CHALMERS

Final report from the IMPRESS project:

Implementation of integrated environmental information systems

Raul Carlson
Maria Erixon
Markus Erlandsson
Karolina Flemström
Sandra Häggström
Johan Tivander
Ann-Christin Pålsson

IMI - Industrial Environmental Informatics for
CPM - Center for Environmental Assessment of Product and Material Systems
CHALMERS UNIVERSITY OF TECHNOLOGY
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CPM Report 2006:18

Summary

This report presents the most important results from the IMPRESS project, running between September 2004 and September 2006. IMPRESS was financed by CPM, the Center for Environmental Assessment of Product and Material Systems at Chalmers University of Technology and was performed by the Chalmers research group Industrial Environmental Informatics (IMI) and representatives from ABB, Akzo Nobel, Bombardier Transportation, IKEA, ITT Flygt, SCA and Stora Enso. IMPRESS is an acronym for Implementation of Integrated Environmental Information Systems.

In IMPRESS it has been shown how information, methods and tools that supports environmentally related decisions within the industry can be integrated with each other and with the corporate business processes and also how the integration can be implemented into the organisations. The work has been based on existing methods and tools, used in the CPM companies today.

In IMPRESS, a general integration method has been developed based on practical experiences of integration between existing methods and tools for environmental management. This method has also been tested technically in practice by integrating five of the tools used in the project; Life Cycle Assessment, Environmental Management Systems, Design for Environment, Emission Trading and Chemical Risk Management. In six industrial case studies, each specific method or tool has been developed, tested and improved, and support for implementation in daily work in the industry has been given. Each integrated method and tool perform its specific task efficiently, i.e. it is useful in separate and the project has tested whether benefits can be further achieved by integrating these separately efficient methods and tools. In addition to the case studies, in the academic work integration between the methods and tools has been performed by technically linking them together as independent but information-sharing modules. In this way each method and tool maintain its individual efficiency while at the same time contributing to raising the efficiency of the system of integrated tools. Hence, the integration of methods tools has in IMPRESS been achieved by inter-connecting separate tools, and not my merging methods and tools into new tools.

Integration of the environmental methods and tools developed at IMI and within CPM has been prepared for several years in many different development projects. Concept models, conceptual models, database structures, nomenclatures, manuals, etc. have been designed for integration with each other and with industrial business systems. The IMPRESS project was intended to practically show how integration could be achieved and implemented in practice.

The results from IMPRESS are intended both to be used for technical and organisational integration of computer or paper based information systems to increase the efficiency of environmental management work in industrial companies, and also to be used for educational purposes to explain how different environmental management methods and tools are inter-connected and related to each other. The project has also included a sub-project where exploitation and dissemination of results were discussed and tested. The intention of this subproject was to ensure that the results of the project should be made commercially useful to industry and society.

Project participants

The following persons have actively participated in the work in the IMPRESS project:

From **ABB AB**:
- Lennart Swanström

From **Akzo Nobel AB**:
- Sara Tholin, Sustainable Development
- Johan Widheden, Sustainable Development
- Peter Herder, Casco Products AB
- Kjell Strindholm, Casco Products AB
- George Mirkov, Industrial Coatings AB
- Glenn Svensson, Industrial Coatings AB

From **Bombardier Transportation Sweden**:
- Ylva Bergkvist, Bombardier
- Sara Paulsson, Bombardier
- Ronny Öhman, Bombardier

From **IKEA Group**:
- Carina Andersson, IKEA of Sweden AB
- Gunilla Clancy, IKEA of Sweden AB
- Evamay Lawson, IKEA of Sweden AB
- Ylva Roos, IKEA of Sweden AB
- Annelise Larsen, IKEA of Sweden AB
- Viktoria Olsson, Swedwood International AB

From **ITT Flygt AB**:
- Christian Wiklund, ITT Flygt AB

From **SCA Hygiene Products**:
- Ellen Riise, Personal Care
- Björn Spak, Personal Care
- Helene Jacobsson, Tissue Europe

From **Stora Enso AB**:
- Ola Svending, Stora Enso
- Ulrika Ågren, Stora Enso

From **Industrial Environmental Informatics (IMI), Computing Science, Chalmers University of Technology**:
- Raul Carlson, IMI
- Maria Erixon, IMI

- Markus Erlandsson, IMI
- Karolina Flemström, IMI
- Sandra Häggström, IMI
- Johan Tivander, IMI
- Ann-Christin Pålsson, IMI

In addition, persons with expert knowledge regarding e.g. materials, product development, information systems, etc. have contributed to the results.

Contents

1 Introduction

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The IMPRESS project aimed at showing how information, methods and tools that supports environmentally related decisions within the industry can be integrated with each other and with the corporate business processes and also how the integration can be implemented into the organisations. The work has been based on existing methods and tools used in the CPM companies today.

Environmental information systems and integration have been components in the CPM work since it started in 1996 and also within the research group IMI, established in 2001. Generic reference models and principles have been developed that describe the domain of environmental information and common denominators in all industrial environmental information processing. As new methods and tools have been developed within CPM and IMI they have had generic reference models as a basis. This has provided a thorough understanding of how tools relate to each other. The practical experiences provided from industry collaboration have sharpened the reference models and methods into a useful toolbox addressing the issue of implementing integrated environmental information systems.

In six industrial case studies, each specific method or tool has been developed, tested and improved, and support for implementation in daily work in the industry has been given. Each integrated method and tool perform its specific task efficiently, i.e. it is useful in separate and the project has tested whether benefits can be further achieved by integrating these separately efficient methods and tools. In addition to the case studies, in the academic work integration between the methods and tools has been performed by technically linking them together as independent but information-sharing modules. In this way each method and tool maintain its individual efficiency while at the same time contributing to raising the efficiency of the system of integrated tools. Hence, the integration of methods tools has in IMPRESS been achieved by inter-connecting separate tools, and not my merging methods and tools into new tools.

The results from IMPRESS are intended both to be used for technical and organisational integration of computer or paper based information systems to increase the efficiency of environmental management work in industrial companies, and also to be used for educational purposes to explain how different environmental management methods and tools are inter-connected and related to each other. The project has also included a sub-project where exploitation and dissemination of results were discussed and tested. The intention of this subproject was to ensure that the results of the project should be made commercially useful to industry and society.

In addition to the results presented in this report, many other results have also been produced in each of the eleven sub-projects in IMPRESS, which have been described and presented in reports, papers, prototype software tools and manuals. The description of each sub-project should thus be seen as an introduction to the detailed results that can be found in each of the separate sub-project reports.

2 Overall goals and objectives

The project “Implementation of Integrated Environmental Information Systems” with acronym IMPRESS, aimed at showing how information, methods and tools that supports environmentally related decisions within the industry, can be integrated with each other and with the corporate business processes and also implemented into the organisations.

Companies use several different methods and tools to manage their work with environmental issues. Examples of such tools are Life Cycle Assessment (LCA), Design for Environment (DfE), Environmental Management System (EMS), Management of Chemicals in products and production, etc. These tools are in general maintained and used separately. It is intended that by integrating the tools at the level of their information needs it is possible to make the information management for the tools more efficient, both with regards to data acquisition and with regards to quality maintenance. Figure 1 provides a schematic view of which tools to integrate,

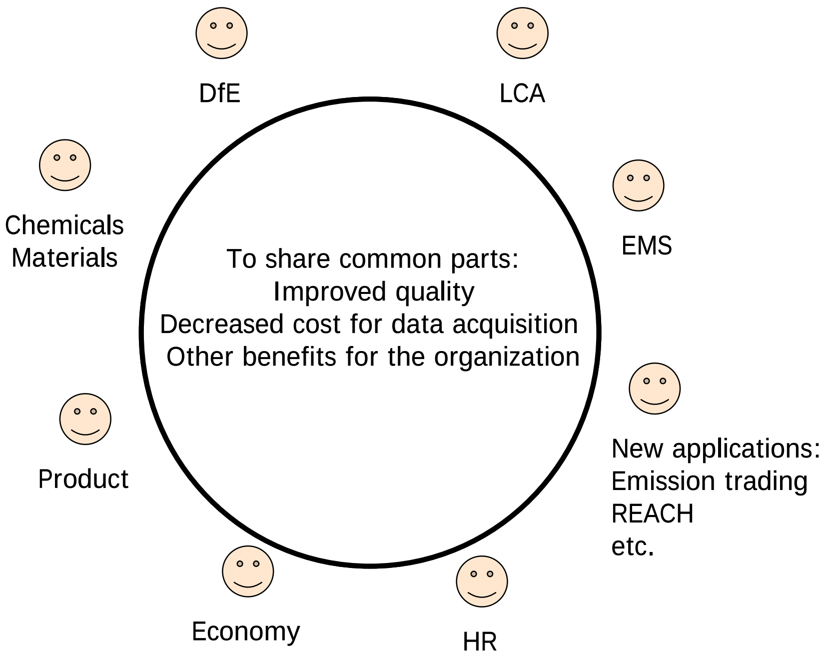

Figure 1. In the integrated system, the common parts of different information management tools are shared in order to decrease costs, improve quality and increase availability of data.

The objectives of the IMPRESS project were to:

- Decrease the cost for industrial environmental management.
- Decrease the cost for developing, using and maintaining data, tools and methods for industrial environmental management.
- Facilitate acquisition of environmental information.
- Provide educational tools for industrial environmental management.

The project also aimed at investigating possibilities for exploitation and dissemination of previous and new CPM results. The exploitation and dissemination is important to guarantee that the CPM-results will survive and be available also after the CPM-projects ends in 2006. It will enhance the value and increase the usability of the results.

Six industrial application and implementation cases were included in the project:

- Emission trading
- Measurement and communication of environmental performance of products
- Environmental management at site and group level
- Risk management adapted to REACH
- Three tools for IPP
- Integration of experiences and new information

These six cases were studied in detail in close cooperation between IMI and CPM companies in different sub-projects, including e.g. market analyses, specific method development, implementation etc. A general integration methodology was regarded in a separate sub-project. Similarly, prototype construction, commercialization work, and knowledge exchange was performed in three different sub-projects.

2.1 Integrating without adding complexity for the user

Integration may become quite complex as many different users with different background knowledge will share a common system. When integrating it must be kept in mind that a resulting integrated system should not add complexity to the user but rather help the user to understand its role in relation to other environmental work done within an organisation.

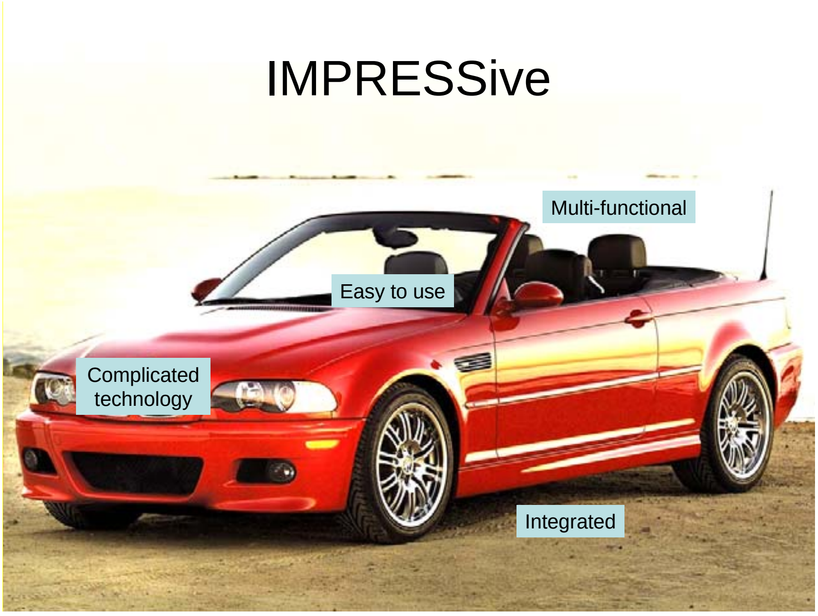

Figure 2 Complex technology – easy to use when integrated for a clear purpose.

Compare with for instance a car (figure 2) which consists of several individually functional systems for steering, propulsion, breaking, lights, fuel distribution, safety, temperature, sound system, etc. It takes a lot of specific competence to build and maintain the car but it is relatively easy to control. In addition all systems are integrated and work together with a common purpose: to move the user from A to B. The user needs however not to neither see or know the technology that lies behind.

3 Background and former work

3.1 Previous research results

Much of the background results used in IMPRESS was developed during CPM phase II, in the project II:F:12 Integrated environmental information systems, in which different work was made on this subject, including two master theses[1&2], the European DfE project RAVEL[3] and REPID[4], the Swedish paper and pulp industry project referred to as the CPM/SSVL-project[5], and various fundamental academic research[6& 7] that is the basis for

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[1] Nilsson I, *"Integrating Environmental Management to Improve Strategic Decision-Making"*, CPM Report 2001:2

[2] Taprantzi A, *"A Systematic Approach for Acquiring Industrial Data and Information for Environmental Applications"*, Report: 01-2005 RCF, Stora Enso Environment, 2001

[3] Ander Å, Dewulf W, Duflou J, *Integrating Eco-Efficiency in Rail Vehicle Design"*, Final RAVEL project report, Brite Euram project, Leuwen University Press, 2001

[4] Bergendorff, M. (Editor) et al, Final report for the EU funded REPID project, 2004

[5] Pålsson A-C, Svending O, Möller Å, Nilsson C, Olsson L, Loviken G, Enqvist A, Karlsson G, Nilseng A, *"An industry common methodology for environmental data management"*, SPCI 2002, 7th International Conference on New Available Technologies, June 4-6, 2002, Stockholm.

the Chalmers-department Industrial Environmental Informatics (IMI). Much of the acquired knowledge about industrial environmental informatics can also be found in the report *"Establishing common primary data for environmental overview of product life cycles; Users, perspectives, methods, data, and information systems"* [8] written for the Swedish EPA.

Practically useful prototype software systems has also been implemented, and are intended for further testing, development and implementation in this project, such as the web-based LCA-software LCA@CPM, that is an integrated tool developed from many different project-deliverables of CPM phase three, e.g. SPINE@CPM systems , DfE Tools (RAVEL/REPID systems), EMS tools (WWLCAW and more) and Tools for basic data (e.g. OMNIITOX end similar systems).

A thorough description of background results and previous experience from CPM and IMI regarding integration is available in the IMPRESS report on the general integration method[9].

3.2 Generic reference models and principles

The high level information model of SPINE defines the scope and provides a structure for environmental information, see figure 3. It is used as a concept reference when analyzing information, to understand what type of data it is and how it relates to other data in a system.

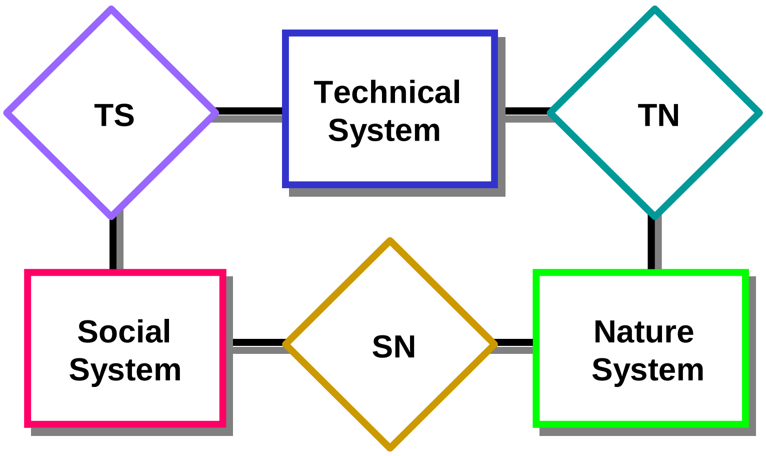

Figure 3 Three types of information are related and compose the scope of environmental information according to this information model. © Copyright Carlson R. IMI, Chalmers University of Technology, 1995

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[6] 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
[7] Carlson R, Pålsson A-C, *"Industrial environmental information management for technical systems"*, Journal of Cleaner Production, 9 (2001) 429-435
[8] Carlson, R. et al.; *"Establishing common primary data for environmental overview of product life cycles"*, Swedish EPA Report 5523, 2005
[9]Erixon M, Tivander J, Pålsson A-C, Carlson R, *"General method for integration of industrial environmental information systems"*, Deliverable from the IMPRESS project, CPM Report 2006:14

Several data formats have been developed within CPM and IMI based on the SPINE information model including formats for life cycle inventory[10 11], life cycle impact assessment[12], environmental assessment of component structures[13], and environmental impact modelling[14].

The navigation model shown in figure 4 is fundamental for industrial environmental information systems and hence also for the integration approach in this project. It describes the strategic role of environmental information systems, which is to provide decision support for efficient and effective control of the sustainability performance of a system, in line with continuous improvement and sustainable development. In practice, this perspective supports e.g. the analysis of the overall purpose of an information system.

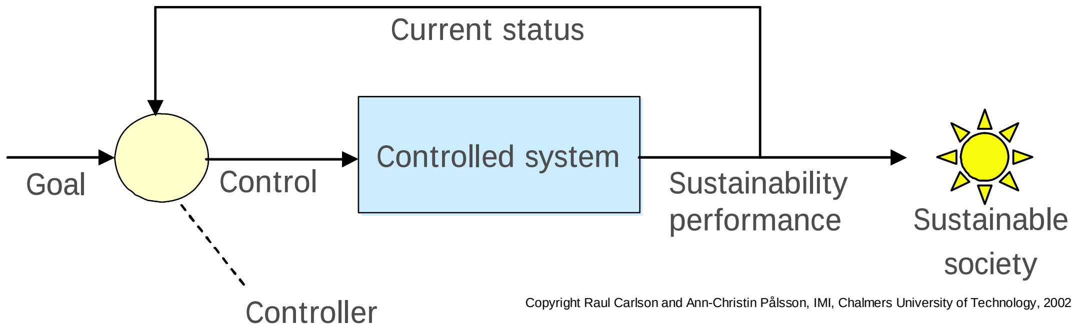

Figure 4 The navigation model describes how decision makers/controllers works to steer a system towards the sustainable society via environmental information.

A central concept in the work with environmental performance of industrial systems is the use of environmental indicators to get a measure the current status and to set goals. Indicators are quantifiable representations of environmental concern, e.g. the degree of recyclability of an electrical motor (weight %), the amount of emission of carbon dioxide from a manufacturing plant (ton CO2), increase of number of cancer cases among a human population (number of persons) etc. The indicators provide key pieces of information to enable communication and understanding between users in an information system such as information suppliers and decision makers. Indicators of various types are included in all methods for assessing and communicating environmental performance. For example within LCA category indicators are used[15]. In the Design for Environment (DfE) method developed in the RAVEL project Environmental Performance Indicators

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[10] Carlson R, Löfgren G, Steen B, "*SPINE, A Relation Database Structure for Life Cycle Assessment*", Göteborg, IVL-REPORT, September 1995
[11] ISO/TS 14048
[12] Carlson R, Steen B, "*A Data Model for LCA Impact Assessment*", Presented at 8th Annual Meeting of SETAC-Europe 1998 14-18 April, Bordeaux
[13] Carlson R, Forsberg P, "*The RAVEL_Information Platform Data Model*", RAVEL project doc nr CPM-000919 (report), 2000
[14] Tivander J, Carlson R, Erlandsson M, Erixon M, Geiron K, "*Concept Model for the OMNIITOX Information System Including OMNIITOX Data Format Definition*", OMNIITOX project report D20 and D26, 2004, EC contract G1RD-CT–2001–00501
[15] ISO 14042, "*Environmental Management – Life Cycle Assessment – Life Cycle Impact Assessment*", 2000

(EPI) are used[16]. A method to define EPIs was also developed in the RAVEL project which can be adopted to other applications than DfE.

PHASES (PHASEs in the design of a model of a System) is a procedural description that structures information about a model of a system, i.e. how primary data is defined and acquired, aggregated into system models and communicated [17]. PHASES is a general structure of the common steps involved when designing any model of a system. There are three specific implementations of PHASETS, PHASENS, and PHASESS, which describes how models of Technical systems, Nature systems and Social systems may be designed respectively (cf. SPINE above). In the method development, this reference model is fundamental to describe the tasks in an information system, and how tasks and information are connected.

Following the direction information takes for reporting, PHASETS (i.e. the implementation of PHASES for models of technical systems) may be described sequentially as figure 5, from bottom up[18]:

0. *Defining an entity for a selected parameter*; The choice of entity to measure and the setting up of the measurement system defines the simplest concept; i.e. the meaning of a measured value.
1. *Sampling an individual value*; The sampling results in a value for the simplest concept, i.e. a measured value.
2. *Forming a frequency function from a set of sample values*; The frequency function aggregates sets of measured values into statistically expressed concepts.
3. *Synthesizing a model of a technical system*; The systems synthesis further aggregates the frequency functions from phase 2 into structured models of technical systems.
4. *Aggregating models of technical systems*; The models of technical systems synthesized in phase 3 may be aggregated into complex concepts describing e.g. averages or cradle to gate systems.
5. *Communicating information between different contexts*; between any two phases 0-4 the resulting data and information, is communicated from the generator to the consecutive phase.

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[16] Ander Å, Dewulf W, Duflou J, *Integrating Eco-Efficiency in Rail Vehicle Design"*, Final RAVEL project report, Brite Euram project, Leuwen University Press, 2001
[17] Carlson R, Pålsson A-C, *"PHASES Information models for industrial environmental control"*, CPM-report 2000:4
[18] Carlson R, Pålsson A-C, *"Industrial environmental information management for technical systems"*, Journal of Cleaner Production, 9 (2001) 429-435

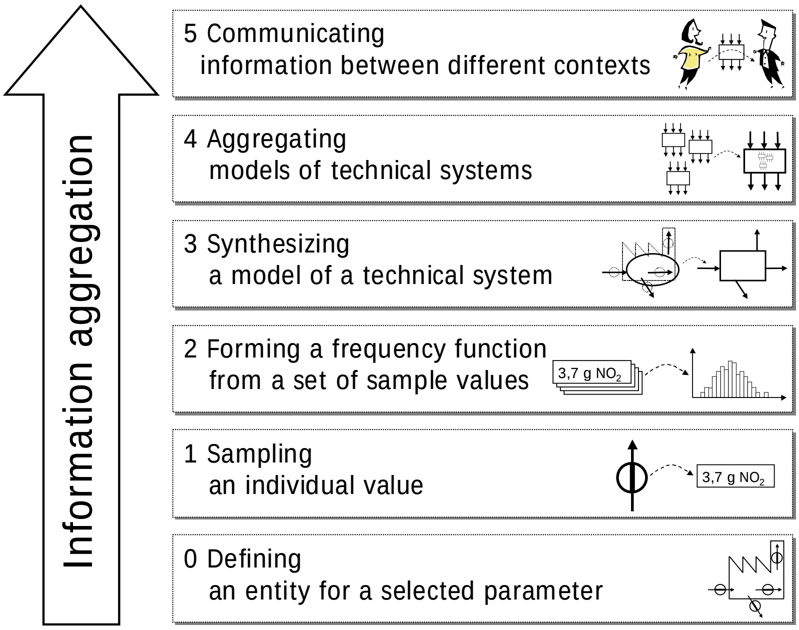

Figure 5 The information aggregation phases in the PHASETS model.

3.3 Benefits with integration

This section describe the benefits of integration of industrial environmental information systems, as experienced in earlier IMI- and CPM-projects. In the integrated system, the common parts of different information systems, which can be both information management tools and databases, are shared in order to decrease costs, improve quality and increase availability of data.

3.3.1 Decreased costs

One advantage with integration is that the same pieces of data or information can be reused in different applications or work tasks in a company. Data collection is generally very expensive and the economic gain from avoiding duplication of the work is obvious.

Access to credible, life cycle-based knowledge and information provides a reliable basis for necessary prioritisation and action and also helps to make sure that measures are taken where they will provide the most benefit[19].

To exemplify what the cost savings can be, in the report "Practical Strategies for Acquiring Life Cycle Inventory Data in the Electronics Industry"[20], LCA experts are interviewed about the time involved in an LCA study. A summary of their views is that it takes between 5 minutes and two years to perform an LCA and it costs between €10,000 and €200,000. Reuse of existing LCA data sets is thus a way to save costs when performing life cycle studies. Further costs for transparent documentation can be saved if the transfer of LCA

[19] Carlson R, et al., *"Establishing common primary data for environmental overview of product life cycles"*, Swedish EPA Report 5523, 2005
[20] Erixon M, *"Practical Strategies for Acquiring Life Cycle Inventory Data in the Electronics Industry"*, CPM Report 1999:3

data sets between different databases can be made efficiently. The cost for importing an LCA data set from a database with another data documentation format has been estimated by a CPM company to decrease from €320 to €140 with an efficient data transfer tool based on ISO/TS 14048[21].

Economical savings may also be made by harmonising environmental indicators, so that the same data sources, tools and expertise can be used for different applications by different users. It is particularly important that primary data can be used for many purposes, since they are expensive to obtain from laboratory tests, advanced modelling or scientific experts.

Available data sources, methods and tools and expertise may be regarded as individual modules of the information system, to be maintained and developed individually. Gaps may be filled by either developing new modules or using existing ones in more flexible ways. Participation and contribution may be voluntary, and if indicators are harmonised and data formats are standardised, each data source, method or tool may easily suit the needs of different users. If harmonisation and standards are introduced, this may motivate participants to benefit from increased flexibility and improved service by delivering data and information to decision makers. [22]

3.3.2 Improved quality

There are also other advantages in terms of easier and faster communication, automatically updated information, better overview of ongoing activities and available information etc.

Integration of existing information system is a practical alternative to replacing the systems with one central system. A central system tend easily to be colossal and is seldom the most effective tool for each specific task as the components need to adjust to the central prerequisites. The specificity of each tool can be kept thus reassuring that each tool used in an application is still the most effective for that specific application.

Integration of existing systems means creation of joints or bridges between the systems so that they can continue to be used as usual, only now they are connected. The end users of the included information management tools do not need to learn to use a new tool. Many of the users of the information management tools that have been integrated will not notice any difference from before the integration. They will continue to work with their specific tasks – environmental management, emission trading, chemical risk management etc. as before, only with the difference that certain data will be a little more accessible. Integration from this perspective will be made in the demonstration tool VIEWS (see section 9).

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[21] Häggström S, *"Basing environmental arguments on ISO/TS 14048 documented facts"*, viewed at http://www.dantes.info/Strategies/EnviroSupp/14048/strategies_14048_background.html, 2006

[22] Carlson R, et al., *"Establishing common primary data for environmental overview of product life cycles"*, Swedish EPA Report 5523, 2005

3.3.3 Increased availability of data

Integrated systems have also advantages in terms of easier and faster access to data. The amount of commonly available data will increase more if the data is stored as primary data, i.e. at a low aggregation level. At a low aggregation level many of the pieces of data needed are identical for different environmental tools, e.g. process flows, product weights etc.

Many of the necessary components of an information system are already available, such as many primary data sources, environmental expertise, useful methods and tools, and documented user requirements. Even though data may be generally available, the lack of actual data is discovered when requested in practice, when searching for data for specific environmental indicators such as "recyclability", "toxicity", "global warming potential" or "acidification potential". Hence, a major weakness of current environmental information systems is that they are full of gaps that are costly to fill. But overall costs can be kept to a minimum if available resources, such as data sources are used to the full, and if resources are used to fill gaps instead of building redundant components, such as new databases or new methods and tools.

4 Project structure and working method

4.1 Project structure

The project structure describes the activities and processes in the project to some extent and this section aims at give the reader a view of the project as a whole. IMPRESS was divided into eleven sub-projects. Each sub-project had one sub-project manager who has been responsible to coordinate the activities and together with the other participants perform the activities or work as well as to report problems and progress to the project manager.

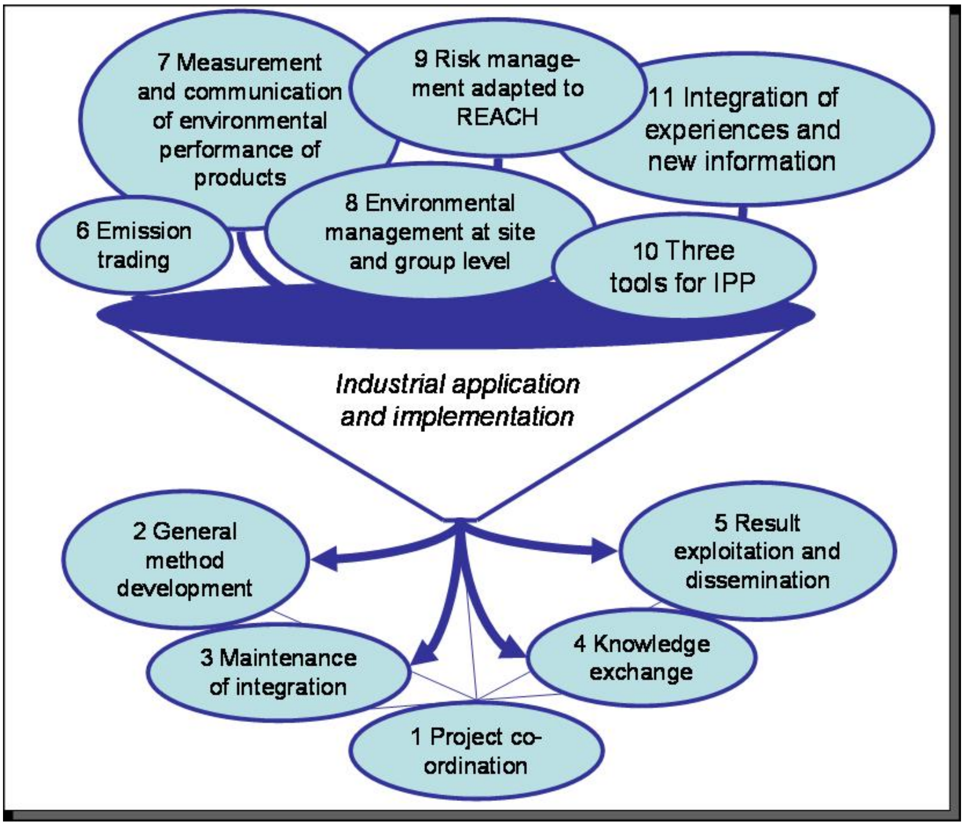

Figure 6 The structure of the IMPRESS project gives an overview of the included areas

Figure 6 illustrates the structure of the project with six case studies (sub-projects 6 to 11) with company participation at the top. At the bottom of the figure are the research sub-project (2 and 3) which is based on the results and experiences from the case studies; sub-project 4 include knowledge exchange between all project participants; sub-project 5 concerned work with exploitation and dissemination of results.

Sub-project 1: Project co-ordination
Overall co-ordination and administration of the project.
IMPRESS project manager: Karolina Flemström, IMI / Johan Tivander, IMI / Sandra Häggström, IMI

Research and development:

Sub-project 2: General method development
The general integration theory development dealt with how the integrated environmental information systems are composed on a high level, i.e. with each other and the business processes. It involved demands from the industrial applications, as well as knowledge and experience from the current research projects and earlier work within CPM. Thus, conclusions were based on scientific results, existing methods and tools, and the work with the industrial application and implementation sub-projects.
Sub-project manager: Maria Erixon, IMI/ Ann-Christin Pålsson, IMI

Sub-project 3: Maintenance of integration
Development of prototypes compatible with the general methodology, to demonstrate how known methods and tools can be integrated and implemented. The current family of tools developed within CPM, and the knowledge at IMI from several projects where additional functionality has been developed, provided the basis for an integrated instrument.
Sub-project manager: Johan Tivander, IMI

Education and knowledge exchange in the whole project:

Sub-project 4: Knowledge exchange
A series of seminars was performed, for education of CPM methodology, exchange of experiences, harmonisation of concepts and tools between the sub-projects etc.
Sub-project manager: Karolina Flemström, IMI

Reassurance of exploitable project result:

Sub-project 5: Result exploitation and dissemination
Identify business ideas and plan to commercialize IMPRESS related CPM results, in a combined effort between developers, industrial end-users and other stake-holders.
Sub-project manager: Maria Erixon, IMI/ Ann-Christin Pålsson, IMI

Industrial sub-projects - applications and implementation:

Sub-project 6: Emission trading
Finding a method and tool to fulfil the system requirements and reporting of CO2 emissions according to the new European Emission Trading Scheme (ETS).
Sub-project manager: Ulrika Ågren, Stora Enso

Sub-project 7: Measurement and communication of environmental performance of products
Implement methods and tools for measurement and communication of environmental performance of products e.g. in terms of Environmental Performance Indicators (EPIs).
Sub-project manager: Christian Wiklund, ITT Flygt

Sub-project 8: Environmental management at site and group level
Implement methods and tools for the environmental work that is performed on the organization level. The focus was on quality improvements of environmental information from production sites and integration of LCA-thinking in environmental management systems.
Sub-project manager: Ellen Riise, SCA

Sub-project 9: Risk management adapted to REACH
Methodology was developed for risk management, adapted to *REACH*. Further specifications of requirements within REACH was monitored and a strategy to incorporate these requirements was developed and applied.

Sub-project manager: Johan Tivander, IMI / Sandra Häggström, IMI

Sub-project 10: Three tools for IPP
The objective of this sub-project was to demonstrate how CPM results can support Integrated Product Policy (IPP).
Sub-project manager: Markus Erlandsson, IMI / Johan Tivander, IMI

Sub-project 11: Integration of experiences and new information
Strategies and methods to make use of experiences and to keep the tools updated by continuous inflow of new relevant information.
Sub-project manager: Sandra Häggström, IMI

4.2 Working method

4.2.1 Integration as a result of the working method

The IMPRESS project was mainly divided in two parts; case studies where both company representatives and IMI personnel participated and academic research which was performed by IMI. As was described in 2.3, sub-projects 6-11 were industrial sub-projects or case studies where applications and implementation of one certain method were in focus. The results and experiences from the case studies were collected and used as input for sub-projects 2 and 3 where the integration method was developed and the technical integration was performed. Sub-project 5 tested the business value of the different results in order to reassure that the project goal of implementation was strived for. Sub-project 4 provided knowledge exchange via seminars so that company representatives only participating in a case study could still gain access to the comprehensive view of the work in IMPRESS.

The working method was found to be very effective for the integration work in the project. As the IMI researchers personally participated in several of the case studies, they experienced which questions and issues that were in fact the same in the different methods and tools. IMI also had internal seminars with focus on integration possibilities between methods, tools, databases etc.

4.2.2 Work procedure

The sub-projects in IMPRESS have all followed the same work procedure consisting of five steps:

1. *State of the art*
   Analysis of previous results and current knowledge in the area
2. *Scoping and market analysis*
   Analysis of the intended use and expected usefulness of the respective methods and tools
3. *Development*
   Academic research, development, tests in participating companies and discussions leading to synthesis of result
4. *Implementation*
   Tests and support for implementation in the participating companies

5. *Commercialisation.*
   Preparing for commercialisation

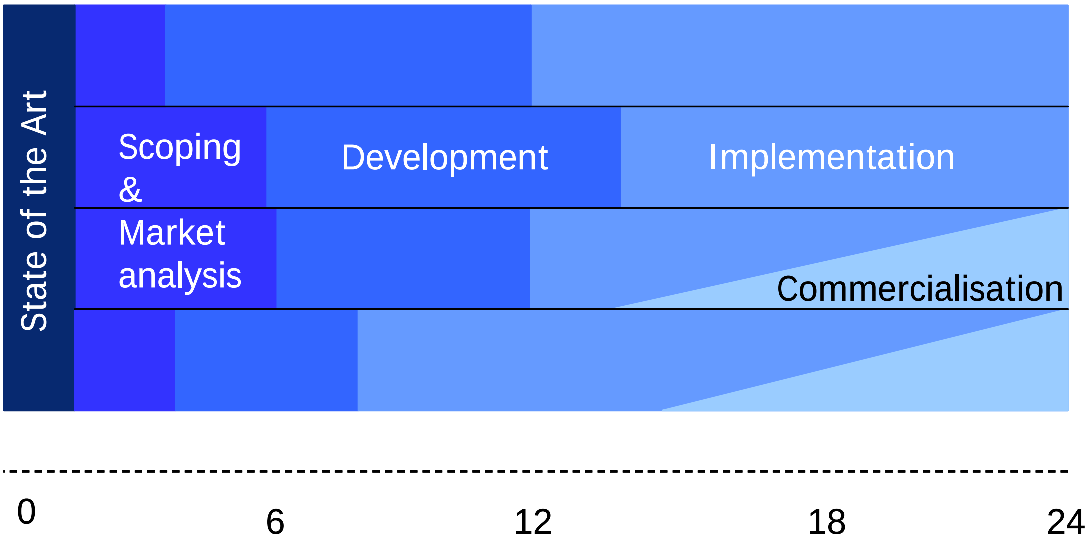

Figure 7. The work flow has been different in different sub-projects depending on research area and sub-project participants.

The pace of fulfilling the different steps in the work procedure has been different in the sub-projects due to the difference in maturity of the different areas and also depending on the sub-project participants, as illustrated by figure 7.

5 Description and conclusions of the work in the industrial sub-projects

5.1 Sub-project 6 – Emission trading

5.1.1 Goal and scope of the work in sub-project 6

The objective of this sub-project in IMPRESS was to find a method and tool to fulfil the requirements on documentation and reporting of CO_2 emissions according to the new European Emission Trading Scheme (ETS)[23]. To assure a sufficient quality of information, streamline the work with emission trading i.e. reporting routines, verification and quantitative results was in main focus in the sub-project. It included methodology development where the legal requirements on the information system in terms of reporting requirements, data quality, data collection and calculation requirements are regarded. Further the objective was to understand and specify how the data can be used in other related applications such as an EMS. Included in the plan of this sub-project were a prototype software development and an implementation and testing part where the method developed should be used in practice at the participating companies. The companies involved in this work were Stora Enso, SCA, and Akzo Nobel.

5.1.2 Description of the work in sub-project 6

The first work activity performed in this sub-project involved an analysis of the legal requirements in the ETS, identification of stakeholders and their requirements at the participating companies, and identification of relevant results from earlier work within CPM and IMI.

As the scope of the information regarding CO_2 emissions concerns technical systems with inputs and outputs it was early decided to map the data reporting requirements in ETS with the available documentation format ISO/TS 14048[24] and the CPM data quality foundation[25]. Interviews were then carried out with production unit representatives within Akzo Nobel and Stora Enso. The purpose was to find out how they were handling emission trading data management in practice at that time.

Typical deviations and conclusions from pre-verifications performed at the companies are in the area of transparency and traceability of data and parameters used. The recommendation from the verifiers that the system for supervision of CO_2 emissions should be integrated in the management system is an indication of the importance of integration with available systems and work processes at the companies.

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[23] Main directive: *”Directive 2003/87/EC of the European Parliament and of the council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC”, EU 2003*

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

[25] Arvidsson P. (Editor) et al, “Krav på datakvalitet CPM:s databas 1997”, CPM-rapport 1997:1

Based on the results from the interviews, the legal requirements, and of the data format mapping, a method for handling emission trading data management was developed. A prototype software tool named "IMPRESS Emission Trading Data Tool" was developed to facilitate the method including documentation and reporting according to the required reporting format of the Swedish EPA[26]. Figure 8 outlines the functionality scope of the tool.

The reporting of emission data based on calculations from input data is divided into data for combustion and for process related emissions. The level of detail of the documentation method presented here is the highest possible that is generally applicable to all installations. Lower detail levels, such as the precise method for acquisition of data at sampling level and statistical aggregation, will vary between installations. For transparent aggregation of the documentation of actual measurements into yearly reporting, references to the underlying data must be made, in accordance with the PHASETS model[27].

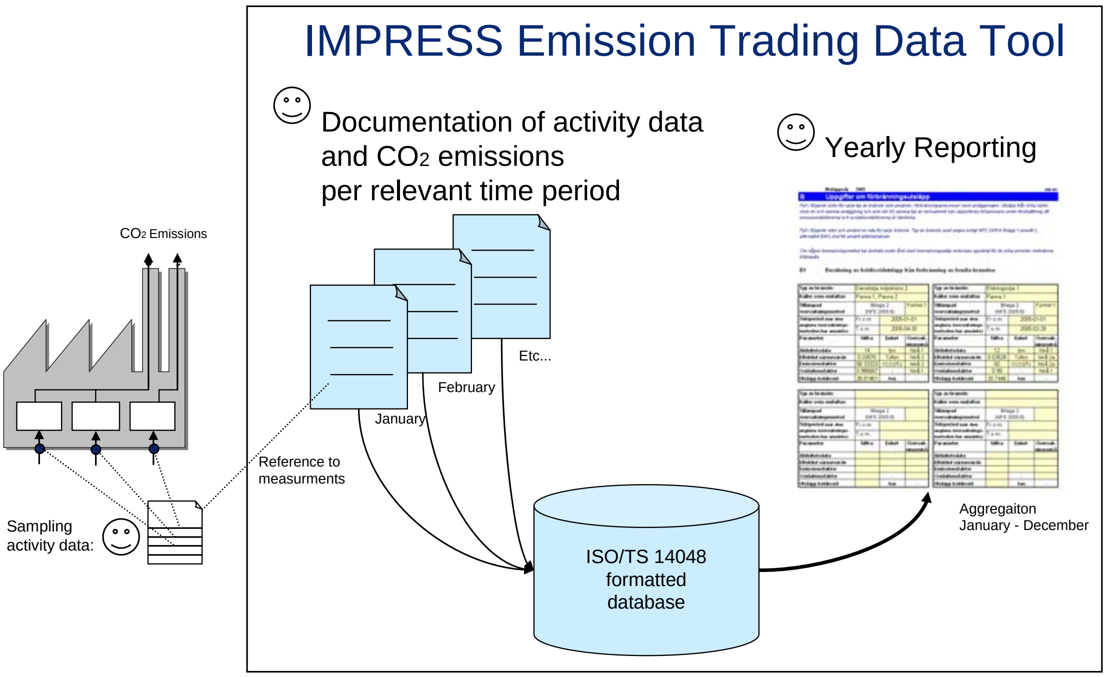

Figure 8 Outline of functionality scope of the IMPRESS Emission Trading Data Tool

It was planned to implement and test the method at the participating companies, involving acquiring relevant data, performing actual calculations and communication of the results. However, due to resource limitations at the companies this step was not

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[26] Naturvårdsverket (Swedish EPA), *"Formulär för utsläppsrapport"* samt *"Vägledning till formulär för utsläppsrapport"*, (Template and manual for an emission trading report), available at http://www.naturvardsverket.se/index.php3?main=/dokument/hallbar/klimat/utslappshandel/utslappshand/rapportering.htm, 2006-06-09

[27] Carlson R, Pålsson A-C, *"PHASES Information models for industrial environmental control"*, CPM-report 2000:4

fulfilled. Testing of the method and report was therefore performed only within the project group.

The IMPRESS Emission Trading Data Tool has been integrated in the VIEWS platform (see section 9) as a practical demonstration on how CO_2 emissions and input activity data can be exported to a tool supporting work with EMS.

5.1.3 Conclusions and learning from the work in sub-project 6

A mapping between the terminology in the EU Emission Trading Scheme (ETS) and ISO/TS 14048 data documentation format has been performed in this sub-project. This mapping is a prerequisite that enables emission trading data from sites to be consistently reused in an integrated environmental information system, as data can be stored and communicated in an international and consensus based data format. The data quality requirements in the EU ETS are facilitated by the generic CPM data quality foundation and the structure and concepts in the ISO/TS 14048 data documentation format. Using the ISO/TS 14048 format for emission trading data, enables a transparent and consistent documentation, which facilitate both the internal and external verification processes. The ISO/TS 14048 data documentation format also enables the communication of CO_2 emission trading data to related applications including EMS and LCA.

The documentation method and format has been implemented in an Excel based prototype tool, named IMPRESS Emission Trading Data Tool. The tool provides functionality for documentation and reporting, supporting the EU ETS requirements. The first testing of the tool developed indicates that the mapping is operational and that the quantitative aggregation of data on CO_2 emissions is transparent and reproducible. Some additional functionality may be needed to adapt it to a specific company or installation.

5.2 Sub-project 7 – Measurement and Communication of Environmental Performance of Products

This section summarizes the work performed in the sub-project "Measurement and Communication of Environmental Performance of Products". A thorough description of the work is available in the sub-project report[28].

5.2.1 Goal and scope of the work in sub-project 7

The main objective of this sub-project has been to develop and implement methods for measurement and communication of environmental performance of products at the participating companies. The measurements are quantified in terms of performance indicators, e.g. Environmental Performance Indicators (EPIs), Sustainability Performance Indicators (SPIs) or Key Performance Indicators (KPIs), according to the RAVEL design for environment (DfE) methodology[29]. The method includes the selection and definition of relevant indicators for the companies, establishing availability of necessary material data, acquisition and documentation of component and material content data of products, and calculation and communication of EPI results to stakeholders. The methods and tools will enable the incorporation of sustainability as one of the relevant decision-factors, comparable to factors as quality and price, in decision-making processes.

The companies that participated in the sub-project are producing very different products. Bombardier Transportation is manufacturing trains, ITT Flygt is manufacturing different types of pumps, and IKEA of Sweden is manufacturing furniture and other products for the consumer market. This wide range of products scoped the types of products handled in this sub-project which provided a case study to investigate the implications of implementing the method for different lines of businesses.

5.2.2 Description of the work in sub-project 7

The activities performed in this sub-project can be summarised by first structuring specific requirements from the participating companies, identify stakeholders and their requirements within e.g. purchasers and outside the companies e.g. from customers. The next step was to define a set of environmental performance indicators (EPIs) based on the requirements of the RAVEL methodology and also to build systems or tools facilitating measurement of environmental performance in terms of the defined EPIs. Tools facilitating measurement and communication of environmental performance in terms of the defined indicators have been identified and a prototype tool demonstrating the DfE methodology has been developed and used in the sub-project. The last steps consisted of implementing the method e.g. acquiring relevant data, performing the actual calculations of the EPIs and to communicate the indicator results etc.

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[28] Carlson R, Erlandsson M, Flemström K, Häggström S, *"Measurement and communication of environmental performance of products"*, CPM Report 2006:2 rev. 1
[29] Ander Å, Dewulf W, Duflou J, *"Integrating Eco-Efficiency in Rail Vehicle Design"*, Final RAVEL project report, Brite Euram project, Leuwen University Press, 2001

In detail the activities performed are presented in the following list:

- Identify, analyse and structure specific requirements from the different companies
- Identify stakeholders of environmentally related information, their requirements and needs within each company
- Define a first set of common indicators (quantifiable and qualitative) for measurement and communication of environmental performance. Iterative work in meetings. If needed, company specific indicators are also developed with support from IMI.
- Develop a methodology for integrating the needed tools and methods with the existing systems within the company.
    - Analyse which other systems that are being used at the companies
- Develop prototype that implements the RAVEL methodology based on the identified requirements
    - Prototype based on the CPM Inventory Tool with evaluation functionality to perform calculation and set target values.
- Implement the set of indicators in the participating companies
    - Educate employees on how environmental performance can be measured and communicated
    - Establish data quality foundation to assure reliable indicator results etc.
    - Acquisition of relevant data to exemplify the method – environmental data, component data etc.
    - Identify connections and applications for e.g. Idemat (for material substitution).
- Analysis of mapping of material lists, analysis of level of detail in material lists and other related tasks etc.
- Calculate the selected EPIs for a set of test products using the developed prototype
- Communicate the EPI results to the identified stakeholders and analyse the results
- Test how the implemented methodology and prototype fulfils the identified requirement

5.2.3 Conclusions and learning from the work in sub-project 7

For products in the industrial market, the requirements are often quantitative, which makes it straightforward to measure the environmental performance in terms of e.g. EPIs. For products in the consumer market the requirements from customers are often more qualitative and dynamic. Differences between these product groups have been noticed but the focus has been on measuring environmental performance in terms of quantitative EPIs.

5.3 Sub-project 8 - Environmental management at site and group level

The objective of this sub-project was to develop, implement and improve methods and tools for the environmental work that is performed on the organization level. Please see the report "Environmental management at site and group level"[30] for more detailed descriptions of the sub-project results.

5.3.1 Goal and scope of the work in sub-project 8

The main aim with this sub-project was to reach controllability of the different environmental information tools used in the companies. The sub-project focused on management and quality improvements of environmental information from production sites, and integration of LCA thinking in environmental management systems. The goal of the sub-project was also to implement and improve the toolbox developed in the previous CPM project "Policy controlled environmental management work"[31], see figure 9.

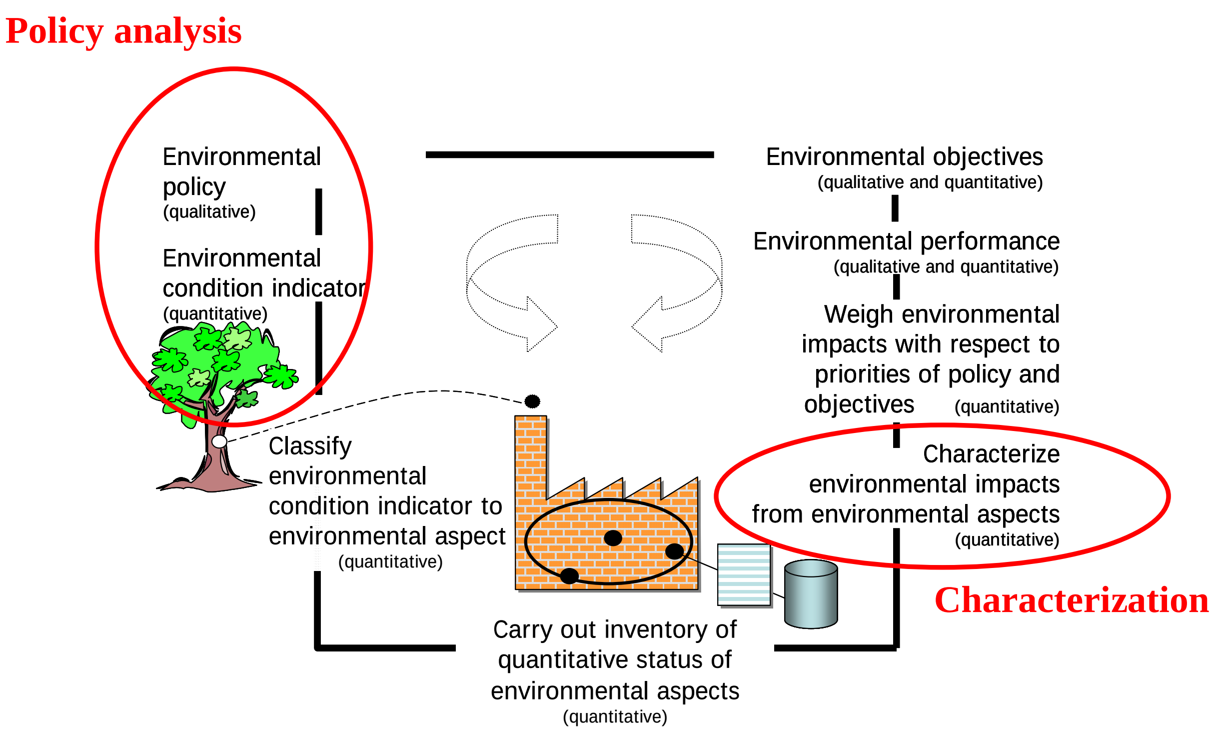

Figure 9 The scope of the work with improvements and support for implementation of the policy controlled environmental management methodology.

[30] Häggström S, Erlandsson M, Riise E, *"Environmental management at site and group level"*, CPM Report 2006:16

[31] Carlson R, Häggström S, Pålsson A-C, *"Policy controlled environmental management work - Final report"*, CPM-report 2004:10

The scope of the sub-project was the environmental management system. The methodology development work in the project focused on some of the parts that were identified as issues for continued work in the "Policy controlled environmental management work" project:

- Support for extraction of environmental condition indicators from the environmental policy
- Development of methodology for local impact assessment
- Upgrading of prototype software tool for policy controlled environmental management work and integration with other software tools

The companies involved in this work have been SCA Personal Care, Stora Enso and Duni.

5.3.2 Description of the work in sub-project 8

5.3.2.1 Support for extraction of environmental condition indicators from the environmental policy

Together with SCA Personal Care, an exercise of extraction of indicators in practice was performed in order to make the methodology step clear. The different definitions on environmental indicators and aspects in the ISO standards were investigated. The experiences drawn from the work and the improvements made in the methodology were documented and a template to support the work with extracting indicators from an environmental policy was created.

5.3.2.2 Development of methodology for local impact assessment

A case study was performed where local characterisation models for P_{tot}, N_{tot} and COD were developed, to give support for the general creation of local characterisation models. Five existing characterisation modelling methods were investigated; the Swedish system for Environmental Product Declaration (EPD), the life cycle impact assessment model EPS 2000, Risk Assessment modelling (RA), the OMNIITOX modelling method (Result from the EU project OMNIITOX), and PHASENS (PHASEs in the design of a model of a Nature System). In connection to this case study, an investigation of available local data for the condition of the environment was made in sub-project 2 "General method development". The result from the study is found in the report "Local environmental impact"[32].

5.3.2.3 Upgrading and integration of the prototype software tool

One of the objectives with starting this sub-project was to improve the prototype software tool EMS@CPM that supports work with the policy controlled environmental management methodology so that it can be used in practice. The work with EMS@CPM has not been in focus for the work performed within the sub-project, as other tools with a lower complexity for the user has met the needs for some of the implementation work performed in the project.

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[32] Häggström S, *"Local environmental impact - Local nature system data availability and local characterization modelling"*, CPM Report 2005:5

5.3.3 Conclusions and learning from the work in sub-project 8

In the previous CPM project "Policy controlled environmental management work", two steps in the methodology developed there were not clear enough to be performed in practice and were developed further; the extraction of indicators from the environmental policy and the adaptation of characterization methodology to local conditions.

The experiences drawn from the work with extraction of indicators were summarized in a template to support the work with extracting indicators from an environmental policy. The work is with great advantage started with creating a draft set of environmental indicators that are possible to calculate in practice. In the SCA exercise, the policy formulation was covered with either operational performance indicators or management performance indicators. This means that a shortcut in the policy controlled environmental management methodology was made. This is also a feasible way to achieve a policy controlled environmental management system. The EPIs and their results can be translated later into ECIs and then weighted based on environmental impact. The impact on the controllability from use of the policy controlled environmental management methodology was investigated. The environmental information acquired and used in e.g. production processes, procurement, education of employees and product design are in many cases the same and great advantages can be made by coordinating this information, whereof controllability is one and of course also a decreased cost for environmental information management.

In this sub-project, local characterisation models for P_{tot}, N_{tot} and COD were developed, as a case study to give support for the general creation of local characterisation models. Five existing characterisation modelling methods were investigated. A methodology for local adaptation of EPS 2000 was chosen to be the most feasible solution. The parallel investigation of available local data about the condition of the environment showed that the local nature data needed for adaptation was accessible.

EMS@CPM has according to requests by the companies been integrated within the IMI portal[33], which also contains a tool for performance of LCA, LCI and IA databases, and tools for conversion of environmental data and for efficient data sharing. The tool has also been integrated in VIEWS, the Visualization of Integrated Environmental Work Spaces, see section 9. Integrated user interfaces decrease the effort that must be put down to learn how to use a new tool and increases thus the accessibility to and the usefulness of the tool. EMS@CPM has further been upgraded with the possibility to update the policy after it has been created, the possibility to update the processes after it has been created and the robustness of the tool has also been improved.

Summarizing, the toolbox developed in the previous CPM project "Policy controlled environmental management work" has been improved and taken one step closer to implementation in practice in industrial companies by the support developed in this sub-project.

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[33] IMI Portal, http://databases.imi.chalmers.se/imiPortal/ , 2006

5.4 Sub-project 9 - Risk management adapted to REACH

The objective of this sub-project was to monitor the development of requirements within REACH, the European Commission's proposed legislation in the chemical area, to develop methodology for risk management adapted to REACH and to develop a strategy to incorporate the REACH requirements with other information systems. More information about the results from the sub-project is found in the "REACH data management report"[34].

5.4.1 Goal and scope of the work in sub-project 9

This sub-project's goal has been to develop methodology for risk management, adapted to REACH (Registration, Evaluation and Authorisation of CHemicals). Further specifications of requirements of the information management within REACH were monitored and a strategy to incorporate these requirements in the existing information management in the CPM companies was developed. A case study was performed to test this strategy for the communications between actors in the supply chain. The possibilities to integrate risk assessment methodology compatible with REACH requirements with the OMNIITOX information system were also investigated.

The project was focused on the information flows to and from companies, i.e. in the supply chains and to and from authorities. Procedures for registration, authorisation and evaluation were thus excluded. The project investigated further only requirements on information in the REACH proposal. The information requirements of the current legislation (which will continue after REACH enters into force) are not either included in the study since the CPM companies already have sufficient knowledge there.

The companies involved in this work have been Akzo Nobel in terms of Akzo Nobel Sustainable Development, Industrial Coatings and Casco Adhesives and IKEA in terms of IKEA of Sweden and Swedwood.

5.4.2 Description of the work in sub-project 9

The work in the project was performed during autumn 2005 and spring 2006 and the information on REACH available at this period has been gathered and analyzed.

The REACH data management report was written directed to CPM companies with the goal to facilitate and support information management required by REACH legislation. The report focuses on information flows to and from companies, i.e. to and from manufacturers, importers and users of chemical products and substances and products containing chemicals. The procedures for registration, authorisation and evaluation are not included in this report, only the *information requirements* for these activities are handled. The report is based on methodology for quality assured and cost effective data acquisition and data management developed within CPM.

A case study was performed where the information flow between two actual stakeholders in the coming chemical legislation REACH was analysed and tested on forehand. The

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[34] Flemström K, Häggström S, Tivander J, *"REACH data management report"*, CPM Report 2006:3

scope of the case study was limited to communication in the supply chain and other obligations such as reporting to authorities were thus excluded. The REACH data management report was used to easy conclude the roles and obligations for each company. In the case study was investigated what data is needed, if and where this data is available and how a lean organisation is formed to manage and communicate this information. The information exchanged could in the end be successfully performed and the experiences from the case study were then summarised to a guideline.

5.4.3 Conclusions and learning from the work in sub-project 9

The roles and obligations for the companies under REACH were vague when the sub-project started and also which substances and articles that are concerned by the proposal. The REACH documents are many and comprehensive and can be difficult to read for the layman. The uncertainties have been clarified during the work. E.g. after structuring up the different roles and obligation as is made in Table 1 in the REACH data management report, it was easy to conclude the roles and obligations for each company.

In the case study it was concluded that the main difference with REACH compared to existing requirements for the communication in the supply chain is that the manufacturer should include exposure scenarios (ES) as annexes to the SDS. The term “exposure scenario” is already used in risk assessment, however with a slightly different meaning, in the current TGD. It was found that the TDS and the working environment directives were the main data sources that were needed and that some information could also be retrieved from the SDS. The description of the operational conditions in the ES is also very similar to the process description in life cycle assessment (LCA) according to ISO/TS 14048 and the ES together with the requested overview of the supply chain is therefore a good basis for integration with LCA.

5.5 Sub-project 10 - Three tools for IPP

The objective of this sub-project was to demonstrate how CPM results can support Integrated Product Policy (IPP). Since there is no specific CPM report on the work done in this sub-project, the description provided here is slightly more detailed than for other sub-projects.

5.5.1 Goal and scope of the work in sub-project 10

The goal of this sub-project has been to improve the previously not industrially tested tools LCA@CPM, OMNIITOX IS and CPM Inventory tool, based on feed-back from demonstrations. It included examination of how the tools can be used to support and facilitate the work with environmental related information handling in general and support IPP in particular. Special focus was put on further development of LCA@CPM since the CPM companies' representatives have expressed a great interest in the development of an LCA tool that could fulfil their needs.

5.5.1.1 Integrated Product Policy (IPP)

In 2001, the European Commission adopted a Green Paper on IPP[35] presenting studies and ideas for strengthening product-focused environmental policies and assisting the growth of a market for greener products.

Integrated Product Policy (IPP) seeks to minimize the environmental degradation caused by products by looking at all phases of a product's life-cycle and taking action where it is most effective. The life-cycle of a product is often long and complicated. It also involves many different actors such as designers, industry, marketing people, retailers and consumers. IPP attempts to stimulate each part of these individual phases to improve their environmental performance. An integrated policy for products will probably need to be based on a mixture of the instruments outlined below[36]:

1. **Getting the Prices Right**
   Getting the prices right is probably the single most effective measure available to stimulate markets for greener products. The consumer is most likely to act if they can feel the advantage in their pocket.
2. **Stimulating Demand for Greener Products**
   If consumers demand green products markets are likely to provide them. However to choose between different products consumers need information which is easily accessible, understandable, relevant and credible.
3. **Strengthening Green Production**
   Once a product is put on the market, it is difficult to reduce its impacts. By focusing on their environmentally friendly design environmental impacts could be prevented.

[35] European Commission, *"Green Paper on Integrated Product Policy"*, 2001
[36] European Commission, information on IPP developments, http://ec.europa.eu/environment/ipp/2001developments.htm, 2006

5.5.1.2 Methods and tools supporting IPP

The IPP concept embraces a whole variety of measures - both voluntary and mandatory - that can be used to achieve the objectives of IPP. These include economic instruments (e.g. the Emission Trading Scheme[37]), substance bans (e.g. Directive 93/67/EEC [38]) , voluntary agreements (e.g. EMAS[39] and OECD/HPV[40]) and environmental labelling (e.g. the Community Eco-label Award Scheme[41]).

In previous work in IMI and CPM, prototype software tools have been developed to support methods and tools such as environmental management systems (WWLCAW[42] and EMS@CPM[43]), life cycle assessment (SPINE@CPM Data Tool[44] and LCA@CPM[45]), environmental risk assessment (OMNIITOX IS[46]) and design for environment (CPM Inventory Tool[47]).

In this sub-project, three tools supporting IPP were selected;

- LCA@CPM
- OMNIITOX IS
- CPM Inventory Tool

An introduction to each tool is found below.

5.5.1.3 LCA@CPM

The LCA@CPM is a user-friendly web based life cycle assessment (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 work is performed in projects in order to allow members e.g. at different locations, in different organizations, etc. to participate in common LCA projects and enable an efficient and secure handling and sharing of data.

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[37] Commission Decision of 29/01/2004, *"Establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council"*, 2004.
[38] EC, *"Directive 93/67/EEC on Risk Assessment for new notified substances"*, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances, 1993
[39] EC, *"REGULATION (EC) No 761/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 March 2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)"*, 2001
[40] U. S. EPA and ICCA/OECD High Production Volume (HPV) Chemicals testing programs, http://www.oecd.org/department/0,2688,en_2649_34379_1_1_1_1_1,00.html, 2006
[41] European Commission, *"Regulation (EC) No 1980/2000 of the European Parliament and of the Council of 17 July 2000 on a revised Community Eco-label Award Scheme"*, 2000
[42] World Wide LCA Workshop (WWLCAW), http://workshop.imi.chalmers.se/, CPM prototype, 2006
[43] IMI portal, http://databases.imi.chalmers.se/imiportal/, IMI prototype, 2006
[44] SPINE@CPM Data Tool, http://spine.imi.chalmers.se/Spine_EIM/prod01.htm, 2006
[45] IMI portal, http://databases.imi.chalmers.se/imiportal/, IMI prototype, 2006
[46] OMNIITOX IS, http://omniitox.imi.chalmers.se/, IMI, 2006
[47] Inventory Tool, http://project.imi.chalmers.se/DfE_InventoryTool/www/Login/Login.asp, 2006, (only accessible to CPM members)

The software tool LCA@CPM was constructed by integrating existing modules and results developed in the context of the competence centre CPM, Centre for environmental assessments of Products and Systems at Chalmers. It is built on the basis of formats, methods and tools such as SPINE[48], IA98[49], EPS 2000[50] and WWLCAW[51]. The user already acquainted with these methods and tools will find it easy to use also LCA@CPM. LCA@CPM is available at the IMI portal[52]; http://databases.imi.chalmers.se/imiportal/.

5.5.1.4 OMNIITOX IS

The EU project OMNIITOX[53] started in 2001 and finished in November 2004. To support the results from the project, an information system called OMNIITOX IS was created. 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 impact assessment models created in the project are also stored in the database. The information system was 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. OMNIITOX IS is available at http://omniitox.imi.chalmers.se/.

5.5.1.5 CPM Inventory tool

The CPM Inventory tool is a web-based application supporting design for environment (DfE) where suppliers can submit data about their components and directly get a measure of the environmental performance of the components by calculating Environmental Performance Indicators. The application also supports a review procedure where data submitted by the suppliers is reviewed by administrators which guarantee that only data of a good quality is imported into an internal environmental database. The tool was developed by Bombardier and Chalmers after the RAVEL project[54], and it is implementing parts of the RAVEL methodology. More information about the CPM

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[48] Global Spine, http://www.globalspine.com/, online database portal, IMI, 2006

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

[50] 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

[51] World Wide LCA Workshop (WWLCAW), http://workshop.imi.chalmers.se/, CPM prototype, 2006

[52] The IMI portal is based on many years of research within the inter-disciplinary area of industrial environmental informatics performed in close cooperation with the industry. Other tools have been developed on the same technical platform as LCA@CPM. These tools are all accessible from the IMI portal which provides a set of integrated tools for industrial environmental information management facilitating efficient environmental work in accordance with ISO standards. The portal is developed and maintained by the department of Industrial Environmental Informatics within the competence centre CPM (Center for Environmental Assessment of Product and Material Systems).The different parts of the portal have been developed within different industrial strategic research projects aiming at increasing efficiency and quality of environmental information management. As the different parts are all based on the same conceptual model and technical platform, the separate parts are together forming the IMI portal.

[53] OMNIITOX, Operational Models aNd Information tools for Industrial applications of eco/TOXicological impact assessments, http://omniitox.imi.chalmers.se/OfficialMirror, 2006

[54] Ander Å, Dewulf W, Duflou J, *"Integrating Eco-Efficiency in Rail Vehicle Design"*, Final RAVEL project report, Brite Euram project, Leuwen University Press, 2001

Inventory Tool can be found in the report from the IMPRESS sub-project 7[55]. CPM Inventory Tool is available for CPM members at http://project.imi.chalmers.se/DfE_InventoryTool/www/Login/Login.asp.

5.5.2 Description of the work in sub-project 10

5.5.2.1 Demonstration and testing of the tools

One of the goals with sub-project 10 was to demonstrate LCA@CPM, OMNIITOX IS and CPM Inventory tool for the CPM companies.

LCA@CPM

LCA@CPM was demonstrated at the IMPRESS project kick-off November 3rd – November 4th, 2004, and at the IMPRESS seminar February 28th – March 1st, 2005.

LCA@CPM was also tested by users in the participating companies in IMPRESS in the beginning of the project. These tests were however postponed as the users did not understand how to use the tool and there was also vital functionality missing which is needed to perform LCA. Some useful feedback was however gained from the test in the companies. Based on this feedback, it was decided that the user interface should be made more user-friendly and a manual should be developed. Support for aggregated systems, and more options for the result presentation should also be implemented before any further tests were performed.

LCA@CPM was released to the public in June 2005, and the tool was tested both within CPM companies as well as in other external companies and academic groups, which resulted in new wishes for improvements. LCA@CPM was then tested and improved at several occasions, see 3.5.2.2 Improvements of LCA@CPM. All the required improvements could however not be met within the scope of this research project.

OMNIITOX IS

As a part of this sub-project the OMNIITOX IS has been demonstrated to CPM companies in context of the DANTES project. OMNIITOX IS was also demonstrated at the planning workshop for IMPRESS. A public version of the OMNIITOX IS was also produced[56]. In the public version all editing functionality have been removed, i.e. it is not possible for the user to change any data. This modification was necessary to minimize maintenance costs of the system. Connectivity to the substance data management functionality in OMNIITOX IS has been included in the Chemical Risk Management tool in the VIEWS platform, see section 9.
The company participating in IMPRESS could not see any direct application of the OMNIITOX IS in their daily work. As this was also a

[55] Erlandsson M, Flemström K, *"Measurement and communication of environmental performance of products"*, CPM Report 2006:2
[56] OMNIITOX IS public portal and http://omniitox.imi.chalmers.se/, 2006

conclusion from the former CPM project "Extension of databases in networking"[57], it was decided to not put further resources on improving the of OMNIITOX IS within IMPRESS.

CPM Inventory tool
The CPM Inventory tool has been demonstrated, tested and improved within sub-project 7 of the IMPRESS project and also in the CPM project "Addressed data acquisition to support implementation of DfE in the CPM companies". Thus, the CPM Inventory Tool was excluded from sub-project 10. The performed improvements of the CPM Inventory tool and related tools for DfE are described in the report from the IMPRESS sub-project 7[58] and the final report from the CPM project "Strategic data acquisition addressed to support implementation of Design for Environment"[59].

5.5.2.2 Improvements of LCA@CPM

The improvements of LCA@CPM were made with three main objectives, increasing the understanding, the functionality and the data availability of the tool.

Understanding the tool

- **Enhanced user documentation**
  A manual on how to use the tool has been created to facilitate the understanding of the tool. The manual contains both an introduction to the tool, a practical guide for working with the tool, definition of important concepts as well as description of all the data fields in the tool. The description of each data field in the tool is also available as help texts in the tool.
- **New user-interface**
  To facilitate a more intuitive understanding of how to use the tool, the user interface of the tool has been redesigned. A new home page for each project ("Project") has been created, where concepts and relations defined within the ISO 14040-series have been used (see figure 10 below). From this page the different parts of the tool are shown, explained and accessible. The usage of terms and pictures which already are familiar to the target users, has shown to make it easier to understand how to use the tool. When entering the LCA@CPM tool, the project overview of the last visited project is shown. The first time the tool is entered, a demonstration project is shown.
  A top menu has also been added to make the navigation between different parts of the tool easy. The top menu is available from all different parts of the tool.
  The user interfaces of the different parts of the tools have also been updated. Goal & Scope, Interpretation, and Critical review have been updated based on concepts and terms used in the ISO 14040-series. All the information is stored in the database using the ISO/TS 14048 data documentation format.

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[57] Erlandsson M, Flemström K, Häggström S, Tivander J, *"Extension of Databases in Networking"*, CPM report 2004:8
[58] Erlandsson M, Flemström K, *"Measurement and communication of environmental performance of products"*, CPM Report 2006:2
[59] Häggström S, Tivander J, Carlson R, *"Strategic data acquisition addressed to support implementation of Design for Environment"*, CPM Report 2006:13

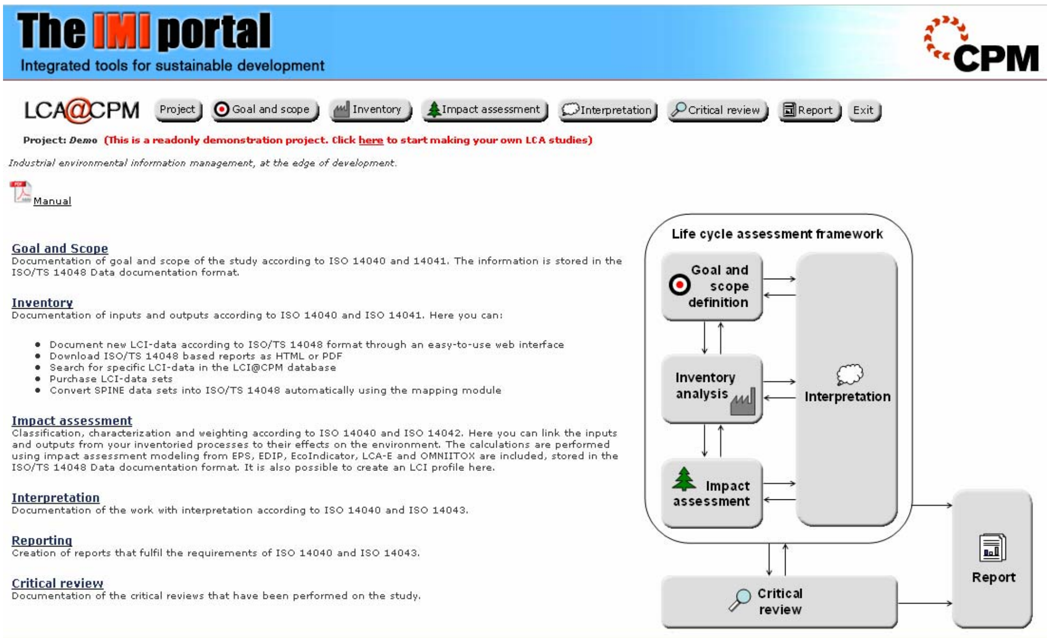

Figure 10 The home page for the project “Demo” in the LCA@CPM tool

- **Public demonstration project**
  When entering LCA@CPM for the first time or when entering the tool without first logging in on the IMI portal, an illustrative demonstration project is shown to guide the user. The user can view all the information which has been acquired in this example LCA study, and also perform calculations. The user can however not make any changes to the data of the demonstration project.

Functionality improvements

- **Support for aggregated systems**
  The aggregation of processes is an important concept when performing LCAs as this enables use of existing data and reuse of the same process data in different LCA studies. Functionality has been added to LCA@CPM to support aggregation of processes.
  When creating a process in the tool, the user needs to define if the process is an aggregated process or a unit process. If an aggregated process is created, processes to include into the aggregated process are imported or created. The included processes are then connected with intermediate flows using a flow chart editor. The included processes are in the flow chart editor shown as boxes and the intermediate flows are shown as arrows between these boxes that points in the direction of the flow.
  For an aggregated process, the inputs and outputs are the sum of the inputs and outputs of the included processes. The sum is called the LCI profile. Which inputs and which outputs that can be added might seem trivial but is in fact not. It depends on the resolution of the impact assessment models that are intended to be used.
  The impact of an input or output can e.g. be dependent on the

substance/material/energy carrier, the origin/destination, the medium from which the input origins or into which the output is received and the geographical location. All the following specifications of the inputs and outputs must therefore be identical if the inputs and outputs shall be automatically added in LCA@CPM: direction, group, name, receiving environment, receiving environment specification and geographical location. The user is however free to make own LCI profiles.
In LCA@CPM, the LCI profile of aggregated processes is automatically calculated and shown under "Inputs and outputs". The inputs and outputs are edited in the process that they origin from.

- **Enhanced calculation functionality**
  The calculation functionality of LCA@CPM has been updated to support aggregated systems and a more general presentation of results.
- **Graphical presentation of LCA results**
  The original table based presentation of LCA results has been updated and made even more transparent. Functionality has also been added for graphical presentation of LCA results.

Data availability

The availability of data is important when performing LCA. Several activities has for that reason been performed within or in coordination with this sub-project to achieve better data availability by improving the communication with different data sources.

- **SPIDER**
  SPIDER[60] is a freely available tool for secure data sharing, which has the goal to increase the data availability for LCA practitioners all over the world and decrease the costs for making LCAs, see figure 11 below. The tool is based on a technology with the highest security demands, but it is still easy to use. SPIDER is open for sharing of files on any text-format, such as EcoSpold, SPINE, etc, but it is based on ISO/TS 14048. The tool was developed within a master's thesis performed at IMI[61], where the supervision was performed within sub-project 10. The SPIDER system has also been maintained, further developed, and disseminated within this sub-project.

[60] Erlandsson M, Carlson R, Mostafa M, Tivander J, Wigren P, *"SPIDER – a technology enabling secure inter-organisational sharing of environmental data"*, 2nd International Conference on Life Cycle Management, Barcelona, September 5-7, 2005

[61] Mustafa M, Wigren P, *"Secure XML file sharing in a JXTA P2P network for inter-organizational industrial collaboration"*, Master's thesis at the Department of Computer Engineering, Chalmers University of Technology, Gothenburg, 2004

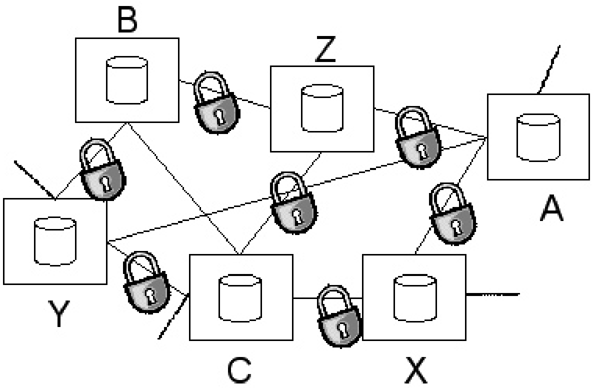

Figure 11 SPIDER aims at bridging the gaps between existing data sources (from Erlandsson et al[62])

- **Client based data documentation tool**
  The IMI portal with the tool LCA@CPM provides functionality for creation and editing of LCI data sets. Experiences within CPM have shown that users are not willing to put any secret data in a database on a web server, even if the data is protected. In response to this requirement a client based data documentation tool[63] was developed, where the data is stored on the users' computers. With this tool, ISO/TS 14048 based XML files can be created, viewed and edited, and printable reports can be generated. The tool has been integrated in the SPIDER system, but it can also be used as a separate tool for data documentation using the ISO/TS 14048 format.
- **Improvements of impact assessment data**
  The data representing the pre-defined impact assessment methods which are used for impact assessment in LCA@CPM (and EMS@CPM) showed to contain some errors which resulted in incorrect LCA results. These errors have been manually corrected using the tool WWLCAW. An overview of the changes performed is provided below:
  - All *Aspects* have been checked and corrected in terms of Direction, Group Receiving environment, Receiving environment specification and Geographical location. About 1500 aspects were erroneous, e.g. referring to an incorrect receiving environment or having undefined properties.
  - Erroneous units of indicators, characterization parameters and weighting factors have been corrected in EDIP and Ecoindicator '99.
  - Harmonisation of differently or wrongly spelled substance names has been made.
- **Conversion of data from ISO/TS 14048 to SPINE**
  Functionality for conversion of SPINE data sets into ISO/TS 14048 data sets, as well as import of ISO/TS 14048 into LCA@CPM already existed within the IMI

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[62] Erlandsson M, Carlson R, Mostafa M, Tivander J, Wigren P, *"SPIDER – a technology enabling secure inter-organisational sharing of environmental data"*, 2nd International Conference on Life Cycle Management, Barcelona, September 5-7, 2005
[63] SPIDER Data documentation tool - http://www.imi.chalmers.se/Projects/ISO_TS_Info_Resources.htm#Data_documentation_tool, 2006

portal. To achieve a better two-way communication with SPINE-based tools and data sources, this has within this sub-project been complemented with functionality for conversion of ISO/TS 14048 data sets into SPINE data sets based on an existing specification[64]. The functionality for import of SPINE datasets has also been improved to handle the variations of the interpretation of the SPINE XFR-format between different SPINE-based software vendors.

- **Conversion of data from EcoSpold to ISO/TS 14048 and SPINE**
  In parallel to this project, functionality for conversion of ecoinvent datasets on the EcoSpold format into ISO/TS 14048 or SPINE has been implemented[65]. To be able to make use of these resulting datasets, the functionality in LCA@CPM was updated to manage ecoinvent nomenclatures and conventions in an as good way as possible.
- **Support for import of XFR-files created in EcoLab**
  The XFR format is a SPINE-based format for communication of LCI data. The original version of LCA@CPM contained functionality for import of XFR files generated in the SPINE data tool. This functionality did however not work for import of XFR files generated in EcoLab, as the EcoLab interpretation of the XFR format differs from the SPINE data tool implementation. Examples of differences are that capital letters are used for names of tables and fields in SPINE data tool XFR files while only small letters are used in the EcoLab XFR files. There are also some differences in tables and fields which need to be handled as well as differences in nomenclatures. The existing functionality for import of XFR data was generalized to also support XFR files generated in EcoLab.

5.5.3 Conclusions and learning from the work in sub-project 10

The focus of this sub-project has been to improve the previously not industrially tested tools LCA@CPM, OMNIITOX IS and CPM Inventory tool, based on feed-back from demonstrations. Furthermore, to explore how these tools used within CPM can be used to support and facilitate the work with environmental related information handling in general and support IPP in particular.

The LCA@CPM is a web based life cycle assessment (LCA) tool supporting work according to the ISO 14040 framework in a transparent way. LCA@CPM has successfully been used to perform LCAs in research. The tool does however not fulfill the requirements for performance of LCAs within the industry, where the requirements on performance and functionality are harder. The requirements that need to be fulfilled for a successful commercialization have been identified and documented.

The sub-project has shown that ISO/TS 14048 is a practically usable format for documentation of LCA-data. The ISO/TS 14048 data documentation format is in LCA@CPM used both for documentation of LCI data as well as for documentation of the LCA study with Goal & Scope and Critical review.

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[64] Carlson R, Erlandsson M, Flemström K, Pålsson A-C, Tidstrand U, Tivander J, *"Data format mapping between SPINE and ISO/TS 14048"*, CPM report 2003:8

[65] Erlandsson M, Pålsson A-C, Häggström S, *"Specification of data conversion from EcoSpold to ISO/TS 14048, SPINE and IA98"*, CPM Report 2006:1

5.5.3.1 Suggestions for future work with the tools

LCA@CPM

The tool LCA@CPM has been improved in accordance with the users needs within this sub-project, and it has successfully been used to perform research tasks at IMI. A broad usage within the industry would however require more robustness and more functionality, e.g. parameterized transport processes. The improvements that need to be performed before a successful commercialization of the tool are summarized below, based on user requirements.

Suggestions on further functionality improvements:

- Support for parameterized transport processes
- More robust system
- Support for amount structures in the calculation functionality
- Improvement of functionality for handling of substances

A requirement for a commercialization is also that a maintenance of the tool is established, which guarantees that the data is secure and that the tool is working and constantly up and running. Furthermore, the maintainer provides user support and education on how to use the tool, etc.

OMNIITOX IS and CPM Inventory tool

Suggested future improvements of the CPM Inventory tool and related tools for DfE are described in the report from the IMPRESS sub-project 7[66] and the final report from the CPM project Häggström S, Tivander J, Carlson R, "Strategic data acquisition addressed to support implementation of Design for Environment"[67].

To further increase the usability of the OMNIITOX IS the following next steps are feasible[68]:

- Integration of the OMNIITOX IS characterisation factor calculation tool with LCIA tools
- Additions of characterisation models
  - even less data requirements
  - also for other impact categories than toxicity
- Development of data acquisition strategies for the implemented models
- Integration of substance database and characterisation factors with Design for environment tools
- Adoption to suit the data management for chemicals according to the REACH system.
- Implementation of an on-line model development tool for simultaneous modelling, documentation, and model implementation.

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[66] Erlandsson M, Flemström K, *"Measurement and communication of environmental performance of products"*, CPM Report 2006:2

[67] Häggström S, Tivander J, Carlson R, *"Strategic data acquisition addressed to support implementation of Design for Environment"*, CPM Report 2006:13

[68] Tivander J, et al., *"Information system implementation report"*, OMNIITOX project deliverable D55, 2004

5.6 Sub-project 11 - Integration of experiences and new information

The objective of this sub-project was to develop strategies and methods to make use of experiences and to keep the tools updated by continuous inflow of new relevant information. Please see the report "Integration of experience and new information"[69] for more detailed descriptions of the sub-project results.

5.6.1 Goal and scope of the work in sub-project 11

The goal of this sub-project was to study and analyze the information flows in organisations. The environmental knowledge and information of an organisation is retrieved, stored and communicated in different ways. New information is retrieved by the employees from newspapers, scientific reports, suppliers and customers etc. A continuous screening of new environmental information is required to keep the methods and tools used within the organisation benchmarked with new developments on related and/or alternative methodology and data. Information on experiences from use of methods and tools is also valuable goods and should be accessible for usage within new work tasks within an organisation. This is necessary for sound and conscious choice of methodology data and tools to use by industry, to navigate towards sustainable development. The scope covered thus all environmentally related information within an organisation.

5.6.2 Description of the work in sub-project 11

The work in sub-project 11 included a state-of-the-art study of management of environmental knowledge and information in organisations based on interviews with employees of the CPM companies, and a state-of-the-art study on the literature in the area of knowledge management and organisational learning.

5.6.2.1 Literature study

A literature study was performed in the area of organisational learning and knowledge management. The two concepts were studies in terms of definitions and theories, important actors and available knowledge. Organisational learning is a characteristic of an adaptive organisation, i.e., an organisation that is able to sense changes in signals from its environment (both internal and external) and adapt accordingly. Knowledge Management is any process which incorporates the desire to expand our range of inquiry with the need to simplify our decisions. This can involve both human and technological applications which help create, organize or share knowledge.

5.6.2.2 Interviews with CPM companies

The interviews with the CPM companies were performed in March and April 2005 by Johan Tivander and Sandra Häggström at IMI. They covered the following perspectives on environmental information:

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[69] Häggström S, Flemström K, Tivander J, Carlson R, *"Integration of experience and new information"*, CPM Report 2006:17

- **use** of environmental information
- **cost** of bad environmental information
- **content** of environmental information
- **channels** for environmental information, and
- **obstacles** for environmental information

It was expressed by the interviewees that environmental information differs from other information in certain ways. For once, it is rarely asked for and needs often to be pushed out to the users. Further, it is considered secondary to economic and technical information, and is not always given the same weight as decision basis. The ideal management system for environmental information was described by the interviewees as: complete, simple to use, cheap, updated, exact, and, most important, it *is used* in the organisation.

5.6.2.3 System for integration of experiences and new information

By viewing the management of environmental knowledge and information from the system perspective, reflections can be drawn, the elements of repetitive kind can be identified, and some of the inefficiencies in the information system might be mended. A first sketch of such a system is drawn in figure 12.

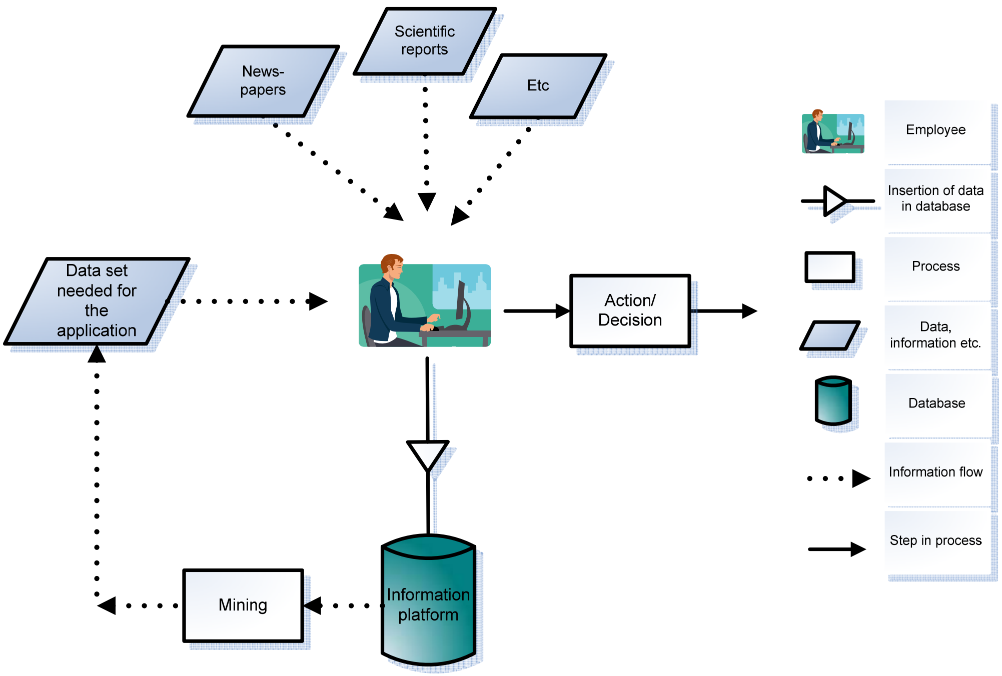

Figure 12. Draft sketch of a system for management of environmental knowledge and information.

The system is built on organisational learning and knowledge management. The employee has access to environmental information in the form of external data sources like newspapers, scientific reports etc. and internal data sources like documents, databases, intranets etc. The employee uses his or hers competence to improve the environmental performance of the organisation and accomplishes new knowledge and experience that can be documented to be reusable at another time or place in the company. A “mining” function provides the employee with the information that is relevant for the work task in question from the general information system where all information is stored.

5.6.3 Conclusions and learning from the work in sub-project 11

The benefits of a structured way to manage knowledge and information in an organisation are several. For the elements of repetitive kind, routines can be created and the focus of the environmental work can be transferred to the areas where more development is needed. Such areas can be interpretations of environmental information adapted to the user of the information or detailed studies of e.g. upstream and downstream effects of environmental measures, local environmental impact etc.

One conclusion that has been made so far is that the extent to which companies, parts in a company or applications of environmental work have a structure for the knowledge and information management is varying. In some organisations or applications, there can be found improvement potentials such as confusions, inefficiencies and inconsistencies. A system can be created for management of knowledge and information based on experiences to accomplish the improvements.

The framework for the methodology is built on organisational learning and knowledge management. These two areas apply for both individuals and the organization they are part of. Man and system are given deeper awareness of what they are part of, the employees make observations and reflections and strive to learn and improve.

6 Description and conclusions of the work in the research sub-projects

6.1 Sub-project 2 - General method development

The objective of sub-project 2, General Method Development, was to develop a general method including practical guidelines for integration of industrial environmental information systems based on a scientific foundation. The method development work and the resulting integration method are described in a separate report[70] which also contains an extensive compilation of previous results from CPM and IMI on the subject of integration methodology, see also section 3. *Background and former work*. A summary is given here.

6.1.1 Purpose and scope of the integration method

The purpose of the general integration method is to make industrial environmental information systems more effective and efficient, i.e. decrease cost for developing, using and maintaining data, tools, and methods for industrial environmental management and to improve controllability of environmental performance.

The scope of the method is limited to industrial environmental management responsibilities, as defined by the ISO 14000 standards. However it is *general* in the sense that it is independent of line of business, quality requirements, technology, methods, tools, concept and data models. *Integration* in this context refers to integration of environmental information management methods and tools, i.e. integration with each other and with corporate business processes.

The intended users of the general integration method is the environmental coordinator (or corresponding) and the industrial environmental informatician (or corresponding). The environmental coordinator has a good overview of the environmental work, i.e. the needs, possibilities etc., and he or she can use the method to better understand and specify the purpose and scope of integration, cost and benefits, the competence requirements for integration. Also, he or she can use the method as support to coordinate the integration. The industrial environmental informatician has knowledge about information system development in the interdisciplinary context of industrial environmental management, and can use the method as support in the integration modelling.

6.1.2 Integration method development

The method is based on experiences from the industrial case studies in sub-projects 6-11 and on previous work with integration within IMI and CPM. Four additional case studies was performed within sub-project 2 in parallel with the development to test and evaluate the method. Three case studies were done within companies: ITT Flygt, SCA Hygiene

[70] Erixon M, Tivander J, Pålsson A-C, Carlson R, *"General method for integration of industrial environmental information systems"*, IMPRESS project deliverable, CPM report 2006:14

Products and Akzo Nobel; and one study was done internally within IMI where an integrated concept tool Visualisation of Integrated Environmental Work Spaces (VIEWS) was implemented, see also section 9 *Visualization of Integrated Environmental Work Spaces – VIEWS*.

A reference group with CPM company representatives and a researcher from Chalmers was also participating to review and guide the method development.

6.1.3 The general integration method

The method for integration of industrial environmental information systems consists of three main steps (see also figure 13):

- *Analysis*
  The purpose and scope of the integration is specified together with the stakeholders. Based on this, the current information system is investigated and described. Also, a draft vision of the integrated information system is developed to visualize the purpose and scope.
- *Synthesis*
  The result from the analysis is synthesized, and possible ways to integrate and rebuild the system is identified and described.
- *Implementation*
  Based on the result from the synthesis, the implementation of the integration is prioritized and decided and the work is planned and performed. The implementation is also evaluated based in the purpose and scope.

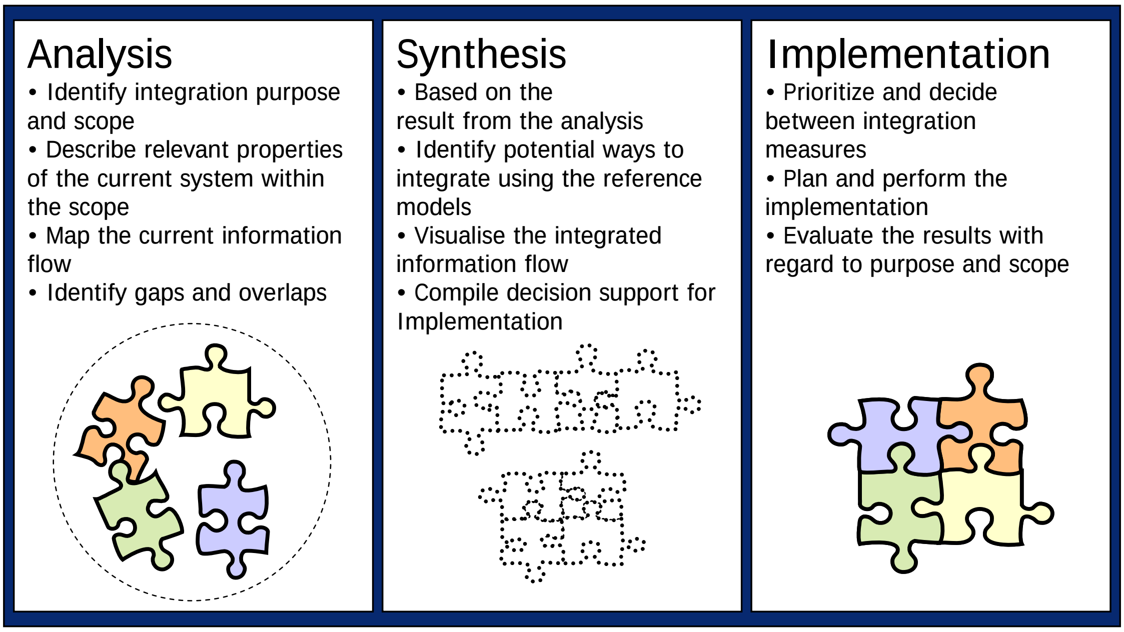

Figure 13 A short description of the three main steps involved in the method for integration of industrial environmental information systems

In the case studies within companies, the steps analysis and synthesis have been performed.

In the case study at *ITT Flygt* the purpose was to integrate the environmental work with the other work done in the product development, to make it more efficient and to be able to generate environmental decision support based on commonly shared and updated data. It was found in the synthesis that an implementation of such a system was feasible. It was also described how the use of environmental information in other functions in the company, such as the sales department and procurement, could be harmonized through a stepwise implementation.

At *SCA Hygiene Products* it was investigated how the work with life cycle assessment (LCA) could be harmonized with the generation of environmental product declarations (EPD). Further the intention was to adopt the technical specification ISO/TS 14048 LCA data documentation format[71] in the LCA work. The necessary actions to implement an integrated LCA and EPD system was described in the synthesis. It was also found that the users of the LCA and EPD results, e.g. the product developers, could generate much of the information themselves. The LCA specialist would then work as a support and possibly as data quality control. This would potentially make the LCA work quicker and make the interpretation of the results by the decision makers easier.

The case study at *Akzo Nobel* concerned integration of the tasks to perform Eco-efficiency analysis and Risk assessment compliant with the future European chemicals legislation REACH. The synthesis resulted in three different solutions depending on method approach and choice of software solution. The decision regarding which alternative is more favourable is related to risks in terms of confidentiality, and costs in terms of education, software maintenance and development and data management.

The case study at IMI aimed applying the method including the practical implementation to create an integrated platform for different environmental information management applications into one common platform called VIEWS. The sub-views are applications for LCA, EMS, DfE, Chemical risk management, and Emission Trading Data management. The resulting VIEWS platform provides a showcase on how these tools can be practically integrated. Shared primary data entered in one view is immediately available in another. Most notably is an integration of the indicator management which is set on a global level and that primes all sub-views with relevant indicator subsets. See also section 9 *Visualization of Integrated Environmental Work Spaces – VIEWS*.

6.1.4 Discussion and conclusions from the general method development

The general integration method developed in this sub-project has been successfully used to identify ways to integrate information systems with different purpose and scope. The stakeholders in the case studies find the results from the synthesis useful as decision support for implementation. Although the implementation part still remains for the companies, an integrated perspective of their information systems is established, which

[71] ISO, *"ISO/TS 14048 Environmental management — Life cycle assessment — Data documentation format"*, 2002

provides an understanding of possibilities to reduce costs of data management and increase controllability of environmental work.

The VIEWS case study showed that it is possible to achieve practical implementation of integrated environmental information systems. The included tools and tasks in the resulting integrated system VIEWS were previously implemented as individual tools. In the integrated system data can be used in multiple applications, and this puts requirements on that the data is managed consistently to avoid misinterpretation and distortion of data as it is communicated between the applications. All the tools included in the implementation of VIEWS were originally developed based on open and documented concept models, databases, and software, which greatly facilitated an efficient synthesis and implementation of the integrated system.

Further improvements of the general integration method should involve more case study experiences from applying the method, specifically of the implementation step. In addition, the theoretical basis, involving integration dimensions and principles, could be further elaborated in research studies.

6.2 Sub-project 3 – Maintenance of integration

The work within sub-project 3 - Maintenance of integration – concerned the development of an integrated data format applicable to all the methods and tools used in the industrial sub-projects 6-11. The maintenance and review of CPM databases such as SPINE@CPM was also included in this sub-project.

The data format named the IMPRESS data format is based on existing data models developed within CPM and IMI. A full description of the IMPRESS data format is available in a separate report from sub-project 3[72].

6.2.1 Objective of the integrated data format

The main objective of the integrated data format was to prove in practice that the previously developed formats could be integrated and to have the resulting integrated data format as a reference example of how to structure data when integrating other information systems. It should provide a structure for the information that shall be integrated, e.g. in terms of identifying what kind of information is needed by different users, finding similarities between information used in different applications, defining relevant level of detail of information, finding support for nomenclatures etc. It can also be used directly to build a database.

6.2.2 Development of the integrated data format

The development of the IMPRESS data format took a starting point in the existing data formats for life cycle inventory[73], life cycle impact assessment[74], environmental

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[72] Tivander J, Carlson R, Erixon M, Pålsson A-C, *"IMPRESS integrated data format"*, IMPRESS project deliverable, CPM Report 2006:15
[73] Carlson R, Löfgren G, Steen B, *"SPINE, A Relation Database Structure for Life Cycle Assessment"*, Göteborg, IVL-REPORT, September 1995

assessment of component structures[75], and environmental impact modelling[76]. These original models have been partly integrated by IMI in a working draft reference model, IMI 2003[77] also including concepts from the ISO/TS 14048 LCA data documentation format[78].

Documentation of the formats and implemented databases based on the formats were assembled. The concept models and tables and fields for all formats were nearly fully covered in available reports from IMI and CPM. The existing databases provided examples on actual data in the fields for further understanding of the concepts.

The overall high level concept of SPINE, was used as a reference model that sets the scope of what is included in domain of environmental information and also the main internal structure of environmental information, see section 3 *Background and former work*. The SPINE concept model has also been used as a main reference model in the general integration method developed in IMPRESS sub-project 2 in parallel to the development of the IMPRESS data format.

The formats were first analysed in terms sorting out common concepts from the concepts exclusive for one format. Common concepts that were identically defined in the formats could be directly integrated. However different definitions in terms of concept name, data type, or relations to other concepts existed. These issues was assembled into “issue areas”, e.g. issues regarding meta data structure, issues regarding resolution of environmental impact model data and environmental impact assessment data, or issues on consistent name spaces and nomenclatures.

A series of discussion seminars was held by within research group IMI on one issue at a time. The discussions started by reaching a common conceptual description of the issue area based on experiences on methods and applications using the information and followed by decisions on the final naming and relations of concepts and also on data format definition for the concept. All decisions were documented in minutes and the resulting format was specified as presented in section *5. The data format* in the sub-project report[79]. A database was also built up as a working tool for direct implementation of the decided format.

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[74] Carlson R, Steen B, *“A Data Model for LCA Impact Assessment”*, Presented at 8th Annual Meeting of SETAC-Europe 1998 14-18 April, Bordeaux

[75] Carlson R, Forsberg P, *“The RAVEL Information Platform Data Model”*, 2000 RAVEL project doc nr CPM-000919 (report)

[76] Tivander J, Carlson R, Erlandsson M, Erixon M, Geiron K, *“Concept Model for the OMNIITOX Information System Including OMNIITOX Data Format Definition”*, OMNIITOX project report D20 and D26, 2004, EC contract G1RD-CT–2001–00501

[77] The work draft reference model is applied in the IMI Portal, involving tools for LCA and EMS, see http://databases.imi.chalmers.se/imiportal/ (2005-11-23)

[78] ISO, *“ISO/TS 14048 Environmental management — Life cycle assessment — Data documentation format”*, ISO Technical specification, 2002

[79] Tivander J, Carlson R, Erixon M, Pålsson A-C, *“IMPRESS integrated data format”*, IMPRESS project deliverable, CPM Report 2006:15

6.2.3 The IMPRESS data format

The resulting format was named the IMPRESS data format. Figure 14 shows and overview of the main concepts and their relations of the format. It can be regarded as a more highly resolved representation of the SPINE model. Blue colours represent technical system concepts, orange represents social system concepts, green represents nature system concepts where the darker green concern environmental impact models and the lighter green concern environmental impact assessment of industrial systems. The grey coloured substance concept is common to both technical and nature system.

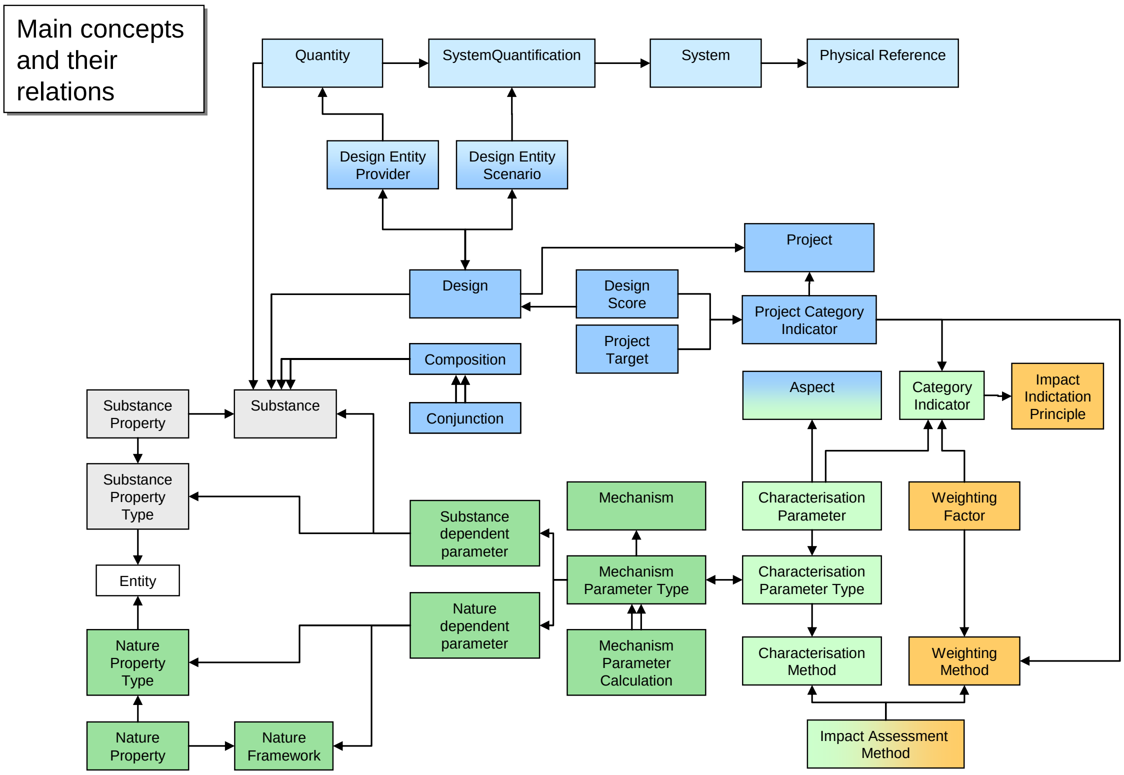

Figure 14 Overview of the integrated IMPRESS data format. Blue colours represent technical system concepts, orange represents social system concepts, green represents nature system concepts. The substance concept is used in all systems.

Each concept in figure 14 corresponds to a table in the format. Several other concepts are included in the format that supports the core.

All tables and fields have been documented in terms of conceptual meaning and with example data. An empty database was created which provide a full source code definition of the format as SQL statements. The integrated IMPRESS data format can be used directly to create a database applicable to all the tools applied within IMPRESS.

The IMPRESS data format is developed based on essential concepts and relations in industrial user domains. Thus, an interpretation of the data is built in to the database and gives the data meaning. Such a database preserves the value of the information, also if software, technical platforms and interfaces are changing.

6.2.3.1 Example extracted from the IMPRESS data format

To illustrate how the IMPRESS data format can be used as a reference in the integration work, an example with integration of substance and material property data is presented. Environmental impact model specialists and DfE specialists both manage substance property information. The DfE specialist deals with properties relevant for the design and component structure of an article, while the environmental specialist deals with toxicological, fate, and exposure properties required to assess how substances interact with the environment. Although these properties are used in different contexts and for different purposes, they share the same conceptual structure, see figure 15. A common database format could therefore correspond to both user requirements.

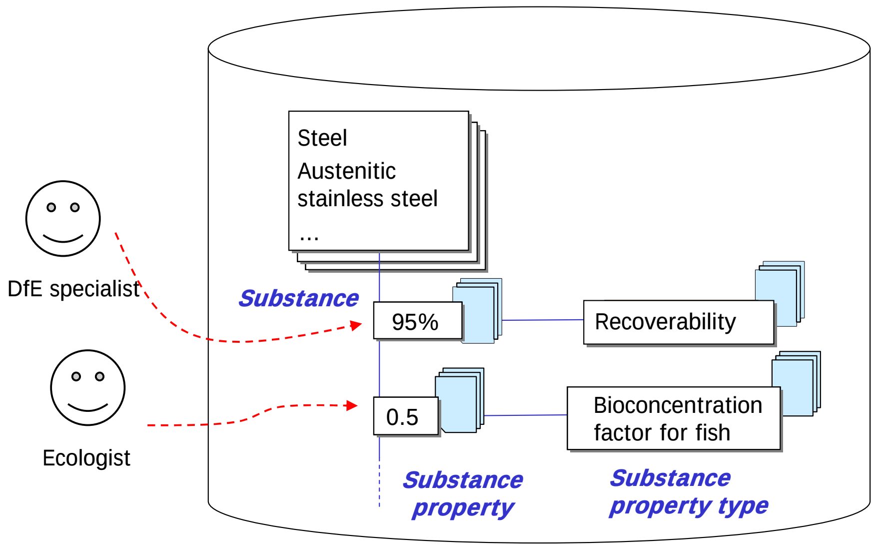

Figure 15 Different users can share the same data format regarding substance properties.

To exemplify how the data format is designed, the tables that correspond to the concepts Substance, Substance property type, and Substance property are shown in figure 16. The concept Substance property parameter type in the data model enables substance properties to have several parameters, e.g. the substance property Boiling point is dependent on the parameter Atmospheric pressure, the substance property Bioconcentration factor for fish is dependent on type of fish, duration of the test, etc. The substance property Recoverability is e.g. dependent on the geographical area.

The similarities between the two perspectives in this example may be rather obvious, but the principle is applicable also for more complex relations, e.g. the conceptual structure for substance properties can also be applied for nature properties such as Average precipitation, Surface area of water, Sun hours per year. Other examples of more complex relations are when integrating data for products or designs with data for processes. More examples of relations between the reference data model and user perspectives is found in the report *“Establishing common primary data for environmental overview of product* *life cycles; Users, perspectives, methods, data, and information systems"* [80] written for the Swedish EPA.

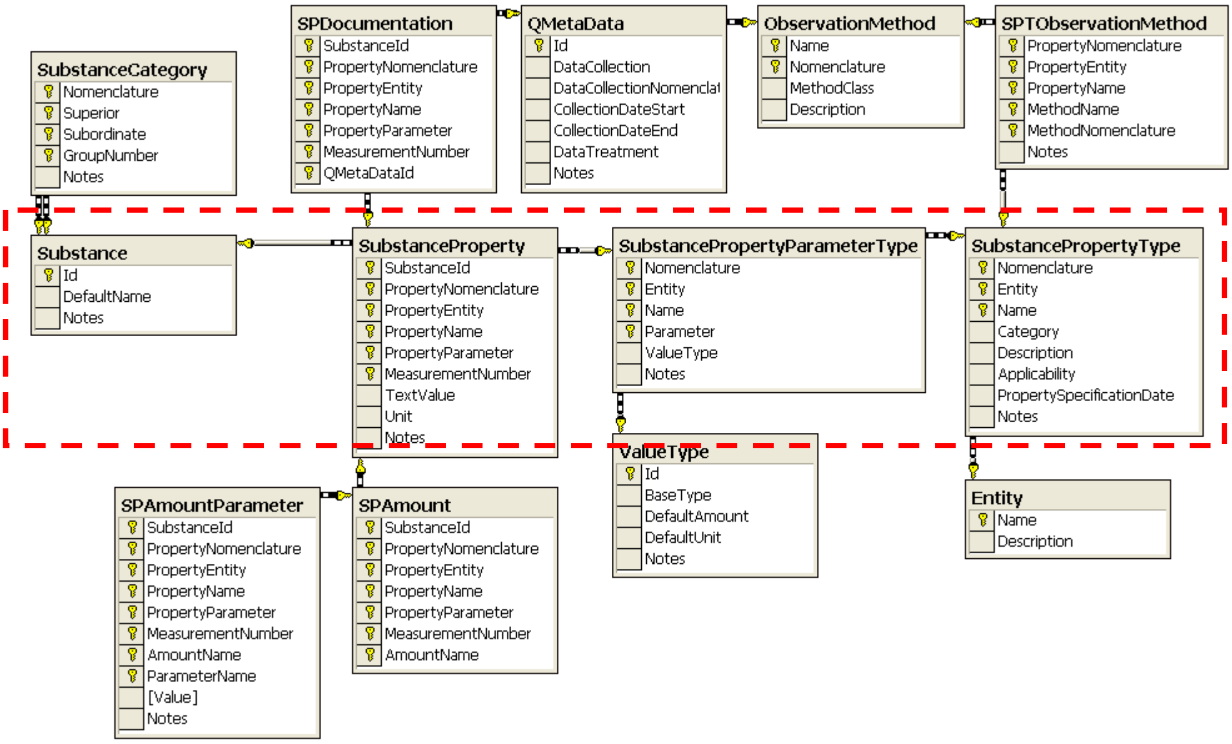

Figure 16 An extraction of the IMPRESS reference data model for structured storage of substance property data.

[80] Carlson, R. et al.; *"Establishing common primary data for environmental overview of product life cycles"*, Swedish EPA Report 5523, 2005

7 Knowledge exchange

The goal of the knowledge exchange activities was to provide forums where knowledge and experiences can be exchanged between CPM companies and CPM companies and academy. Experiences and knowledge that are shared come from the different sub-projects in IMPRESS, from other CPM projects, as well as from previous CPM projects.

Two knowledge exchange seminars have been performed for the whole project group, for education of CPM methodology, exchange of experiences, harmonisation of concepts and tools between the sub-projects etc. The first one treated Life Cycle Assessment (LCA), Environmental Management System (EMS) and Design for Environment (DfE) and the second one practical integration of environmental information, methods and tools. The project results were also communicated outside the project group, at scientific conferences. Finally a kick-out was held in the end of the project to summarize the results from the project.

Below is a more detailed description of these knowledge exchange events.

7.1 Seminar on LCA, EMS and DfE

An interactive seminar on Life Cycle Assessment (LCA), Environmental Management System (EMS) and Design for Environment (DfE) experiences within CPM and the participating companies was held February 28- March 1, 2005 at Chalmers for the whole project group. The aim of the seminar was to discuss and exchange knowledge in the areas of LCA, EMS and DfE. The meeting was planned and prepared by IMI participants and several of the participants in the companies. Reporting on the status of the work in the sub-projects was also included in the seminar.

7.2 Seminar on integration of environmental information tools

An interactive seminar on practical integration of environmental information, methods and tools and the advantages with this was held December 8, 2005 at Chalmers for the whole project group. The aim of the seminar was to discuss and exchange knowledge on integration. An IMPRESS full group meeting was also held in connection with this meeting where results and next steps of all sub-projects were demonstrated by the sub-project leaders (both IMI and company participants).

7.3 The IMPRESS kick-out

A kick-out for the project IMPRESS was held the 26th of September 2006. The aim was that companies that had only participated in one or two of the industrial case studies would get a chance to see the project from an overall perspective.

The presentations held at the kick-out were based on the experiences gained at the visits at the CPM companies (see section 7.4). The results from each of the sub-projects in IMPRESS were presented and the integration between the different methods and tools was visualized with the demonstration tool VIEWS (see section 9).

7.4 External knowledge exchange

In addition, IMPRESS results have been communicated outside the project during the project runtime at the LCM conference in Barcelona in September 2005, FLIPP/CPM conference at Chalmers in March 2005, the CPM workshop 24th of January 2006, the LCE conference in Leuven in May/June 2006 etc. Because many of the participants from the industry have participated in more than one sub-project and since each IMI-personnel in IMPRESS all have participated in more than three sub-projects, knowledge exchange between different sub-projects has been good. Similarities and synergy have been discovered at an early stage and harmonization of activities has been performed where possible.

8 Results exploitation and dissemination

The objective of IMPRESS sub-project 5, “Results exploitation and dissemination”, was to identify business ideas and develop a plan to commercialize CPM results.

8.1 Background

Since the start of CPM, the database and information system for LCA data sharing and publication has been at main focus for the common work and industrial interest[81]. The computer network, common nomenclatures, quality review, ISO standardization, practical support etc. associated with this work is industrially valuable and may also represent both an economical value as well as a commercial market. A durable and sustainable future for these results will need a durable and sustainable business idea, with well-defined products and services and well-defined customers and other financing stake holders.

Previous results to use as input are e.g. the integrated toolbox developed from the different deliverables within CPM phase three, i.e. LCA@CPM (enhanced SPINE@CPM systems) , DfE Tools (RAVEL/REPID systems), EMS tools (WWLCAW and more) and Tools for primary environmental data (e.g. OMNIITOX and similar systems).

8.2 Purpose and Scope

The main purpose of this sub-project was to reassure that the result that have been achieved during the ten years of work the in the competence centre CPM will remain and be able top be used in the future. After CPM the industry need to rely on commercially durable and sustainable suppliers and vendors for the methods and tools developed within CPM. This project is starting to identify the business idea, in a combined effort between developers, industrial end-users and other stake-holders of the society. This includes e.g. to distinguish between commercially exploitable results that are prepared to be further disseminated as they are and theoretically underdeveloped results that still need to be further understood and developed.

The sub-project aimed also to force the work with implementation of methods and tools to be focused on durability in the long run, in order to assure genuine user-friendliness in the CPM tools, provide them with support functions etc.

The scope of the sub-project is the available IMPRESS related environmental information tools and the industrial needs at the CPM companies of IMPRESS related environmental information tools.

[81] Carlson R., Pålsson A-C; *"Establishment of CPM's LCA Database"*; CPM Report 1998:3

8.3 Overview of the available environmental information tools

8.3.1 Schematic picture of available environmental information tools at CPM

A specified task in this sub-project was to draw a schematic picture of available IMPRESS related environmental information tools at CPM.

In sub-project 3 “Maintenance of integration”, the IMPRESS tools were assembled and a map of the integration intention was sketched as a prospect of the LCA/DfE/EMS-seminar in February-March.

8.3.2 Summary of industrial environmental informatics needs within CPM

Another task in the sub-project was to identify and specify industrial needs of IMPRESS-related environmental information (management) tools at the CPM companies. At a brainstorming session within IMI to capture the companies’ needs, identified through work with in IMPRESS and other projects the following results were the outcome:

Explicit needs

- Build LCA tool
- LCA tool
- Database for environmental properties of materials
- Emission trading tool
- REACH management tool
- Communication of environmental performance of products
- Communication of environmental performance of sites
- Measure environmental performance of products
- Measure environmental performance of sites
- Control confidential data
- LCI data suitable for the company’s specific needs
- Generic LCI data
- Characterization data suitable for the company’s specific needs
- Establish continuous inflow of data
- Appreciation of environmental competence internally
- Participation in the regular business activities
- Support in different issues

Implicit needs

- Support for in-house system development
- Operationalize the policy/increase controllability
- Integration
- Advantages through better solutions than others

Obstacles in methodology development

- Contact with right users
- Information systems (security settings) at companies

- System development resources
- Data management resources

Market
- Competitors
- Vague sale channels
- Resource deficiency regarding our competence

8.3.3 Compilation of CPM results for exploitation

Sub-project 5 had also the aim to formulate input for decision to the CPM board, regarding ways to commercialize, exploit, and further disseminate CPM-results.
A compilation of CPM results within Industrial Environmental Informatics was made in terms of:

- Data models
- Methods
- Manuals
- Technical specifications
- Prototypes
- Databases
- Data
- Nomenclatures
- Concept and explanation models
- Company relations
- Trademarks

The compilation was discussed at an IMI internal meeting and further structured into publicly available results that are free for anyone to exploit (published reports, methods etc), and prototype candidates for products. The list of the available prototypes was structured into the following groups:

- In practical use in commercial organization
  - Practically useful, but not salable in current form:
    - WWLCAW
    - LCA@CPM
    - Data conversion
    - IMPRESS-adaptation of CPM inventory tool, with report tool included
    - SPINE@CPM Data Tool
    - SPINE@CPM
- Commercially requested from potential market
  - LCA@CPM
  - Streamlined tools for LCA, DfE, EMS, EPD, ERA, GHG emission, REACH
  - EMS@CPM
  - IMPRESS-adaptation of CPM inventory tool, with report tool included

    - Tool to configure the 14048 data format for data documentation based on user needs
- Potentially commercial
    - SPIDER
    - SPINE LCI data review tool
    - SPINE LCI data quality classification tool
    - Client-based LCI-data documentation tool based on ISO 14048 data format
    - Tool for import of characterization factors from OMNIITOX IS to LCA@CPM
    - Tools for data transfer between formats (Eco-Spold, SPINE – ISO 14048)

Estimates of the investments that have been made to develop the results were compiled, and also estimates of potential value of results were developed. The compilation and the estimates of investments and value were presented to the CPM board in November 2005. The board was generally positive to exploitation.

8.4 Different ways to commercialize, exploit, and further disseminate CPM results

8.4.1 Support for implementation and application for commercialization of results from VINNOVA programme of competence centers

A notification of interest was sent to VINNOVA in August 2005, based on an announcement regarding support for implementation and application for commercialization of results from their programme of competence centres (including 28 centres at 8 universities in Sweden). 2,5 MSEK was distributed to about 10 projects/ideas.

IMI received 200 kSEK from VINNOVA for supporting commercialization of CPM results. A company will be formed and the money will be spent on start up of business activities.

8.4.2 Report regarding spin-offs and patent and license of products

The possibility of spin-offs and patent and license research results were investigated in meetings with Henrik Jansson at Chalmers Innovation and Henric Rhedin at Chalmers Industriteknik (CIT). They informed about Chalmers Innovation systems (CIS), what to think about regarding spin-offs and what Chalmers Innovation requires and can contribute with, the procedure of patent and license, and an on-going patent and license project at Chalmers. A short report was compiled with the acquired information (Appendix 2)

8.4.3 Information about commercialization

One of the tasks in this sub-project was to look after the project members' interest in commercialization of CPM results, to inform about the current status and have an open forum for discussing these issues. As a consequence of the many questions regarding this matter that came up during the kick-off in the beginning of November 2004, an informative slide show "Information about commercialization" (in Swedish) was compiled and sent out to all participants in January 2005 and it was also published at the IMPRESS internal website. The slide show was also presented in short at the project seminar at February 28th – March 1st 2005. No further questions or comments have come from the project participants after this information.

8.5 Visits at CPM companies

The results from IMPRESS were also demonstrated at the companies in September 2006. All CPM companies received an invitation to an individual presentation. The intentions with the presentation were to reach out with research results and receive feedback from the companies. VIEWS was a central part of the presentation and discussions and included in the demonstration were also short presentations of background results such as reference models used and experiences from previous projects. It was found that VIEWS worked well as support to visualize, understand, and define problem formulations specific to each company and to find ideas to proceed to find solutions. Specifically the practical demonstration of an integrated policy and indicator management was helpful to understand the benefits of integrated environmental information systems.

8.6 Conclusions from sub-project 5

In this sub-project, steps have been taken in the direction of making the results from the CPM work able to commercialize. This has included tasks such as informing all project participants about the current status regarding commercialization of CPM results and having an open forum for discussion. This has been a very successful part of this sub-project as there were many questions regarding the commercialization in the beginning of IMPRESS and after information was sent out, no more questions were received.

Different ways of commercialize, exploit, and further disseminate CPM results were investigated, such as the possibility of spin-offs and patent and license research. IMI has also received funding from VINNOVA to support commercialization of research results that IMI has developed within CPM.

A compilation of existing IMPRESS related tools, both commercially exploitable results that are prepared to be further disseminated as they are and theoretically underdeveloped results that still need to be further developed, was made and also an identification and specification of the industrial needs of IMPRESS related environmental information (management) tools at the CPM companies. This information was used to formulate an input for decision to the CPM board, regarding ways to commercialize, exploit, and further disseminate CPM results.

9 Visualization of Integrated Environmental Work Spaces – VIEWS

VIEWS is a visualization of what it may look like to work with environmental work spaces that are integrated in reality. In VIEWS, there are five different environmental work spaces: Life cycle assessment (LCA), Environmental management systems (EMS), Design for Environment (DfE), Chemical Risk Management (CRM) and Emission Trading Scheme (ETS).

The work with VIEWS has been performed as a case study within IMPRESS sub-project 2 "General method development". The work spaces have been integrated using the general integration method developed in sub-project 2. The integration work has been transparently performed and documented.

9.1 Accomplishing integration in practice

The work with industrial environmental informatics within CPM has since it started focused on the possibility to integrate different environmental information systems. The interfaces between tools and methodologies such as LCA[82], ERA[83], DfE[84], EMS[85] have been studied in order to find the overlaps and the gaps. All the prototype software tools have been constructed in a general way, using the same or compatible database formats[86]. Everything has been made to prepare for an actual integration in the future.

In IMPRESS sub-project 2, "General method development", a general methodology for integration of industrial environmental information systems has been developed, see section 6. Using this methodology, IMI has, in practice, integrated the methods and tools that have been involved in IMPRESS. The result is visualised in a common user interface – VIEWS (Visualization of Integrated Environmental Work Spaces).

By accomplishing the integration in practice, the following results were achieved:

- VIEWS is a proof that it is possible to integrate different environmental methods and tools in practice
- VIEWS serves as a practical education tool for demonstrating how different environmental management tools can be integrated
- The problems and difficulties that were encountered in the implementation integration work with VIEWS have been overcome and the experiences are added to the integration methodology

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[82] Carlson R, Pålsson A-C, *"PHASES Information models for industrial environmental control"*, CPM-report 2000:4

[83] Flemström K, Carlson R, Erixon M, *"Relationships between Life Cycle Assessment and Risk Assessment - Potentials and Obstacles"*, Swedish EPA Report 5379, 2004

[84] Carlson R, Forsberg P, *"The RAVEL_Information Platform Data Model"*, RAVEL project doc nr CPM-000919, 2000

[85] Carlson R, Häggström S, Pålsson A-C, *"Policy controlled environmental management work - Final report"*, CPM Report 2004:10

[86] Carlson R, Pålsson A-C, *"Slutrapport projekt II:F:12 Integrerade Miljöinformationssystem"*, CPM rapport 2001:17 (in Swedish)

- VIEWS can serve platform for further research including measuring cost effectiveness of having integrated environmental methods and tools

9.1.1 Theoretical basis from previous research results

The work with VIEWS is based on previous research results from Industrial Environmental Informatics (IMI).

9.1.1.1 Environmental Performance Indicators

Raul Carlson described in the article from 2002[87] how Environmental Performance Indicators (EPIs) are central to all environmental management, regardless of whether it concerns management of organisations, product design, procurement, or sales. Without distinct and quantifiable dimensions that can be understood and measured using high-quality information, any environmental management will be merely cultural and rhetoric; only the first rough improvements may be gained from sheer understanding of environmental issues. There are no alternatives to developing and managing EPIs in situations like environmental product improvements or trade-off dilemmas between alternative investments to improve the environmental performance of products or production facilities.

VIEWS is therefore built-up from one common selection of indicators (for environmental performance) for all the work spaces. The common indicator set reassures that the same goals are strived for in all applications.

9.1.1.2 Integrated Business Environmental Information Management

The integration of a business' entire environmental information management is described in the article about the IBEIM (Integrated Business Environmental Information Management) system from 2001[88]. IBEIM was designed to encompass and integrate all environmental information management activities within business organisations, and in their external communication.

The IBEIM design is based on an overall view including all current needs and has an open design towards future demands, as long as these future demands are formulated in a way similar to current demands. This means that environmental management concerns industrial and other human activities and is expressed in terms of environmental indicators and physical flows that are assessed with for example impact and risk assessment methodologies. IBEIM structures information acquisition and storage. It supplies a structured approach to information communication and aggregation, all the way from measured entity and up to highly aggregated reports. In addition, it supplies standard communication formats as well as translations between different formats. All these functions and structures are needed for a truly integrated information system.

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[87] Carlson R, *"Environmental Performance Indicators"*, The International Council on Systems Engineering (INCOSE), Published in INSIGHT, Vol 5 Issue 2 July 2002 p. 22-23
[88] 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

9.2 Implementation of VIEWS

The work with integrating the methods and tools used in IMPRESS was performed in accordance with the general methodology for integration developed in sub-project 2 “General method development”. The methodology contains three steps; analysis, synthesis and implementation.

9.2.1 Survey and analysis of existing information system

This section presents the results from the survey and analysis of the existing environmental information system.

9.2.1.1 Purpose of integration

The reasons and expected benefits from the integration were found to be:

- A possibility to look at the same data from different views (Life cycle assessment (LCA), Environmental management systems (EMS), Design for Environment (DfE), Chemical Risk Management (CRM) and Emission Trading Scheme (ETS))
- To provide a visual platform in order to easier understand what is implied by integrating different tools and methods.

The benefit of the result can be measured by:

- The amount of new possibilities to look at data from different views.
- The number of IMPRESS project participants that state that the VIEWS platform increase their understanding of how integration can be implemented in reality.

9.2.1.2 Scope of integration

The scope of VIEWS was to cover and integrate the different tasks, methods and tools that were dealt with in the industrial sub-projects of the IMPRESS project. This included the tasks Life cycle assessment (LCA), Environmental management systems (EMS), Design for Environment (DfE), Chemical Risk Management (CRM) and Emission Trading Scheme (ETS). A set of corresponding software tools developed by IMI and CPM were selected:

- The LCA tool WWLCAW
- The DfE tool CPM Inventory tool + EPI reporting tool
- The EMS tool EMS@CPM
- The ETS tool IMPRESS Emission Trading data tool
- Support for assembled risk documents needed for the REACH legislation

The IMI material database (material nomenclature and substance properties) was used for the DfE data supply. The life cycle inventory (LCI) data base LCI@CPM was used for the LCA data supply. Some additional data needed to be acquired to provide good example data fulfilling the purpose of VIEWS, e.g. product specific data from the companies. The CPM data quality criteria were to be used for new data acquisition. The limitations in resources lead to the decision to only include the impact assessment method EPS 2000, and hence only LCI data matching the scope of the EPS method was acquired.

A specific aim was to integrate the use of indicators in all the included tools and methods.

The tasks included in the integration scope are:

- Already implemented with existing methods and tools:
    - Document CO2 emission data
    - Produce Emission Trading report
    - Document LCI process data
    - Perform LCIA
    - Policy analysis
    - Calculate Environmental Performance of process
    - Document component structure
    - Document material properties
    - Calculate EPI according to RAVEL methodology
    - Acquire substance properties
- Other tasks where only a method is available
    - Document yearly process data
    - Chemical risk data management
    - Document and report exposure scenarios

9.2.2 Synthesis of the integrated system

9.2.2.1 The vision of an integrated information system

The vision including all work tasks within the scope of the integrated information system VIEWS - Visualization of Integrated Environmental Work Spaces is shown in figure 18.

The dotted lines set the scope boundary of the integrated information system. The information system delivers information in the five areas LCA, ETS, EMS, CRM and DfE. The receiver of the information is indicated by the label at the end of the black arrows. In the case of LCA, CRM and EMS, the information is managed further into reports outside the scope of the VIEWS information system. The red oval shapes represent the information that is delivered by the information system. For each of the five areas it is marked what tasks are involved, who will perform the tasks. The black lines represent system internal data communication and the lines are labelled with what kind of data is communicated. The blue lines are new communication interfaces between the tools.

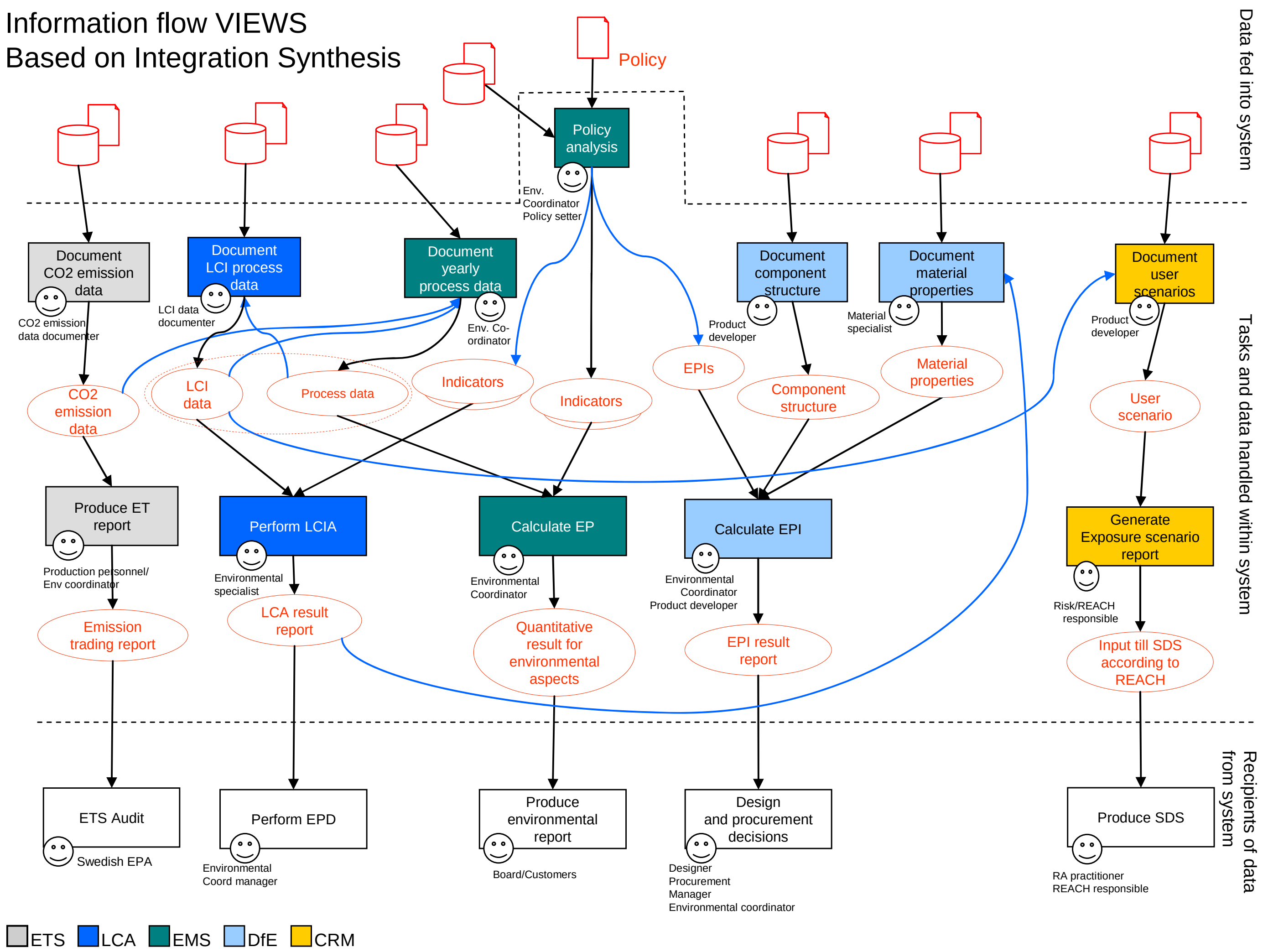

Figure 17 Illustration of the information flow as implemented in the integrated information system VIEWS.

9.2.3 Implementation of information system

9.2.3.1 Common user interface for the different work spaces

Indicators are used in LCA, ETS, EMS, DfE, and environmental impact modelling. A common indicator management view for the indicators was created. The set of relevant indicators are connected to an environmental policy which is shown in the indicator management view. This policy is common for all tools so that all tools work with common priorities towards the same goal. An integrated selection of indicators for all tools is thus made. For a specific study, a case specific selection of indicators can be made in the respective tools.

A common product management view was also made to give the user an overview of the information that is available for each product; life cycle inventories, component structure etc. Likewise, a common process management view was made to give an overview of the available process information; inventories for EMS and LCA are listed.

9.2.3.2 Integration interface between DfE and LCA

The interface between DfE and LCA was constructed as material properties in terms of life cycle indexes in the material property database. The life cycle indexes were created by calculation of LCA results, cradle to gate, with the EPS 2000 impact assessment method and the results are stored as material properties in the IMI material database. The material property life cycle index requires thus that an LCA data set exists for that material. Both characterization and weighting is included in the life cycle index. The life cycle index is recalculated if any changes are made to the LCA data set so that the value is always updated, compare with ETS data to the EMS work space below.

9.2.3.3 Integration interface between EMS, LCA and ETS

The gate to gate life cycle inventory (LCI) data set and the documentation of the inputs and outputs for the environmental management system (EMS) have been merged in VIEWS. This means that the same data set is used for both purposes. When the data set is shown in the LCA work space, the functional unit is e.g. 1 kg of product, and when the data set is shown in the EMS work space, the functional unit is scaled to the yearly production. The data requested by the emission trading scheme (ETS) is regarded as a subset to EMS, but with enhanced documentation requirements. The inputs and outputs documented in an ETS data set can thus be imported to a data set in the EMS work space and continuously updated, compare with LCA data to the DfE work space above.

9.2.3.4 Integration interface between LCA and CRM

Data for the exposure scenarios for chemical substances created in the CRM tool can be imported from an LCA study. The name and class of the process where the substance is used and information about operational conditions description of the operational conditions matches the content in the ISO/TS 14048 fields “Name”, “Class” and “Technical content and functionality” which can be imported. In the CRM tool there is also a link to substance data from OMNIITOX IS.

9.2.3.5 System development

Additional new functionality was needed in order to integrate the tools and create a common user interface for the different work spaces:

- User interface for VIEWS with a common logon for all tools and new entrances to the tools
    - Common indicator management view with connections to the different views that are used to work with different indicators.
    - Common product management view with all products included in VIEWS
    - Common process management view with all processes included in VIEWS
- Import of data from one work spaces suitable for another work space

    - Search functions for data from one work spaces suitable for another work space
    - Identification of the property that will be exported
    - Scaling of data to the unit of the new work space
- Update of data imported from one work space to another
    - Store the information that the property is used in another work space
    - Store information about scaling factors between different work spaces for each data set

The design for environment (DfE) tool in IMPRESS, the CPM Inventory Tool, was further developed in VIEWS in order to clearly separate the user interfaces for the designer and the environmental coordinator:

- *Environmental coordinator's interface* with the possibility to define indicators, setting target values and document specific values on the material properties
- *Designer's interface* where designers and suppliers can document component structures and material content of products and components

Substantial improvements were done to the LCIA calculation and reporting functionality. Any bugs encountered in the existing tools was followed up and eventually fixed. This included miscalculations done by the LCA tool. The security handling was also harmonized between the tools to reduce the number of required user logins to make it easier to navigate between the work spaces.

9.2.3.6 Data collection

A data collection was performed to supply VIEWS with data relevant for all companies participating in IMPRESS in order to show how VIEWS can be used for them:

- Environmental policy to be valid for the entire VIEWS
- Definition of relevant products, one product from each of the IMPRESS companies
    - Product data – materials, component structure etc.
    - Production data – inputs and outputs from production site
- LCA data sets for the selected products and the included materials
    - Cradle to gate data sets
    - Gate to gate data sets
- The environmental aspects covered by the impact assessment method EPS 2000 (which were the data categories[89] for the inventories)
- Definition of relevant EPIs and material properties needed for the EPI calculations.
    - Target values on EPIs for different products
- Safety data sheets for the selected products
- Emission trading data for the relevant sites

[89] ISO, *"ISO 14041: Environmental management - Life cycle assessment - Goal and scope definition and inventory analysis"*, 1998

9.2.3.7 Documentation and manuals

The individual tools already had user manuals with varying quality. A new manual was written for the overall VIEWS web-platform and the individual manuals were revised and edited into a consistent format. Additional help texts were written for the new integration interfaces.
The development work was documented and included in the general method report.

9.2.3.8 Demonstration and evaluation of VIEWS

Use case testing
A test of the platform was done in order to discover potential flaws and receive recommendations for improvements. A temporary employee at IMI conducted the test and it was intentional that the person was not familiar with CPM results. The results from the tests led primarily to improvements of user manuals and navigation help as it sometimes was difficult to understand which the current view was, especially when working with data communication between the views.

End user demonstrations
At the end of the IMPRESS project the resulting VIEWS platform was demonstrated to the CPM companies. IMI personnel made individual presentations to ABB, IKEA of Sweden, Stora Enso, Schenker, and Bombardier Transportation. VIEWS was also a central part of the presentation and discussions at the IMPRESS kick-out where ITT Flygt, SCA, and Swedwood participated. The intentions with the presentation were to reach out with research results and receive feedback from the companies. It was emphasized in the presentations that VIEWS is a demonstration tool, not intended for direct use in industry. Included in the demonstration were also a short presentations of background results such as reference models used and experiences from previous projects.

9.3 Description of VIEWS

VIEWS is in practice a model or demonstration system illustrating how an integrated environmental information system look like in practice. The environmental information management tools can be used independently but underneath, they have an integrated structure and data can easily be shared between the tools.

In the integrated system developed within IMPRESS, there are five different environmental information management tools – or *end user applications*; life cycle assessment (LCA), environmental management systems (EMS), design for environment (DfE), chemical risk management (CRM) and emission trading scheme (ETS).

9.3.1 Conceptual illustration of VIEWS

A conceptual illustration of VIEWS was created based on the reference models SPINE and PHASETS are a are integrated like the picture below illustrates.

The environmental work spaces are different environmental information management tools, e.g. LCA, DfE, EMS etc. The number of integrated applications can be all from 2 (then forming a triangular cylinder together with PHASETS) and upwards. In Figure 19 below, examples with 5 and 3 environmental information management tools are shown.

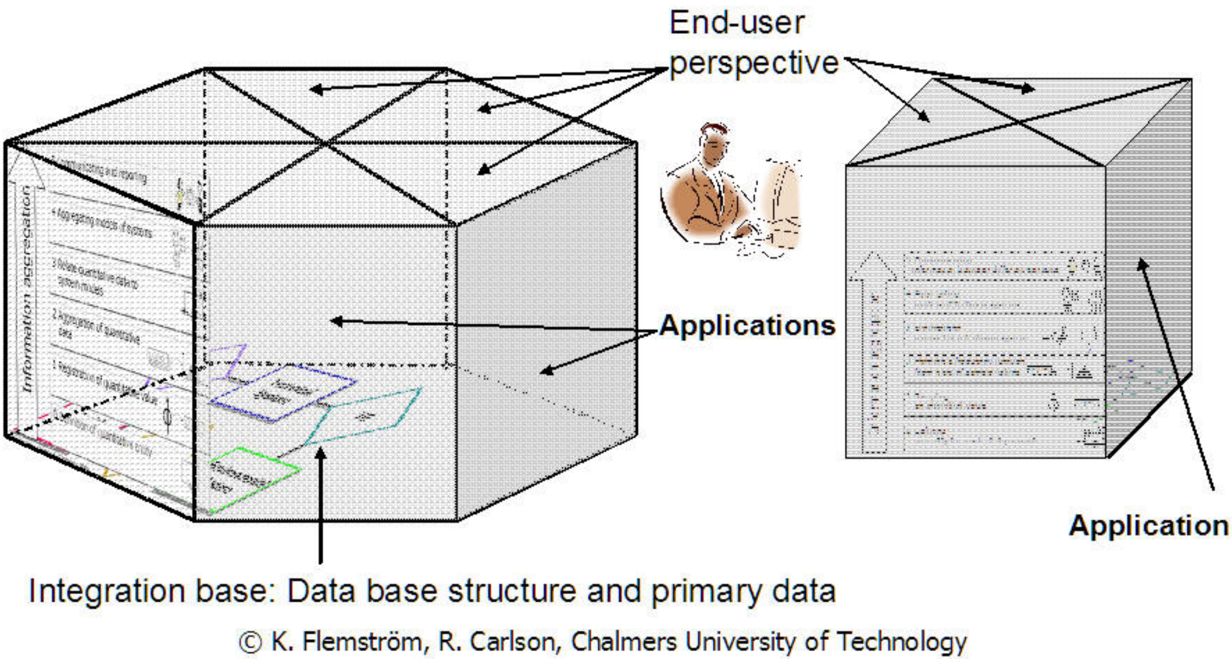

Figure 18 Visualization of different work spaces, five integrated work spaces on the left and three integrated work spaces on the right, and PHASETS as one side in both models. The base of the figures are a common information platform represented by the SPINE information model

In VIEWS, five applications are integrated; Life Cycle Assessment (LCA), Design for Environment (DfE), Environmental Management System (EMS), Emission Trading (ET) and Chemical risk management (CRM). It is therefore illustrated as a hexagonal cylinder, where the sixth side is the PHASETS reference model. The conceptual illustration of VIEWS is shown in from two different angles in figure 20 below.

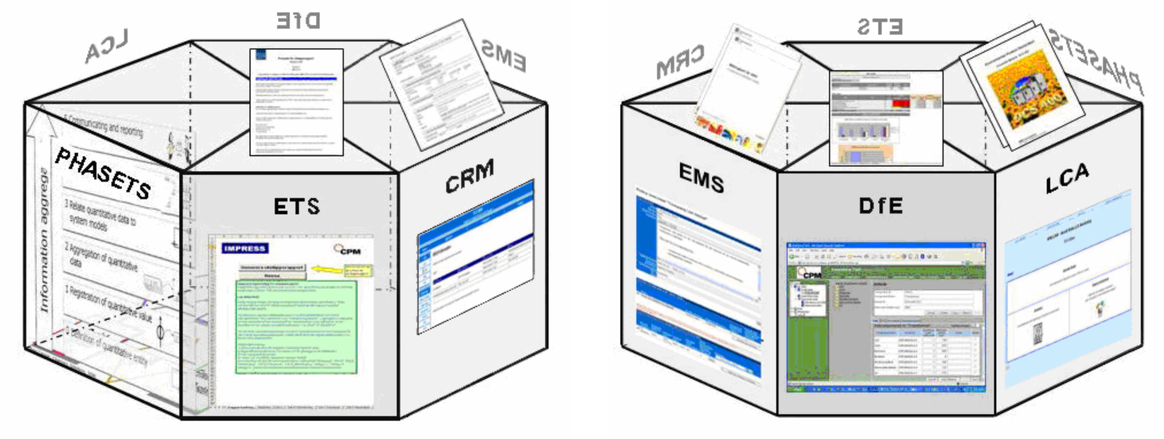

Figure 19 Illustration of VIEWS in IMPRESS with five applications and two reference models: PHASETS and SPINE.

The conceptual illustration can also be seen at the start page when opening VIEWS as shown in figure 21.

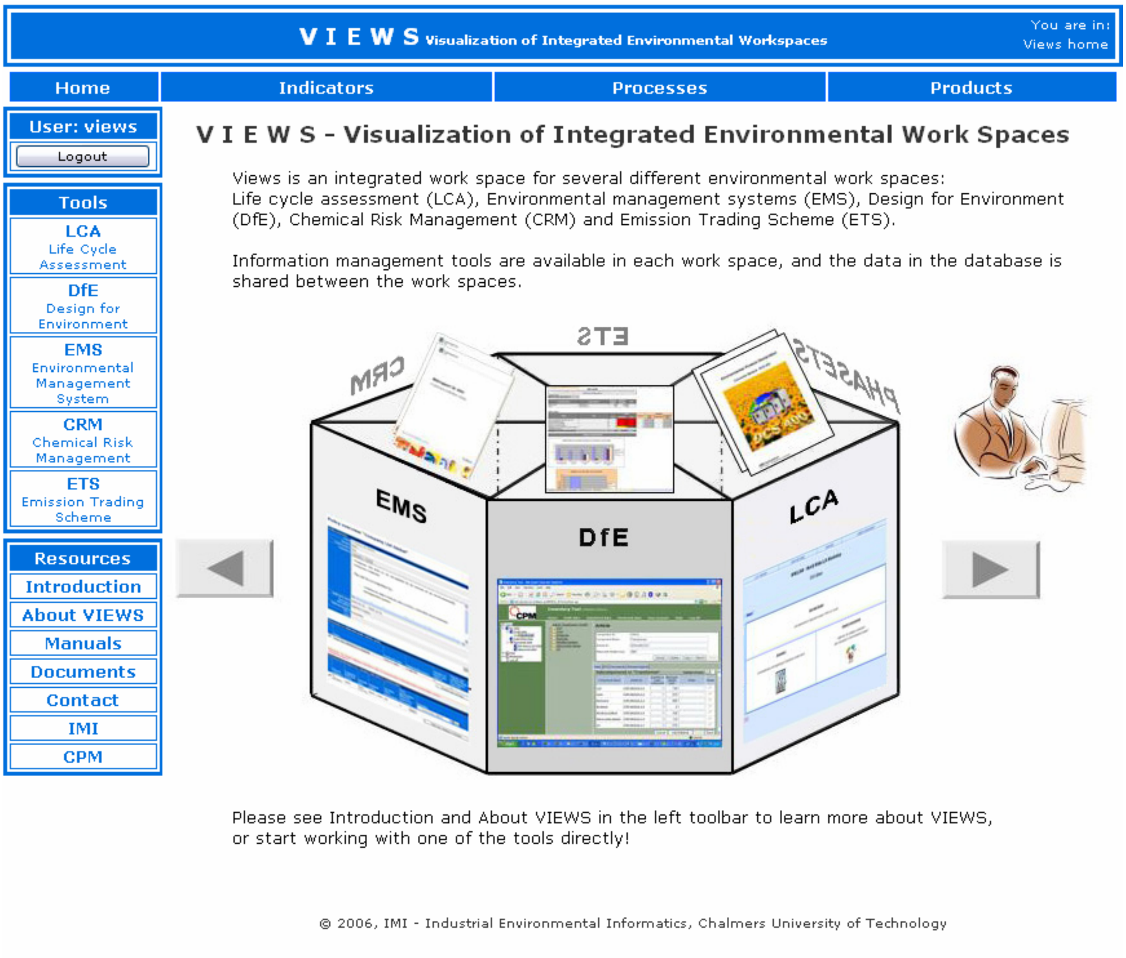

Figure 20 Screenshot of the VIEWS start page.

9.3.2 How to use VIEWS

VIEWS is a tool to demonstrate integration in practice. It is not intended nor suited to be used directly in operational business.

VIEWS is not a new tool replacing old tools. VIEWS consists of joints or bridges between the tools so that they can continue to be used as usual, only now they are parts of a connected system. The environmental information management tools can be used independently but underneath, they have an integrated structure and data can easily be shared between the tools. This modularized system makes it also possible to add other information tools to the integrated system later. Figure 22 below show the Inventory Tool for DfE opened within the VIEWS platform.

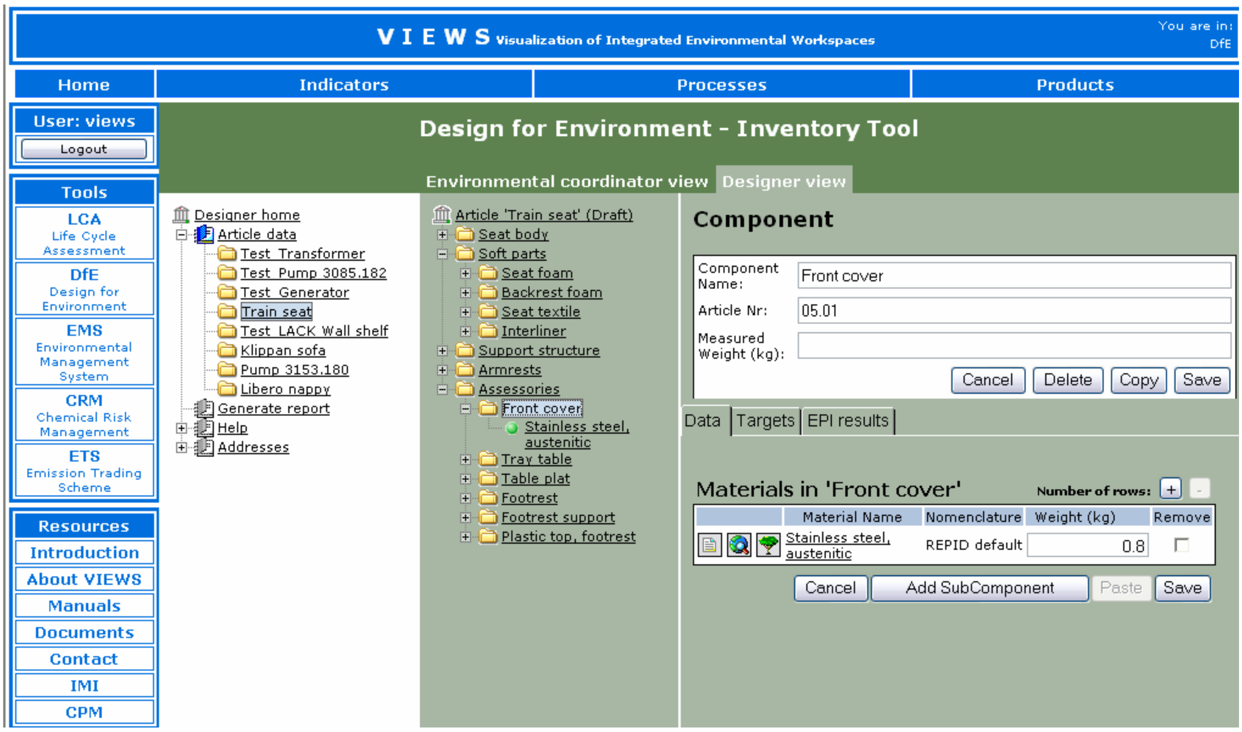

Figure 21 Screenshot of the VIEWS Inventory Tool.

9.4 Conclusions from the work with VIEWS

The work with VIEWS resulted in a successful implementation of integration of tools used within IMPRESS, as intended. The VIEWS platform provides a hands-on tool to look at the same data from different views (Life cycle assessment (LCA), Environmental management systems (EMS), Design for Environment (DfE), Chemical Risk Management (CRM) and Emission Trading Scheme (ETS)). VIEWS is a tool primarily for demonstration and educational purposes to show possibilities to integrate different tools. It should be noted that the VIEWS platform is not intended as a tool that can be directly used by a company for their operational work.

The benefit of the result can be measured by:

- The amount of new possibilities to look at data from different views.
- The number of IMPRESS project participants that state that the VIEWS platform increase their understanding of how integration can be implemented in practice.

With regard to new possibilities to look at data from different views an example is LCA data. Process data originating from data acquired for LCA can be viewed in the EMS tool and vice versa. A specific Process view has been included with a combined list of all processes in the system. The technical functionality description part of the process data can be viewed as exposure scenario data in the CRM tool. Material properties used in the DfE tool that are based on LCA calculations are connected with the original LCA data. This makes a total of five different possibilities to view the same LCA data in the same information system.

Based on the reactions from company representatives to whom the VIEWS platform was demonstrated we conclude that the integration purpose to provide a visual platform in order to easier understand what is implied by integrating different tools and methods has been partly fulfilled. VIEWS in itself may not be sufficient to describe the integration benefits or process but should be accompanied with a clear presentation of the underlying reference models and methods. In this way VIEWS can be seen as a practical support to understand fundamental principles of integration of industrial environmental information systems. In the discussions at the presentations at the CPM companies VIEWS worked well as support to visualize, understand, and define problem formulations specific to each company and to find ideas to proceed to find solutions. Specifically the practical demonstration of an integrated policy and indicator management was helpful to understand the benefits of integrated environmental information systems.

This work involved the coordination of the information management of tools that have been developed individually. In this process it became evident that it is crucial to have a clear understanding of the original meaning of the information pieces used in each tool. All the tools included in the implementation of VIEWS were originally developed based on documented and open concept models, database formats, and software. This greatly facilitated an efficient synthesis and implementation of the integrated system. A close dialogue between data collectors and software developers also helped to keep the development on within the intended scope.

To conclude as prerequisites for integration it is ideal that the method of the original each individual part of the system follows a well understood concept model with a well defined scope, based on real world entities and relations.

10 Conclusions

In this project, it has been shown how information, methods and tools that supports environmentally related decisions within the industry, can be integrated with each other and with the corporate business processes and also how the integration can be implemented into the organisations. The work has been based on existing methods and tools, used in the CPM companies today. Some highlights from the project are presented below.

10.1 Experiences of integration

Integration of the environmental methods and tools developed at IMI and within CPM has been discussed for several years[90]. The database structures and nomenclatures etc. have been chosen to prepare for future integration. The IMPRESS project has finally shown that this work has actually been relevant and useful as the integration has now been implemented in practice.

In IMPRESS, the general integration method has been developed based on practical experiences of integration between existing methods and tools for environmental management. This method has also been tested in practice by integrating five of the tools used in the project; Life Cycle Assessment, Environmental Management Systems, Design for Environment, Emission Trading and Chemical Risk Management. The result from this integration can be seen in the demonstration tool VIEWS (see section 9).

In section 2, Overall goals and objectives, it is described in detail the expected benefits with integration:

- **Decreased cost for industrial environmental management**
- **Decreased cost for developing, using and maintaining data, tools and methods for industrial environmental management**
- **Increased quality of the information**
- **Facilitated acquisition of environmental information**

In addition two new benefits from the work with integration have been found:

- **Increased control of environmental work**
  It is already known that there exist both overlaps and gaps between different tasks in the environmental management of companies. Examples of overlaps are documentation of process data, which is demanded both for emission trading, environmental management systems and for life cycle assessment studies and documentation of substance and material properties which is demanded both for risk management and design for environment. These overlaps are visualized in the demonstration tool VIEWS (see section 9). Examples of gaps are real data from suppliers and sub-suppliers on upstream effects and material properties, which are today filled with statistic data that will not reflect any improvements made. Increased possibilities of control could result in that resources that are today spent

[90] Carlson R, Pålsson A-C, *"Slutrapport projekt II:F:12 Integrerade Miljöinformationssystem"*, CPM rapport 2001:17 (only in Swedish)

on overlaps instead could be put on the areas where there exist gaps.

The work with controllability connects all the environmental work performed in a company to reach the environmental goals, as described in the figure 17 below.

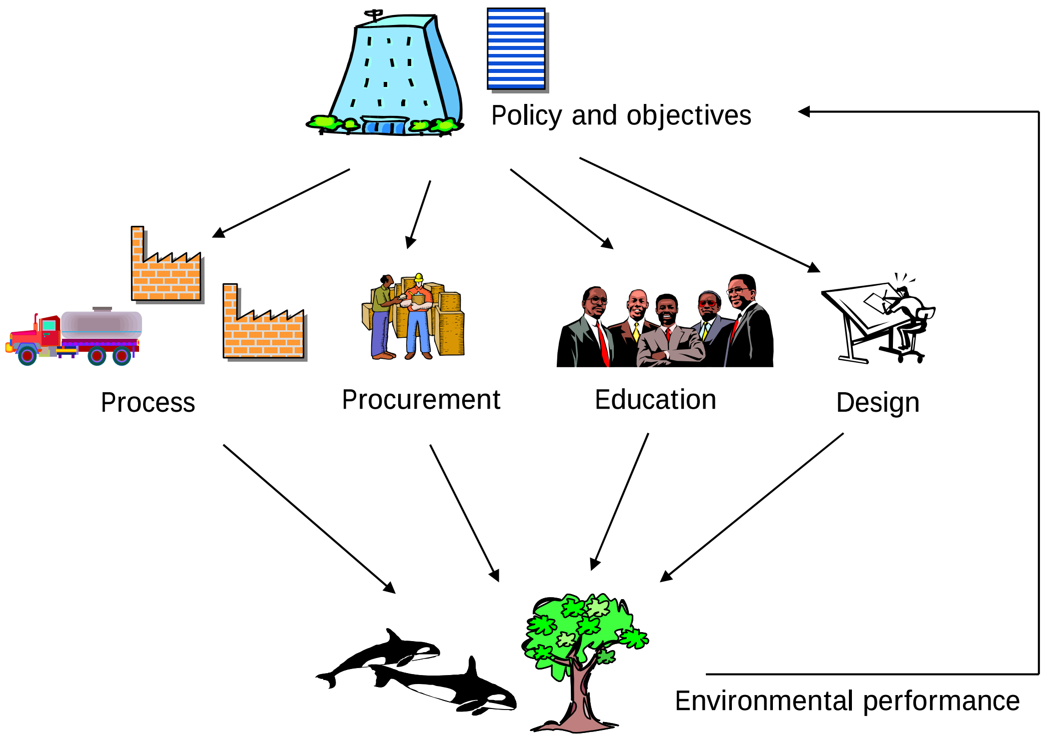

Figure 22 The policy and the environmental goals of the company is the same for all environmental work in the company. The activities all contribute to the overall environmental performance. The policy and goals are updated based on the results from the measurement of the environmental performance.[91]

The environmental work with transport and production processes, procurement, education of employees and product design should be striving in the same direction. A coordination of the environmental goals, the indicators for environmental performance and information is therefore necessary.

- **Increased knowledge of activities and tools**
  Another benefit of the integration is that during the work with the integration, the company's knowledge of both their activities and tools increases. This has the advantage that synergies between different work tasks can be found, the activities can be streamlined and each employee can clearer see its own role in the system.

[91] Häggström S, Erlandsson M, Riise E, "*Environmental management at site and group level*", CPM Report 2006:16

It must however be concluded that the extent to which integration is economically favourable varies between companies. It is seldom economic to integrate all tools, instead integration should only be performed where the benefits are obvious and the cost is recovered in a foreseeable future.

10.2 Provision of educational tools for industrial environmental management

One of the aims with IMPRESS was to explain how environmental information, methods and tools in an industrial company can be integrated with each other and with the corporate business processes and also implemented into the different parts of the organisation. The demonstration tool VIEWS (see section 9) was constructed to visualize the integration to make it more comprehensible. VIEWS was used in presentations for the CPM companies at several occasions and with great success. It showed how different environmental methods and tools are connected and served as a basis for discussions of how the environmental work in companies is structured. The report "General method for integration of industrial environmental information systems" [92] is also a tool to explain the methodology behind practical integration.

10.3 Possibilities for exploitation and dissemination of previous and new CPM results

In order to reassure that the work in IMPRESS was striving in a direction where the methods and tools developed could be used in practice and created business value for the participating companies, one part of the project was to explore the possibilities for exploitation of the results.

With IMPRESS, further steps have been taken in the direction of making the results from the CPM work between 1996 and 2006 able to commercialize. Different ways to commercialize, exploit, and further disseminate CPM results were investigated, such as the possibility of spin-offs and patent and license research. IMI has also received funding from VINNOVA to support commercialization of research results that IMI has developed within CPM.

10.4 Conclusion summary

In six industrial case studies, each specific method or tool has been developed, tested and improved, and support for implementation in daily work in the industry has been given. The methods and tools each perform their specific task with efficiency, i.e. they are useful and effective separately. In addition, in the academic work, integration between them has been performed by linking them together as independent but connected modules. This way the methods and tools can keep their efficiency for the original task while they at the same time contribute to raising the efficiency in the other tools.

The results from IMPRESS are both intended to be used for practical integration and increase of the efficiency of the environmental management work in industrial

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[92] Erixon M, Tivander J, Pålsson A-C, Carlson R, *"General method for integration of industrial environmental information systems"*, IMPRESS project deliverable, CPM report 2006:14

companies, and also for educational purposes, i.e. explaining how different environmental methods and tools are connected. The project has also included a part where the possibilities for exploitation and dissemination of previous and new CPM results have been examined.

Appendix 1. Project results

List of resulting reports from the project

The IMPRESS project has resulted in 9 CPM-reports:

- Häggström S, *"Local environmental impact - Local nature system data availability and local characterization modelling"*, CPM Report 2005:5
- Erlandsson M, Flemström K; *"Measurement and communication of environmental performance of products"*, CPM Report 2006:2
- Flemström K, Häggström S, Tivander J, *"REACH data management report"*, CPM Report 2006:3
- Flemström K, Tivander J, *"Transparent handling of emission trading data according to EU Emission Trading Scheme (ETS)"*, CPM Report 2006:4
- Erixon M, Tivander J, Pålsson A-C, Carlson R, *"General method for integration of industrial environmental information systems"*, CPM report 2006:14
- Tivander J, Carlson R, Erixon M, Pålsson A-C, *"IMPRESS integrated data format"*, CPM Report 2006:15
- Häggström S, Erlandsson M, Riise E, *"Environmental management at site and group level"*, CPM Report 2006:16
- Häggström S, Flemström K, Tivander J, Carlson R, *"Integration of experience and new information"*, CPM Report 2006:17
- Carlson R, Erixon M, Erlandsson M, Flemström K, Häggström S, Pålsson A-C, Tivander J, *"Implementation of integrated environmental information systems"*, CPM Report 2006:18

List of resulting papers from the project

The IMPRESS project and results have been or will be presented at the following conferences:

- Flemström K, Carlson R, Erixon M, Erlandsson M, Häggström S, Tivander J, *"Implementation of Integrated Environmental Information Systems"*, Proceedings from LCM Conference in Barcelona, 2005
- Flemström K, Carlson R, Erixon M, *"Relationships between Life Cycle Assessment and Risk Assessment"*, Proceedings from LCM Conference in Barcelona, 2005
- Flemström K, *"Implementation of Integrated Environmental Information Systems"*, Proceedings from FLIPP Conference at Chalmers University of Technology, 2005
- Häggström S, Carlson R, Flemström K, *"Transparent translation of design data to environmental impact data"*, Proceedings of the LCE 2006 Conference, 2006
- Häggström S, Tivander J; *"Implementation of Integrated Environmental Information Systems and VIEWS"*, presented at NORLCA, October 2006
- Häggström S, Carlson R, *"Wishful and pragmatic selection of environmental performance indicators for Design for Environment"*, presented at EcoBalance, November 2006

- Häggström S, Carlson R, Pålsson A-C, *"Integrated information management for chemical safety assessment and LCA"*, presented at EcoBalance, November 2006
- Tivander J, Häggström S, Carlson R, Pålsson A-C, *"An Integrated Implementation of Design for Environment and Life Cycle Assessment Applications"*, presented at EcoBalance, November 2006
- Tivander J, Erixon M, Carlson R, Pålsson A-C; *"A General Method for Integration of Industrial Environmental Information Systems"*, presented at EcoBalance, November 2006

List of resulting prototype tools and databases from the project

Databases:

SQL Server format

- IMPRESS_SP6 - for the Emission Trading Data Tool and VIEWS
- IMPRESS_SP7 – including the IMI material database for the CPM Inventory Tool
- Views_DfE - for the DfE tool in VIEWS
- IMI2003_IA_IMPRESS - Updated IA model data used in LCA@CPM
- IMI2003_Management - series of databases for the IMI Portal including LCA@CPM, LCI@CPM, and EMS@CPM tools
- IMI2003_OMNIITOX_merge - Implementation of the IMPRESS data format

Access format

- VIEWS_test_IAFIX.mdb LCA, EMS and CRM within VIEWS

Prototype software tools:

- VIEWS http://workshop.imi.chalmers.se/workshopviews
- CPM Inventory Tool http://project.imi.chalmers.se/IMPRESS_SP7/
- Emission Trading Data Tool (Excel format) also accessible within VIEWS
- OMNIITOX IS public version http://omniitox.imi.chalmers.se/
- IMI Portal including LCA@CPM, LCI@CPM, and EMS@CPM http://databases.imi.chalmers.se/imiportal/

Appendix 2. Spin-offs and patent and license of products

Summary from meeting with Henrik Jansson at Business Development and Finance, Chalmers Innovation, and Henric Rhedin at Commercial Research and Development, CIT
Maria Erixon and Karolina Flemström, IMI, 2005-05-11

Introduction
In sub-project 5 'Result exploitation and dissemination' in the CPM-project IMPRESS, the task is to suggest ways to commercialize, exploit, and further disseminate IMPRESS-results, as a contribution to the CPM steering committee when they are deciding about the future of CPM. This report is part of this contribution.

There are several different ways to commercialize research results. One way is to start a company as a spin-off from research activities. Another is to patent and license a product and/or business model. We have met with Henrik Jansson at Business Development and Finance, Chalmers Innovation, and Henric Rhedin at Commercial Research and Development, CIT, to find out more about spin-offs and patent and license of products. The result is summarized in this report.

Chalmers Innovation System (CIS)
CIS today includes seed-financing from *Chalmers Invest AB*, start-up of companies and advanced business training at *Chalmers School of Entrepreneurship*, company support (incubation) from the foundation *Chalmers Innovation*, commissioned research through *Chalmers Industrial Technology* (CIT) and leading-edge research in the field at the department of technology management and economics.
Advanced research and development is organized through the joint *Center for Intellectual Property Studies* (CIP) with a view to reinforcing the existing innovations system and helping to build a stronger infrastructure for the handling of innovations.

Spin-offs
The requirements for investing in a product and/or business idea at Chalmers Innovation (CI) is that the idea
- Is unique
- Is based on technical components
- Has a global market
- Is supported by originators that are willing to enter into partnership with CI

CI can help out with office facilities, practical knowledge, networks, and financing.

A way to start out is to think about what the driving forces for the exploitation is. Is it to earn money or to be able to make further research, i.e. writing articles, go to conferences etc. or is it a combination of these things? Next step could be to find out whether it is possible to take out a patent. In this case the news value is very important. Further questions to think about before contacting Chalmers Innovation a second time are:

- What are the benefits of the product or service?
- Who wants to buy it?
- What are they willing to pay?
- Who owns the results, i.e. who is the originator? In Sweden the originator at a university owns his/her results.

If CI believes in the idea, they will make further market analysis etc.

How to take out a patent for a product
The first step in the process of taking out a patent for a product is to write an invention report. The report includes information regarding the invention, the financing, publications and stakeholders and it is made as a support for those who want to take out the patent.

The second step is to make a patent application, which is done in collaboration with a patent bureau. The application includes technical descriptions and requirements. This step should be made thoroughly. Economical support for this work can be applied for at Innovationsbron Väst.

After that a temporary patent can be applied for, and then a national, international etc. It is recommended that a patent is taken out in those countries where the product is planned to have a market, i.e. not where it is produced. It cost about 500kkr to have a patent under 20 years, plus the charge for patent in each country (about 10kkr each).

Patent and license project at Chalmers
Henric Rhedin at Commercial Research and Development, CIT, told us about an on-going project at Chalmers that aims at patent and license products within the field of nanotechnology. Chalmers has bought patents from researchers and plan to license the patent to companies. The researchers will get 28% of the profits and the company pays e.g. for a PhD-student and the patent costs. Royalties will also be disbursed to the originator. Chalmers are especially interested in patent that have applications in several markets and that is a part of a strategic patent portfolio.

More information
More information can be found at:

Chalmers Innovation	http://www.chalmersinnovation.com
Chalmers Industriteknik	http://www.cit.chalmers.se
Chalmers School of Entrepreneurship	http://www.entrepreneur.chalmers.se
Center for Intellectual Property Studies	http://www.cip.chalmers.se
Connect Väst	http://vast.connectsverige.se
Innovationsbron Väst	http://www.innovationsbronvast.se
Patent- och registreringsverket	http://www.prv.se