CHALMERS

Extension of Databases in Networking

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Summary

In the CPM project "Databases in Networking", academic research on understanding, quality and commercial aspects of industrial environmental information systems is performed. The extension part was added to the project for development of operative solutions. The project is basically practical, following recommendations from academic research, but is also intended as educational. The extension part of the Databases in Networking project has also aimed to demonstrate research results within the framework of the EU project DANTES [1].

The results from two European research projects in which Industrial Environmental Informatics (IMI) have participated, OMNIITOX[2] and REPID[3], have been presented to the member companies of the Centre for Environmental Assessment of Product and Material Systems (CPM). Practical solutions for how to make use of the results have then been found through discussions and analysis.

In the OMNIITOX project the lack of knowledge of toxicological consequences in life cycle assessment (LCA) is addressed. Impact assessment models for the effects of toxic substances on humans and nature has been developed. The impact assessment models created in the project are also stored in an information system called OMNIITOX IS together with physical, chemical and toxicological data on substances and also nature data. The discussions with the companies showed that the OMNIITOX results were valuable for the industry and most useful if they could be integrated with existing LCA tools. An LCA tool called LCA@CPM was therefore constructed by integrating different parts of an LCA tool already developed in CPM projects in co-operation with the CPM project A16 "Industrial applications of future information systems for impact assessment".

The LCA@CPM prototype is a user-friendly web based LCA-tool supporting LCA practitioners at companies and organizations to work according to the ISO 14040 framework in a transparent way. It is a tool for managing all information needed when working with LCA based on the ISO 14040 series framework and the ISO/TS 14048 data documentation format. The database structure used in LCA@CPM includes model parts that enable storage of data from the REPID information system which facilitates future data sharing.

The REPID project is an implementation of the successful RAVEL project in which a Design for Environment (DfE) methodology was developed to achieve efficient communication of environmental performance throughout the supply chain for the railway industry. The aim of REPID was to reach a practical agreement on a set of Environmental Performance Indicators (EPIs), a practically useful and common material list, and an open data format, all included in the methodology. The discussions in this study showed that measurement and communication of environmental performance not only suit the railway industry well, but also other industries. Further, the interest for the RAVEL methodology and the REPID results is high and there is an interest to implement the EPIs for internal and to some extent external communication in the CPM companies.

[1] Demonstrate and Assess New Tools for Environmental Sustainability, http://www.dantes.info/

[2] Operational Models aNd Information tools for Industrial applications of eco/TOXicological impact assessments, http://www.omniitox.net/

[3] Rail sector framework and tools for standardising and improving usability of Environmental Performance Indicators and Data formats, http://www.railway-procurement.org/repid.htm

A case-study has also been performed in this project where a supply chain material inventory system has been implemented based on the RAVEL methodology. Results from the REPID project have also been included in the case-study in terms of the common material list and the common EPIs. The case-study showed that it is possible to implement a cost efficient supply chain material inventory system based on the RAVEL methodology.

Table of Contents

1 INTRODUCTION 1

1.1 DATABASES IN NETWORKING 1
1.2 EXTENSION OF DATABASES IN NETWORKING 1

2 GOAL AND SCOPE 3

2.1 GOAL OF THE PROJECT 3
2.2 SCOPE OF THE PROJECT 3

3 OMNIITOX 4

3.1 GOAL AND SCOPE OF THE OMNIITOX PART 4
3.2 INTRODUCTION TO THE OMNIITOX PROJECT 4
3.2.1 Background to the project 4
3.2.2 Expected results from the OMNIITOX project 4
3.3 WORKING METHOD 5
3.4 INTERVIEW RESULTS 6
3.4.1 Current work with toxicological aspects 6
3.4.2 Driving forces for the work 6
3.4.3 Need for toxicological information 6
3.4.4 Foreseeable future demands 7
3.4.5 Implementation of OMNIITOX IS 7
3.5 CONCLUSIONS 7

4 REPID 9

4.1 GOAL AND SCOPE OF THE REPID PART OF THE PROJECT 9
4.2 INTRODUCTION TO THE REPID PROJECT 9
4.2.1 Summary and background of the project 9
4.2.2 Measurement and communication of environmental performance in the supply chain 9
4.3 WORKING METHOD 10
4.3.1 Questionnaire 11
4.4 INTERVIEW RESULTS 11
4.4.1 Current work with product related environmental aspects 11
4.4.2 Driving forces for the work 12
4.4.3 Need for communication of environmentally related information 12
4.4.4 Material data handling 13
4.4.5 Future improvement on product related information 13
4.4.6 Results from the presentation and discussion of the REPID results within the DANTES project group 14
4.5 DISCUSSION ON INTERVIEW RESULTS 14
4.6 ISSUES TO CONSIDER WHEN ADAPTING AND IMPLEMENTING THE RAVEL METHOD 16

5 DEVELOPMENT OF A SUPPLY CHAIN MATERIAL INVENTORY SYSTEM 17

5.1 BACKGROUND 17
5.2 METHOD 17
5.3 RESULT 18
5.3.1 Tools for translation of data between previous system and a RAVEL system 18
5.3.2 The Inventory Tool 19
5.3.3 The Inventory Administration Tool 19

6 DEVELOPMENT OF LCA@CPM 20

6.1 BACKGROUND 20
6.2 METHOD 20
6.2.1 Specification of requirements 20
6.2.2 Reuse of previous results 21
6.2.3 Technical aspects 23
6.3 RESULT 23
6.3.1 Goal and scope 24
6.3.2 Inventory 24

6.3.3 Impact Assessment *24*
6.3.4 Interpretation *24*
6.3.5 Reporting *24*
6.3.6 Critical review *24*

7 CONCLUSIONS 25

7.1 OMNIITOX 25
7.2 REPID 25
7.3 DEVELOPMENT OF A SUPPLY CHAIN MATERIAL INVENTORY SYSTEM 26
7.4 LCA@CPM 26
7.5 SUGGESTIONS FOR FUTURE WORK 26

1 Introduction

The "Extension of Databases in Networking" is a subproject in the "Databases in Networking" project to which a short introduction is given below.

1.1 Databases in Networking

The project "Databases in Networking" was started at the Centre for Environmental Assessment of Product and Material Systems (CPM) the 1st of February 2002. The project focused on solving some of the most critical problems identified in the previous CPM project "Integration of industrial environmental information systems". These were identified as the understanding, quality and commercial aspects of industrial environmental data. It aimed at establishing different communication-channels for industrial environmental data and analyzing them from the viewpoints of understanding and credibility by combining industrial case-studies and academic research.

1.2 Extension of Databases in Networking

The extension part of Databases in Networking was added to allow for development and implementation of operative solutions. The aim was that the experiences made from the practical development and implementation should complement the analytical case studies and theoretical studies of the research part of the project, as well as generate practically useful results for the CPM member companies. It was planned to start the 1st of January 2003 but did in fact not start until the 1st of April 2004.

The results from the European research projects OMNIITOX[4] and REPID[5] in which Industrial Environmental Informatics (IMI) have participated were to be applied to the CPM companies. The aim was to give IMI personnel practical experience of introducing and integrating information systems in industrial companies. Knowledge of the CPM companies and experience of solving practical problems with industry gives the IMI personnel valuable competence for future development of industrial environmental information systems. The work has been divided into an OMNIITOX part and a REPID part and this report has therefore also this structure.

The project has also included a case study where a supply chain material inventory system was developed in cooperation with Bombardier Transportation, based on results from European research projects RAVEL and REPID.

Furthermore, a web-based LCA tool has been developed by integration of previous CPM results. This part of the project has been conducted in coordination with project A16 "Industrial applications of future information systems for impact assessment" that had the aim to facilitate industrial application of the OMNIITOX results by integration with other CPM results and where the gap between LCI and IA has been overcome.

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[4] Operational Models aNd Information tools for Industrial applications of eco/TOXicological impact assessments, http://www.omniitox.net/

[5] Rail sector framework and tools for standardising and improving usability of Environmental Performance Indicators and Data formats, http://www.railway-procurement.org/repid.htm

The Extension of Databases in Networking results will be used for the Chalmers-matching of the EU-project DANTES [6] and also as input to the PhD theses of the main project. The results will be disseminated via the DANTES network and through the actual implementations in the CPM companies.

[6] Demonstrate and Assess New Tools for Environmental Sustainability, http://www.dantes.info/

2 Goal and scope

2.1 Goal of the project

- Demonstrate research results for the CPM companies within the framework of the EU-project DANTES
- Integrate different high quality environmental information systems to facilitate and reduce costs for environmental data
- Gather experience from the practical development and implementation to complement the analytical case studies and theoretical studies
- Generate practically useful results for the CPM member companies
- Give the IMI personnel practical experiences of introduction and integration of information systems in industrial companies

2.2 Scope of the project

The project was designed to help CPM results go “all the way” from academic research to practical implementation, which is the main purpose of CPM and the strategic goal for CPM phase III. Some integration problems may be so complex that this project may not actually achieve practical implementation, but will have to settle with an improved specification of the problems.

3 OMNIITOX

3.1 Goal and scope of the OMNIITOX part

The purpose of the OMNIITOX[7] part of the project is to present the OMNIITOX results, inventory the need for toxicological information and find practical solutions for how to make use of the results in the CPM companies. The work has been performed in coordination with project A16 "Industrial applications of future information systems for impact assessment", where the OMNIITOX results were to be industrially applied by integration with other CPM methods and tools. It is also a preparation of case studies regarding OMNIITOX for the research part of "Databases in Networking".

3.2 Introduction to the OMNIITOX project

3.2.1 Background to the project

The EU project OMNIITOX started in 2001 and will finish in November 2004. Five main issues are addressed in the project:

- Comparison of life cycle impact assessment (LCIA) and environmental risk assessment (ERA)
- Comparing LCIA methods
- Extending the scope of LCIA methods
- Development of the OMNIITOX Information System
- Use of life cycle assessment (LCA) for regulatory assessment of chemicals

The toxicological consequences have previously been a neglected area in life cycle impact assessment (one of four phases in an LCA), mostly because of lack of knowledge. OMNIITOX addresses this lack of knowledge. In the project impact assessment models for the effects of toxic substances on humans and nature has been developed. Also, the extent to which environmental risk assessment and life cycle assessment overlap and complement each other has been investigated and the knowledge from the area of environmental risk assessment has been used as far as possible in the work with impact assessment models.

The ten project partners are: Chalmers University of Technology, Danmarks Tekniske Universitet, Universiteit Leiden P.B., Universitaet Stuttgart, Ecole Polytechnique Fédérale de Lausanne, Volvo Technology Corporation, Procter & Gamble Eurocor, Stora Enso AB, Antonio Puig S.A., Randa Group S.A. and the European Chemicals Bureau, Joint Research Centre.

3.2.2 Expected results from the OMNIITOX project

Within OMNIITOX detailed work has been done regarding the improvement of understanding across disciplinary boundaries e.g. expert toxicologists' clarifying needs and impact assessment modelers' data needs. In addition, a lot of effort has been laid on producing computational

[7] Operational Models aNd Information tools for Industrial applications of eco/TOXicological impact assessments, http://www.omniitox.net/

reports and interfaces for different academic and industrial users. The expected result is that impact assessment models for toxic substances, which both hold scientific consensus and are also able to be implemented in industrial applications will be produced.

To support the results from the project, an information system called OMNIITOX IS has been created in the project and will also be a result of its own. The information system includes a database containing physical, chemical and toxicological data on substances and also nature data such as e.g. geological, meteorological and biophysical properties. The data have been acquired from the IUCLID[8] database and from case studies made in the project. The impact assessment models created in the project are also stored in the database.

The information system is developed by Industrial Environmental Informatics (IMI) and provides the possibility to create characterization parameters that are functions of the substance properties and nature properties for which data are stored in the database. This is made through the construction of a model of toxicological impacts on humans and eco-systems. The model is developed co-operatively by the expert toxicologists from the participating universities and the system modelers at IMI.

The OMNIITOX modeling method is a general modeling method that is another result from the project and can be used for other impact assessment modeling than toxicological effects.

3.3 Working method

In the "Extension of Databases in Networking" project, all CPM companies were contacted and offered a telephone interview for employees working with toxicological issues, life cycle assessment and environmental management. In the interviews, the company's work with toxicological information was surveyed and the interviewees were informed about the results from OMNIITOX.

The interviewed companies are Duni, SCA, Volvo AB, ITT Flygt, ABB, Bombardier Transportation and Akzo Nobel. The other CPM member companies did either not find the OMNIITOX project interesting or could not find any time for participation.

The questions that were asked at the interviews were:

- How do you and your company work with toxicological aspects in the environmental work today?
- What are the driving forces in your work with toxicological aspects?
- What toxicological information is needed in your work?
- What do you foresee regarding future demands of toxicological information?

Conclusions were drawn together with the interviewees and discussions of how to proceed. The most interested companies were visited for further discussions.

[8] IUCLID is an acronym for International Uniform ChemicaL Information Database and contains information on toxicity of substances.

3.4 Interview results

3.4.1 Current work with toxicological aspects

At the CPM companies today, the toxicological aspects are mainly addressed in the part of the environmental work that is focused on the work environment. Toxicological aspects are more seldom taken care to in work focused on the effects on the nature, e.g. in environmental management systems, LCA, etc.

The toxicological information used is mostly qualitative and not quantitative. The material safety data sheets[9] are at some companies the only documents with which toxicological information is communicated. Many of the companies work with lists of prohibited and restricted materials that they avoid as far as possible. These lists are constructed by expert groups at the companies, and a classification is made of new materials before they are used.

The companies use different tools for environmental assessments. The use of LCA varies between the CPM companies, but a common trend is that the use decreases. The companies that perform LCA studies do not take the toxicological aspects in consideration because of the lack of reliable characterization methods, but if there were such methods available they would be used. Sometimes further studies of the products are made to supplement the results of the LCA, which may include toxicological aspects. Some companies develop Environmental Product Declarations (EPD), which are based on the LCA results, but the EPD does currently not include any toxicological information. Also, Environmental Risk Assessment (ERA) is used at some of the companies.

Some of the CPM companies have constructed their own databases with information on the physical, chemical and toxicological properties of substances. Others use commercial databases as Chemical Substances (supplied by the Swedish Chemicals Inspectorate – KemI), ChemSources etc.

3.4.2 Driving forces for the work

The driving forces in the work with toxicological aspects at the interviewed CPM companies are mainly laws and regulations as they demand that the companies have control over the chemicals used by the company, especially the regulations of working environment. Other driving forces are interest from customers, neighbors and NGOs. The customers demand information about the use of chemicals with the motive to protect their brand from damage. Some of the companies have a driving force of their own in their policy formulations.

3.4.3 Need for toxicological information

Toxicological information is asked for from several stakeholders and the interviewees expressed the need of the company to have the necessary information to satisfy these stakeholders because it is a matter of reliability to the brand. The companies do sometimes co-operate via trade organizations to compile the information necessary for a specific business. Some companies are regulated by several directives that cover different aspects of the products, and they are obliged to deliver this information. Some examples are the product safety directive, the medical devices directive, the cosmetics directive etc. all in which toxicological aspects are concerned.

[9] A Material Safety Data Sheet (MSDS) is a document that gives detailed information about the nature of a chemical, such as physical and chemical properties, health, safety, fire, and environmental hazards of a chemical product.

The toxic impact assessment models in LCA that exist show inconsistent results. The lack of reliable impact assessment models for toxicological effects is a deficiency in LCA studies as the toxicological impact of the products are usually excluded for that reason. LCA and ERA are run in parallel in spite of the fact that there is an overlap between them. Besides, the results from LCA are often inconsistent with the results from ERA.

3.4.4 Foreseeable future demands

At all companies, an increased demand for toxicological information is foreseen in the future, especially concerning the work environment. A more effective management of the information is therefore needed to reduce the costs. Those of the companies that have eco-labeled products need already to continuously update their information.

The environmental product declarations (EPD) contain currently no demands on declaring the toxicological aspects of the product but this may be voluntarily added. In the future, there is also a possibility that the work with Product Specific Requirements (PSR) may start to include toxicological aspects.

There is a need of combining the knowledge from LCA and ERA as there is an overlap between them. If there was consensus between the methods the reliability of the results would increase a lot. Another future possibility is that LCA will be legally implemented and that assessment of the toxicological impacts will be included in the requirements.

REACH will impact the work with toxicological information, though how much is still uncertain. The responsibility for the information on substances will however most probably be moved from the authorities to the companies, with the consequence that an increased amount of information will have to be managed by the companies. The results from OMNIITOX can support REACH which is a possibility that the companies found very interesting.

3.4.5 Implementation of OMNIITOX IS

The interviews showed that the companies wanted further developments of the OMNIITOX results to adapt it better to specific needs. One example is that the impact assessment models are currently difficult to adapt to local conditions. A natural system is in the model defined by 140 nature properties and a lot of work is therefore needed to create a new model of a natural system. The emissions are also distributed evenly over the whole natural system, and the damage is thus often calculated to be less than in reality where emissions are usually concentrated to a much smaller geographical area.

Another example is that care to reaction products is not taken. The impact assessment models regard the life length of the substances but not what is produced after the substances have reacted. Reaction products such as metallic complexes or metabolites have different impact and can sometimes be more hazardous than the original substance. Also, care to synergic or counteractive effects between different substances is not taken in the impact assessment models.

3.5 Conclusions

All the interviewed companies have a need for information on toxicological properties of substances and wish to access it at low cost and effort. The companies have also a need for information on physical and chemical properties of substances. Most companies use databases with substance information, of various quality and content, in their daily work. The

continuously increasing amount of information to manage, which will be further increased by REACH, demands more effective management.

The CPM companies have a lot to gain if the competence and knowledge developed under the work with OMNIITOX could be transferred to them. The toxicological impact assessment models can be used both for LCA and for Environmental Management Systems (EMS). It is preferable if the new information can be used in already existing information tools so that the user interface is familiar, as the threshold to make use of the information would be lower. It is of vital importance that the information tool is understandable and easy to use. Each new user interface demands more effort for the environmental information management. In the interviews it was emphasized that the best solution to meet the need to access toxicological information at low cost and effort was to integrate the OMNIITOX results with an existing LCA tool.

The toxicological information used in the CPM companies today is mostly qualitative. The OMNIITOX information system contains quantitative toxicological data and quantified characterization factors for use in life cycle assessment or environmental management work. The database created in the project contains quality data, both substance property data and nature property data which is desirable for many industrial companies also without the other results.

The results from OMNIITOX can support REACH, which was the original idea in the OMNIITOX project, but due to delays in the REACH project this has not been practically possible. The OMNIITOX database can be used to supply the information required for REACH. A matching between OMNIITOX and REACH would mean that the input data for the toxicology impact assessment model will be chosen while considering the data input needed for REACH. This would have the advantage of a shared database for the two applications, and LCA with regard to toxic impacts can easily be produced using the information that has had to be produced to comply with the REACH requirements.

4 REPID

4.1 Goal and scope of the REPID part of the project

The purpose of the REPID[10] part of the project "Extension of Databases in Networking" is to present the results from the REPID project to the CPM companies and to find practical solutions how the results can fit into their daily work. The goal has also been to investigate the potential need for the REPID results through interviews and discussions and also to find work processes on how to implement some part of the REPID results suiting their specific needs.

This part is also, like the OMNIITOX part, a preparation of case studies regarding REPID for the research part of the "Databases in Networking" project.

4.2 Introduction to the REPID project

4.2.1 Summary and background

The EU-project REPID, started in 2002 and ended in 2004, has advanced the railway industry towards introducing Design for Environment (DfE). The project, coordinated by UIC (International Union of Railways) and UNIFE (the Union of European Railway Industries), is an implementation of the successful Brite-Euram III project RAVEL[11] (1998-2001) in which a DfE methodology was developed. The aim of REPID was to reach a practical agreement on a set of Environmental Performance Indicators (EPIs), a practically useful and common material list, and an open data format, all included in the methodology. The standardization of EPIs and the data format within the sector is a prerequisite for achieving meaningful and comparable measurement of environmental performance. Based on the material list, the data format and the standardized EPIs, a design supportive software application was implemented by SEMCON Sweden. This application can be used to analyze and communicate eco-efficiency of the design of trains and train-components, in terms of the REPID EPIs. The application can be integrated with existing product management systems, which is a prerequisite to achieve a widespread acceptance of its use in the daily work. In the REPID project, integration with the CAD-tool CatiaV5 has been used as a showcase. These solutions have been developed for the railway industry, but are also applicable to any other line of business in the manufacturing industry.

Project partners are: Alstom, Bombardier Transportation, Chalmers University of Technology, Deutsche Bahn, Siemens and the trade organizations for operators, UIC and manufacturers, UNIFE and their European railway network.

4.2.2 Measurement and communication of environmental performance in the supply chain

The RAVEL methodology and the REPID tools provide communication and measurement of environmental performance based on materials in the supply chain, and a connection between market requirements and the product design. The communication is based on measurable EPIs,

[10] Rail sector framework and tools for standardising and improving usability of Environmental Performance Indicators and Data formats, http://www.railway-procurement.org/repid.htm

[11] Rail Vehicle Eco-Efficient Design, http://repid.imi.chalmers.se/ravel/

and it is technically facilitated by a common communication format for data exchange. By using the RAVEL methodology the customer can communicate environmental requirements and targets to the manufacturing companies. The manufacturers can calculate the actual environmental performance in terms of the defined EPIs, and communicate the results back to the customers. The manufacturers can also utilize the same language when communicating environmental performance with their sub-suppliers.

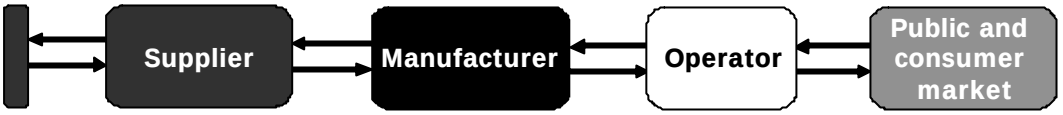

Fig. 2 The RAVEL methodology and the REPID tools provide communication and measurement of environmental performance

4.3 Working method

The aim of the REPID part of the project "Extension of Databases in Networking" has been to present the results from REPID where the RAVEL methodology has been successfully implemented in the railway industry and to discuss how these results can be used and refined to suit the needs of CPM companies.

First an invitation email was sent to the contact persons at all CPM member companies presenting the goal and scope of the REPID part of the project "Extension of Databases in Networking". In the email it was suggested that a meeting could take place with the company and personnel at IMI.

The CPM companies ITT Flygt, Volvo AB and Volvo Cars were positive to the proposal and IMI personnel Markus Erlandsson and Karolina Flemström visited them. The agenda for the meeting was:

- Presentation of IMI and CPM
- Goal and scope of the meeting
- Background of the method – the RAVEL and REPID projects
- Description of the DfE method
- Information management
- Examples of software solutions
- Discussion

In the first part of the meeting, a presentation was held by Markus Erlandsson and Karolina Flemström about IMI, CPM, RAVEL, REPID and the method.

The discussion in the last part of the meeting was based on how the RAVEL methodology could suit each company and their needs. A questionnaire was used in the discussion which included questions about the material inventory at the companies, handling of environmental information and measurement of environmental performance, handling of nomenclatures at the company etc, see section 4.3.1.

At the three companies, Volvo Cars, ITT Flygt and Volvo AB, employees working with product development, environmental management, research and development and quality participated in the interviews.

The other CPM companies that did not participate in this part of the project did either not find the RAVEL methodology and the REPID results interesting and useful for their products and needs, or could not find any time for a meeting.

The RAVEL methodology and the results from the REPID project were also presented for the participants in the DANTES project group i.e. ABB, Stora Enso and Akzo Nobel, which also are CPM member companies. After the presentation a discussion was held and the comments and conclusions are presented in section 4.4.6.

4.3.1 Questionnaire

The following questions where posed to the participants during the meeting in the initial phase of the discussion.

1. How do you work with product related environmental information today?
    a. Do you work with LCA?
    b. Do you use environmental indicators?
2. Which are the driving forces for the company to work with this?
3. Which are the needs for communication of environmentally related information for your products?
    a. towards customers
    b. towards sub-suppliers
    c. towards authorities
4. Do you have environmental related requirements on your suppliers today?
5. Do your suppliers provide you with information about material content for the component they deliver?
6. How is the flow of product information in the company?
    a. How are component structures stored? (CAD, PDM...)
    b. How are material choices stored? (CAD, PDM,)
    c. Is there a common material nomenclature?
7. How are nomenclatures handled in the company?
8. Is it technically and practically feasible to add environmental properties to all materials in your material databases?

4.4 Interview results

4.4.1 Current work with product related environmental aspects

All of the interviewed companies have knowledge of which materials their products consist of e.g. in terms of material data systems and supplier information. To avoid usage of specific materials, the restricted and prohibited substance lists also named black and grey lists are used. These lists of materials consist of materials forbidden or restricted by law and/or by company

policy and are often used in internal and external communication and when setting requirements together with suppliers.

Life Cycle Assessment (LCA) and Environmental Product Declarations (EPD) are performed and used at some of the interviewed companies. Not many new complete LCA studies are performed today by comparison with 10 years ago. One of the interviewed companies has even stopped performing LCA studies since they have already identified the "hot spots" of their product's life cycle.

The term Environmental Performance Indicator (EPI) from ISO 14031 is well-known. Different kinds of EPIs are used internally in the interviewed CPM companies to perform an assessment of the product's environmental impact or in internal communication between departments. In type II environmental declarations EPIs for production, use and end of life are used e.g. emissions of CO_2 and NO_x in the usage phase and material recycling in the end of life phase.

The interviewed companies also have ISO 14001 environmental management systems implemented.

The product related environmental information is used by environmental coordinators and sometimes also designers at different parts of the company. The information is mainly used to assure compliance with legal regulations. Product related environmental information is also used in purchasing departments e.g. in terms of environmental safety data sheets.

For all the interviewed companies the usage phase is identified as the phase with highest environmental impact from the product's life cycle perspective. This means that properties as efficiency, energy use, emission of CO_2 and NO_x etc are of vital importance in the environmental work at the companies. The environmental impact from materials is thus not in main focus today for the environmental work at the interviewed CPM companies.

For some products the environmental work is strongly connected to the life cycle cost of the product. Energy use is then the most crucial environmental impact for the company since energy use is the most important issue possible to influence to reduce the life cycle cost.

4.4.2 Driving forces for the work

Money is the driving force for the overall work and the environmental work which is directly connected to lower costs, is for that reason often prioritized within the interviewed companies. This means that performance indicators of a product as e.g. long lifetime and high efficiency are highly prioritized environmental aspects. Legislation on the product is also important for the environmentally related work, e.g. recycling requirements in the End-of-Life (ELV)-directive, requirements on CO_2-emissions, noise etc.

4.4.3 Need for communication of environmentally related information

With customers

The need for communication much depends on the product and the customer. As an example, a customer buying a bus requires information on recycling and a customer buying a refuse lorry requires information on emission and noise.

Business to business customers require environmental product declarations and also cost and usage related information. There are no direct requirements from private customers. Indirect environmental requirements as a long lifetime and high efficiency are however important for all customers.

With suppliers and sub-suppliers

Material content of the products needs to be communicated. Restricted and prohibited lists are often used.

There are also requirements on the suppliers in terms of implementation of environmental management system e.g. ISO 14001.

To authorities

Compliance with legal requirements (national or international) on e.g. noise, emissions, fuel consumption and prohibited materials.

4.4.4 Material data handling

After request, suppliers supply the interviewed CPM companies with information about the material content of the delivered products. Different information systems are used for this purpose e.g. at one company the International Material Data System (IMDS)[12] is used by suppliers to register all materials used in the components and semi-components.

Material content and product structures are sometimes stored in different databases using different information systems at the interviewed CPM companies. The material standards used are e.g. ISO-and DIM-standards or the company's own material standards. The companies' material lists vary very much in size, from 200 to 20 000 materials. Handling of nomenclatures in e.g. IMDS is a crucial issue where much effort has been made.

Material content, product structure, weight of each material in the components is stored at several of the interviewed companies.

4.4.5 Future improvement on product related information

In one of the interviewed CPM companies, recycling data and other environmental related product information will probably be included in the material handling system within a few years. A standardized communication format will probably also be developed for communication of material information and also to be used for some type of quantitative measurement of environmental performance. Fire and safety information will not be included in the future since another system is used for these areas today.

At another of the interviewed companies there are discussions about implementing a recycling system where indicators on recycling could be a good solution.

Some related work is currently performed in this area. For example, there is a project running in the car industry closely related to parts of the REPID and RAVEL projects and the method. The knowledge from REPID could be valuable input to this project.

[12] Public webpage: http://www.mdsystem.com/html/en/home_en.htm

4.4.6 Results from the presentation and discussion of the REPID results within the DANTES project group

The REPID results and the RAVEL methodology was presented and discussed on a meeting within the DANTES project[13]. The CPM member companies ABB, Stora Enso and Akzo Nobel participated on this meeting.

These CPM companies did not fully see the general usability of the RAVEL method for their companies. For example, Akzo Nobel pointed out that for the chemical industry it is hard to calculate the environmental performance based on the input chemical substances. In addition, information about the use of the products and not only the input chemicals used, is very important in the chemical industry when assessing if the product is environmentally hazardous or not. The RAVEL method is developed for the manufacturing industry and it does hence need to be adapted and further developed to also suit the process industry.

At the meeting was also discussed the degree of difficulty to define general and common EPIs and set target values if a company's products are diverse and also if the different production sites of a company differ too much e.g. in terms of location. The most important aspect of the EPIs is that they are understandable and important for all involved parties. If such indicators cannot be found on a global level, indicators and above all target values of the indicators has to be defined on a local level where they are important and understandable.

The RAVEL methodology, which describes how measurement and communication of the environmental performance of products can be achieved mainly based on the material content of products, was first implemented within the railway industry. However, it is applicable to any line of business in the manufacturing industry. It is also important to remember that the result from the REPID project only provides one example of an implementation of the RAVEL method. If the method would be implemented within other line of businesses it will probably look differently.

4.5 Discussion on interview results

One conclusion of the interviews is that the companies found the results from the RAVEL and REPID project very interesting. The interviews and discussions showed that measurement of environmental performance in the design phase and communication of the results throughout the whole supply chains not only suit the railway industry well, but also the car industry and internal communication in the pump industry.

In companies where material inventory is an important part of the daily work the RAVEL method could easily be implemented. In the car industry for example the work with IMDS has resulted in a material database and a platform for material inventory to be used by suppliers and sub-suppliers. With a standardized communication format and environmental related information included, the RAVEL method could be successfully integrated with IMDS and implemented in the company according to the persons performing the interviews. Important work would need to be performed regarding defining EPIs suiting the industry but some of the EPIs defined for the railway industry could be reused.

For the pump industry many of the already defined EPIs could be used and some specific indicators for pumps need to be developed. For companies producing a homogenous group of products, a set of common EPIs could be suitable. Many persons interviewed thought that the REPID EPIs could be used in internal communication at the company in particular.

[13] Demonstrate and Assess New Tools for Environmental Sustainability, http://www.dantes.info/

One important conclusion from the interviews is that there is a need for measurement and communication of environmental performance in the energy area, e.g. energy consumption, efficiency etc. These are not material related indicators but this area can also be handled by the RAVEL methodology. Nevertheless, more knowledge is needed to create well defined non-material related EPIs.

In companies where indicators and material inventory are already used internally, the need for implementing the RAVEL methodology is not obvious. However, there is a need for a methodology of how to set target values for different indicators.

LCA and material data handling systems e.g. IMDS or other, are and have been two important methods/systems at the companies. LCA work with LCA tools, e.g. LCAiT and Ecolab, and work with the EPS-method or similar has been performed separated from the material handling system before. However, a combination of material handling systems and LCA was considered an interesting approach.

IMDS contains very detailed information on the material content of different parts used in products from the automotive industry. The major part of the information is directly inserted into the system by different sub-suppliers. IMDS does hence contain detailed information on the production phase of a product's life cycle as illustrated in figure 3 below. If this information could be complemented with generic down-stream information on e.g. the resource extraction, and generic up-stream information from the usage phase and end-of-life phase, information on the whole life cycle will be acquired. This information can be used for measurement and communication of the product's environmental performance. Applying this approach, which is the core of the RAVEL methodology, on the automotive industry does of course involve some difficulties. Above all are there many nomenclature issues to be solved. The pay-back will however be great since the material inventory system IMDS already is established within the automotive industry.

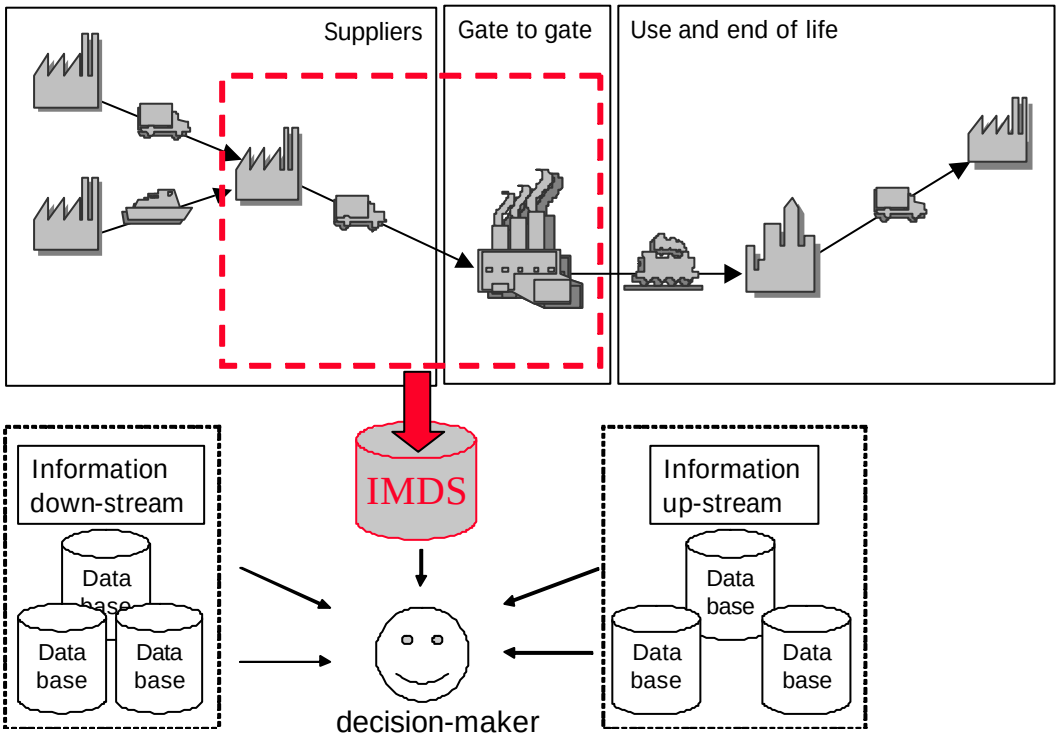

Fig. 3 Illustration of a combination of LCA and the material handling systems IMDS

4.6 Issues to consider when adapting and implementing the RAVEL method

The RAVEL method is developed as a generally designed environment method to be used within different industries producing different types of products. The REPID project implemented the method in the railway industry. When implementing the method in other manufacturing industries than the railway industry, there is a need to specify and customize many elements for the specific company or industry sector. The method also need to be adapted and further developed when implementing the method within lines of businesses where the environmental performance cannot be directly calculated from the materials, as for example the processing industry.

The tools supporting the method are developed to facilitate the communication between the different stakeholders e.g. the designer, supplier, environmental coordinator etc. This is accomplished by a well-developed presentation format which enables easy communication of the EPI results and requirements. The EPI results need to be transparent, i.e. the underlying material data and data documentation as well as the component structure is also presented. Further, when implementing the method the tool developed should facilitate a correct use of the method.

In the REPID project the knowledge of the end of life phase e.g. recycling and waste, has been better than the knowledge of the environmental impact of the usage phase. Therefore improvement of EPIs in the usage and production phase would be preferred. During the interviews EPIs in the areas of energy consumption, noise and use of oil in production have been identified as important. More work need to be done in these areas.

5 Development of a supply chain material inventory system

5.1 Background

The EU-project RAVEL[14] running 1998-2001 resulted in a Design for Environment (DfE) methodology which later was implemented in the EU-project REPID[15] as described in section 4.2.1.

After the successful RAVEL project and in parallel with REPID, Bombardier Transportation initiated a process where they started to implement the RAVEL methodology and the REPID results within the company. The goal of this process was to enable measurement of environmental performance based on the material content of the products utilizing the RAVEL method which was commonly developed within the railway industry. To be able to know the material content of the products a supply chain material inventory system needed to be implemented. In this part of the "Extension of Databases in Networking" project, a case study has hence been performed where a supply chain material inventory system has been developed based on the RAVEL methodology and partial results from REPID as a show-case.

The major part of this case study was performed the REPID project had resulted in an updated version of the RAVEL data model. The data format defined in RAVEL has for that reason been used in the implementation phase of this case study. This data format was however only slightly modified within the REPID project, so the information can easily be transferred between systems based on the different data models. The standardized Environmental Performance Indicators (EPIs) and material list developed within the REPID project has however been integrated within the system developed in this case study.

5.2 Method

The RAVEL method is a DfE-method that provides measurement and communication of environmental performance of products in terms of performance indicators as described in section 4.2.2. Important characteristics for performance indicators that are used in a DfE-system are that the indicators are measurable, able to be controlled by the DfE-process and address important and well defined environmental issues. To be able to analyze a specific design, a component structure consisting of all the components and materials in the component is needed for the design. Also needed to perform the measurement are a common material list and material property data for each material in the list, and calculation rules for each EPI. The calculation rules define how the material property data, for the materials found in the component structure, shall be aggregated to reach a result for each EPI.

In the start up phase of this case study it was discussed and planned in detail which steps that were needed to be taken when replacing Bombardier Transportation's prior system for environmental assessment by a system based on the RAVEL methodology. The following steps were identified:

[14] Rail sector framework and tools for standardising and improving usability of Environmental Performance Indicators and Data formats, http://www.railway-procurement.org/repid.htm

[15] Rail Vehicle Eco-Efficient Design, http://repid.imi.chalmers.se/ravel/

- Establish a two-way translation for the information in the previous system and the new RAVEL system.
- Implement an inventory tool for acquisition of data from sub-suppliers
- Implement a tool for administration of the data delivered by the suppliers and for administration of common material list and material property data

The inventory tool together with the administration tool supports an approach where information about the product always is delivered together with the product as suggested in the paper IBEIM[16]. The inventory tool is an implementation of IBEIM as a network capable unit enabling environmental supply chain management, as defined in that paper.

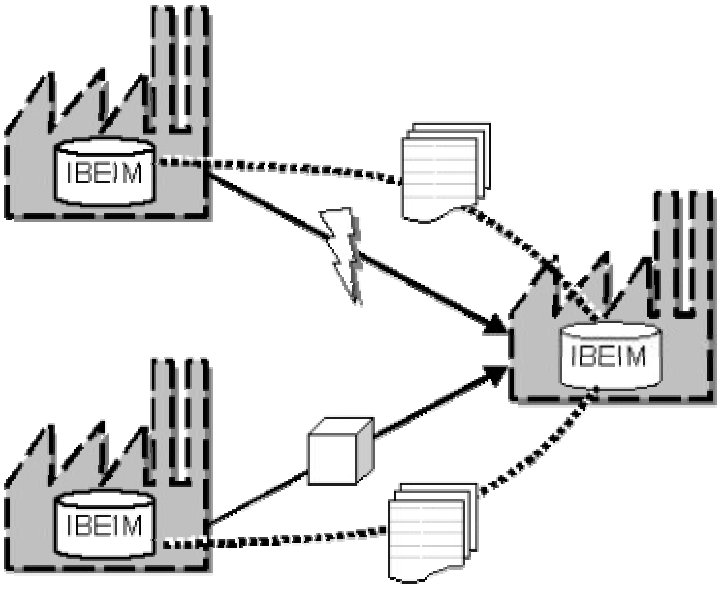

Fig. 2 The inventory tool is an implementation of IBEIM as a network capable unit where information on the product is delivered together with the product

5.3 Result

5.3.1 Tools for translation of data between previous system and a RAVEL system

When moving from one system to another, it is of vital importance that it is possible to transfer information smoothly between the different systems. For that reason a mapping between the previous system used at Bombardier Transportation, called Envira, and the new RAVEL system called BEND, was developed. Since the data models are based on different methodologies no exact mapping could be found, but the distortions of the information this caused were handled and a mapping of sufficient quality could be established. The mapping was implemented using Visual Basic as a data transfer tool named “Envira to RAVEL tool”.

A mapping from the RAVEL system BEND back to Envira was also established since functionality that only was implemented in the Envira system needed to be used. The transfer process between the BEND and Envira databases was divided into two steps:

[16] Carlson R., Erixon M., Forsberg P., Pålsson A.-C.; "System for Integrated Business Environmental Information Management"; Advances in Environmental Research, 5/4 (2001) p. 369-375

1. Export of data from BEND to Excel-file using the tool "RAVEL to Envira tool " implemented in Visual Basic
2. Import of Excel-file to the Envira database using Envira's import functionality.

5.3.2 The Inventory Tool

The Bombardier Inventory Tool is an internet based tool which demonstrates how suppliers can provide environmental data about their products in an efficient way. The suppliers can log on and deliver data about their components directly into a RAVEL formatted database. It is also possible for the suppliers to analyze their data directly in the tool and get feed-back on the environmental performance of the components by calculating Environmental Performance Indicators.

In the tools that Bombardier up to now has used for Design for Environment, all information needed had to be given specially for this purpose. A change from Envira into a RAVEL-formatted database gives the possibility in the future to gather information from other systems without any effort. A possibility for suppliers themselves to compile information directly into the database is another benefit.

The application is composed of interconnected asp-pages, and it interacts with a RAVEL formatted Microsoft SQL Server database.

Since the tool will be used as a general CPM show-case, a version of the tool with a neutral CPM layout was developed. This version is called the CPM Inventory Tool[17] and it is available for CPM members.

5.3.3 The Inventory Administration Tool

The Inventory Administration Tool is an internet based tool that provides administration of the Inventory tool. The main functionality of the administration tool is to:

- Administrate the material list
- Administrate the environmental properties for each material which are used in the calculation of the indicators
- Review components submitted by the suppliers and either approve or reject the information.
- Analyze the environmental performance of the components in terms of the EPIs
- Import components from the database containing the suppliers data to the correct position in an internal environmental database
- Administrate user accounts for the Inventory Tool

Since the tool will be used as a general CPM show-case, a version of the tool with a neutral CPM layout was developed. This version is called the CPM DfE Administration Tool[18] and it is available for CPM members.

[17] http://project.imi.chalmers.se/DfE_InventoryTool/www/Login/Login.asp

[18] http://project.imi.chalmers.se/DfE_AdministrationTool/www/Login/Login.asp

6 Development of LCA@CPM

6.1 Background

The goal of this part of the project was to develop an LCA-tool that is inexpensive for the user. The tool shall support LCA practitioners at companies and organizations to work according to the ISO 14040 framework in a transparent way. It shall furthermore provide support for documentation so that a data quality according to the CPM data quality foundation can be achieved. It was decided to develop an information system for the entire LCA by integrating the existing modules and reusing other CPM results to develop the remaining parts. The work has been performed in coordination with the CPM project "Industrial applications of future information systems for impact assessment" and has given the IMI personnel experience of what integration of information systems means in practice.

In the context of CPM, tools and methods have been created, that individually constitute specific modules of an LCA tool e.g. SPINE[19], LCI@CPM[20], IA98[21], EPS[22] and WWLCAW[23]. One of the aims for the CPM work with data and informatics has been to integrate the different high quality environmental information systems to facilitate and reduce costs for environmental data. The information systems developed at IMI have therefore been constructed to be compatible. Other results from IMI have built on the CPM conceptual base and data quality management, and the results have been successfully used in other projects e.g. OMNIITOX and in the development of ISO/TS 14048[24].

6.2 Method

Integration of industrial environmental information systems practically implies format and software development, reformatting of information, and merging of nomenclatures.

6.2.1 Specification of requirements

The different functionalities required for the LCA tool was specified and the previous results were inventoried as to how they could fill the functions. The facilities that the LCA tool was going to supply were:

- Project management
    - Ability to create new projects

[19] Carlson R, Löfgren G, Steen B (1995): "SPINE – A Relational Database Structure for Life Cycle Assessment", Report B1227, Swedish Environmental Research Institute, Göteborg

[20] http://kakapo.imi.chalmers.se/nukes/index.html

[21] Carlson R., Steen B.; "A Data Model for LCA Impact Assessment"; Presented at 8th Annual Meeting of SETAC-Europe 1998 14-18 April; Bordeaux

[22] 1) Steen B (1999): A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – General system characteristics CPM report 1999:4, Chalmers University of Technology, Sweden
2) Steen B (1999b): A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – Models and data of the default method CPM report 1999:5, Chalmers University of Technology, Sweden

[23] http://workshop.imi.chalmers.se/

[24] ISO/TS 14048:2002, Environmental management – Life cycle assessment – Data documentation format

    - Control the access to own projects
- Goal and Scope
    - Documentation of goal and scope according to the ISO 14040 framework
- Inventory
    - Documentation of modeling of processes, inputs and outputs etc according to the ISO 14040 framework
    - Import of data sets from other databases
    - Search and purchase of data sets from the LCI@CPM database
    - Ability to edit data sets
    - Convert SPINE data sets to ISO/TS 14048 compatible data sets
- Impact assessment
    - Use of the impact assessment methods EPS 2000, EDIP, Eco-indicator '99 and LCA-E
    - Use of the characterization methods developed in OMNIITOX
    - Calculation of results from characterization and weighting separately
- Interpretation
    - Documentation of interpretation according to the ISO 14040 framework
- Reporting
    - Automatic generation of reports, based on documentation
- Critical Review
    - Documentation of performance of and results from critical reviews

6.2.2 Reuse of previous results

IMI has previously built up a system for handling LCI information based on the ISO/TS 14048 data documentation format, named LCI@CPM. The model for LCI@CPM was the precursor SPINE@CPM, a system that used the SPINE format. The inventory part of the tool, LCI@CPM contains the same functionalities such as creating, editing and exchanging LCI data sets but the format of the information is changed to ISO/TS 14048. Within this project the other phases of LCA, i.e. goal and scope, impact assessment and interpretation, have been supplemented to develop a system called LCA@CPM.

The development of LCI@CPM application did also involve development of a new integrated data model called "IMI 2003 integrated data model". This data model has been used and further developed in the development of LCA@CPM. The data model had previously not been used for storage of information related to goal and scope or interpretation. This was however solved by handling a LCA study as a process as defined in ISO/TS 14048. The data fields of the ISO/TS 14048 technical specification were inventoried to find how they could satisfy the requirements of the ISO 14040 framework. It was found that the fields of ISO/TS 14048, which is originally a format for documentation of LCI data, corresponded with the requirements proposed by ISO 14041, the standard describing the goal and scope phase of LCA. The structure of the documentation (headings) has been made according to ISO 14041 but the actual data fields all come from ISO/TS 14048. The interpretation part is not yet implemented but it is

planned that an inventory will be made of the ISO/TS 14048 format to find matching fields for documentation of the interpretation according to ISO 14043, similar to the matching made for the goal and scope documentation.

The impact assessment part of the data model is based on the impact assessment data model developed in 1998 by Raul Carlson and Bengt Steen and called IA98[25]. A documentation format for the impact assessment data compatible with ISO/TS 14048 was also already developed[26].

The major part of the functionality of the LCA@CPM application has been developed through integration of functionality developed in previous projects. The mapping functionality between the SPINE and the ISO/TS 14048 format was developed in the project KC5 "Database maintenance and development". This project also resulted in the system LCI@CPM from which functionality for data documentation of processes in accordance with ISO/TS 14048 and functionality for automatic generation of report has been reused in LCA@CPM.

Functionality for calculation and characterization, as well as project management functionality comes from the CPM-project A20 "Policy controlled environment management". Structure, methodology and data are partly taken from WWLCAW, where the impact assessment methods EPS 2000[27], EDIP[28], EcoIndicator '99[29] and LCA-E[30] were already implemented using the IA98 data model for impact assessment. LCA@CPM will also in the future be complemented with the characterization factors from OMNIITOX IS, when the results from this project are available. Functionality for transfer of characterization factors has been performed in the related CPM project A16 "Industrial applications of future information systems for impact assessment". Another result from this project that was used in LCA@CPM was the synthesis of the substance nomenclatures.

As have been mentioned earlier in the report, well maintained nomenclatures are important when sharing information with others, in other organizations or with other competence. Merging of nomenclatures is hence a crucial task in the work with integrating information systems, e.g. different substance nomenclatures are used for different purposes and in different contexts. Also the computability is highly dependent on well maintained nomenclatures. When integrating life cycle inventory data and impact assessment models a mapping and harmonization of the substance nomenclatures used is needed to be able to get any useful result

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[25] Carlson R., Steen B.; "A Data Model for LCA Impact Assessment"; Presented at 8th Annual Meeting of SETAC-Europe 1998 14-18 April; Bordeaux

[26] Carlson R., Pålsson A-C. "Documentation of environmental impact assessment, compatible with SPINE and ISO/TS 14048" IMI-report 2002:1

[27] 1) Steen B: A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – General system characteristics CPM report 1999:4, Chalmers University of Technology, Sweden
2) 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, Chalmers University of Technology, Sweden

[28] 1) Henrik Wenzel, Michael Hauschild and Leo Alting (1997): Environmental assessment of products Vol. 1, Methodology, tools and case studies in product development, London Chapman & Hall
2) Michael Hauschild and Henrik Wenzel (1998): Environmental assessment of products Vol. 2, Scientific background, London Chapman & Hall.

[29] Mark Goedkoop and Renilde Spriensma (2000) " The Eco-indicator 99: A damage oriented method for Life Cycle Impact Assessment" Methodology Report, Second edition

[30] LCA-E(EPS/EPD), LCA-E(EDIP/EPD), LCA-E(ECOI/EPD) are impact assessment methods developed by Maria Erixon at IMI, Chalmers within the project "LCA Electronics – Inventory" (LCA-E) during the year 2001. They are adaptations of the EPS, EDIP and Eco-indicator methods to the Swedish EPD system.

from a characterization. Carbon dioxide can for example also be named CO_2, Koldioxid or O=C=O, but this should not prevent linking between LCI data and impact assessment models.

6.2.3 Technical aspects

LCA@CPM is a web-based tool implemented using Java 2 Enterprise Edition (J2EE). Installation problems and problems related to future updates of the software are minimal, since no client installations are needed for a web-based tool. The J2EE technology does also provide many advantages such as:

- Scalability – the tool can handle both a small number as well as a big number of users
- Platform independence – The tool can be installed on almost any computer and any operating system
- Easy to replace underlying database software
- A lot of free open-source solutions available (JBoss/Tomcat)

The LCA@CPM tool is built on the existing portal PHP Nukes[31] which is an open source solution built on the JBoss[32] application server. The Nukes portal has a lot of built-in functionality, among others handling of users and groups, security system with encrypted passwords and layout functions, which decreased the costs for developing the LCA@CPM tool. The java technology does also involve a highly modularized way of programming, which is very useful when integrating systems. The same implemented functionality can be used in many different contexts and in many different applications, which diminishes the costs for both maintaining the systems as well as development of new functionality.

The technical improvements were to a large extent developed in the CPM project KC5 "Database maintenance and development" and are profited by of all CPM projects performed by Industrial Environmental Informatics.

6.3 Result

The LCA@CPM prototype is a user-friendly web based LCA-tool supporting LCA practitioners at companies and organization to work according to the ISO 14040 framework in a transparent way. It is a tool for managing all information needed when working with LCA based on the ISO 14040 framework and the ISO/TS 14048 data documentation format. The work is carried out in projects and this enables the project owner to admit or restrict access to the information stored in the project for other users.

The LCA@CPM prototype is accessible for CPM members on the web-portal found at http://kakapo.imi.chalmers.se/nukes/index.html.

The LCA work is divided in six parts in the tool:

- Goal and Scope
- Inventory
- Impact assessment
- Interpretation

[31] http://www.jboss.org/products/nukesjboss

[32] http://www.jboss.org/

- Reporting
- Critical Review

Below is a short description of the content, intended use and functionality of each part.

6.3.1 Goal and scope

The goal and scope part of the tool provides the possibility to document the goal and scope part in accordance with the ISO 14041 standard.

6.3.2 Inventory

The inventory part of the tool provides the possibility to document and edit life cycle inventory data in the ISO/TS 14048 data documentation format, review and buy data sets from the LCI@CPM database, import data sets from other databases and convert data sets from SPINE format to ISO/TS 14048 format through a mapping functionality. All life cycle inventory data sets found in the older SPINE@CPM database has been mapped to the new format and can be found in the LCI@CPM database.

6.3.3 Impact Assessment

The impact assessment part of LCA@CPM contains three fully documented impact assessment models; EPS 2000, EDIP and Eco-indicator where both characterization models and weighting models are included. In addition, the LCA-E impact assessment methods are also included.

Characterization models and characterization factors from OMNIITOX IS will be added when they are finished. The coverage of the environmental impact in LCA@CPM is thus better than before since there have not been any reliable toxicity or eco-toxicity models for impact assessment in LCA.

6.3.4 Interpretation

In the interpretation part, the identification of significant issues, the evaluation and the conclusions and recommendations can be accounted for in accordance with the ISO 14043 standard. This function is however not yet implemented.

6.3.5 Reporting

The reporting part provides the possibility to automatically generate and download a full report, where the user selects which parts of the LCA study to include in the report.

6.3.6 Critical review

In the critical review part of LCA@CPM a possibility to account for the critical reviews made on the study is provided.

7 Conclusions

There is a great interest in the results from both the OMNIITOX and the REPID projects in the CPM companies, and the potential to make practical use of them is high.

In their current environmental work, the interviewed companies have a lot in common. They all work with material lists and safety data sheets and they have ISO 14001 certificates.

The results from this work will be used in the main project "Databases in Networking".

7.1 OMNIITOX

The CPM companies produce and manage toxicological information for a number of purposes; reporting to authorities, internal communication, customer information, surveillance of local environmental impacts etc. The companies already use databases with substance and nature data, and the OMNIITOX database is thus useful per se as it is quality assured. In addition, the OMNIITOX database contains impact assessment models with which the effects of toxic substances on humans and the eco-system can be assessed.

The companies wish to access the information at low cost and effort. In the interviews it was emphasized that the best solution to meet the need to access toxicological information at low cost and effort was to integrate the OMNIITOX results with an existing LCA tool. The effort to assimilate new knowledge decreases if the user interface of the tool is already familiar. It was therefore decided to construct the prototype LCA tool LCA@CPM.

7.2 REPID

Communication of environmental performance throughout the supply chain, the basis for the RAVEL design for environment method which was implemented within the REPID project, is crucial in the interviewed companies and there was a large interest of the presented methodology. Environmental performance indicators are only partly used today but the interest to use EPIs in internal communication and also to some extent in external communication is high.

Due to different material handling systems in the companies specific implementations need to be performed to adapt and connect the internal systems with a DfE system and to facilitate working according to the RAVEL methodology.

In many companies the usage phase and production phase of their products have the largest environmental impact. In the REPID project the knowledge of the end of life phase e.g. recycling and waste, has been better than about the non-material related environmental impact of the use and production phase. Therefore improvement of EPIs in the use and production phase would be preferred. Therefore, EPIs in the areas of energy consumption, noise and use of oil in production should be developed and carefully defined based on the earlier knowledge of defining EPIs in the REPID and RAVEL projects. Many of the material related EPIs developed in the REPID project could however be reused according to the interviews.

The use of LCA has decreased compared to a few years ago in some of the interviewed companies. A combination of LCA, material data systems and the DfE methodology was considered interesting and a LCA-based material related EPI could be useful.

7.3 Development of a supply chain material inventory system

It was in this case study successfully demonstrated that it is possible to implement a supply chain material inventory system based on the RAVEL methodology. The usage of the RAVEL method enables cost-efficient and understandable measurements of the environmental performance in terms of Environmental Performance Indicators. The establishment of a common set of EPIs, a common material list, and a common communication format within the railway line of business, which has been performed in the REPID project in parallel to the activities in this case-study, is however a consensus process that requires a lot of time and resources. It is though important to remember that the results from the procedure are of vital importance not only in the area of environment. A common material list, or well-defined translations between different material lists, would also facilitate more cost-efficient management of the data in many other areas within a company.

A change of direction regarding the data systems policy at Bombardier required the functionality of the developed supply chain material inventory system to be integrated with other systems. This integration is currently performed at Bombardier. The applications are however useful for demonstration of the DfE-methodology, and they will be the starting point for the sub-project "Measurement and communication of environmental performance of products" in the project proposal "Implementation of Integrated Environmental Information Systems" which is planned to run in phase IV of CPM.

7.4 LCA@CPM

The LCA@CPM prototype is a user-friendly web based LCA-tool supporting LCA practitioners at companies and organization to work according to the ISO 14040 framework in a transparent way. It is a tool for managing all information needed when working with LCA based on the ISO 14040 series framework and the ISO/TS 14048 data documentation format. It was developed by integrating the different parts of an LCA tool already developed in CPM projects. The development has given the IMI personnel experience of how integration of information systems is carried out in practice.

7.5 Suggestions for future work

A presentation of the OMNIITOX and REPID results will be held at the DANTES meeting 7-8 September 2004 to disseminate the results from this study. The following is a list of suggested work to be done in this area based on the conclusions of the interviews performed and related work.

- Adaptation and implementation of REPID methodology in CPM companies i.e. implementing environmental performance indicators for internal or external communication. This work is suggested to be performed in a new CPM project.
- Defining new usage and production phase related environmental performance indicators in cooperation with companies to meet the requirements from the industry.
- Information transfer between LCA@CPM and REPID information system, to improve data accessibility. The databases have been prepared to enable such transfer.
- Integration of OMNIITOX IS and REACH. Match OMNIITOX and REACH by choosing the input data for the toxicology impact assessment model while considering the data input needed for REACH. The two applications could benefit from a shared database. This could work is suggested to be performed in a new CPM project.

- Further development of LCA@CPM
    - Improved user manual
    - Functionality for aggregation of systems, which will make it possible to include sub-processes in the inventory
    - Functionality for creating and editing impact assessment methods
    - Improved graphical presentation of results
    - Functionality to save and download documents related to the critical review