, depending on the user, the target group and the purpose of the study. To be able to gain a perception of the quality of data in every single case, there must be carefully documented metadata, i.e. data about data. The same year saw the first manual for LCI data documentation according to CPM's data quality criteria.[60]

1999 saw the publication of a radically overhauled and extended manual for LCI data documentation according to CPM's data quality criteria and the SPINE format[61], as well as support for the data quality reviewing process within CPM[62]. In the same year there was a revision of the CPM report "Requirements of data quality, CPM's database 1997"[63], which contained a comparison of the SPINE format and CPM's data quality requirements with the ISO 14041:1998 standard.[64] Training in CPM's data quality requirements, the SPINE format, documentation methodology, etc. is an important element of work on maintaining the data quality in SPINE@CPM.[65] The concept of data quality that is applied within CPM was developed during stage 2, and the result was summarised in "FAQT – Fundamentals of data quality for industrial environmental information systems".[66]

A licentiate's dissertation was presented in 2001, focusing on the relevance of the data quality aspect, in which the author asked how the most relevant LCI data could be selected when there were variances in the same or similar unit processes.[67] The proposal put forward was that data must be documented in such a way as to enable the person conducting the LCA to decide easily which of the processes he should choose, without having detailed knowledge of these processes.

3.4.3 Data exchange, formats and standards

On the basis of its experiences, CPM initiated and drove the standardisation process that resulted in the ISO/TS (Technical Specification) 14048 LCA data documentation format[68]. This is based on, among other things, experiences from work on the SPINE format. In the same year that the technical specification was ready, CPM compiled and published examples of applications of the format in the documentation of eleven data sets.[69] The documentation of these data sets was the result of work at CPM that had run in parallel with the development of the technical specification. CPM wanted to make sure that the format was easy to understand and to use in practice. At the same time, a report was written aimed at systems analysts and programmers, containing implementation support for an electronic data exchange and storage format based on ISO/TS 14048.[70] The implementation process is described with the aid of XML (Extensible Markup Language) and relational database modelling.

In the final report for the standardisation project for CMS's second stage, which was published in 2001, the project manager summarises that CPM has completed its objective of being involved in the initiation and production of the ISO/TS 14048 technical specification.[71] He also confirms that CPM can play an important role in introducing the standard into international business operations and operational routines, which will require such processes as training and interpretation.

One project that was used as a basis for work on standardisation was an investigation that tested the SPOLD format[72], compared and mapped out the SPINE format with the SPOLD format.[73] Some of the conclusions of this work were that SPOLD's operational results were inflexible and difficult to understand, while SPINE guarantees the retention of data quality when entering from another format.

A project aimed as harmonising formats was co-ordinated by CPM during 1999-2000, in which LCA software developers and users developed solutions to simplify data communication between various tools.[74] CPM was also invited to act as advisor in a project undertaken within the IRIS industry network during 1999. CPM's role was to help ensure that Sirii's environmental data network was not developed beyond the framework that had been drawn up in the form of consensus decisions within Nordic and Swedish work on the SPINE system and the current status within ISO.[75] This collaboration resulted in a tool and a format that partly corresponds with both nationally and internationally accepted standards. The collaboration did, however, ensure that compatibility between the Sirii format and the SPINE format could be guaranteed. CPM produced a more detailed review of the results in the collaborative project's final report.

3.4.4 Models and strategies for data acquisition

Several data acquisition projects have been undertaken within the framework of CPM's activities since the outset in 1996. The projects have focused on varying issues. Besides the main purpose of adding quality-reviewed data to the SPINE@CPM database, CPM has tried, for example, to develop methods and systems for data acquisitions, formatting, training and quality control.

In 1997 a project worth ten points towards their degree was produced by students in the second year of a Scientific Problem-solving course at the University of Gothenburg..[76] The assignment from CPM was to find out the extent to which environmental reports that form the basis of the statutory permit testing of a business can serve as a basis for providing information to produce an LCA. The conclusions were that they do not provide sufficient information, although they can provide some useful information about the business and its products and processes.

During 2001 CPM, in collaboration with the European aluminium industry (EAA – European Aluminium Association), formatted LCI information in its official environmental report in SPINE format according to CPM's data quality criteria.[77] The purpose of this work was partly to reach agreement on which LCI data was representative for the industry, and partly to document and teach the formatting method, the SPINE-format (as valuable knowledge and preparation ahead of the application of ISO/TS 14048) and CPM's data quality criteria.

An undergraduate thesis with a more strategic emphasis on data acquisition, as applied in the electronics industry, was undertaken during 1998-1999.[78] In her conclusions, the author concludes that it is important to have a strategically well-structured data acquisition process in a company. Depending on the purpose of data acquisition, there are different demands on quality and quantity, and at the same time cost and time calculations vary. This must be taken into consideration in the strategies that form the basis of the data acquisition process, so that it is possible to make well-considered investments in daily work that provide returns in the longer term.

A development of the PHASES information models for industrial environmental control was presented in a CPM report in 2000.[79] These models can be used for information relating to the three systems, technology, environment and society, that are linked together in an LCA. These can simplify and structure the information system, data flow, data quality management, system analysis modelling, reporting, etc. The project entitled "Methodology for processing environmental data from the forestry industry", was a collaboration between CPM and SSVL (Forestry Industries' Environmental Research Foundation).[80] In this project, a quality assurance system was developed to control environmental data within the PHASES information models. CPM has suggested an ISO standard based on PHASES. The name proposed for the standard is "Standardisation of verifiable collection and preparation of environmental information", and the work will be launched in 2003 in the form of a workshop under the guidance of CPM.

3.4.5 Integration of information systems

In the final report on the Integrated environmental information systems project, following CPM's second stage, the author concludes that during the project the IMI (Industrial Environmental Informatics) research group has produced a number of partial solutions within various sub-projects, and that it is important to consolidate these in the next stage.[81] Sub-projects and results highlighted in this context are the establishment and development of the SPINE system and the SPINE@CPM database, the international standardisation of the ISO/TS 14048 Data documentation format, the development of methodology to process data in the Swedish forestry industry, and the development of methodology and tools for environment-friendly product development in the European rail industry. The final report from the RAVEL (RAil VehicLe eco-efficient design) EU project included a summary of the needs for environment-friendly product development and requirements from the European rail industry, methodology for defining eco-efficiency and a description of implementation in an information system and a web-based software program.[82]

Within the framework of the CPM-SSVL project[83] and a licentiate project, in 2001 a report was written presenting an analysis of the current status of environmental information available and delivered within the Swedish paper and pulp industry, as well as the tools being used.[84] The author's conclusions include the comment that one problem with the access to information is the lack of transparent documentation (metadata) describing the data that is currently stored. At present you have to contact the "right" people to understand what the data represents, i.e. which technical system is used, which assumptions have been made, etc. A suggested communication model to analyse the demand for and follow-up on environmental information within a company was developed in a thesis during 2001.[85] This thesis was produced with the aid of tutorship financed by CPM and is based on methodology developed by CPM.

3.4.6 Networks and trade

In 1998 CPM's executive board decided that the SPINE@CPM database should be commercialised. Proposals of how this could be achieved were presented in a report entitled "Establishing trading structures for LCI data: a report describing CPM's strategy to develop trade in LCI data"[86]. It contains strategies describing the ways in which the exploitation of SPINE@CPM might be achieved, and describes what CPM's role might be in a network stretching beyond CPM's own boundaries. The report provides concrete assistance in describing how data management, sales and reviewing might work in a large network, applying CPM's experiences and methodology.

3.5 Sources of data and information

The courses of data and information that are owned or initially financed by CPM are:

- **SPINE@CPM** – LCI data
  SPINE@CPM currently contains around 500 SPINE-documented LCI data sets, or activities as they are called in the SPINE system.
- **WWLCAW** – Data for life cycle impact assessment (IA – Impact Assessment)
  WWLCAW (World Wide LCA Workshop) contains both SPINE-documented LCI data and data for life cycle impact assessment according to the three methods EPS – Environmental Priority System for product design[87 88], EDIP – Environmental Design of Industrial Products[89 90] and Eco-indicator '99[91]. WWLCAW is essentially an Internet tool that supports data acquisition projects by enabling all members to view the same data sets and discuss them via the Internet. A computer-based process of consensus enables a decision to be made on which data sets are suitable for use in the project.
- **LCA-E** – LCA data for PCBs
  This tool contains structured data that is used to create a simplified LCA on PCBs. Subcomponents included in the database are pattern boards, IC circuits, various kinds of resistors, etc., and the LCI system included raw material extraction, processing, production and assembly of PCBs. As far as the application phase is concerned, only energy consumption is included. All LCI data comes from the SPINE@CPM database. The IA system covers the life cycle impact categories in the EPD system, and the IA methods adapted for these are EPS, EDIP and Eco-indicator '99.

Other CPM-related sources of data and information:

- **The OMNIITOX database** – Data for toxicological characterisation in life cycle impact assessment.
  This database will contain physical, chemical and toxicological data about substances and information on their toxicological impact on people and the natural environment in the form of characterisation models and ocaktorer. It will also include an information portal for risk assessment (ERA – Environmental Risk Assessment).

- **RAVEL/REPID** – A tool that supports product development (DfE – Design for environment) in the rail industry.
  The tool contains material databases, lists of restricted and banned materials, and calculations of recycling ratios, etc. for the rail industry.

Other data sources used in CPM's work are listed in appendix 6. UNEP/ SETAC's latest compilation of LCI databases all over the world, "Current Availability of LCI Databases in the World"[92], can be downloaded from the website www.sylvatica.com/unepsumm.htm.

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4 *Knowledge gaps and limitations in information acquisition and provision.*

This chapter explains the knowledge gaps and limitations in information acquisition and provision as mentioned by the companies during interviews. Many comment on the LCA as a tool for a product-related environmental analysis, and the benefits and shortfalls identified. For example, the limited access to data is stated to be a major problem. Companies also mention support for data communication and inspiration for dynamic problem-solving as being important areas, in which resources need to be invested in order to develop work on products' life cycle impact in future. Finally, they comment on the potential of CPM collaboration and how it can be improved to suit the companies and their situation in the future.

In 1998 a seminar was held in Gothenburg entitled "Swedish LCA research — a look back and future development"[93], in a collaboration between the Swedish Environmental Protection Agency's Waste Research Committee and CPM. The report summarises experience in the development of methodology and applications in the LCA field during this period, and discusses development options for the future. Many of the views contained in this chapter were already mentioned in the discussions in 1998, e.g. difficulties in acquiring and thus gaining access to LCI data from subcontractors and raw materials suppliers (especially small companies and foreign suppliers), confusion in terminology and concepts in data communication, as well as difficulties in gaining access to quality-assured LCI data.

4.1 LCA as a tool for a product-related environmental assessment

According to the CPM companies, there are many benefits in the use LCA as a tool to assess the environmental impact of products. Above all, it provides a systematic way of working with the life cycle impact of products and data acquisition, it provides an overall perspective on the product's environmental impact, and it can help all parties in the supply chain to understand their contribution and responsibility. Many companies believe that LCA is the only practical tool that they are aware of that is also compatible with finance, technology and quality work.

But according to the CPM companies there are also deficiencies in the application of LCA and knowledge gaps, above all with regard to local environmental conditions and the toxic environmental impact of products. This is a problem that CPM and other research and development bodies in this field must work on.

The local environmental situation is often not even included in an LCA at present, not even in the result and the interpretation, as perhaps should be the case. For example, a person who is not familiar with issues in the field of LCA might easily interpret a relatively high rate of water consumption as being negative, even if there is plenty of water available at the site, for example, of a manufacturing process, whereas a relatively low rate of water consumption, which can have disastrous consequences at the manufacturing location, is interpreted as being positive. These environmental considerations are difficult to include in an LCA at present, as it is usually not related to local conditions. However, many people believe that this is important information that should be included in interpreting the LCA results and should therefore also be included when the results are communicated. In order to avoid these problems of interpretation, there are CPM companies that have adopted the practice of including their external EMAS report with their LCA results, as this report contains information about the local environmental conditions. Other companies believe that the purpose of an LCA is a reduced overall environmental impact, whatever the recipient, and that the local environment has little to do with the environmental impact. If a manufacturing process is transferred to a more sensitive natural environment, you must have worked to reduce the environmental impact, regardless of whether or not the previous natural environment was more robust. But as the life cycle impact assessment in the LCA is developed, the geographical resolution of models will become more detailed, and the local conditions can become a natural element of an LCA in cases where this is desirable.

At present the environmental impact of toxic substances is rarely or never included in an LCA. This is not because the LCA as a method is not suitable for measuring this kind of environmental impact, but because research and development is required of models to describe this impact, as is data acquisition to be able to run the models and simple tools to communicate or integrate this information into current LCA work. This work is currently under way, in one instance in an EU project that CPM helped to set up and involving several CPM companies. The result of this and other similar projects will mean that in time it will also be possible to include the environmental impact of toxic substances in an LCA.

Many CPM companies believe that reviews and system demarcation should be discussed more in an LCA context, in order to focus more on system solutions or functions rather than an isolated product or a given material. For example, you can direct all your attention towards the environmental disadvantages of a packaging material, without taking into account the environmental benefit for the product, e.g. in the form of reduced transport of the product due to a longer shelf life, and reduced scrapping of products with an overdue expiry date, etc. Companies have no mechanisms that actually utilise the holistic perspective in an LCA to find solutions to the environmental problem. According to the companies, there is also very little acceptance of this kind of discussion in society at the moment.

Other views are that the LCA methodology needs to be further developed and specified, and the formulation of results adapted for recipients. The ISO standards that describe LCA methodology at present are too general for the assessments to be reproducible. Different methods are applied due to the scope for interpretation, and people do not really know how they influence the results. The EPS method is an LCA tool that is used in product development at many of the companies, but how does a result from this method compare to the result from another method? The results from an LCA are often difficult to interpret for non-LCA experts, which limits the area of application. Interpretation keys are needed in order to be able to optimise the dissemination and utilisation of LCA results.

There are also questions that cannot be answered with the aid of an LCA, e.g. those relating to the work environment. In this respect it is natural for companies to work in parallel with LCA and the work environment, just as they work in parallel with finance, quality, technology, etc. LCA is not the only tool used in environmental work, but it can be used in many contexts and the general belief is that in future it will be possible to include both local environmental conditions and toxic impact. Until this is achieved, users will have to add such knowledge and information in other ways, including those mentioned above.

4.2 Cost and quality of LCI data

Another limiting factor in the use of LCA at present is the cost of data acquisition. At the moment there is much simplification and system demarcation in the field of LCA, as there is little access to LCI data, and the cost of data acquisition is too great.

Many believe that the solution to the problem of limited access to data is more, larger, and preferably public LCA databases. But in order to satisfy the market's requirements for an increased information flow, consideration must also be given to the companies' fear of information being used incorrectly. It is a case of having to identify the risks, inform about them and eliminate them in a way that is acceptable to all concerned. Relevant questions to ask are: What are the risks in using LCA databases? What happens if data is incorrectly interpreted? How can we avoid this? Who is the most suitable body to administer and develop the databases? etc. CPM does a lot of work on questions relating to data quality and database management, in order to find solutions that are sustainable for all parties involved. This report contains a few suggestions based on these experiences.

4.3 Support for data communication

Many of the CPM representatives interviewed mention that the information flow in the supply chain is often limited by companies with few resources. Larger companies have obtained certification under ISO 14001 or EMAS, and these are actively engaged in their own environmental work, placing demands on their suppliers. If suppliers have limited resources there is not much they can do, even if they want to. Maybe they do not even understand the demands being made by the customer. The customer in turn says that sometimes it is difficult to know who to talk to at these companies, that it is difficult to be understood when they use ISO-related terms, etc.

So how do you support raising competence levels in small and medium-sized companies, and improving data communication? The CPM companies' suggestions including training and mentoring projects. Others advocate company partnerships within a given supply chain. One important task is to create a common terminology for those who are to communicate data, a common language and format that everyone understands and shares. ISO standards in this area provide everyone actively working on such issues with a common platform, but there have to be some stages of interpretation to translate the standards into practice, to be understood and used by buyers and suppliers. This creates the facility and saves time for data communication, both between people and computers.

4.4 Inspiration for dynamic problem-solving

Authorities and companies play different roles in environmental work. One perspective is that authorities are good at static systems, meaning, for instance, control of emissions and chemicals, and legislation in this field, whereas companies work more with dynamic systems, which have to be optimised from one day to the next, or maybe from one hour to the next. Collaboration between these parties can lead to very effective environmental work, but it demands respect for one another's knowledge and work. Companies believe that it is important to have clearly-defined requirements for product performance, while at the same time the authorities must not exert a high level of control over their business activity. There can then be a risk that the dynamic system is forced to become static, to the benefit of certain businesses or products that have a beneficial situation at that precise moment. This does not necessarily provide a fair picture, for example, of a product group's life cycle impact.

The fact that a product can be presented as being environmentally unsustainable, e.g. in the media, on the basis of incorrect information, has been and continues to be a major problem for companies in their environmental work. Companies are therefore demanding a more balanced kind of environmental work, with less rigid control and more dynamic problem-solving and support for various kinds of collaboration, for example like that taking place within CPM at present. This work also provides the conditions for a company to gain knowledge about its own business and products, and to be proactive in the field of product-related environmental assessment.

4.5 CPM collaboration in future

The focus of CPM's third stage is on introducing the results of development and test work from the first stages into reality, i.e. adapting the results with regard to financial aspects and focusing on functionality and value. For example, CPM can help companies to see applications of the result in their business. This also means that CPM must not limit itself to developing expert tools, but continue development work and produce tools that are easy to use in day-to-day work routines for all concerned. Companies believe in simplified tools as a means of helping many people gain an initial understanding of the issue, and they believe that work with these will create a demand for more "complete" tools. The simplified tools thus serve as a training exercise and a catalyst for the use of more complex tools. More support must also be provided when implementing the tools in the companies, e.g. through training and support in project management.

CPM is currently discussing a new collaboration with Chalmers Environmental Initiative (CEI), which will give CPM broader, stronger acceptance at Chalmers. For example, it will reinforce its external activity, so that CPM is able to communicate its results more easily and be a stronger player in the field of national and international collaboration, in contact with Swedish Environmental Protection Agency, the Department for the Environment, the EU, IPP work, the USA's Environmental Protection Agency (EPA), etc.

CPM can also become more active in supporting companies in their internal communication relating to environmental work, focusing on training buyers and customers, and helping them set up collaboration with other companies in CPM; the most natural partner in collaboration is often Chalmers.

As far as CPM's databases are concerned, there is a demand for better co-ordination of the EPS index. Many of the companies are working to produce new indices themselves, and there is a desire that these be reviewed and stored by CPM, so that they can be of benefit to others. Administration of this data should follow the same principles as for the SPINE@CPM database, with a clear organisation, data quality requirements, quality review, etc.

93 AFN, Swedish Environmental Protection Agency and CPM, Swedish LCA research - a look back and future development, seminar held on April 2nd 1998 in Gothenburg,
AFR report 199, June 1998

5 *One way of using CPM's results to provide guidance towards Swedish environmental quality objectives*

The Swedish quality objectives and their interim targets are listed in appendix 1 and the introduction to this report contains a little more information about these, together with references, for those who wish to find out more.

You can link products' life cycle impact to environmental quality objectives by means of the procedure described in section 1.3.1 Quantitative life cycle impact assessment. In the same way that a company's environmental work is guided by its policy and objectives, Swedish environmental work is guided by the environmental quality objectives. Through these, Sweden has defined what is meant by "environment" in this context, and defined which are the first steps in the process towards a better environment. In order to perform a quantitative life cycle impact assessment on the basis of these objectives, a number of indicators must then be identified and quantified. There are many ways of doing this. In order to show how this might be done, here is a concrete example from a case study undertaken in a project entitled "LCA-E – Life Cycle Assessment in the Electronics Industry"[94].

In the LCA-E project they used the environmental impact categories as defined in the Swedish EPD system[95], i.e. Resource consumption and Emissions of pollutants (greenhouse gases, ozone-depleting gases, acidifying gases, gases that contribute towards ground-level ozone and eutrophic substances). If you make a very schematic comparison between these environmental impact categories and the Swedish environmental quality objectives, see figure 1, you see that environmental quality objectives 4 Non-toxic environment and 6 Safe radiation environment are not covered by the EPD system. Otherwise it appears that all environmental objectives are represented to some degree (but note, for example, that the Swedish environmental quality objectives do not take into account Swedish mineral resources, which the EPD system does). If we ignore these two environmental objectives for a moment, accepting that these could

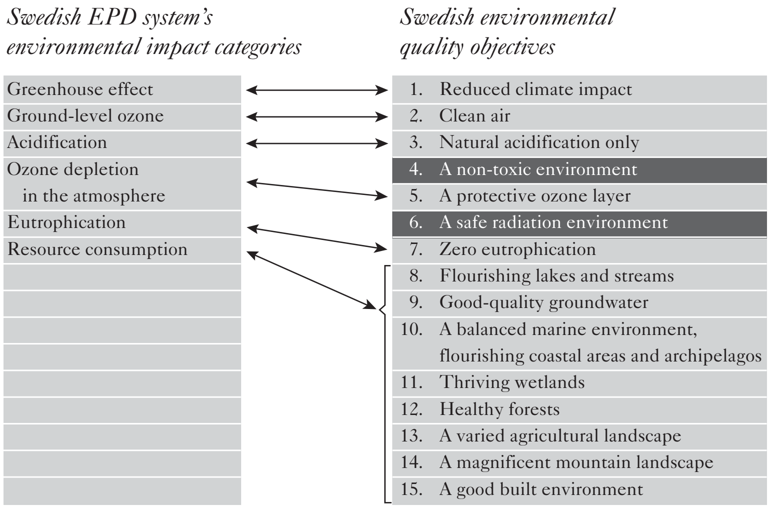

Figure 1: *A schematic comparison between the Swedish environmental objectives 2002 and the Swedish EPS system's environmental impact categories. Environmental quality objectives 4. (a non-toxic environment) and 6. (a safe radiation environment) are not covered by the EPD system.*

also be included in a similar way, you can proceed to take a closer look at the identification of indicators and the quantification applied in the case study.

The three environmental impact methods EPS – Environmental Priority System for product design[96 97], EDIP – Environmental Design of Industrial Products[98 99] and Eco-indicator '99[100] were modified to match the EPD system's definition of "environment". This meant, for example, that methods of characterising chronic and acute eco-toxicity in water and earth, and human toxicity via air, earth and water, were excluded from EDIP and Eco-indicator '99, and that toxic metals and pesticides were excluded from the EPS system. Otherwise the indicators and quantification method used were as in the three different methods for life cycle impact assessment. For example the indicators for EDIP: *Global Warming Potential*, *Ground-level ozone creation*, *Acidification*, *Ozone Depletion*, *Eutrophication* and *Resource consumption, e.g. aluminium consumption*, *oil consumption*, *and wood consumption*. Some examples of quantification indicators in the EPD system are kg CO_2 equivalents for Global Warming Potential, g C_2H_4 equivalents for Ground-level ozone creation and g SO_2 equivalents for Acidification. The result of a life cycle impact assessment relating to Global Warming Potential for a substance would thus be: actual emissions of pollutants (kg) _ characterisation factor (kg CO_2 equivalents/kg substance) = characterisation result (kg CO_2 equivalents).

The result of a life cycle impact assessment must ultimately be linked back to the objectives, so that it is possible to draw conclusions about a product's positive or negative environmental impact and the scale of it. For example, the interim target for environmental quality objective *1. Reduced climate impact* is to reduce emissions of greenhouse gases.

Extract from interim targets according to the Swedish parliament:
"Reduced emissions of greenhouse gases (2008-2012)
Swedish emissions of greenhouse gases must, as an average for the period 2008-2012, be at least four per cent lower than emissions in 1990. This interim target must be achieved without compensating for absorption in carbon sinks or for flexible mechanisms. In 2050 total emissions in Sweden should be less than 4.5 tonnes of carbon dioxide equivalents per inhabitant per year, subsequently continuing to fall."[101]

According to the case study, it is thus possible to use the quantitative life cycle impact assessment to link the actual emissions of pollutants from a product's life cycle to a specific environmental quality target. If there are also statistics for Sweden you can, for example, calculate how much various product groups or industries are contributing towards achieving the objectives. It should, however, be noted that the indicators do not always coincide, although the environmental impact categories do, e.g. the indicator for resource consumption can be measured in kilos of resource consumed according to the EDIP method or in the form of reduced reserves according to the EPS method. At present the Swedish environmental quality objectives do not take into account national extraction of resources, but focus instead on issues such as biodiversity. Mapping may still be relevant in some applications, the relevance depending on the nature of the application. The extent to which it is relevant in this context can, of course, be debated, but this case study is only intended to serve as an example.

From this perspective, the tools developed within CPM can be applied to provide guidance towards the Swedish environmental quality objectives, e.g. in the case study described above we can use the SPINE@CPM database to produce an inventory to emissions and resource consumption for electronic products, EPS methodology and data for a life cycle impact assessment and the web-based calculation tool for simplified LCAs. These three tools thus exemplify how the software platforms, databases and methods developed within the CPM collaboration can be used to assess the environmental impact and guide various decision-making situations, e.g. towards the Swedish environmental quality objectives.

94 Erixon M, Information System Supporting a Web Based Screening LCA Tool, CPM report 2001:14

95 AB Svenska Miljöstyrningsrådet, Bestämmelser för Certifierade miljövarudeklarationer, EPD, Svenska tillämpning av ISO TR 14025 TYP III miljövarudeklarationer, 1999:2

96 Steen B, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS) Version 2000 - General System Characteristics, CPM report 1999:4

97 Steen B, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS) Version 2000 - Models and Data of the Default Method, CPM report 1999:5

98 Wenzel H, Hauschild M, Alting L, Environmental Assessment of Products, Volume 1: Methodology, tools, and case studies in production development, 1997

99 Wenzel H, Hauschild M, Environmental Assessment of Products, Volume 2: Scientific background 1998

100 Goedkoop M, Spriensma R, The Eco-indicator 99, A damage oriented method for Life Cycle Impact Assessment, Methodology Report, 2000

101 Sweden's environmental objectives, public portal for our 15 environmental objectives: www.miljomal.nu/index.php

6 *Collaboration between various parties in the future to improve flows of knowledge and information*

This chapter contains a collaborative model, partly to improve flows of knowledge and information between various parties within Sweden in the future, but mainly as the best way of providing base information for various decision-makers. The collaborative model is based on knowledge and experiences developed and summarised at the environmental informatics area within CPM. In 2001 this area became an independent administrative part of the Chalmers unit Industrial Environmental Informatics (IMI), which further develops knowledge and experiences of quantitative assessment of environmental performance, the structure and exploitation of databases, data quality control, data exchange (formats and standards), models and strategies for data acquisition, integration of information systems together with networks and trade.

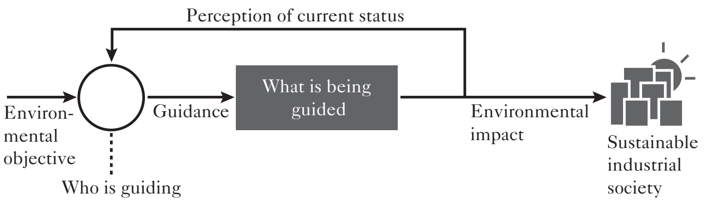

Figure 2
Model for guiding an industrial system towards a dynamic definition of sustainability.[102]

IMI is developing an information management tool for industry and academia to use to guide industrial systems towards sustainability. This tool is intended as a research vision, in which a decision-maker can be provided with sufficient information to guide any kind of industrial system towards a dynamic definition of sustainability.

For decision-makers, information about objectives and the current status is crucial in controlling the industrial system. The collaborative model focuses on how decision-makers in such situations can be given sufficient, up-to-date base information in a more efficient way.

6.1 The main players

A study presented in the Swedish Environmental Protection Agency's report "On the way towards environment-friendly products"[103] identifies the main players in the supply chain. These players are presented here in groups that are adapted for the collaborative model.

- Authorities, special
  - The Swedish Environmental Protection Agency (NV), which is the government's central environmental authority. They aim to drive and co-ordinate work to achieve a strong, wide-ranging environmental responsibility in society. Their support to other players in their environmental work involves in the first instance developing and disseminating knowledge, formulating requirements and ambition levels, and follow-up and evaluation.104

  - Statistics Sweden (SCB), which produces official (national) statistics on various aspects of society and ensures that these are easily available. The statistics must be up-to-date, reliable and objective.105
  - Universities and colleges, whose work involves responsibility for providing education based on scientific or artistic principles and tried and tested experience, assuming a responsibility for basic research and collaborating with the local community and providing information about its activities.106
- Companies that provide the community with products and services. These can be various kinds of company, e.g.
  - Manufacturing companies
  - Transport companies
  - Waste management and recycling companies
- Industry organisations and trade associations are groups of companies that have joined forces to optimise their activities through collaboration, e.g. in terms of environmental work, external communication, database management and administration, etc.
- Consultants, whose services are bought in by companies in areas in which they lack the necessary expertise, whose activities are governed mainly by legislation in the area.
- Competence centres and research institutes, which constitute an important bridge between academia and industry where problem-solvers and problem-owners can meet
- Non-Governmental Organisations (NGOs), which constitute a joint voice representing various groups in society. They represent the general public's interests and try to influence the major players, such as companies and authorities, by such means as lobbying.
- Customers, i.e. both private customers, so-called end customers, and professional customers, so-called corporate customers, i.e. individuals or groups of individuals in the so-called "market".

In order for environmental work to be effective, decision-makers in society must have access to a coherent, credible body of knowledge and information on which to base their decisions. This means that knowledge and information must flow from universities and colleges to those who are producing and then on to those buying products and services. In this respect industry organisations and trade associations important channels in disseminating knowledge and information through research, education and information activities from companies to legislators and vice versa. Industry organisations often represent small and medium-sized companies, whereas skill centres constitute networks for larger companies.

The most important roles and relationships in a network can be described briefly as follows:

- Knowledge is created and administered by universities
- Decision-making situations are identified in business situations, i.e. within companies
- Regulations and requirements are formulated by authorities
- Knowledge and needs are disseminated by competence centres and industry organisations.
- Information, e.g. in the form of databases, is naturally administered close to the living, practical knowledge, e.g. close to companies in the supply chain.

This network is then used by the customer who consumes the product or service, in order to apply the right and the responsibility to decide. In order to be able to make sound decisions based on a system perspective, they should be based on sound base information, so that the customer can easily weigh up issues such as: is product A or B best from an environmental perspective? Sound base information can, for example, demand interpretation keys in order for the customer to understand the terms, relationships and results that are compiled and presented. The EPS system contains such interpretation keys, and work is proceeding at CPM to further develop these.

6.2 Information that a decision-maker needs

A quantitative life cycle impact assessment requires information about the supply chain, its environmental impact and the opinions that people might have about the value created by the supply chain and about the environmental impact that occurs. Figure 2 depicts the relationship between the supply chain in the Technical System, the values in the Social System and the environmental impact in the Environmental System. The technical system comes into contact with the social system, e.g. as the social system guides the technical system and benefits from the products and services produced. The technical system comes into contact with the environmental system, where, for example, various emissions to air and water are received. Finally, there is a link between the social system and the environmental system, as the social system uses the environmental system, e.g. for recreation, and evaluates the effects of emissions.

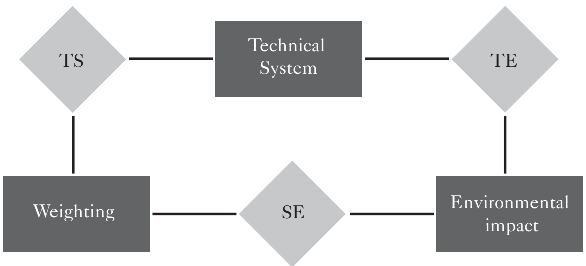

Figure 3
A schematic description of the SPINE information model, which is a general analytical system model to provide a decision-maker with the information required when making an environment-related decision.[107] The rhomboids TS, TE and SE depict the relationship between the various systems, and thus also define what information needs to be acquired and whether each of the systems for decisions are to have a full set of base information.

A decision-maker must thus have access to information about all three sub-systems, the technical system, the environmental impact and the weighting, in order to be able to perform a quantitative life cycle impact assessment, see figure 4. There is an internationally accepted technical specification that describes a format for the information that is required from the technical system (Technical System in figure 4), the data documentation format ISO/TS 14048[108]. There are also standards and methods that support the production of such data, e.g. the PHASES method, which was applied practically within the CPM-SSVL project [109] and ISO 14041 Life Cycle Inventory[110], which describes how technical systems are modelled for life cycle assessments. The TYPE III environmental product declaration also has quality criteria for the documentation of

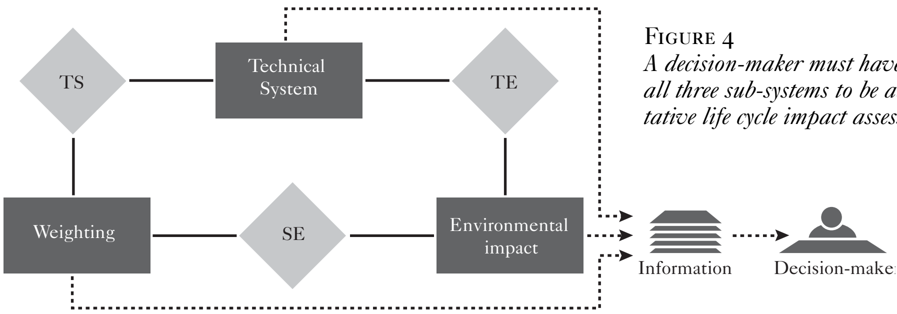

Figure 4
A decision-maker must have access to information on all three sub-systems to be able to perform a quantitative life cycle impact assessment.[115]

LCI data[111]. As far as information on environmental impact and weighting is concerned, there is at present no internationally standardised data format, although within CPM one has been developed and tested in various practical applications. Some preparatory work is also under way for such standardisation in the EU project CASCADE[112]. A methodology for a life cycle impact assessment and weighting is partly described in ISO 14042 Life Cycle Impact Assessment[113]. With these existing standards and initiatives, a data documentation format and methodology have been developed for environmental impact and weighting according to the SPINE model.[114]

So far, the focus of data acquisition has been on the technical system, i.e. LCI data. It is also relatively easy to find certain weighting information, e.g. the Swedish environmental objectives, and various indicators mentioned in European IPP work, e.g. resource consumption, energy consumption and waste [116]. It is, however, still difficult to find systematic prioritisation between competing indicators and objectives for more than a small number of LCA environmental assessment methods (EPS, EDIP, Eco-Indicator '99). But the greatest shortage of information involves the description of environmental impact, i.e. information that describes, in a way that is easy to interpret and is well co-ordinated, the sensitivity in various natural areas and the various consequences of human impact. Greater efforts to co-ordinate such information is just as important as efforts to create various LCI databases.

6.3 Sources of information and co-ordination

Information about the three sub-systems, the technical system, environmental impact and weighting, is available form various sources, see figure 5. Information about the technical system can be found, for example, in companies, industry organisations and authorities, but effective network structures are required for it to be possible to communicate data and for the information flow to work satisfactorily, e.g. data trade networks and various centrally financed networks. The SPINE@CPM database is an example of what a quality-assured LCI database might look like and how one can be administered. CPM has also drawn up fundamental rules for a data exchange network in its report entitled "Establishing trading structures for LCI data"[117]. **In order to draw the full benefit from both SPINE@CPM and such trading structures, co-ordinating projects are required that specify the application of data.** The strategy of specifying the application of data in commercial databases is significantly different from other parties' recommendations in this area, which advocate, for example, so-called "non-allocated data"[118]. The purpose of creating a database can be, for example, TYPE III environmental product declarations, industry databases, product category data, etc. For example, in Korea they have created a national database of environmental product declarations. Projects are also under way at present that aim to create an international network, including a collaboration between UNEP and SETAC and in the

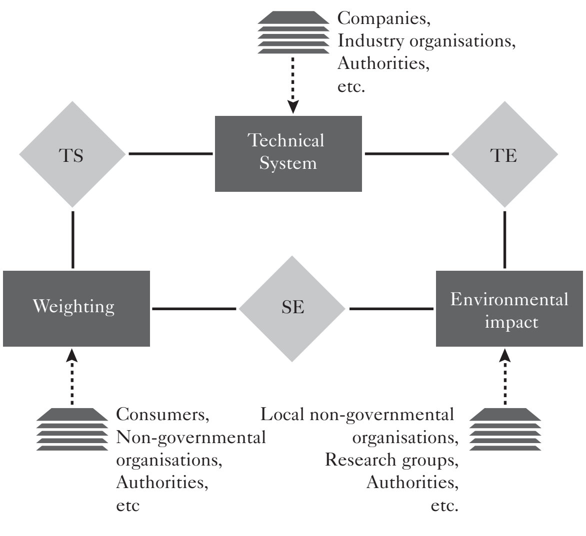

Figure 5
Information for the three sub-systems, the technical system, environmental impact and evaluation, is stored in various sources.[120]

AGS project (Alliance for Global Sustainability)[119], which involves ETH Zürich, MIT, Chalmers, the Catholic University of Chile (IIP-FADEU-PUC), the University of Botswana and the University of Witwatersrand.

As a rule, information on environmental impact is difficult to find. *There are individual sources at local non-governmental organisations, research groups and authorities, but there is no co-ordination of these sources.* One good model of what such co-ordination might look like can be seen in the OMNIITOX project[121]. This project co-ordinates knowledge and information about environmental impact from toxicologists and modellers of environmental systems. In the same way it should be possible to co-ordinate information about such issues as the greenhouse effect, acidification and eutrophication, so that it is then possible to use this information in a uniform way for a quantitative life cycle impact assessment.

Information for weighting may be found, for example, in consumers, non-governmental organisations and authorities. Consumers choose products on the basis of their evaluations, non-governmental organisations have a purpose with their activities, and authorities formulate objectives, e.g. the Swedish environmental quality objectives. **In this context, however, there is a major need for policy development, in which clearly-defined approaches are drawn up, indicating a coherent, long-term strategy.**

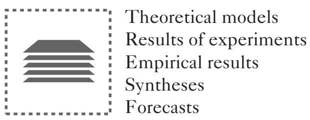

Figure 6
The databases that contain information on the technical system, environmental impact and evaluation must contain data on theoretical models, results of experiments, empirical results, syntheses and forecasts

Databases that contain data for the various sub-systems must contain information on theoretical models, results of experiments, empirical data, syntheses and forecasts, see figure 6. In terms of environmental impact, for example, this means mathematical models in the form of complete cause/effect relations, results of toxicity tests and extrapolations, large-scale tests in natural systems, aggregation and synthesis, e.g. for various species within the same system, as well as estimates of effects in the future.

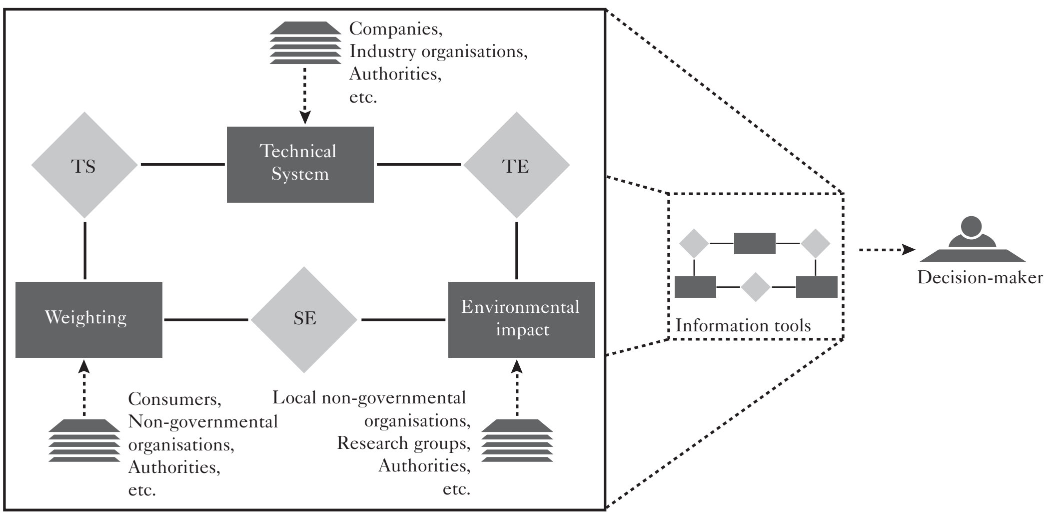

Figure 7
A quantitative life cycle impact assessment requires the integration of information from the three sub-systems (technical system, environmental impact and evaluation) in one tool for the decision-maker.[124]

In order for it to be possible to co-ordinate information from the three sub-systems for use in a life cycle impact assessment, an integration tool is required, see figure 7. One such tool is currently being developed at the Industrial Environmental Informatics department at Chalmers University of Technology. The tool is called WWLCAW (World Wide LCA Workshop), and is available for study on the Internet [122]. WWLCAW contains such features as the calculation tool[123] for simplified LCAs in the electronics industry, as described in chapter 5, as well as tools that process life cycle inventory, environmental impact and weighting separately.

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102 © Carlson R, IMI – Industrial Environmental Informatics, Chalmers University of Technology

103 Swedish Environmental Protection Agency, På väg mot miljöanpassade produkter, Report 5225, July 2002, appendix 4

104 The Swedish Environmental Protection Agency's website: www.naturvardsverket.se, 14-12-2002

105 Statistics Sweden website: www.scb.se, 14-12-2002

106 The Swedish Ministry of Education and Science's website: http://utbildning.regeringen.se/index.htm, 14-12-2002

107 © Carlson R, CPM, Chalmers University of Technology

108 ISO/TS 14048, Environmental Management – Life Cycle Assessment – Data Documentation Format, International Organization of Standardization, 2001

109 Pålsson A-C et al, An industry common methodology for environmental data management, 2002, Platform presentation at SPCI 2002, 7th International Conference on New Available Technologies

110 ISO 14040, Environmental Management – Life Cycle Assessment – Principles and framework, International Organization of Standardization, 1998

111 Eriksson E, Lindfors L-G, Pålsson A-C, Ribbenhed M, Manual för granskning av livscykelanalyser, LCA – med applikation på EPD, Manual, AFR report 248

112 More information about the EU project CASCADE is on the website: http://192.107.71.126/cascade

113 ISO 14042, Environmental Management – Life Cycle Assessment – Life Cycle Impact Assessment, International Organization of Standardization, 1999

114 Carlson R, Pålsson A-C, Documentation of environmental impact assessment, compatible with SPINE and ISO/TS 14048, IMI report 2002:1, IMI – Industrial Environmental Informatics, Chalmers University of Technology, 2002

115 © Carlson R, Erixon M, Pålsson A-C, IMI – Industrial Environmental Informatics, Chalmers University of Technology, 2002

116 Green paper on integrated product policy, COM (2001) 68, Brussels 07-02-2001, cf. picture on p. 6 of the Swedish translation

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118 IVL Swedish Environmental Research Institute, Kunskap om produkters miljöpåverkan, tillgång, behov och uppbyggnad av livscykeldata, Swedish Environmental Protection Agency report 5229, July 2002

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120 © Carlson R, Erixon M, Pålsson A-C, IMI, Chalmers University of Technology, 2002

121 Information about OMNIITOX may be seen at www.omniitox.net/, which is administered by Johan Tivander at IMI, Chalmers University of Technology, 17-12-2002.

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Appendix 1:
Sweden's environmental quality obectives and interim targets

Reference: Sweden's environmental objectives, official portal for our 15 environmental objectives, 22-11-2002
http://www.miljomal.nu/index.php

1. Reduced climate impact
   Reduced emissions of greenhouse gases (2008-2012)

2. Clean air
   Sulphur dioxide content (2005)
   Nitrogen dioxide content (2010)
   Ground-level ozone content (2010)
   Emissions of volatile organic compounds (2010)

3. Natural acidification only
   Fewer acidified waterways (2010)
   Break the trend of soil acidification (2010)
   Reduced sulphur emissions (2010)
   Reduced nitrogen emissions (2010)

4. A non-toxic environment
   Knowledge of the health and environment-related properties of chemical substances (2010)
   Health and environment-related information on products (2010)
   Phasing out of particularly hazardous substances (2003-2015)
   Ongoing reduction of risks to health and the environment from chemicals (2010)
   Guideline values for environmental quality (2010)
   Polluted areas (2005)

5. A protective ozone layer
   Emissions of ozone-depleting substances

6. A safe radiation environment
   Emissions of radioactive substances (2010)
   Cases of skin cancer caused by the sun (2020)
   Risks associated with electromagnetic fields (on an ongoing basis)

7. Zero eutrophication
   Action plan for lakes, watercourses and coastal waters (2009)
   Reduced emissions of phosphorus pollution (2010)
   Reduced emissions of nitrogen pollution to the sea (2010)
   Reduced emissions of ammonia (2010)
   Reduced emissions to air of nitrogen oxides (2010)

8. Flourishing lakes and streams

Action plan for natural and cultural environments (2005-2010)
Action plan for restoration of watercourses (2005-2010)
Creation of water supply plans, etc. (2009)
Replenishment of animals and plants that live in water (2005)
Action plan for threatened species and fish stocks (2005)
Action plan for good surface water status (2009)

9. Good-quality groundwater

Protection of geological formations (2010)
Consequences of changes in the groundwater level (2010)
Quality requirements for groundwater (2010)
Action plan in accordance with the EC's framework directive for water (2009)

10. A balanced sea environment, flourishing coastal areas and archipelagos

Protection for coastal areas and archipelagos (2005-2010)
Strategy defining how the coastal areas' and archipelagos' cultural heritage and the agricultural landscape can be protected and used (2005)
Action to protect endangered marine species (2005)
Reduction of by-catches (2010)
Adaptation of fish catches (2008)
Disruption from boat traffic (2010)
Discharges from vessels (2010)
Action plan in accordance with the EC's framework directive for water (2009)

11. Thriving wetlands

Strategy for protection and care (2005)
Long-term protection of wetlands (2010)
Forest truck roads over wetlands (2004)
Establishment and restoration of wetlands (2010)
Action plan for endangered species (2005)

12. Healthy forests

Long-term protection of forest land (2010)
Greater biodiversity (2010)
Protection of cultural remains (2010)
Action plan for endangered species (2005)

13. A varied agricultural landscape

Care of meadows and grazing land (2010)
Preservation and creation of small habitats in the agricultural landscape (2005)
Care of culture-bearing landscape features (2010)
Genetic resources in domesticated species of plants and animals (2010)
Action plan for endangered species and habitats (2006)
Farm buildings of cultural and historical value (2005)

14. A magnificent mountain landscape

Limit damage to soil and vegetation (2010)
Reduced noise levels in the mountains (2010)
Protection of areas of great natural and cultural value (2010)
Action plan for endangered species (2005)

15. A good built environment

Planning documentation (2010)
Buildings of cultural and historical value (2010)
Noise (2010)
Gravel extraction (2010)
Reduction of waste volumes (2005)
Uniform standard of landfill sites (2008)
Energy consumption, etc. in buildings (2010)
Effect of buildings on health (2020)

Appendix 2:
CPM reports 1997–2002

2002

CPM report 2002:1
Land use LCA – a top-down approach
Göran Swan

CPM report 2002:2
Formatting Data for EAA According to the CPM Data Documentation Criteria
Maria Erixon

2001

CPM report 2001:1
FAQT – Fundamentals of data quality for industrial environmental information systems
Raul Carlson, Ann-Christin Pålsson

CPM report 2001:2
Integrating Environmental Management to Improve Strategic Decision-Making
Ingar Nilsson

CPM report 2001:3
Estimation of the Years of Lost Life (YOLL) as a consequence of the nuclear fuel cycle
Ove Edlund

CPM report 2001:4
Communication of product related environmental information, User requirement studies of Environmental Product Declaration, EPD, systems
Cecilia Solér

CPM report 2001:5
The relevance Aspect of Life Cycle Inventory Data Quality
Bo von Bahr

CPM report 2001:6
A state-of-the-art study of the: Environmental information supplied to the actors of the Swedish pulp and paper industry and the tools used to provide it
Ola Svending

CPM report 2001:7
Identification of significant environmental aspects and their indicators
Bengt Steen

CPM report 2001:8
First examples of practical application of ISO/TS 14048 Data Documentation Format
Raul Carlson, Ann-Christin Pålsson

CPM report 2001:9
Data definition and file syntax for ISO/TS 14048 data exchange
Raul Carlson, Johan Tivander

CPM report 2001:10
A Life Cycle Process Model
Karin Gäbel

CPM report 2001:11
Förenklad LCA-baserad information; En intervjuundersökning bland slutkunder [Simplified LCA-based information: an interview-based survey of end customers]
Sofia Medin, Anna-Karin Byström, Kristina Larsson

CPM report 2001:12
Availability of metals in the earth's crust – Leaching tests on silicate minerals
Bengt Steen, Gunnar Borg

CPM report 2001:13
Slutrapportering av SPINE-kursverksamheten under CPM etapp II [Final report on SPINE course activity during CPM stage II]
Maria Erixon

CPM report 2001:14
Information System Supporting a Web Based Screening LCA Tool
Maria Erixon

CPM report 2001:15
Recycling of Metallic Materials in LCA: Recommendations
Tomas Rydberg

CPM report 2001:16
Slutrapport projekt II:F:11 Databasuppbyggnad [Final report, project II:F:11 Database creation]
Compiled by Ann-Christin Pålsson, project manager

CPM report 2001:17
Slutrapport projekt II:F:12 Integrerade Miljöinformationssystem [Final report, project II:F:12 Integrated Environmental Information Systems]
Compiled by Ann-Christin Pålsson and Raul Carlson, project managers

CPM report 2001:18
Slutrapport projekt II:F:13 Standardisering [Final report, project II:F:13 Standardisation]
Compiled by Raul Carlson, project manager

CPM report 2001:19
Slutrapport projekt II:F:14 Verksamhetsledning [Final report, project II:F:14 Company management]
Compiled by Raul Carlson, project manager

2000

CPM report 2000:1
Modelling and Simulation in LCA
Peter Forsberg

CPM report 2000:2
Facilitating Data Exchange between LCA Software involving the Data Documentation System SPINE
Editor: Maria Erixon

CPM report 2000:3
Etablering av handelsstrukturer för LCI-data [Establishing trading structures for LCI data] – a report describing CPM's strategy for the development of data trading
Raul Carlson, Maria Erixon, Ann-Christin Pålsson

CPM report 2000:4
PHASES - Information models for industrial environmental control
Raul Carlson, Ann-Christin Pålsson

CPM report 2000:5125
Environmental Valuation and LCA
Magnus Bengtsson

Internal report, October 2000
Report to international evaluation group

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CPM report 1999:1
Introduction and guide to LCA data documentation using the CPM documentation criteria and the SPINE format
Ann-Christin Pålsson

CPM report 1999:2
Utveckling av verktyget för miljöanpassad produktutveckling [Development of tool for environment-friendly product development]: Affect on Environment
Per Johansson

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Practical Strategies for Acquiring Life Cycle Inventory Data in the Electronics industry
Maria Erixon

CPM report 1999:4
A Systematic Approach to Environmental Priority Strategies in Product Development (EPS) Version 2000 - General System Characteristics
Bengt Steen

CPM report 1999:5
A Systematic Approach to Environmental Priority Strategies in Product Development (EPS) Version 2000 – Models and Data of the Default Method
Bengt Steen

CPM report 1999:6
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Jan Agri, Elisabeth Andersson, Alena Ashkin, John Söderström

CPM report 1999:7
Livscykelanalys av bildkonferens - en jämförelse med andra kommunikationssätt [Life cycle assessment of a videoconference — a comparison with other methods of communication]
Elin Eriksson, Ulf Östermark

CPM Internal Report 1999
Review of LCI data at SPINE@CPM
Ann-Christin Pålsson

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Magnus Bengtsson

CPM report 1998:2
Evaluation of Land Use in Life Cycle Assessment
Editor Göran Swan

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Raul Carlson, Ann-Christin Pålsson

CPM report 1998:4
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Anne-Marie Tillman

CPM report 1998:5
An Assessment of the SPOLD format with comparison between SPOLD and SPINE
Maria Erixon, Sara Ågren

CPM Internal Report
Overview of databases and data sources for life cycle inventory data
Ann-Christin Pålsson

Swedish LCA research a look back and future development
Seminar held on April 2nd 1998 in Gothenburg
AFR report 1998

GRI, 1998
Rekommendations för kommunikation av miljömärkning av Typ III inom ramen för ISO 14000 [Recommendations for communication of Type III eco-labelling within the framework of ISO 14000]
Cecilia Solér

1997

CPM report 1:1997
Krav på Datakvalitet, CPMs Databas 1997 [Data quality requirements, CPM's database 1997]
Editor: Peter Arvidsson

CPM report 2:1997
EPS systemet, en översiktlig presentation [The EPS system, an outline presentation]

CPM report 3:1997
12 Vanliga Frågor med Svar om CPM:s LCA-Databas [12 common questions and answers about CPM's LCA database]
Raul Carlson

CPM report 4:1997
Strategin kring arbetet med CPM:s LCA-Databas [The strategy for work with CPM's LCA database]
Raul Carlson

CPM report 5:1997
Miljörapport som underlag till livscykelanalys [The environmental report as the basis of a life cycle assessment]
Maria Erixon, Sara Ågren

CPM report 6:1997
Handbok vid arbete med datakvalitet och SPINE [Manual for work on data quality and SPINE]
Ann-Christin Pålsson

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125 This CPM report was originally assigned number 1 (2000:1) but due to administrative errors, the number had to be changed to 5 (2000:5).

Appendix 3: *Interview questions*

CPM companies' work on product-related environmental assessment

1. How do you work to reduce the environmental impact of your products?
2. How do you obtain knowledge of the environmental impact of your products? From whom and how?
3. How do you disseminate knowledge of the environmental impact of your products? To whom and how?

Knowledge and information about the environmental impact of products within CPM

4. What are the strategic/practical benefits of collaboration within CPM?
5. How could this collaboration be improved?

Knowledge and information about the environmental impact of products in society

6. How do you relate to/collaborate with other players in the supply chain, such as production companies, suppliers, authorities, EU bodies, industry organisations, end consumers, professional customers, waste management organisations, etc.?
7. How could this collaboration be improved?
8. How do you want other players in the supply chain to collaborate?
9. What opportunities and obstacles in the information flow have you identified in your own and CPM's collaboration?

APPENDIX 4:
LCI data from SPINE@CPM: 485 activities

Example of what an LCI data set (activity) in SPINE@CPM looks like

SPINE@CPM Report generator 3.3, by Raul Carlson, A-C Pålsson,
Chalmers University of Technology, 2001

SPINE@CPM Data Tool 3.3

Transparent LCI Data Documentation and Reporting

START DATA SET DOCUMENTATION:

Description of the technical system; The Object of Study

Name: Heavy truck with two trailers, long distance, Euro 0
Category: Gate to gate
Sector: Land transport
Function: Operation of heavy truck with two trailers for long distance transports, approximately 24 m long with a curb weight of 60 tons and a maximum load of 40 tons.

Fuel: diesel, MK 1 (sulphurous content: 2 ppm).
Fuel consumption: high 5.5 l/10 km, medium 4.9 l/10 km, low 4.3 l/10 km.
Engine type: Euro 0 (1987-1992).
Utilization level: 70% by weight.

Geographical location:
Mail Address: Sweden

Owner:
Mail Address: Not relevant

Details on how the data acquisition was performed; The Inventory

Persons and organizations involved with the data acquisition

Practitioner:
Mail Address: Swedish haulages and transport companies

Reviewer:
Name: None, to be reviewed.

Purpose of the data acquisition

Commissioner:
Mail Address: NTM

Intended User:
Suppliers and buyers of goods transports. Environmentally responsible staff at any company interested in environmental assessment of the activities of the company.

General Purpose:
There is an interest to compile a set of data for the different traffic modes that are accepted by representatives for all traffic modes (air, rail, road and sea). In order to be able to make correct assessments, it is crucial to have knowledge of the different functions used for calculations, assumptions and environmental load of different modes of transportation. The ambition within NTM (Network for goods transportation and the environment) is to compile and document relevant environmental interventions associated with different transport systems, and to localize gaps of knowledge. The network is also intended to serve as a forum for discussion between different actors in the transport business.

The members of NTM consists of organizations representing road, rail, air and sea transport companies, interest groups, authority, university, research institutes etc. Example of organizations that participate in the work:
BTL (Bilspedition Transportation and Logistics), ASG, SJ, FFA (The Aeronautical Research Institute of Sweden), Swedish Shipowners' Association, The Swedish Road Haulage Association, The Swedish Environmental Protection Agency, Vägverket, Sjöfartsverket, Department of Transportation and Logistics at Chalmers University of Technology and the Swedish Society for Natural Conservation

Detailed Purpose:
The first step in the work of NTM was to gather available data for energy use and emissions for the operation of different goods transport systems. The work is conducted in working group 1 of NTM, which consists of representatives from the organizations that are members of NTM. All work is based on voluntary contributions from the representatives. Data was obtained for energy use and emissions to air, both from the traffic systems and the energy supply systems (i.e. oil refining and electricity generation)

The ambition was to present a span constructed by a ”low”, an average and a ”high” value since the energy use and emissions to air in real traffic situations may vary greatly. These differences were calculated as differences in fuel and electricity consumption for the technology in use today. Where available, measurement data for regular traffic would be reported. The aim was also to get a picture of future energy use and emissions from transportation, through best available technology and future regulations, not yet in use.

Choice of functional unit

Functional Unit: 1 tonkm, 70 %
Explanation of Functional Unit:
Energy use and emissions refer to the transportation of 1 ton goods 1 kilometer for an utilization level of 70%. An utilization level of 70% is considered to be representative for Swedish domestic long-distance traffic if empty trips are not included.

Choice of system boundaries

Nature Boundary:
Regulated emissions to air are included. The parameters that are presented are:
– regulated emissions for diesel engines: NOx, HC, particles and CO
– fuel regulated: SO2
– tax regulated CO2.

Diffuse emissions to air, emissions to water and ground, noise, encroachment and other environmental loads have not been considered.

Time Boundary:
Data are valid for trucks produced 1987 - 1992
Geographical Boundary:
The data is based on Swedish conditions.
Other Boundaries:
The average utilization level is 70% that is representative for Swedish domestic traffic if empty trips are not included

Parameters not considered
– External conditions i.e. road conditions, climate etc.
– Maintenance level of the vehicle

Excluded subsystems
– Exhaust emission control
– Pre-combustion, i.e. production and distribution of the fuel
– Maintenance of the vehicle
– Erection and operation of infrastructure
– After-treatment of the vehicle
– Handling of production rests

Description on use of allocation methods; Allocations:
N/A
Systems expansions:
N/A

Recommendations on the use of data

Applicability:
The data should not be used for any detailed study of transport systems. More detailed information is needed in order to carry out such studies, e.g. regarding the vehicle -type -age and performance, fuel type, the nature of the goods, the utilization level etc. For a specific transport, the company carrying out the transport should be contacted in order to get information on how the goods are handled and how the transport is carried out.

Calculating the environmental impact in relation to transport work and utilization level is most appropriate if a calculation over a longer period of time (e.g. a year) is needed, e.g. in a transport contract. In such a case, different types of vehicles and utilization levels may have occurred.

The standard values presented in this activity should not be used if specific information on the fuel consumption for the transport is available. In this case, the fuel consumption should instead be used as a basis to calculate the emissions from the transport. See General QMetaData for emission factors that can be used to calculate emissions per liter fuel used.

The age categories of the vehicles compiled in the work are:
Older than 1990,
Euro 0: Introduced 1987, law from 1990
Euro 1: Introduced 1991, law from 1993
Euro 2: Introduced 1993, law from 1996
However, in order to improve the accuracy of the calculations, the user ought to know the Euro-class (emission standards) of the vehicle, rather than to base the calculations on the age of the vehicle.

Handling of goods
The data presented by NTM is representative for a terminal based transport system. The vehicles can be used in different ways, primarily altering the degree of utilization. Several other types of road based cargo transport systems is not well described by the data (e.g. oil and excavated materials)
Terminal based road transports generally consists of 1-3 parts:
1. Collection of the goods to terminal
2. Long-distance transport between terminals
3. Distribution of the goods from terminal
The collection and distribution routes are generally performed by smaller vehicles while the inter-terminal traffic is operated by larger units, typically with a higher degree of utilization.

– Wholesale goods (>1000 kg) are generally not handled via terminal. The goods is collected by a truck and driven straight to the customer. The truck may however collect a trailer at the terminal for further transport.
– General goods (100-1000 kg) are generally handled via terminal. The goods may be both weight and volume limited
– Parcel goods (<100 kg) are normally handled in small vehicles

The following vehicles and equipages are used in terminal based transport systems in Sweden:
– Parcel truck/van, max 3.5 tonnes is mainly used for transportation of parcels.
– Light truck, max 8 tonnes is used for local distribution, mainly in city traffic.
– Truck, max 18 tonnes is used for district distribution and local distribution in city traffic.
– Truck, max 24 tonnes is mainly used for transportation of general (styckegods) and wholesale (partigods) goods.
– Heavy truck with trailer, max 60 tonnes is used for long distance transports. The towcar for the equipage is a truck, max 24 tonnes. The vehicle is not permitted in the EU and is only used for Swedish domestic long-distance transport. The vehicle is also permitted in Finland.
– Truck with semi-trailer, max 42 tonnes is used for international long-distance traffic.

Utilization level
The data is only applicable for an utilization level of 70 % which is considered representative for Swedish transports according to the Swedish Road Haulage Association and the firms of haulage that has participated in the work. It should however be noted that the average utilization level might vary between different types of goods and firms of haulage. There are however no general rules on how to assess the utilization level for a specific transport. There are some types of goods (e.g. timber and chemicals) that generally have an utilization level of 50 % (i.e. full load one way and empty return trip, due to specialized vehicles). There may also be regional differences. The major shipping agents may be assumed to have a higher utilization level than smaller firms of haulage. The utilization of company internal vehicles is generally low.

The utilization level includes both weight and volume limited goods, but not empty trips. During 1996 24 % of all transports were empty transports. Most of the empty transports (90%) were performed on distances shorter than 100 km. The share of empty trips for different types of goods during 1996 were according to SCB (Statistics Sweden):
– excavated materials and round timber - 50%
– manufactured products (wholesale goods) - slightly more than 20%
– provisions and animal forage - approx. 15%
– mixed cargo (general goods) approx - 10 %.

Bulky goods
The data may be used for bulky goods by recalculation of the volume to an equivalent weight by the following conversion factor: 250 kg/m3. The conversion factor is generally accepted in the transportation business.

Fuel
The fuel used is diesel environmental class 1, except for petrol driven delivery vans who are assumed to use standard unleaded petrol. According to the Swedish Petroleum Institute, the major part of all diesel fuel oil sold at present time is of class 1 (> 85% at June 1996). Class 1 diesel oil has the lowest aromatic carbon and nitrogen content of all diesel oil sold in Sweden, resulting in lower particle, carbonhydrate and NOx emissions.

Precombustion, i.e. extraction, refining and distribution of the fuel are not included in the data. NGM propose that data from Blinge et. al (Arnäs, P-O, Blinge, M., Bäckström, S., Furnander, Å. ”Livscykelanalys av drivmedel - En studie med utgångspunkt från svenska förhållanden och bästa tillgängliga teknik”, Meddelande 95, Department of Transportation and Logistics, Chalmers University of Technology, 1997) should be used. This study is based on best available technology and Swedish conditions that is likely to yield a low figure.

International road transports
The data may be used for international transport if the data is recalculated for diesel environmental class 3. This will alter both the SOx emission and the regulated engine emissions. Generally the fleets in western Europe is composed of newer vehicles than in Sweden. The utilization of the vehicles may also vary in different countries.

About Data:
The calculations of data on heavy trucks are based on the fuel consumption of the vehicle. The fuel consumption data have been obtained by simulations of heavy vehicles in traffic under Swedish conditions. Volvo Trucks and Scania made these simulations, especially for NTM. The data on emissions are based on measurements in accordance with applicable standards for certification.

Notes:
The person stated as “Practitioner” is the contact person for the data for truck transportation in NTM.
The data is continuously updated, and the data user should therefore always make sure to use the most recent version of the data, which is published on the NTM homepage: http://www.ntm.a.se.

The work within NTM will continue to further increase the knowledge of different environmental interventions associated with goods transportation.

The major Swedish actors in the transportation business, which are members of NTM (e.g. SJ, BTL, ASG etc.), will use the data as a basis for environmental assessment of different transportation alternatives.

The secretary for NTM is Anna Hadenius, TFK - Transport Research Institute, Stockholm.

Administrative and general information on the dataset

Copyright:
NTM
Availability: Public
Publication:
www.ntm.a.se
Data documented by: Magnus Blinge, Dept. for Transportation & Logistics, Chalmers University of Technology
Documentation reviewed by: Ann-Christin Pålsson, CPM, Chalmers University of Technology
Date Completed: 1998 - 08

Flow table

The inventory profile is not published in this report, but can be purchased from CPM, Chalmers. Go to www.globalspine.se, www.cpm.chalmers.se or www.imi.chalmers.se for more information.

Description of methods used to obtain the data; Flow Meta Data

For the entire data set; General Flow Meta Data

Time period during which the data was acquired; Date Conceived: 1998 - 08
Type of method used to obtain the data; Data Type: Derived, unspecified
Description of Method:
Data have been put together for NTM by a group of manufacturers and hauliers, i.e. Volvo, Scania, BTL, ASG, Swedish Hauliers Assosiation. Data are presented in relation to the transport work, in g/tonkm. The utilization level is assumed to be 50% for delivery vans and medium-sized lorries in local distribution traffic and 70 % for long distance transport with heavy trucks.

The utilization level is based on the load carrying weight, i.e. the weight on which the customer price is based. This means that bulky cargo is multiplied with a factor in order to compensate for taking up volume. The average break-point density is 275 kg/m3. Energy use and emissions per tonkm with a truck should be based on the load carrying weight.

The quantity value for the energy use refer to average fuel consumption, the maximum and minimum value refer to changes in the fuel consumption due to degeneration, driving behavior etc.. The emissions of CO_2 and SO_2 are based on the fuel consumption. For emissions of NOx, HC, particles and CO, The emission data have been produced through simulations conducted by Volvo Trucks and Scania in 1997. The simulations were based on certification values for engines and fuel consumption under actual operation for Swedish conditions.

For medium and light lorries, the emission values have been obtained from certification values for new engines that are operated in accordance with established operating cycles, e.g. ECR-49 (IVL and Mercedes).

Emissions data related to fuel consumption

Emission factors (g/liter)

		Euro 0	Euro 1	Euro 2
Law from:	1980	1990	1993	1996
NOx	52+/- 5	44	27	23
HC	6+/- 2	2.1	1.8	1.3
PM	3+/- 2	1	0.5	0.35
CO	8+/- 3	3.7	3.4	2.5

This shows emissions factors in g/l for heavy lorries. With fuel consumption as a basis, it is possible to calculate the emissions. The data on emissions are based on measurements in accordance with applicable standards for certification.

liters/100 km	Empty	Full load
Distribution lorry (Payload 8.5 ton)	20-25	5-30
Med.-size lorry (Payload 14 ton)	25-30	30-40
Heavy lorry w trailer (Payl. 26 ton)	22-27	32-38
Heavy lorry w 2 trail. (Payl. 40 ton)	28-33	43-55

Represents:
NTM

Notes:
Calculating the environmental impact in relation to transport work and utilization level is most appropriate if a calculation over the year is needed, e.g. in a transport deal, which often covers a year's time. In such a case, different types of vehicles and utilization levels may have occurred.

:END DATA SET DOCUMENTATION
SPINE@CPM Report generator 3.3, by Raul Carlson, A-C Pålsson, Chalmers University of Technology, 2001

List of all 485 activities in SPINE@CPM

1. “Other” electronic components assembly
2. Aluminium recycling by refiners
3. Australia, electricity generation mix 1998
4. Austria, electricity generation mix 1998
5. Belgium, electricity generation mix 1998
6. Biofuel electricity energy system, EPD-version
7. Biogasification of solid municipal waste
8. Cable assembly
9. Canada, electricity generation mix 1998
10. Capacitor for hole mounting assembly
11. Capacitor for surface mounting assembly
12. Cargo vessel, medium-sized (8´-2´ dwt)
13. Cargo vessel, small (<2´dwt)
14. Cargo vessels, large (>8´ dwt)
15. Cement production
16. Cleansing of glass containers
17. Cleansing of juice bottles
18. Clearing of young forest
19. Coal fired plant for heat and power production
20. Coarse mortar production
21. Coastal shipping
22. Combined heat and power plant with support systems
23. Combustion of bio fuel
24. Combustion of coal
25. Combustion of natural gas
26. Combustion of oil
27. Combustion of waste
28. Combustion of waste to generate heat and electricity
29. Composting of solid municipal waste
30. Connector assembly
31. Converting waste-oil into fuel oilComposite system
32. Copper alloy casting of block metal from scrap
33. Copper casting and drawing to 0.06mm wire
34. Copper casting and drawing to 0.6mm wire
35. Copper casting and drawing to 8mm wire
36. Copper casting, drawing and laquering to 0.6mm wire
37. Copper casting, drawing and polmer coating to 0.6mm wire
38. Copper continuous casting
39. Copper extrusion and drawing to profiles
40. Copper extrusion and drawing to tubes
41. Copper ore concentrate preparation and delivery
42. Copper ore mining
43. Copper ore mining and concentration
44. Copper production
45. Copper rolling to strips
46. Copper skew rolling, pilgering and drawing to tubes
47. Crushing and cleaning of broken glass
48. CuNi10Fe extrusion and drawing of tubes
49. CuNi10Fe extrusion and pilgering of tubes
50. CuNi10Fe semicontinuous casting
51. CuSn6 casting and drawing to wire
52. CuSn6 casting and rolling to strips
53. CuSn6 continuous casting
54. CuZn37 casting and drawing to wire
55. CuZn37 casting and extruding over core to tubes
56. CuZn37 casting and rolling to strips
57. CuZn37 continuous casting
58. CuZn37Pb chill casting
59. CuZn39Pb2 casting and pressing to rods
60. Czech Republic, electricity generation mix 1998
61. Degradation of chemical pulp, CP, in a landfill
62. Degradation of chemo-thermo-mechanical pulp, CTMP, in a landfill
63. Delivery van, distribution, diesel
64. Delivery van, distribution, petrol
65. Denmark, electricity generation mix 1998
66. De-watering of water-sludge
67. Diesel combustion
68. Diesel driven freight train, future
69. Diesel driven freight train, T44 engine
70. Diesel engine, Euro 0
71. Diesel engine, Euro 1
72. Diesel engine, Euro 2
73. Diesel engine, future
74. Diesel production
75. Diesel propulsed train.
76. Diode wafer production and assembly
77. Dry wood chips fired plant for heat and power production - Large plant
78. Electric freight train, wagon load
79. Electric freight train, wagon load, including electricity production
80. Electrically driven combi train, future
81. Electrically driven combi train, RC engine
82. Electrically driven freight train 230 meters, future
83. Electrically driven freight train 230 meters, RC engine
84. Electrically driven freight train 700 meters, future
85. Electrically driven freight train 700 meters, RC engine
86. Electrically driven intermodal train, RC engine
87. Electrically driven intermodal train, RC engine, including electricity production
88. Electrically driven system train (Circuit-working), RC engine
89. Electrically driven system train (Circuit-working), RC engine, including electricity production
90. Electrically driven system train, future
91. Electrically driven system train, RC engine
92. European Union, electricity generation mix 1998
93. Extraction and beneficiation of rock phosphate
94. Extraction and grinding of dolomite
95. Extraction of crude oil
96. Extraction of crude oil and gas
97. Extraction of dolomite
98. Extraction of dolomite
99. Extraction of feldspar

100. Extraction of lime, Unacceptable
101. Extraction of Portland soda
102. Extraction of sand
103. Extraction of sulphur and production of sulphuric acid
104. Extraction to ABS APME
105. Extraction to polycarbonate APME
106. Extraction to polyethylene all grades APME
107. Extraction to polyethylene HD APME
108. Extraction to polyethylene LD APME
109. Extraction to polyethylene linear LD APME
110. Extraction to SAN APME
111. Extraction to toluene APME
112. Extraction to xylene APME
113. Extraction, beneficiation and grinding of kieserite
114. Extraction, beneficiation and grinding of potash salt
115. Ferry
116. Ferry, 700-7000 tonnes
117. Ferry, 700-7000 tonnes, future
118. Fertilizing in silviculture
119. Final felling
120. Finland, electricity generation mix 1998
121. Flame laminate treatment of textiles
122. Flexible PUR foam
123. Forwarding of harvested wood
124. France, electricity generation mix 1998
125. Freight plane, MD-82, 300 km
126. Freight plane, MD-82, 600 km
127. Freighter, 2000-8000 dwt
128. Freighter, 8000-2000 dwt, future
129. Freighter, larger than 8000 dwt
130. Freighter, larger than 8000 dwt, future
131. Freighter, smaller than 2000 dwt
132. Freighter, smaller than 2000 dwt, future
133. Freight-Train Luleå to Halmstad
134. Freight-Train Umeå to Halmstad
135. Fuel gas electricity energy system, EPD-version
136. Fuel gas electricity energy system, ETH - full version
137. Gas-turbine power plant with support systems
138. General Purpose Polystyrene (GPPS)
139. Germany, electricity generation mix 1998
140. Glassworks
141. Glulam wood production
142. Greece, electricity generation mix 1998
143. Grinding of dolomite
144. Heavy truck with international semitrailer, max 40 tonnes, future
145. Heavy truck with international semitrailer, max 40 tonnes, manufactured after 1996 [Euro 2]
146. Heavy truck with international semitrailer, max 40 tonnes, manufactured before 1992 [Euro 0]
147. Heavy truck with international semitrailer, max 40 tonnes, manufactured between 1992 and 1995[Euro 2]
148. Heavy truck with one trailer, long distance, Euro 0
149. Heavy truck with one trailer, long distance, Euro 1
150. Heavy truck with one trailer, long distance, Euro 2
151. Heavy truck with one trailer, long distance, made before 1990
152. Heavy truck with trailer, max 60 tonnes, future
153. Heavy truck with trailer, max 60 tonnes, manufactured after 1996 [Euro 2]
154. Heavy truck with trailer, max 60 tonnes, manufactured before 1992 [Euro 0]
155. Heavy truck with trailer, max 60 tonnes, manufactured between 1992 and 1995 [Euro 1]
156. Heavy truck with two trailers, long distance, Euro 0
157. Heavy truck with two trailers, long distance, Euro 1
158. Heavy truck with two trailers, long distance, Euro 2
159. Heavy truck with two trailers, long distance, made before 1990
160. Heavy truck, max 18 tonnes, future
161. Heavy truck, max 18 tonnes, manufactured after 1996 [Euro 2]
162. Heavy truck, max 18 tonnes, manufactured before 1992 [Euro 0]
163. Heavy truck, max 18 tonnes, manufactured between 1992 and 1995 [Euro 1]
164. Heavy truck, max 24 tonnes, future
165. Heavy truck, max 24 tonnes, manufactured after 1996 [Euro 2]
166. Heavy truck, max 24 tonnes, manufactured before 1992 [Euro 0]
167. Heavy truck, max 24 tonnes, manufactured between 1992 and 1995 [Euro 1]
168. High purity copper production from primary raw materials
169. High purity copper production from secondary raw materials
170. High sea shipping
171. Hungary, electricity generation mix 1998
172. Hydro electricity energy system, EPD-version
173. Hydro electricity energy system, ETH - full version
174. Hydro-electric power station with support systems
175. Iceland, electricity generation mix 1998
176. Incineration of aluminium
177. Incineration of corrugated board
178. Incineration of linoleum
179. Incineration of paperboard for liquids
180. Incineration of polyethylene
181. Incineration of polystyrene
182. Incineration of PVC
183. Incineration of starch
184. Incineration of wood
185. Inductor assembly
186. Integrated circuit capsule assembly
187. Inventory of Volvo painting plant, TB4
188. Ireland, electricity generation mix 1998
189. Italy, electricity generation mix 1998
190. Japan, electricity generation mix 1998
191. Jet plane, A 300-B4, 1200 km
192. Jet plane, A 300-B4, 600 km
193. Jet plane, B727-200, 1200 km
194. Jet plane, B727-200, 600 km

195. Jet plane, B737-300QC, 1200 km
196. Jet plane, B737-300QC, 600 km
197. Jet plane, B747-400, 1200 km
198. Jet plane, B747-400, 600 km
199. K30 ready mixed concrete production
200. K40 ready mixed concrete production
201. Korea, electricity generation mix 1998
202. Landfill disposal
203. Landfilling of solid municipal waste
204. Laying of linoleum-floor
205. Light truck, distribution, Euro 0
206. Light truck, distribution, Euro 1
207. Light truck, distribution, Euro 2
208. Light truck, distribution, made before 1990
209. Light truck, max 3,5 tonnes, diesel driven
210. Light truck, max 3,5 tonnes, gasoline driven
211. Light truck, max 8 tonnes, future
212. Light truck, max 8 tonnes, manufactured after 1996 [Euro 2]
213. Light truck, max 8 tonnes, manufactured before 1992 [Euro 0]
214. Light truck, max 8 tonnes, manufactured between 1992 and 1995 [Euro 1]
215. Lignite electricity energy system, EPD-version
216. Lignite electricity energy system, ETH - full version
217. Liquid crystal display unit assembly
218. Locomotive two-stroke engine
219. Luxembourg, electricity generation mix 1998
220. Manufacturing of Cold Rolled Steel Tubes, 41,55 x 37,21 or 47,75 x 41,01 mm
221. Manufacturing of Hot Rolled Round Steel Billets, 80 mm
222. Manufacturing of Hot Rolled Square Billets, 150 mm
223. Manufacturing of Hot Rolled Steel Tubes, 70,7 x 47,5 mm
224. Manufacturing of polyurethane insulation
225. Manufacturing of PU elastics
226. Manufacturing of SKF's Spherical Roller Bearing
227. Manufacturing of the Plain bearing GE30
228. MDI - PUR precursors
229. Medium speed, four-stroke diesel vessel engine, 80 % engine load
230. Medium speed, four-stroke diesel vessel engine,20 % engine load
231. Medium weight truck, regional, Euro 0
232. Medium weight truck, regional, Euro 1
233. Medium weight truck, regional, Euro 2
234. Medium weight truck, regional, made before 1990
235. Metal surface treatment of car- and boat details
236. Mexico, electricity generation mix 1998
237. Mining to sodium chloride APME
238. Mining to sodium hydroxide APME
239. Mounting profile production
240. Natural gas fired combination plant for heat and power production
241. Natural gas fired combination power plant with support systems
242. Natural gas fired plant for heat production - Small plant
243. Natural gas fired plant with flue gas condensation for heat and power production
244. Netherlands, electricity generation mix 1998
245. New Zealand, electricity generation mix 1998
246. N-fertilizer production
247. Norway, electricity generation mix 1998
248. Nuclear electricity energy system, EPD-version
249. Nuclear electricity energy system, ETH - full version
250. Nuclear power plant with support systems
251. OECD Europe, electricity generation mix 1998
252. OECD North America, electricity generation mix 1998
253. OECD Pacific, electricity generation mix 1998
254. OECD total, electricity generation mix 1998
255. Oil condensing power plant with support systems
256. Oil electricity energy system, EPD-version
257. Oil electricity energy system, ETH - full version
258. Ore-based steel production
259. Particleboard production
260. Passenger plane, MD-82, 300 km
261. Passenger plane, MD-82, 600 km
262. Peat fired plant for heat and power production
263. PET
264. Planting softwood plants
265. Plasterboard production
266. Poland, electricity generation mix 1998
267. Polyether-polyols - PUR precursors
268. Polyethylene
269. Polypropylene
270. Portugal, electricity generation mix 1998
271. Potentiometer assembly
272. Preparation and anti-corrosive treatment of construction steel
273. Pre-stressing wire production
274. Pre-treatment of biowaste
275. Primary aluminium production
276. Primary copper production
277. Printed board assembly
278. Printing works
279. Processing of waste-oil into fuel oil
280. Production and assemblage of parts to the engineering industry
281. Production and refining of metal components
282. Production of 0,005-0,02 mm double-rolled aluminium foil
283. Production of 0,02-0,2 mm single-rolled aluminium foil
284. Production of a Corrugated Board Box (182*62*182)
285. Production of Alkyl Polyglucosides (APG) from coconut oil
286. Production of ammonia
287. Production of ammonium nitrate
288. Production of Bearing Steel
289. Production of benzene (APME)
290. Production of blister copper
291. Production of butadiene

292. Production of cameras, magazines and accessories
293. Production of CAN fertilizer
294. Production of CAN fertilizer (Composite system)
295. Production of cooling fluid, R134a
296. Production of copper anodes
297. Production of dimethylether from energy forest
298. Production of Dowel Adhesive PVAC 3370
299. Production of energy forest
300. Production of EPDM
301. Production of ethyl alcohol using energy forest and the CASH-method
302. Production of ethyl alcohol using energy forest and the CHAP-method
303. Production of ethyl alcohol using energy forest and the enzyme-method
304. Production of extruded aluminium profiles
305. Production of Hardener 2545 for urea formaldehyde resins
306. Production of Hardener 2580 for urea formaldehyde resins
307. Production of high-density polyethylene
308. Production of hot mix for asphalt pavement
309. Production of hydrogen (cracker) (APME)
310. Production of injection moulding
311. Production of insulation glass wool
312. Production of insulation rockwool
313. Production of iron oxide
314. Production of Iron Powder
315. Production of Kraftliner
316. Production of latex rubber
317. Production of Linear Alkylbenzene Sulphonates (LAS)
318. Production of linoleum
319. Production of linseed oil
320. Production of linseed oil in Sweden
321. Production of low-density polyethylene
322. Production of lubricating oil
323. Production of mastic
324. Production of matte copper
325. Production of methanol using energy forest
326. Production of methylene diphenyl diicocyanate, MDI (APME)
327. Production of nitric acid
328. Production of nitric acid (Landskrona)
329. Production of nonylphenol and dinonylphenol
330. Production of NP 27-5 fertilizer
331. Production of NP 27-5 fertilizer (Composite system)
332. Production of NPK 20-3-5 fertilizer
333. Production of NPK 20-3-5 fertilizer (Composite system)
334. Production of nylon 66 (APME)
335. Production of paint and anti corrosion agents
336. Production of paint, thinner and enamel mainly for surface treatment of steel
337. Production of PE-film
338. Production of pentane (APME)
339. Production of petrochemical Alcohol Ethoxylates (AE) with 3 moles of ethylene oxide (EO)
340. Production of petrochemical Alcohol Ethoxylates (AE) with 7 moles of ethylene oxide (EO)
341. Production of petrochemical Alcohol Sulphates (AS)
342. Production of phosphoric acid
343. Production of phosphoric acid (48 % P2O5)
344. Production of plastic strips and film
345. Production of polyamide 66 containing 30% glass fiber (APME)
346. Production of polybutadiene (APME)
347. Production of polyethylene resin (HDPE), (APME)
348. Production of polyethylene terephthalate (APME)
349. Production of polymethyl methacrylate (APME)
350. Production of polyols (APME)
351. Production of polypropylene (APME)
352. Production of polystyrene (APME)
353. Production of polyvinyl chloride, emulsion polymerized (APME)
354. Production of polyvinyl chloride, suspension polymerized (APME)
355. Production of powdered limestone
356. Production of powdered wood
357. Production of primary copper
358. Production of PVC
359. Production of PVC calendered sheet (APME)
360. Production of PVC injection moulding (APME)
361. Production of PVC pipe (APME)
362. Production of PVC unplasticised film APME
363. Production of rolled aluminium sheet
364. Production of self-adhesive labels etc used in the manufacturing, food and pharmaceutical industry
365. Production of Semi chemical Fluting
366. Production of Soap from palm oil/palm kernel oil
367. Production of sodium sulphate
368. Production of solvey soda
369. Production of styrene (APME)
370. Production of sulphuric acid by roasting of pyrite
371. Production of titanium dioxide
372. Production of toluene diisocyanate (APME)
373. Production of TSP fertilizer
374. Production of TSP fertilizer (Composite system)
375. Production of Urea-formaldehyde resin 1202 (UF 1202), Wood Adhesive
376. Production of Urea-formaldehyde resin 1205 (UF 1205), Wood Adhesive
377. Production of Urea-formaldehyde resin 1206 (UF 1206), Wood Adhesive
378. Production of Urea-formaldehyde resin 1274 (UF 1274), Wood Adhesive
379. Production of washing soda, Unacceptable
380. Production of Wetfix I (adhesion promoter used in hot mix for asphalt pavements)
381. Production of Wine Ethanol Fuel (ETAMAX D), excluding grape cultiv. and wine prod.
382. Production of Wine Ethanol Fuel (ETAMAX D), including grape cultiv. and wine prod.
383. Production of wood Adhesive PVAC 3316

384. Production of wood Adhesive PVAC 3318
385. Production of wood Adhesive PVAC 3326
386. Propane fired combination plant for heat and power production
387. Propane fired plant for heat production - Large plant
388. Propane fired plant for heat production - Small plant
389. Pulverized wood fired plant for heat and power production - Large plant
390. Pulverized wood fired plant for heat production - Small plant
391. PVC
392. Rail transport - 10 trucks
393. Rail transport - 10 trucks
394. Rail transport - 52 trucks
395. Rail transport - 52 trucks
396. Recycling and temporary storage of metals
397. Recycling of polyethene
398. Red brass sand casting
399. Refining of crude oil
400. Refining of crude oil in to diesel
401. Refining of crude oil in to petrol
402. Reinforcement bar production
403. Relay assembly
404. Remelting of aluminium scrap
405. Resistor for hole mounting assembly
406. Resistor for surface mounting assembly.
407. Resistor network assembly
408. Retapping of cooling medium in tanks
409. Rigid PUR foam
410. Roll-on-roll-off vessel (RoRo)
411. RoRo vessel, 2000-30000 dwt
412. RoRo vessel, 2000-30000 dwt,future
413. Sawed construction timber production
414. Scrap-based aluminium production
415. Scrap-based steel production
416. Scrap-based steel production
417. Si wafer production and Si wafer processing for integrated circuits
418. Si wafer production and Si wafer processing for transistors
419. Silviculture of softwood Composite system
420. Slow speed, two-stroke diesel vessel engine, 20 % engine load
421. Slow speed, two-stroke diesel vessel engine, 80 % engine load
422. Soil preparation
423. Solid waste management, Composite system
424. Sorting of solid municipal waste
425. Spain, electricity generation mix 1998
426. Steam cracking of refined oil products
427. Steel jointing production
428. Steel rail production
429. Steeping of gas tanks
430. Stone coal electricity energy system, EPD-version
431. Stone coal electricity energy system, ETH - full version
432. Storage and distribution of chemicals and intermediate storage of hazardous waste.
433. Storage of ammonia
434. Sweden, electricity generation mix 1998
435. Swedish average electricity production, Composite system
436. Swedish electricity production system
437. Swedish reinforcement steel mix
438. Swedish sheet steel mix
439. Switzerland, electricity generation mix 1998
440. Tankers
441. TDI-PUR precursors
442. Thermal treatment of solid municipal waste
443. Thinning of forest area
444. Transistor assembly
445. Transportation of crude oil to Sweden
446. Treatment of hazardous waste
447. Treatment of hazardous waste from industries and municipalities
448. Treatment of oil-contaminated waste water
449. Treatment of oil-contaminated waste water
450. Treatment of sewage
451. Treatment of waste oil from industries and municipalities
452. Tree plant nursing
453. Truck Göteborg to SAKAB
454. Truck Halmstad to Göteborg (Scrap)
455. Truck Halmstad to Göteborg (Water-sludge)
456. Truck Halmstad to SAKAB
457. Truck Jönköping to Halmstad
458. Truck Reci Göteborg to Sävenäs
459. Truck with semitrailer, max 42 tonnes, future
460. Truck with semitrailer, max 42 tonnes, manufactured after 1996 [Euro 2]
461. Truck with semitrailer, max 42 tonnes, manufactured before 1992 [Euro 0]
462. Truck with semitrailer, max 42 tonnes, manufactured between 1992 and 1995 [Euro 1]
463. Truck, long distance transportation
464. Truck, regional distribution
465. Truck, urban distribution
466. Turkey, electricity generation mix 1998
467. United Kingdom, electricity generation mix 1998
468. United States, electricity generation mix 1998
469. Vattenfall electricity production system
470. Vessel Göteborg to Halmstad
471. Vessel Halmstad to Slite
472. Vessel Loudden to Halmstad
473. Virgin aluminium production
474. Virgin steel production
475. Waste disposal
476. Waste disposal of building, industrial and hazardous waste
477. Waste to energy plant
478. Wind electricity energy system, EPD-version
479. Wind power plant with support systems
480. Wood chips fired plant (with stoker) for heat and power production – Large plant
481. Wood chips fired plant (with stoker) for heat production - Small plant
482. Wood fired CFB plant for heat and power production - Large plant
483. Wood fired CFB plant for heat production - Small plant
484. Wood pellets fired plant for heat and power production - Large plant
485. Wood pellets fired plant for heat production - Small plant

Appendix 5:
IA data from WWLCAW: 6 environmental impact methods and 204 characterisation models

Environmental impact method

EDIP126 127, 1997

Category indicators

1. Aluminium consumption
2. Antimony consumption
3. Beryllium consumption
4. Cadmium consumption
5. Coal consumption
6. Cobalt consumption
7. Copper consumption
8. Gold consumption
9. Iron consumption
10. Lanthanum consumption
11. Lead consumption
12. Manganese consumption
13. Mercury consumption
14. Molybdenum consumption
15. Natural gas consumption
16. Nickel consumption
17. Oil consumption
18. Palladium consumption
19. Silver consumption
20. Tantalum consumption
21. Tin consumption
22. Wood consumption
23. Zinc consumption
24. EF(ac) (equivalency factor for acidification)
25. EF(ne) (equivalency factor for oxygen depletion)
26. EF(po) (equivalency factor for ground level ozone creation)
27. EF(etp) (equivalency factor for microorganisms in sewage treatment plants)
28. EF(etsc) (equivalency factor for chronic ecotoxicity in soil)
29. EF(etwa) (equivalency factor for acute ecotoxicity in water)
30. EF(etwc) (equivalency factor for chronic ecotoxicity in water)
31. EF(hta) (equivalency factor for acute human toxicity from air)
32. EF(hts) (equivalency factor for acute human toxicity from soil)
33. EF(htw) (equivalency factor for acute human toxicity from water)
34. GWP (global warming potential)
35. ODP (ozone depletion)

Characterisation models

1. Contributions to EF(ac) (equivalency factor for acidification)
2. Contributions to EF(ne) (equivalency factor for oxygen depletion)
3. Contributions to EF(po) (equivalency factor for ground level ozone creation)
4. Contributions to EF(etp) (equivalency factor for microorganisms in sewage treatment plants)
5. Contributions to GWP (global warming potential)
6. Contributions to ODP (ozone depletion)
7. Contributions to resource consumptions
8. Contributions to EF(etsc) (equivalency factor for chronic ecotoxicity in soil) via emissions to air
9. Contributions to EF(etsc) via emissions to soil
10. Contributions to EF(etsc) via emissions to water
11. Contributions to EF(etwa) (equivalency factor for acute ecotoxicity in water) via emissions to water
12. Contributions to EF(etwc) (equivalency factor for chronic ecotoxicity in water) via emission to air
13. Contributions to EF(etwc) via emissions to soil
14. Contributions to EF(etwc) via emissions to water
15. Contributions to EF(hta) (equivalency factor for acute human toxicity from air) via emissions to air
16. Contributions to EF(hta) via emissions to soil
17. Contributions to EF(hta) via emissions to water
18. Contributions to EF(hts) (equivalency factor for acute human toxicity from soil) via emissions to air

19. Contributions to EF(hts) via emissions to soil
20. Contributions to EF(hts) via emissions to water
21. Contributions to EF(htw) (equivalency factor for acute human toxicity from water) via emissions to air
22. Contributions to EF(htw) via emissions to soil
23. Contributions to EF(htw) via emissions to water

Substance cover

Approx. 170 different substances.

Environmental impact method

Eco-indicator 128, 1999

Category indicators

1. PDF (Potentially Disappeared Fraction)
2. DALYs (Disability Adjusted Life Years)
3. Resource damage

Characterisation models

1. Acidification and eutrophication impact on PDF (Potentially Disappeared Fraction)
2. Carcinogenic substances air emissions impact on DALYs (Disability Adjusted Life Years)
3. Carcinogenic substances soil emissions impact on DALYs
4. Carcinogenic substances water emissions impact on DALYs
5. Climate change impact on DALYs
6. Ecotoxic substances air emissions impact on PDF
7. Ecotoxic substances soil emissions impact on PDF
8. Ecotoxic substances water emissions impact on PDF
9. Fossil fuels extraction impact on resource damage
10. Ionising radiation air emissions impact on DALYs
11. Land-use impact on PDF
12. Minerals extraction impact on resource damage
13. Ozone layer depletion impact on DALYs
14. Respiratory effects impact on DALYs

Substances

Approx. 170 different substances.

Environmental impact method

EPS[129] [130], 2000

Category indicators

1. Base cat-ion capacity
2. Crop
3. Drinking water
4. Fish & meat
5. Fossil coal
6. Fossil oil
7. Irrigation water
8. Morbidity
9. Natural gas
10. NEX (Normalised EXtinction of species)
11. Nuisance
12. Severe morbidity
13. Severe nuisance
14. Wood
15. YOLL (Years Of Lost Life)
16. Al reserves
17. Ar reserves
18. Au reserves
19. B reserves
20. Ba reserves
21. Be reserves
22. Bi reserves
23. Br reserves
24. Cd reserves
25. Ce reserves
26. Cl reserves
27. Co reserves
28. Cr reserves
29. Cs reserves
30. Cu reserves
31. Dy reserves
32. Er reserves
33. Eu reserves
34. F reserves

35. Fe reserves
36. Ga reserves
37. Gd reserves
38. Ge reserves
39. H reserves
40. He reserves
41. Hf reserves
42. Hg reserves
43. Ho reserves
44. I reserves
45. In reserves
46. Ir reserves
47. K reserves
48. La reserves
49. Li reserves
50. Lu reserves
51. Mg reserves
52. Mn reserves
53. Mo reserves
54. N reserves
55. Na reserves
56. Nb reserves
57. Nd reserves
58. Ne reserves
59. Ni reserves
60. O reserves
61. Os reserves
62. P reserves
63. Pb reserves
64. Pd reserves
65. Pr reserves
66. Pt reserves
67. Rb reserves
68. Re reserves
69. Rh reserves
70. Ru reserves
71. S reserves
72. Sb reserves
73. Sc reserves
74. Se reserves
75. Sm reserves
76. Sn reserves
77. Sr reserves
78. Ta reserves
79. Tb reserves
80. Te reserves
81. Th reserves
82. Ti reserves
83. Tl reserves
84. Tm reserves
85. U reserves
86. V reserves
87. W reserves
88. Y reserves
89. Yb reserves
90. Zn reserves
91. Zr reserves

Characterisation models

1. Arable land use impact on NEX (Normalised EXtinction of species)
2. Arsenic air emissions impact on severe morbidity
3. Arsenic air emissions impact on YOLL (Years Of Lost Life)
4. Benzene impact on crop
5. Benzene impact on morbidity
6. Benzene impact on NEX
7. Benzene impact on YOLL
8. BOD impact on NEX
9. Butadiene impact on crop
10. Butadiene impact on morbidity
11. Butadiene impact on NEX
12. Butadiene impact on severe morbidity
13. Butadiene impact on wood
14. Butadiene impact on YOLL
15. Cd air emissions impact on morbidity
16. Cd air emissions impact on severe morbidity
17. Cd air emissions impact on YOLL
18. Cd soil emissions impact on morbidity
19. Cd water emission impact on YOLL
20. CFC-11 impact on crop
21. CFC-11 impact on morbidity
22. CFC-11 impact on NEX
23. CFC-11 impact on severe morbidity
24. CFC-11 impact on wood
25. CFC-11 impact on YOLL
26. CO impact on crop
27. CO impact on Morbidity
28. CO impact on NEX
29. CO impact on Nuisance
30. CO impact on Severe morbidity
31. CO impact on wood
32. CO impact on YOLL
33. CO2 impact on crop
34. CO2 impact on Morbidity
35. CO2 impact on NEX
36. CO2 impact on Severe morbidity
37. CO2 impact on Wood
38. CO2 impact on YOLL
39. COD impact on NEX/
40. Cr air emissions impact on severe morbidity
41. Cr air emissions impact on YOLL
42. Cu water emission impact on YOLL
43. Ethylene impact on crop
44. Ethylene impact on morbidity
45. Ethylene impact on NEX
46. Ethylene impact on severe morbidity
47. Ethylene impact on wood
48. Ethylene impact on YOLL
49. Forest land for roads and other hard-made surface use impact on NEX
50. Forest land for roads and other hard-made surface use impact on wood
51. Forest land use impact on NEX
52. Formaldehyde impact on crop
53. Formaldehyde impact on morbidity
54. Formaldehyde impact on NEX/
55. Formaldehyde impact on severe morbidity
56. Formaldehyde impact on wood
57. Formaldehyde impact on YOLL
58. Freons impact on crop
59. Freons impact on morbidity
60. Freons impact on NEX
61. Freons impact on severe morbidity

62. Freons impact on wood
63. Freons impact on YOLL
64. H2S impact on base cat-ion capacity
65. H2S impact on crop
66. H2S impact on fish&meat
67. H2S impact on morbidity
68. H2S impact on NEX
69. H2S impact on nuisance
70. H2S impact on severe morbidity
71. H2S impact on wood
72. H2S impact on YOLL
73. HCI impact on base cat-ion capacity
74. HCI impact on crop
75. HCI impact on morbidity
76. HCI impact on NEX
77. HCI impact on nuisance
78. HCI impact on severe morbidity
79. HCI impact on wood
80. HCI impact on YOLL
81. HF impact on base cat-ion capacity
82. HF impact on crop
83. HF impact on fish&meat
84. HF impact on morbidity
85. HF impact on NEX
86. HF impact on nuisance
87. HF impact on severe morbidity
88. HF impact on wood
89. HF impact on YOLL
90. Hg air emissions impact on morbidity
91. Hg air emissions impact on fish&meat
92. Hg soil emissions impact on morbidity
93. Hg soil emissions impact on NEX
94. Hg water emissions impact on fish&meat
95. Hg water emissions impact on morbidity
96. Hg water emissions impact on NEX
97. Littering impact on severe nuisance
98. Methane impact on crop
99. Methane impact on morbidity
100. Methane impact on NEX
101. Methane impact on severe morbidity
102. Methane impact on wood
103. Methane impact on YOLL
104. N2O impact on base cat-ion capacity
105. N2O impact on crop
106. N2O impact on fish&meat
107. N2O impact on morbidity
108. N2O impact on NEX
109. N2O impact on nuisance
110. N2O impact on severe morbidity
111. N2O impact on wood
112. N2O impact on YOLL
113. NH3 impact on base cat-ion capacity
114. NH3 impact on crop
115. NH3 impact on fish&meat
116. NH3 impact on morbidity
117. NH3 impact on NEX
118. NH3 impact on nuisance
119. NH3 impact on severe morbidity
120. NH3 impact on wood
121. NH3 impact on YOLL/
122. Noise impact on severe nuisance
123. NOx impact on Base-cat-ion capacity
124. NOx impact on Fish&meat
125. NOx impact on Morbidity
126. NOx impact on NEX
127. NOx impact on Nuisance
128. NOx impact on Severe morbidity
129. NOx impact on Wood
130. NOx mipact on YOLL
131. N-tot impact on fish&meat
132. N-tot impact on NEX/
133. Other VOC impact on crop
134. Other VOC impact on NEX
135. Other VOC impact on severe morbidity
136. Other VOC impact on wood
137. Other VOC impact on YOLL
138. Pb air emissions impact on severe nuisance in the world
139. Pb water emissions impact on severe nuisance
140. Pesticides impact on morbidity
141. Pesticides impact on NEX
142. Pesticides impact on severe morbidity/
143. Pesticides impact on YOLL/
144. PM10 impact on crop
145. PM10 impact on morbidity/
146. PM10 impact on NEX/
147. PM10 impact on nuisance
148. PM10 impact on severe morbidity
149. PM10 impact on wood
150. PM10 impact on YOLL
151. Propylene impact on crop
152. Propylene impact on morbidity
153. Propylene impact on NEX/
154. Propylene impact on severe morbidity
155. Propylene impact on wood/
156. Propylene impact on YOLL
157. P-tot impact on NEX/
158. Resource consumption impact on resource reserves
159. SO2 impact on base cat-ion capacity
160. SO2 impact on crop
161. SO2 impact on fish&meat
162. SO2 impact on morbidity
163. SO2 impact on NEX
164. SO2 impact on nuisance
165. SO2 impact on severe morbidity
166. SO2 impact on wood
167. SO2 impact on YOLL

Substances

Approx. 240 different substances

The following environmental impact methods are variations of the previous three original methods: 131

Environmental impact method

LCA-E(EDIP/EPD), 2001

Characterisation models

1. Contributions to EF(ac) (equivalency factor for acidification)
2. Contributions to EF(ne) (equivalency factor for oxygen depletion)
3. Contributions to EF(po) (equivalency factor for ground level ozone creation)
4. Contributions to GWP (global warming potential)
5. Contributions to ODP (ozone depletion)
6. Contributions to resource consumptions

Environmental impact method

LCA-E(ECOI/EPD), 2001

Characterisation models

1. Acidification and eutrophication impact on PDF (Potentially Disappeared Fraction)
2. Climate change impact on DALYs
3. Fossil fuels extraction impact on resource damage
4. Land-use impact on PDF
5. Minerals extraction impact on resource damage
6. Ozone layer depletion impact on DALYs
7. Respiratory effects impact on DALYs

Environmental impact method

LCA-E(EPS/EPD), 2001

Characterisation models

1. Arable land use impact on NEX (Normalised EXtinction of species)
2. CFC-11 impact on crop
3. CFC-11 impact on morbidity
4. CFC-11 impact on NEX
5. CFC-11 impact on severe morbidity
6. CFC-11 impact on wood
7. CFC-11 impact on YOLL
8. CO2 impact on crop
9. CO2 impact on Morbidity
10. CO2 impact on NEX
11. CO2 impact on Severe morbidity
12. CO2 impact on Wood by elevated temperature
13. CO2 impact on YOLL
14. COD impact on NEX
15. Ethylene impact on crop by oxidation
16. Ethylene impact on severe morbidity by oxidation
17. Ethylene impact on YOLL by oxidation
18. Formaldehyde impact on crop by oxidation
19. Formaldehyde impact on severe morbidity by oxidation
20. Formaldehyde impact on YOLL by oxidation
21. Freons impact on crop
22. Freons impact on morbidity
23. Freons impact on NEX
24. Freons impact on severe morbidity
25. Freons impact on wood
26. Freons impact on YOLL
27. H2S impact on base cat-ion capacity
28. H2S impact on crop
29. H2S impact on fish&meat

30. H2S impact on morbidity
31. H2S impact on NEX
32. H2S impact on severe morbidity
33. H2S impact on YOLL
34. HCl impact on base cat-ion capacity
35. HCl impact on fish & meat
36. HCl impact on NEX by acidification
37. Methane impact on crop by global warming
38. Methane impact on morbidity
39. Methane impact on NEX
40. Methane impact on severe morbidity by global warming
41. Methane impact on wood by global warming
42. Methane impact on YOLL by global warming
43. N2O impact on crop by global warming
44. N2O impact on morbidity by global warming
45. N2O impact on NEX by global warming
46. N2O impact on severe morbidity by global warming
47. N2O impact on wood by global warming
48. N2O impact on YOLL by global warming
49. NH3 impact on base cat-ion capacity
50. NH3 impact on fish&meat
51. NH3 impact on NEX by acidification and eutrofication
52. NH3 impact on wood by eutrofication
53. NOx impact on Base-cat-ion capacity
54. NOx impact on Fish&meat
55. NOx impact on NEX by eutrofication
56. NOx impact on Wood by eutrofication
57. N-tot impact on fish&meat
58. N-tot impact on NEX
59. Other VOC impact on crop
60. Other VOC impact on severe morbidity by oxidation
61. Other VOC impact on YOLL by oxidation
62. P-tot impact on NEX
63. Resource consumption impact on resource reserves
64. SO2 impact on base cat-ion capacity
65. SO2 impact on fish&meat
66. SO2 impact on NEX by acidification

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128 Goedkoop M, Spriensma R, The Eco-indicator 99, A damage oriented method for Life Cycle Impact Assessment, Methodology Report, 2000

129 Steen B, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS) Version 2000 - General System Characteristics, CPM report 1999:4

130 Steen B, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS) Version 2000 - Models and Data of the Default Method, CPM report 1999:5

131 Erixon M, Information System Supporting a Web Based Screening LCA Tool, CPM report 2001:14

Appendix 6: *Sources of data and information used in CPM collaboration*

The SPINE@CPM database includes industry and product data from:

- APME – Association of Plastics Manufacturers in Europe (www.apme.org)
- EAA – European Aluminium Association (www.eaa.net)
- NTM – The Network for Transport and the Environment (www.ntm.a.se)
- SIK - The Swedish Institute for Food and Biotechnology (www.sik.se) (artifical fertiliser)
- ETH – Swiss Federal Institute of Technology Zurich (www.ethz.ch) (energy systems, packaging solutions)
- Ericsson (electronic components)
- StoraEnso (forestry)
- Vattenfall (energy systems)
- SKF (ball bearings, steel, etc.)

For more information about these and other sources in SPINE@CPM, go to www.globalspine.com and then on to the LCI database.

Other CPM-related sources of information and data:

- Aquire
- ATSDR Tox FAQ
- Baltic Sea Environment Bibliography 1970
- CalTOX
- Cancerlit
- Carcinogenic Potency Database
- Catalogue of Substances Hazardous to Water
- Chemfinder
- Chemical Carcinogenesis Research Information system
- ChemIDplus
- Chemlinks
- CIS
- Cosmetic Ingredient Review
- DAIN - Metadatabase of Internet Resources for Environmental Chemicals
- DART- Developmental and Reproduction Toxicology
- DATALOG
- DOSE - Dictionary of Substances and their Effetcs
- ECB - Existing Chemicals
- ECDIN - Environmental Chemicals Data and Information Network
- EHC - Environmental Health Criteria
- EMIC - Environmental Mutagen Information Center
- Environmental Fate Database
- ETICBACK - Environmental Teratology Info Center Backfile (before 1989).
- EXICHEM
- Experimental LogP
- Extoxnet

- Federal Register
- GENE-TOX
- GINC - Global Information Network on Chemicals
- Hazardous Chemicals Database
- Health Effects Notebook for Hazardous Air Pollutants
- HSDB - Hazardous Substances Data Bank.
- IARC - Monographs Programme on the Evaluation of Carcinogenic Risks to Humans
- IRIS - Integrated Risk Information System
- ITER - International Toxicity Estimates for Risk
- IUCLID - International Uniform Chemical Information Database
- Kompass
- Material Safety Data Sheet
- MEDLINE
- MSDS Search
- N-Class Database
- NIOSH - Immediately dangerous to life or health concentrations (IDLHs)
- NIOSHTIC - 2
- NTP Health and Safety - National Toxicology Program
- OLDMEDLINE
- PHYSPROP- The Physical Properties Database
- Plants
- PRTR - Pollutant Release and Transfer Registers
- REDs - Reregistration Eligibility Decision
- SCIRUS
- Scorecard
- SOLV-DB
- Swedish Product register
- TOXLINE
- TOXNET
- TRI- Toxics Release Inventory
- TSCATS - The toxic substance control act test submission database
- US Patent
- USES-LCA
- Web Page Reviews - 1997

For more information about these data sources go to
http://honeybee.imi.chalmers.se/omniitox_area/datasources.asp.

Other sources mapped out within CPM since 1998 include:

- IVAM (www.ivambv.uva.nl) (buidlng material, agriculture, electronics, waste management)
- FEFCO – European Federation of Corrugated Boards Manufacturers (www.fefco.org)
- STFI - Swedish Pulp and Paper Research Institute (www.stfi.se)
- KCL ECODATA (The Finnish Pulp and Paper Research Institute) (www.kcl.fi)
- IKP – Institut für Kunststoffkunde und Kunststoffprüfung (GaBi) (www.ikpgabi.uni-stuttgart.de)
- PIRA – Packaging Industry Research Association (www.pira.co.uk)
- PRé (Simapro) (www.pre.nl) (materials, transportation, processing, use, waste treatment)
- CIT Ekologik (LCAiT) (www.ekologik.cit.chalmers.se) (energyware, transportation, material)
- Ecobilan/Ecobalance (TEAM) (http://www.ecobalance.com/index.html) (material, energy, transportation)
- IRIS – Industrial Research Institutes in Sweden, SIRII (www.sirii.org)

For more information about these and other sources, see CPM's internal report entitled "Overview of databases and data sources for life cycle inventory data" 132 from 1998 and UNEP/SETAC's latest compilation og LCI databases from all over the world, "Current Availability of LCI Databases in the World" 133, which can be downloaded from www.sylvatica.com/unepsumm.htm.

132 Pålsson A-C, Overview of databases and data sources for life cycle inventory data, Internal CPM report, 1998

133 Norris G, Notten P, Current Availability of LCI Databases in the World, 2002

Report 5349

Measuring the environmental impact of products

In order to limit the environmental impact of products in accordance with an environment-oriented product policy, there is a need for increased, shared knowledge and information about the environmental impact of products – from the extraction of raw material, manufacturing, usage, handling to transport activities at all stages.

This report presents the knowledge and experience within this field at CPM at Chalmers University of Technology. Since its formation in 1996, CPM has worked with knowledge and information about the environmental performance of products in a life cycle perspective. The report includes references to gaps and limitations, potential for development, a possible link to environmental quality objectives and proposals of collaboration between various parties to improve the flows of knowledge and information regarding the environmental impact of products.

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