CHALMERS

Environmental management at site and group level

Deliverable from IMPRESS sub project 8

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Summary

This report is the result of a sub project included in the CPM project “Implementation of integrated environmental information systems”, with acronym IMPRESS. The goal of this project was to develop, implement and improve tools and methods for the environmental work that is performed on the organization level. The project was started in autumn 2004 and finished in 2006.

In the previous CPM project “Policy controlled environmental management work”, two steps in the methodology developed there were not clear enough to be implemented in practice and were developed further in this sub project; the extraction of indicators from the environmental policy and the adaptation of characterization methodology to local conditions. An exercise of extraction of indicators was performed in practice in order to make this methodology step clear. 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. To create support for adaptation of characterization methodology to local conditions, local characterisation models for eutrophicating emissions were developed. Different existing characterisation modelling methods were investigated, and a methodology for local adaptation of EPS 2000 was chosen to be the most feasible solution.

The prototype software tool EMS@CPM, that supports work with the policy controlled environmental management methodology was improved and it was also integrated with other environmental information tools within the IMI portal. The tool has also been integrated in VIEWS, the Visualization of Integrated Environmental Work Spaces, that is further described in the Final report from the IMPRESS project.

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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1 Introduction

The project “Environmental management at site and group level” was a sub project of the CPM project IMPRESS (IMPlementation of integRated Environmental information SystemS). The objective of this sub project was to develop, implement and improve tools and methods for the environmental work that is performed on the organization level. The project was started in autumn 2004 and finished in 2006.

1.1 The IMPRESS project

The IMPRESS project (acronym for IMPlementation of integRated Environmental information SystemS) ran between 2004 – 2006, and 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.

The companies participating in the project were Akzo Nobel, Bombardier Transportation, Duni, IKEA, ITT Flygt, SCA and Stora Enso. Research and development work was performed together with the research group Industrial Environmental Informatics (IMI) at Chalmers University of Technology. The project was funded by the Swedish competence Center for environmental assessment of Product and Material systems (CPM).

The overall task of IMPRESS was to implement method and tool integration with business processes in a number of industrial companies. The objectives 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 to enhance the value and increase the usability of the results.

The specific methods and tools studied in this project are design for environment (DfE), environmental risk assessment (ERA), and life cycle assessment (LCA) from a product perspective, environmental management systems (EMS) and LCA from a process perspective, and CO_2-emission trading (ET) from a societal perspective. 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 the 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, technical maintenance for integration, commercialization work, and knowledge exchange was performed in three different sub-projects.

1.2 Background

The strategies for the environmental work are made up at the management level at most companies. The environmental department keeps the highest competence in environmental issues and is responsible for providing the management with the information needed to make the right decisions. The environmental management system (EMS) is a fully implemented tool for this work and accepted in the CPM companies. The use of EMS as a tool for delivering information for decision-making can be further improved by standardizing and quality assurance. The quality assurance of the environmental data is an important issue to improve as to give the information delivered to the management credibility. Standardizing of the information improves the understanding and comparability.

A previous CPM project, called "Policy controlled environmental management work"[1], has delivered a so called "toolbox" with methodology and tools for a policy controlled environmental management system (EMS).

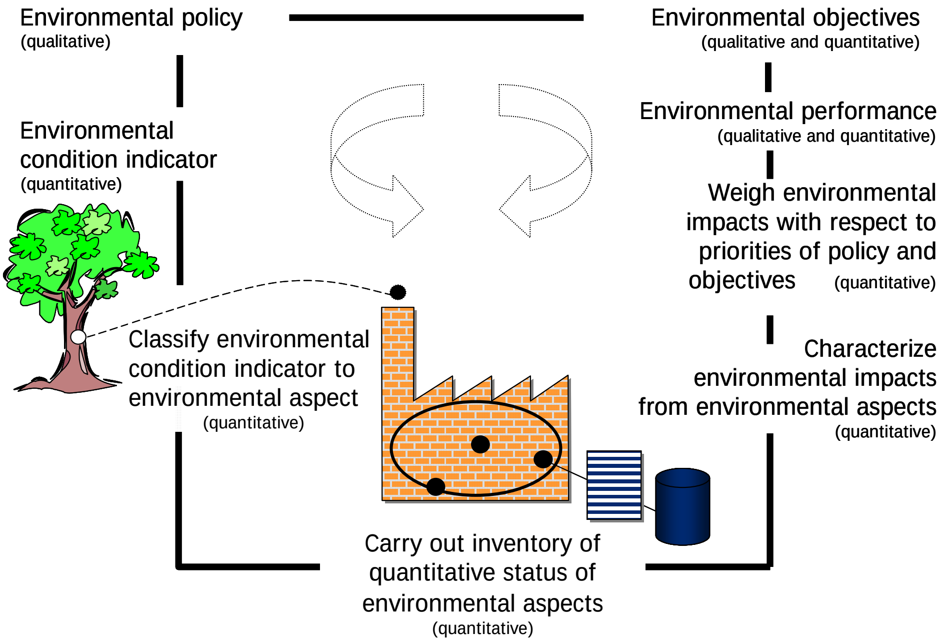

Figure 1. **The policy controlled environmental management methodology provides a structured procedure for connecting the environmental policy with the everyday environmental management work.**

The methodology was built up from results in earlier projects in which IMI has participated, such as REPID[2], IA98[3] and CPM/SSVL[4]. These projects have delivered methodology and tools for

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[1] Carlson R., Häggström S., Pålsson A-C. "Policy controlled environmental management work - Final report" CPM Report 2004:10, Chalmers University of Technology, Sweden

[2] Flemström K (2003), "Environmental Performance Indicator (EPI), Methodology in REPID", Chalmers University of Technology, Sweden

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

[4] The CPM/SSVL methodology is based on PHASETS [Carlson R, Pålsson A-C (2001): "Industrial environmental information management for technical systems", Journal of Cleaner Production, 9 (5): 429-435, Elsevier Science Ltd] and SPINE [Carlson R, Löfgren G, Steen B (1995): "SPINE – A Relational

different parts of an environmental management system and in the "Policy controlled environmental management work" project, the different components were compatibilized and integrated. The methodology developed in the project is described in the report "Manual for Policy Controlled Environmental Management Work"[5].

Experiences from the project, carried out in the previous and third phase of CPM, showed the advantages of using methodology, knowledge and competence from life cycle assessment in the environmental management work at companies. It was also stated that as the amount of information to be handled increases with time, efficiency of the management of information in the environmental management system is a necessity. In this project, the work with the "toolbox" continues with filling the gaps and improving the weaknesses to enable implementation of the results in companies.

1.2.1 Issues for continued work identified in CPM project "Policy controlled environmental management work"

The limitations of the toolbox for policy controlled environmental management work were identified as:

- The limited amount of data in the database.

  Regardless of the size of the database, there will always be missing data. The effort of collecting new data is bound to lead to that the existing data is overused and applied for cases for which they are not suitable. It is therefore important that the data user understands the limitations of available data, and take responsibility to not overuse data.
- Integration with other software tools

  At the moment the prototype tool covers the needs of the environmental management system, but it is an advantage if there are other needs that can be covered with the same tool. The user will not have to change to a different software environment for each problem.
- Local impact assessment

  Further support for local impact assessment needs to be developed.
- Finding other connections between aspects and indicators

  There is a risk that environmental impacts are only searched for "under the light of the lamp" and that the real environmental problems are not detected. There is a need to integrate new knowledge and use experiences gained from the practical work.
- Commercialization

  The prototype software tool was constructed to support the methodology and for educational use. The participating companies have shown great interest in the development of a commercial tool that can be used in the industry.

Database Structure for Life Cycle Assessment", Report B1227, Swedish Environmental Research Institute, Göteborg]

[5] Häggström S., Carlson R., Pålsson A-C. "Policy controlled environmental management work - Manual" CPM-report 2004:11

2 Goal and scope for the project

The objective of this sub project has been to develop, implement and improve tools and methods for the environmental work that is performed on the organization level. The focus lies on management of environmental information from production sites and other information tasks handled by e.g. a company's environmental department.

2.1 Project goal

The main goal with this sub project was to reach controllability of the different environmental information tools used in the companies. The sub project aimed also at implementing and improving the toolbox developed in the previous CPM project "Policy controlled environmental management work".

2.2 Project scope

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

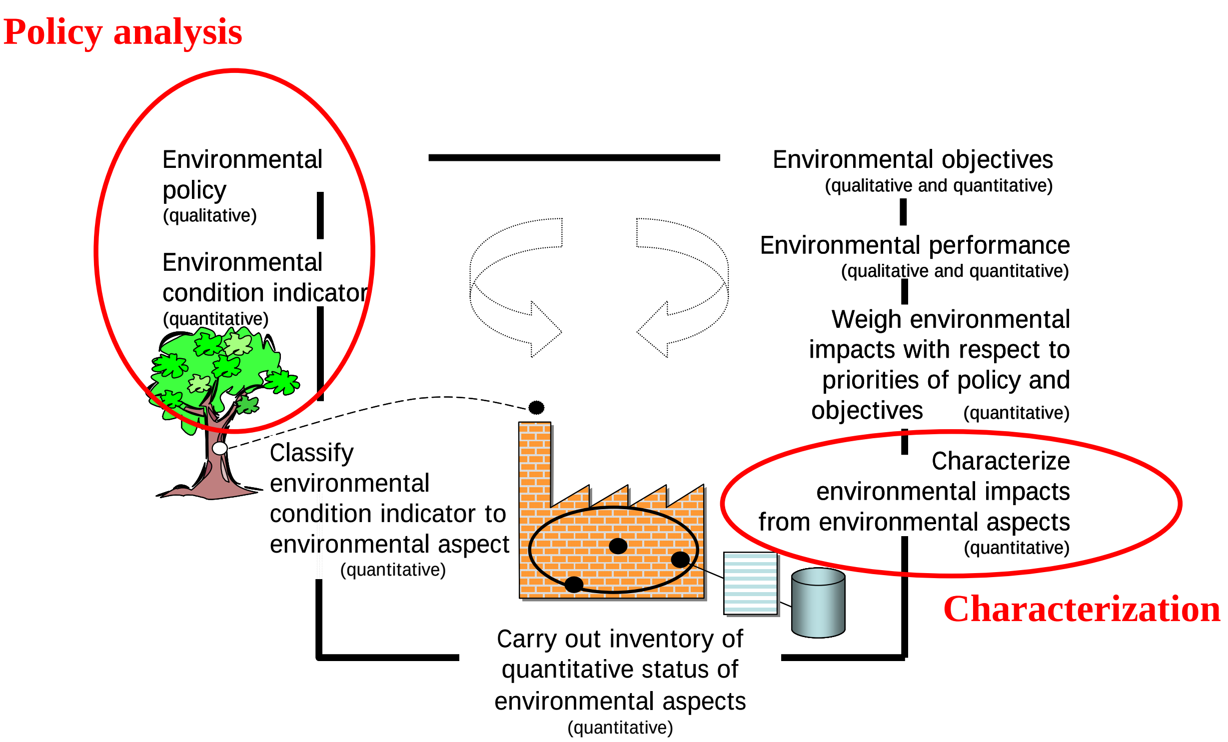

Figure 2. **The scope of the work with improvements and support for implementation of the policy controlled environmental management methodology.**

3 Working methods and participation

The following persons have participated in the project:

- Markus Erlandsson, IMI
- Sandra Häggström, IMI
- Johan Tivander, IMI
- Ellen Riise, SCA
- Björn Spak, SCA
- Ola Svending, Stora Enso
- Agneta Enqvist, Duni

In the project, the work has been directed at filling the gaps of the policy controlled environmental management methodology and facilitate implementation in companies. Therefore the work has been performed as five different tasks:

- Development of local impact assessment methodology
- Implementation of policy controlled methodology in companies
- Analysis and improvement of controllability in companies
- Upgrading of prototype software tool
- Integration with other environmental information systems

The results from the different tasks are described below.

4 Extraction of environmental condition indicators from the environmental policy

Support for extraction of environmental condition indicators from the environmental policy was developed in the sub project. This was a step in the methodology that was not clear enough to be performed in practice and therefore needed to be developed further. The work was made in workshops with participants from SCA Personal Care and Industrial Environmental Informatics.

4.1 Environmental indicators

There are different types of indicators defined by different organizations and named in different ways. Below is a presentation of relevant definitions of indicators from ISO 14001, ISO 14031, ISO 14042 and the RAVEL methodology that are used in policy controlled environmental management work.

4.1.1 ISO 14031

The ISO 14031[6] standard describes two general categories of indicators for environmental performance evaluation:

- Environmental Performance Indicator (EPI):
  Specific expression that provides information about an organization's environmental performance. There are two types of EPIs:
    - Management performance indicators (MPIs), describe the organisation's capacity and effort to realise environmental decisions
    - Operational performance indicators (OPIs), describe the environmental performance of the organisation's activities.
- Environmental Condition Indicator (ECI):
  Specific expression that provides information about the local, regional, national or global condition of the environment. This information can help an organization to better understand the actual impact or potential impact of its environmental aspects.

4.1.2 ISO 14001

The EPIs of ISO 14031 are compatible with the definition of environmental aspects in the ISO 14001 standard:

- environmental aspect:
  element of an organization's activities or products or services that can interact with the environment

4.1.3 ISO 14042

The ECIs of ISO 14031 are compatible with the definition of category indicators in the ISO 14042 standard:

- category indicator
  quantifiable representation of an impact category (class representing environmental issues of concern to which LCI results may be assigned)

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[6] ISO 14031:1999 (1999): Environmental management – Environmental Performance Evaluation – Guidelines, European Committee for Standardization, Brussels

4.1.4 RAVEL

The environmental performance indicators are addressed by the ISO 14031 standard to be used when evaluating the environmental performance of organizations, but results from the RAVEL project[7] showed that the indicators can also be used to evaluate environmental performance of e.g. products, activities, processes, hardware design and services[8].

4.1.5 Policy controlled environmental management work

The ISO 14031 division into environmental performance indicators (EPIs) and environmental condition indicators (ECIs) is used in policy controlled environmental management work[9]. The terminology used for EPIs in the project "Policy controlled environmental management work" was environmental aspects following the ISO 14001 standard. The policy was interpreted with ECIs and these were hence translated into environmental aspects with LCA methodology. In this project, the ISO 14031 standard terminology with EPIs, OPIs and MPIs has instead been used.

4.2 The RAVEL/REPID indicator methodology

The methodology for defining and implementing environmental performance indicators (EPIs) based on the policy formulation was developed within the Brite-Euram III (EU) project RAVEL[10] (Rail Vehicle Eco-Efficient Design) project running 1998-2001, and implemented within the railway industry in the REPID[11] (Rail sector framework and tools for standardizing and improving usability of Environmental Performance Indicators and Data formats) project running 2002-2004. The RAVEL/REPID methodology has been used for the indicator extraction in this sub project.

The key issues in the RAVEL/REPID indicator methodology are:

- The indicators must be measurable
- The indicators must be able to control by the company
- The indicators must be affected by the activities of the company
- The indicators must address important and well defined environmental issues

In the work with formulating the EPIs it is also important to consider:

- The receiver of the information.
  The indicator must be formulated so that the people and functions that will use the information can understand it.
- How the indicator will be measured.
  The people or functions responsible for measuring the indicator are also identified.
- How the data will be supplied.
  The availability of data controls the cost for the indicator and is a crucial factor in the implementation of the indicator in the organisation.

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[7] Ander, A, Duflou, J., Dewulf, W., et al, Integrating Eco-efficiency in Rail Vehicle Design, Leuven University Press, 2001

[8] Carlson, R., Environmental Performance Indicators, Industrial Environmental Informatics, Chalmers University of Technology, Published July 2002 Issue of Insight

[9] Carlson R., Häggström S., Pålsson A-C. "Policy controlled environmental management work - Final report" CPM Report 2004:10, Chalmers University of Technology, Sweden

[10] Ander, A, Duflou, J., Dewulf, W., et al, Integrating Eco-efficiency in Rail Vehicle Design, Leuven University Press, 2001

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

The RAVEL/REPID EPIs are life cycle indicators, i.e. they represent the impact on the nature from all phases in the product's life cycle. One EPI expressing one aspect in the product or the production process will thus have impact on different environmental condition indicators, as illustrated by Figure 3 below.

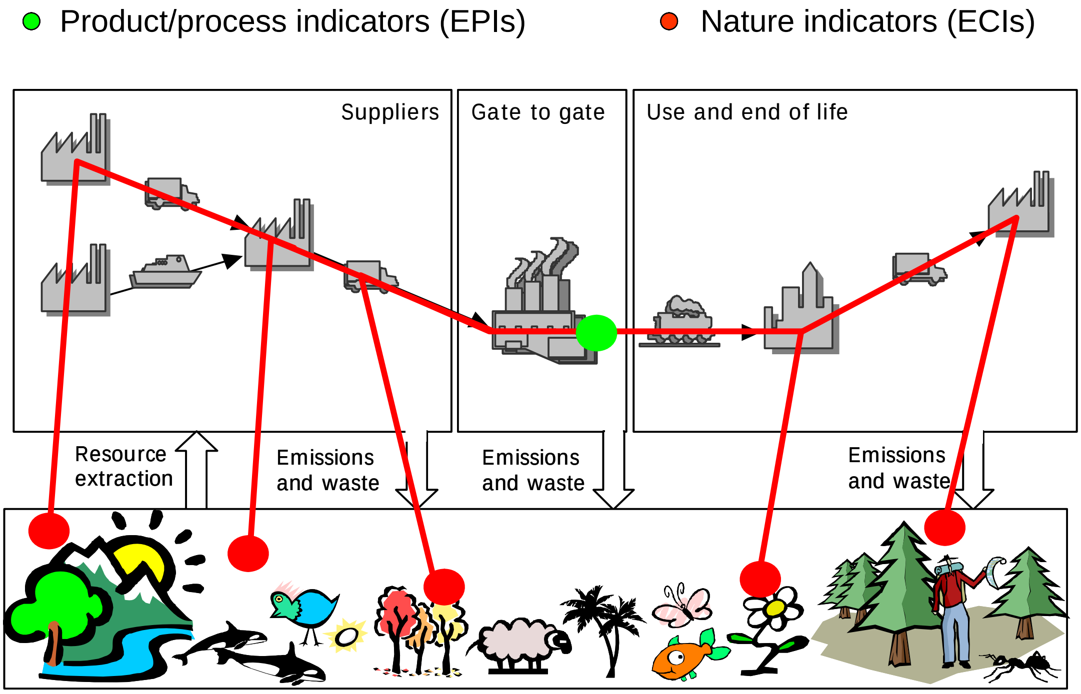

Figure 3. **The scope of an environmental performance indicator in the RAVEL/REPID methodology.**

Through different choices in the product/process development, the environmental performance of the resulting product is controlled. For example, by choosing a material with low content of hazardous substances, the environmental impact during the whole life cycle is reduced.

One environmental performance indicator can only represent and measure a small part of the environmental impact, therefore a set of several indicators, together representative for e.g. the organizations impact needs to be defined.

Environmental performance indicators can be either quantitative or qualitative. In the RAVEL/REPID methodology, the focus is on quantitative environmental performance indicators. Quantitative, numerical measures offer many advantages since it is easy to measure, compare and communicate them.

4.3 Extraction of indicators from the environmental policy

Together with SCA Personal Care, an exercise of extraction of indicators was performed in order to make the methodology step clear. The experiences drawn from the work and the improvements made in the methodology were documented.

4.3.1 Extraction of environmental performance indicators from the environmental policy

In the document "Strategic Environmental Direction for SCA Personal Care", the policy of the SCA Group has been broken down to more operative formulations to be used in this business unit, and is thus a sub policy to the corporate environmental policy. The formulations in the document are close to environmental performance indicators. It was therefore easier to cover this formulation 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 drawback of not having defined environmental condition indicators representing the policy is that environmental performance indicators cannot be weighted based on the impact on the environment. The impact on the environment from environmental performance indicators is not independent from the product, the process, the geographical site and the modelling of the life cycle scenario. The different EPIs can instead be prioritized from other perspectives, e.g. technological, economical and market potential perspectives.

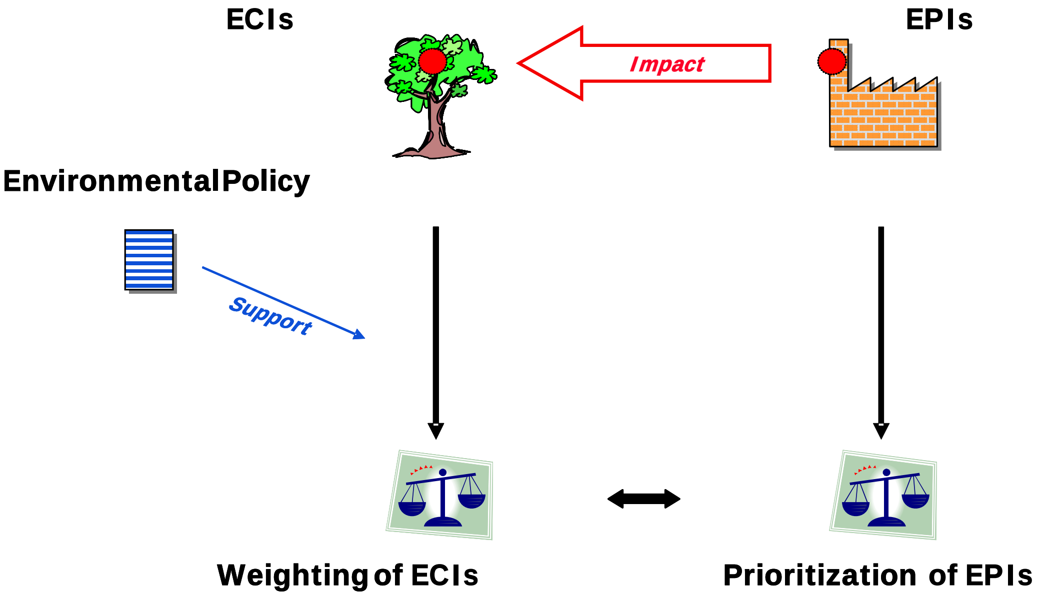

***Figure 4.* Weighting between environmental aspects can be made scientifically based on the values in the environmental policy if they are translated condition indicators**

The EPIs and their results can however be translated later into ECIs and then weighted based on environmental impact. This has been made in IMPRESS sub project 7[12], and is further described in the article "Transparent translation of design data to environmental impact data"[13].

4.3.2 Support for extraction of indicators from policy

A template for the work with extracting indicators from an environmental policy was created, see Appendix IV.

The main additions in the template compared to the RAVEL/REPID methodology can be summarized as:

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

[13] Carlson, R., Flemström, K., Häggström, S., "Transparent translation of design data to environmental impact data", 13th CIRP International Conference on Life Cycle Engineering, Leuven, 2006

- The definitions of the indicators need to be thoroughly made before the feasibility and relevance of and indicator definition can be apprehended.
- Drawing a picture of the physical reference (the site) with the inputs and outputs that are relevant for the calculations of the indicator results is a good help in defining which physical data that would actually be needed for the calculations.
- Each indicator shall be communicated to the units that contribute to the indicator value so that it is understood by and meaningful to that unit and they can work to improve the value.
- Data in existing information systems is used as far as possible before data is requested from another unit.

4.3.3 Experiences from the work

Different environmental performance indicators are relevant for different functions in the organizations. Common environmentally related indicators are difficult to find and aggregate in a company consisting of different organisational units; production sites and central activities such as product development, common environmental issues, procurement and logistics. Production sites have a juridical responsibility at their location that can be very different between the sites. It is also difficult to find a fair comparative measure for products as they can have very different function and give different "added value" to the customers.

4.4 Implementation of indicators

To achieve controllability of the environmental performance of an organization, quantitative measurements are needed according to the saying "what is measured is improved" [14].

The work is with great advantage started with creating a draft set of performance indicators that are possible to calculate in practice. This means that it is possible to start discussions in the organization about what is actually relevant to measure, if the input data is available, how the measurement is best performed and how much it will cost. The draft set of indicators and the definitions of the indicators are intended to be modified later on. The resolution of the indicators for e.g. each function, each product, different packaging and/or material can also be increased. The updating of the indicators will probably continue and be an iterative process as the organization changes with time.

4.4.1 Implementation of an indicator set at SCA Personal Care

In the exercise at SCA Personal Care, a draft set of indicators was created consisting of management performance indicators (MPIs) and operational performance indicators (OPIs). These were defined in detail and the OPIs were also calculated in order to see that the definitions were actually feasible. That the indicators were able to be calculated demonstrated that they in practice are measurable, which according to the RAVEL methodology is a necessary prerequisite for an operative indicator set.

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[14] Carlson R., Häggström S., Pålsson A-C. "Policy controlled environmental management work - Final report" CPM Report 2004:10, Chalmers University of Technology, Sweden

4.5 Analysis of controllability

When implementing the methodology for policy controlled EMS, the impact on the controllability from use of the methodology was investigated.

4.5.1 The scope of the environmental management work

The work with controllability connects all tools used in a company to reach the environmental goals, as described in the picture below.

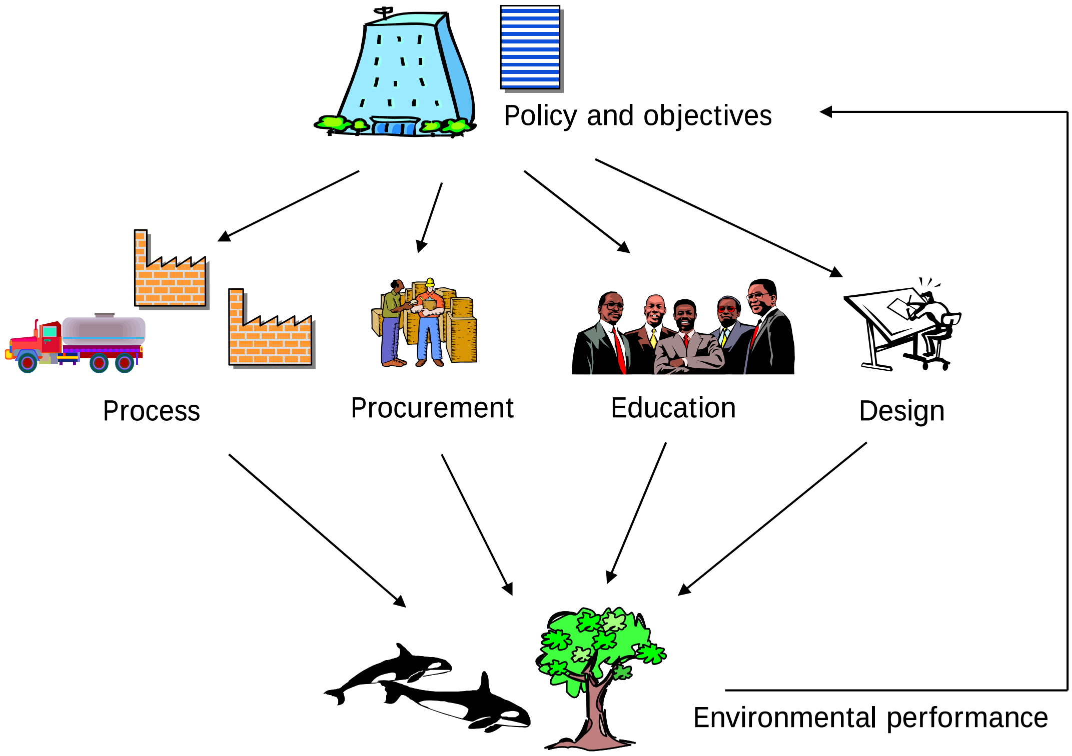

Figure 5. **The scope of the environmental management system. The EMS controls aspects that in their turn have impact on indicators.**

The environmental information used in transport and 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.

The scope of the environmental management system is however limited to comprise the environmental aspects that can be influenced by the organization's activities. The scope of the policy controlled environmental management work is also limited to comprise the environmental aspects that are indicated in the policy, or required due to laws and regulations. If the policy does not mention a certain environmental area or impact and no regulation etc. demands it, this means that the environmental aspects with such impacts should not be considered in the environmental work in other way than that a proposal of changes to the policy should be made.

5 Development of local impact assessment methodology

A conclusion from the project "Policy controlled environmental management work" was that further support for local impact assessment needed to be developed[15]. In this sub project, local characterisation models for P_{tot}, N_{tot} and COD are developed, as a case study to give support for the general creation of local characterisation models. This work was performed in parallel with an investigation of available local data about the condition of the environment that was made in sub project 2 "General method development". The result from the study is found in the report "Local environmental impact"[16].

The first step was to investigate the existing and available methods for local characterisation modelling. For the case study, the EPS method was chosen, both because it already contained models for impact of P_{tot}, N_{tot} and COD emissions and because via the CPM competence centre it was possible to get support from professor Bengt Steen who was project leader of the development of the method.

5.1 Environmental impact models

The general form for an environmental impact model is a mathematic expression for the impact on an indicator as the consequence of a certain load. The mathematical expression is built up of nature and/or substance properties, as illustrated in the figure below.

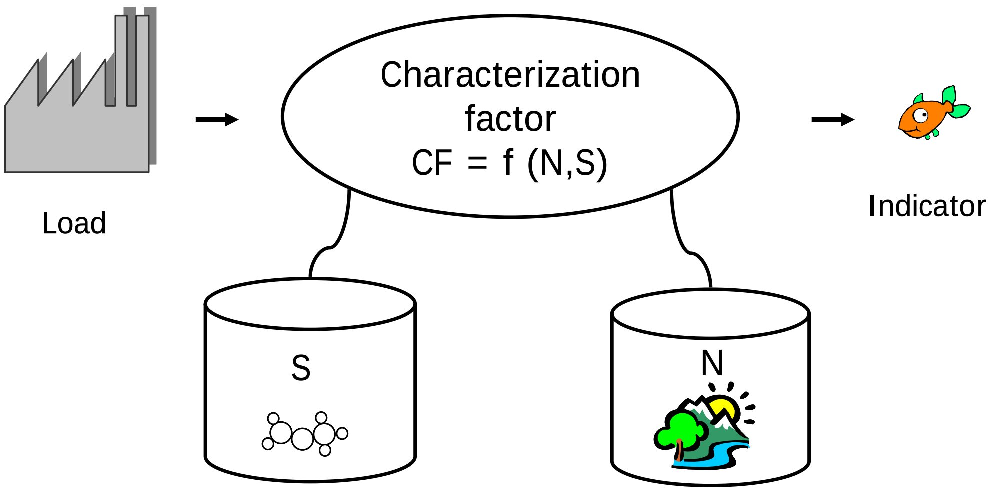

Figure 6. **A general environmental impact model. The characterization factor is a mathematical expression for the impact on an indicator as the consequence of a certain load. The characterization factor is a function of nature (N) and/or substance (S) properties.**

Nature properties are data about the condition of the environment and the degree of geographical detail of the models depends on the degree of detail on the available nature data.

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[15] Carlson R., Häggström S., Pålsson A-C. "Policy controlled environmental management work - Final report" CPM Report 2004:10, Chalmers University of Technology, Sweden

[16] Häggström S.; "Local environmental impact - Local nature system data availability and local characterization modelling"; CPM Report 2005:5

5.2 Environmental impact from P_{tot}, N_{tot} and COD

An increased input of phosphorus and nitrogen to water bodies with low oxygen concentrations leads to eutrophication, which has negative effects such as increased turbidity, accelerated oxygen depletion due to the decay of organic matter, and changes in the diversity and composition of flora and fauna. In fresh water, it is usually the supply of phosphorus that regulates the production of algae and other plants, while in marine water it is the supply of nitrogen[17]. COD (chemical oxygen demand) refers to a group of substances that also contributes to the damage by consuming oxygen in water bodies where the oxygen concentration is already low. In water bodies without risk for oxygen deficiencies the nutrients can have positive effects such as increased fish production.

Oxygen depletion is widely used as an indicator for eutrophication. While oxygen levels above 4.5 ml/l are considered to cause no problems for macroscopic animals, levels below this cause increasing stress to most organisms.[18] Another indicator of eutrophication is the concentrations of nutrients in the water body. A lake is considered hypertropic if the phosphorous content is more than 100 µg P/l[19]. A third indicator of eutrophication is the primary production (the synthesis of organic matter (C) by plants) that is dependent on phosphorous emissions, turbidity and depth. A lake is considered eutrophic if the primary production exceeds 75-250 g C/m^2 and year[20].

Besides oxygen depletion, no environmentally detrimental effects are known from emissions of P_{tot}, N_{tot} and COD.

5.2.1 Environmental aspects

To be able to take care to the different nature conditions described in the previous section a distribution model for water bodies can be created that will describe which areas that are exposed to the emissions. Distribution models are in general very expensive and another solution is to divide the emissions of N-tot, P-tot and COD into different environmental aspects (or loads) after the nature criteria:

N-tot

- Emission of N-tot to fresh water with high oxygen concentration
- Emission of N-tot to fresh water with low oxygen concentration
- Emission of N-tot to marine water with high oxygen concentration
- Emission of N-tot to marine water with low oxygen concentration

P-tot

- Emission of P-tot to fresh water with high oxygen concentration
- Emission of P-tot to fresh water with low oxygen concentration
- Emission of P-tot to marine water with high oxygen concentration
- Emission of P-tot to marine water with low oxygen concentration

COD

- Emission of COD to fresh water with high oxygen concentration

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17 http://www.internat.naturvardsverket.se/index.php3?main=/documents/legal/assess/assedoc/lakedoc/nutri1.htm

18 http://www.helcom.fi/environment2/eutrophication/en_GB/oxygen/

19 http://www.ma.slu.se/Miljotillst/Eutrofiering/Hypertrofikarta.ssi

20 Karin Sandqvist, "Kriterier för en hållbar fisketurism i Sjuhärad", Avdelningen för Tillämpad miljövetenskap, Göteborgs universitet, 2005

- Emission of COD to fresh water with low oxygen concentration
- Emission of COD to marine water with high oxygen concentration
- Emission of COD to marine water with low oxygen concentration

This way, the responsibility for estimating (or measuring) the conditions of the local environment is given to the person collecting the emission data for the environmental aspects, which is supposed to be a person with good knowledge of the geographical location. Generally, the marine water bodies south of the Åland Sea are considered to be N limited, and the water bodies north of the Åland Sea P limited. Fresh water bodies such as lakes and water courses are P limited. Suggested local characterization factors for these environmental aspects can be found in Appendix VI.

5.3 Investigation of existing characterisation factors

Five existing characterisation modelling methods were investigated:

- EPD (Swedish system for Environmental Product Declaration)
- EPS (Swedish impact assessment model Environmental Priority Strategies)
- RA (Risk Assessment)
- OMNIITOX modelling method (Result from the EU project OMNIITOX)
- PHASENS (PHASEs in the design of a model of a Nature System)

Phosphorous to water, NOx and COD are also together with SOx the non-chlorinated emissions that are restricted in the criteria for the Nordic environmental label Svanen[21]. A chapter about these criteria is therefore also included to be able to compare the ranking of the significance. The modelled effects and the characterisation factors of the methods are summarised in Table 1 below:

Model	Modelled effect	Factor for N_{tot}	Factor for P_{tot}	Factor for COD
EPD	Oxygen depletion	20 g O_2/g N to air 20 g O_2/g N to water	140 g O_2/g P to water	1 g O_2/g COD
EPS	Extinction of species Production capacity in nature	1.8E-13 NEX/kg N-tot. –0.401 kg fish/kg N-tot	5E-13 NEX/kg P-tot	9.18E-15 NEX/kg COD
RA	Risk	-	-	-
PHASENS	-	-	-	-
OMNIITOX	Human toxicity Ecotoxicity	NOx	-	-

***Table 1.* There are existing characterisation factors for P_{tot}, N_{tot} and COD in the EPD and the EPS systems. The EPD system has modelled the mid-point effect for the three substances in question as oxygen depletion. The EPS system has two end-point effects; extinction of species and production capacity in nature. The EPD and EPS models are both global. Risk assessment and OMNIITOX have models for toxicological impact, but no particular characterisation factors for P_{tot}, N_{tot} and COD. The effect modelled with the PHASENS model can be both end-point and mid-point effects.**

[21] http://www.svanen.nu/

5.3.1 EPD modelling method

The EPD evaluation of eutrophicating substances is based on the calculations of Matts-Ola Samuelsson[22] of how much organic material that nitrogen and phosphorous generate. These calculations are in their turn based on the C:N:P relationship of plankton. The results from measurements of the C:N:P relationship has been varied but Redfield et al from 1963 (106:16:1) was chosen by Samuelsson since that ratio is the most accepted and used. Reversed photosynthesis revealed that 1 mole organic carbon consumes 1.3 moles oxygen. This relationship implies that 1 mole of nitrogen mediate production of organic material that will consume 8.6 moles of oxygen when decomposed, and 1 mole of phosphorous mediates production of organic material that will consume 138 moles of oxygen.

Samuelsson suggest that the LCA analysis of nitrogen and phosphorous include two scenarios, N-limited and P-limited. "However, if only nitrogen is emitted to a system that is limited by phosphorous this nitrogen will mediate a production of organic material. The amount of production depends on the concentration of phosphorous in the system. Even though a system is nitrogen limited a load of phosphorous will give a production of organic material that is dependent on nitrogen concentration" (Samuelsson, 1993).

NOx emitted to the air will eventually be deposited on land and water. The deposition on land can cause terrestrial eutrophication. A fraction of nitrogen deposit on land will leak to the aquatic system and be a part of the aquatic eutrophication. Between 100% and 0% can be assumed to reach the aquatic system. The site-specificity determines how much of the emissions that will be supposed to reach the studied system. Non-site specific calculations mean that 100% of the emissions are emitted to an aquatic system. Samuelsson suggests that for site specific calculations the Wassman approached can be used, where the lowest percentage exported is 24% and the highest 52%. The two scenarios will give the upper and lower limits of oxygen consumption.

The evaluation of eutrophicating substances in the EPD system assumes the maximum scenario that Lindfors et al. describes[23], where all emissions contribute, both P- and N-emissions to both land and water.

5.3.2 EPS modelling method

The characterisation factor for N-tot impact on the EPS indicator fish & meat is based on a study in Skälderviken[24] which is a Swedish location.

The characterisation factors for N-tot and P-tot impact on the EPS indicator NEX are calculated by dividing the indicator value[25] with the global emissions of nitrogen and phosphorous respectively[26] and multiplying with the fraction of the extinction caused by the substance[27]:

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[22] Samuelsson, M-O, 1993, *Life Cycle Assessments and Eutrophication. A concept for calculation of the potential effects of nitrogen and phosphorous*, IVL Report No B1119, IVL, Stockholm, Sweden

[23] Lindfors, L-G. et al., 1995, *Nordic Guidelines on Life-Cycle Assessment*, Nord 1995:20, page 114, Nordic council of Ministers, Copenhagen.

[24] SNA, Sveriges National Atlas, (Swedish National Atlas), (1991), *Miljön*, page 100, SNA Förlag, Stockholm University.

[25] 10% of the threat to bio-diversity in Scandinavia is due to eutrophication. On a global scale, the threat to bio-diversity is assumed to be less, 1%, as warmer regions are less sensitive to excess nitrogen. The indicator value is thus 0.01 NEX (Steen, 1999).

[26] The global emission of nitrogen to water during 1990 is estimated to 5E+10 kg and phosphorous to water 2E+9 kg (Steen, 1999).

$CF_{N\text{-}tot}$: 0.9*0.01 NEX/5E+10 kg = 1.8E-13 NEX/kg N-tot
$CF_{P\text{-}tot}$: 0.1*0.01 NEX/2E+ 9 kg = 5E-13 NEX/kg P-tot

A local adaptation of the EPS method would mean that in fresh water (lakes and rivers), only phosphorous has an impact (and causes thus 100% of the eutrophication) and the impact of nitrogen is set to zero. Likewise, in ocean water, the impact of phosphorous is set to zero and nitrogen causes 100% of the eutrophication. Adapting the characterisation factor to Scandinavian condition also mean assuming the emission of eutrophicating substances in Scandinavia ten times as serious as elsewhere. By dividing with the emissions of P and N in Scandinavia, a more fair figure would also be achieved.

The characterisation factor for COD impact on NEX is determined by an equivalency method described by Lindfors et al.[28] using the results from Samuelsson[29] with N-tot as reference substance. The local adaptation of the N-tot factor would thus also lead to a change of the COD factor. For lakes and rivers, COD should be calculated with P-tot as reference substance.

5.3.3 Risk assessment modelling method

Risk assessment (RA) is traditionally focused on risk characterisation for toxic effects from substances. Risk characterisation is an estimation of the severity and incidence of adverse effects likely to occur in a human population or environment. The risk characterisation is divided into hazard assessment and exposure assessment. The hazard assessment consists of hazard identification and a dose response assessment. A hazard (also called effect) assessment is integrated and compared to an exposure assessment in completing a risk characterisation to investigate if the concentration of a substance released to the environment, the Predicted Environmental Concentration (PEC) remains below the Predicted No Effect Concentration (PNEC), the harmful concentration. The predictions are based on substance properties such as density, toxicity, risk for allergy, etc[30]. The risk characterisation is therefore defined as the ratio between PEC and PNEC[31]. If the ratio is above 1 it means that there is a risk.

EUSES (European Union System for the Evaluation of tool of Substances) is one example of a decision- support tool, which enables persons to carry out assessments of the general risks posed by a substance to man or the environment[32].

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[27] 90% of the extinction caused by eutrophication is allocated to nitrogen. The figure is based on a rough estimation of the relative size of polluted ocean and sweet-water where oxygen-free bottoms may occur. 10% is thus allocated to phosphorous (Steen, 1999).

[28] Lindfors, L.G.,Christiansen, K., Hoffman, L., Virtanen, Y., Juntilla, V. Leskinen, A., Hanssen, O-J., Rønning, A., Ekvall, T. and Finnveden, G., *LCA-Nordic, Technical report No 10*, Tema Nord 1995:503, Nordic Council of Ministers, Copenhagen 1994.

[29] Samuelsson, M-O, 1993, *Life Cycle Assessments and Eutrophication. A concept for calculation of the potential effects of nitrogen and phosphorous*, IVL Report No B1119, IVL, Stockholm, Sweden

[30] www.dantes.info

[31] ECB (2003), *Technical Guidance Document in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances and Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market*, viewed at http://ecb.jrc.it/cgi-bin/reframer.pl?A=ECB&B=/Technical-Guidance-Document/

[32] EUSES can be found at European Chemicals Bureau’s (ECB) website: http://ecb.jrc.it/existing-chemicals/

5.3.3.1 EUSES

The European Union System for the Evaluation of Substances (EUSES)[33] was developed for quantitative assessment of the risks posed by chemical substances to man and the environment. EUSES is a software tool that contains a model of the nature with default values that are possible to exchange for local ones and thus create a local model. The system is developed for assessment of toxic effects and there is no model for e.g. eutrophication. The EUSES model for risk assessment has been adapted by Universiteit Leiden P.B.[34] into a characterisation model for LCA, called USES-LCA.

5.3.3.2 OMNIITOX modelling method

The OMNIITOX modelling method provides a way to a structured documentation of the environmental impact model. Just as with the data model SPINE, where processes are documented as a system of sub-processes, the mechanisms are documented as a system of sub-mechanisms that are reusable in other contexts than the original.

5.3.3.3 Toxicity modelling

The model is developed to be general and can be used for any impact category. The only impact category currently implemented in the OMNIITOX model is toxic impact. The modelling of toxic impact potential for LCA has previously been questioned, since the different available models were contradictory. The OMNIITOX model for toxic impact potential was developed cooperatively by five European universities; Chalmers University of Technology, Danmarks Tekniske Universitet, Universiteit Leiden P.B., Universitaet Stuttgart and Ecole Polytechnique Fédérale de Lausanne, in order to achieve scientific consensus.[35]

5.3.3.4 Local modelling

The OMNIITOX model can be used to document other impact assessment models to make them transparent. Also, in the work with local characterisation, the OMNIITOX modelling method can be useful.

The nature systems can be divided in smaller units and thus lead to locally adapted models. At the moment there are only three nature systems for which there exists data: “Europe”, “World”, and “World except Europe”. These can be seen as “default” data of EUSES; in OMNIITOX there are three different sets of default data. The units can be of arbitrary size, e.g. a country, a town etc.

5.3.4 PHASENS modelling method

PHASENS, PHASEs in the design of a model of a Nature System, is a specification of the PHASES model[36]. PHASENS describes how information about changes in systems not being controlled by humans are communicated and analyzed, from definition of an environmental

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[33] RIVM, VROM, VWS (1998); *Uniform System for the Evaluation of Substances 2.0 (EUSES 2.0)*; National Institute of Public Health and the Environment (RIVM), Ministry of Housing, Spatial Planning and the Environment (VROM), Ministry of Health, Welfare and Sports (VWS); The Netherlands

[34] Mark A.J. Huijbregts (1999), *Priority assessment of toxic substances - development and application of the multi-media fate, exposure and effect model USES-LCA*, updated version 1999, Universiteit Leiden P.B., Institute of Environmental Sciences (CML)

[35] www.omniitox.net, OMNIITOX project reports: *OMNIITOX information system material*, Erixon, Flemström, et al, 2004 and *Conceptual model report*, Carlson, Tivander, Erixon, et al 2004

[36] Carlson R., Pålsson A-C.; *“PHASES Information models for industrial environmental control”*, CPM-report 2000:4

category indicator up to final reporting. Management of information about changes in the nature in accordance with PHASENS gives information quality assurance.

PHASENS refers to information required for characterisation, as described in the standard ISO 14042.

Phase 0 in PHASENS requires strong rigidity regarding the application of environmental measurement techniques by explicitly requiring *which* natural environmental system and *which* quantitative entity a piece of information about an environmental change addresses.

Explicit declaration of nature systems and entities is valuable when comparing changes in e.g. different time-scales, different geographical scales, or different biological habitats within the same geographical and temporal scales.

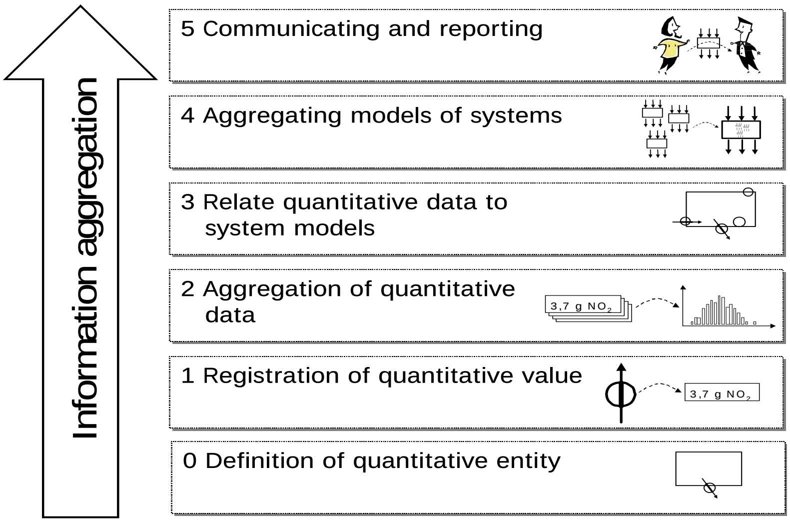

Figure 7. **PHASES - PHASEs in the design of a model of a System.**

5.3.5 Svanen criteria

The Nordic environmental labelling system Svanen has criteria for emissions of P_{tot}, NOx and COD[37]. The impact of the emissions is not explicitly regarded. The criteria are based on available technology solutions:

“So that all production methods and paper grades can be used, a model based on the emissions from various types of pulp is employed. The model is based on pulps with different origins being allowed to have different levels of emission to water and air. The emission requirements on the production of pulp have been established based on knowledge of the relevant emissions from the pulp and paper industry, and on knowledge of what is feasible from a process technical point of view. The environmental gain is made by approval being granted only to the least environmentally harmful pulp in each type of production process.

The environmental assessment of the emissions from production is made on the basis of emissions of COD and phosphorus to water, and the emission of sulphur and NOx to air during production. COD, phosphorus, sulphur and NOx area assessed as a single entity by employing a calculation model.”

The coefficients for calculations are shown in Appendix III.

[37] Nordic Ecolabelling (2003), Ecolabelling of Tissue Paper, Criteria document 16 June 2000 – 29 October 2006, Version 3.4

5.4 Case study: Local adaptation of EPS for eutrophication

The impact assessment method EPS 2000[38] was developed within CPM (Centre for the environmental assessment of Products and Material systems). EPS uses three different ways to model impact; *empiric*, where the top-down perspective is applied, *mechanistic*, where the bottom-up perspective is applied, and *equivalency* modelling where the impact from one substance is estimated based on comparison with the impact from a similar substance.

The environmental impact due to eutrophication is assigned to the following impact categories:

- **Biodiversity**
  Category indicator: NEX
  NEX is an abbreviation of "Normalised EXtinction of species". The extinction rate of species in the world is not known. The indicator value for normal extinction rate of species is set to 1 NEX (NEX is also the indicator unit). This means that an activity that hypothetically account for 50% of the world's extinction of species will get an indicator value of 0.5 NEX.
- **Ecosystem production capacity**
  Category indicator: Fish and meat
  The production rate of fish is an indicator of eutrophication. The indicator unit is kg.
- **Recreational and cultural values**
  Category indicator: *none defined*

The specific expressions of the characterization factors in EPS 2000 are listed in Appendix I.

5.4.1 Choice of local category indicators

The choice of category indicators for the local impact modelling was made by Johan Tivander and Sandra Häggström, both at Industrial Environmental Informatics and professor Bengt Steen at the Department of Environmental Systems Analysis at Chalmers University of Technology.

5.4.1.1 Indicators for biodiversity

The extinction rate of species due to eutrophication is not known. In EPS it has been estimated with the fraction of red listed species that are assumed by science expertise to be threatened by eutrophication. In Scandinavia for example, 10% of the red listed species are assumed to be threatened by eutrophication[39]. The category indicator value for eutrophicating substances' impact on NEX is therefore 0.1 NEX. This empirical way of modelling does not suit adaptation to too small areas.

5.4.1.2 Indicators for ecosystem production capacity

The effect on the production rate of fish due to addition of eutrophicating substances is described by the figure below.

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

[39] ArtDatabanken, "Rödlistade arter i Sverige", http://www.artdata.slu.se/

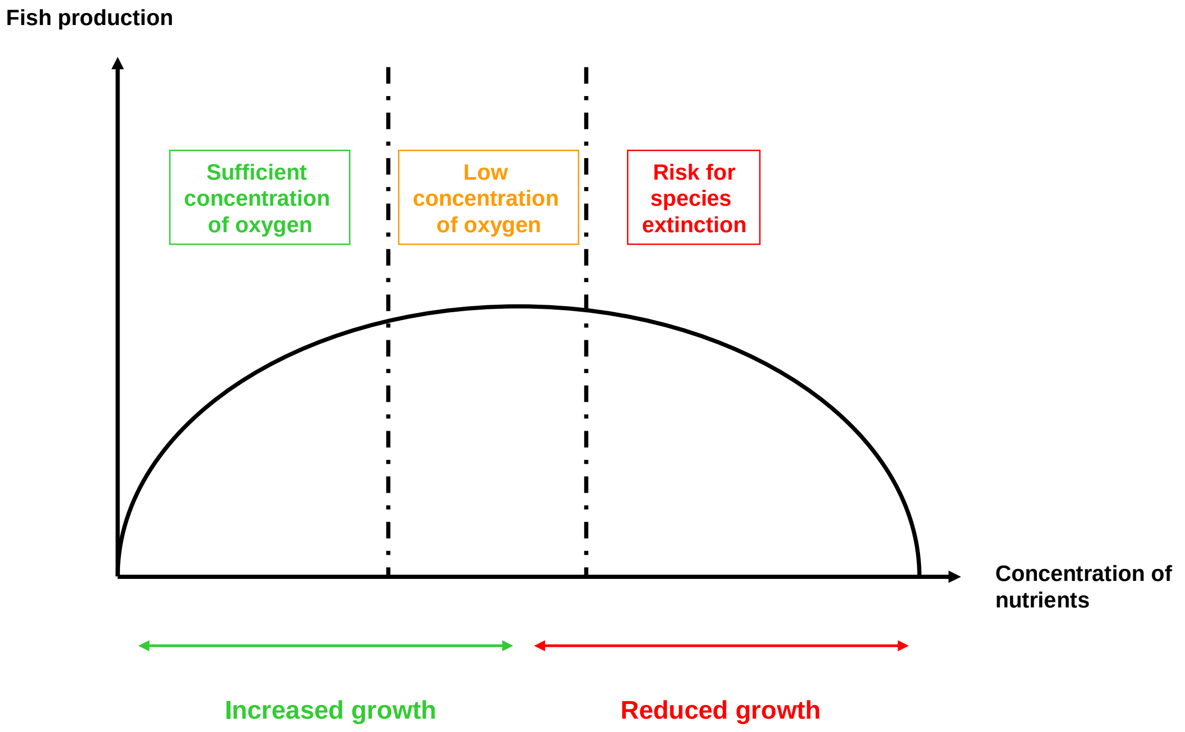

Figure 8. **Fish production as a function of concentration of nutrients.**

The effect of adding eutrophicating substances or nutrients to water is dependent on the oxygen concentration in the water. If the oxygen concentration is high, the nutrients will lead to an increase of fish production, but when the water is eutrophicated, the oxygen concentration will be so low that there is a reduction in fish production and also a risk that species can be extinct (i.e. impact on the NEX indicator). The local impact model will need to take care to the oxygen concentration of the drainage areas to which the emission of eutrophication substances is made. An introduction of conditions for the models will lead to that the model for increased growth can be used when the oxygen concentration is above a certain value and the model for decreased growth can be used when the oxygen concentration is below that value.

5.4.1.3 Indicators for recreational and cultural values

A discussion was held about other indicators of environmental impact that might be suitable for local impact modelling. The subjectivity of the selection of safe guard objects and/or environmental issues was however considered too high. Cultural and recreational values, the EPS impact category, can e.g. also be represented by the production rate of fish and additions of new category indicator were decided to be left outside the scope.

5.4.2 Adaptations

5.4.2.1 Phosphorous contribution to increased fish production

The impact on fish production from phosphorous was not modelled in EPS 2000 due to the fact that it has both positive and negative impacts depending on the oxygen level in the water[40]. By introduction of conditions in the model, phosphorous impact has been modelled here. When emitted to n-limited water bodies, phosphorous is assumed to have zero impact, and when emitted to p-limited water bodies it is assumed to cause all the eutrophication effects. If the oxygen concentration is below a certain value, then the "eutrophication model" is valid. If the oxygen concentration is above that value, then the "nutrient model" is used. The P-tot impact on fish and meat can be modelled with an equivalency method with N-tot as reference.

According to Matts-Ola Samuelsson[41], 1 mole of P equals 16 moles of N in eutrophicating effect and translated to kilograms 1 kg of P equals 7 kg of N. This figure corresponds to the content of nutrients in fish fodder[42] where there is 8 times as much P to N. The equivalence factor is thus set to 7. The uncertainty in the equivalence factor is assumed to be the same as for the equivalence factors in EPS 2000, i.e. described by a log-normal distribution with a standard deviation corresponding to a factor of 5.

5.4.2.2 Models for decrease of fish production due to eutrophication

The EPS model for increase of fish production due to anthropogenic emissions of nutrients is based on an investigation of the fish production in Skälderviken. The uncertainty factor when using the results for other parts of the world is assumed to be in the order of factor 4[43]. An investigation of Kalmarsund made by the National Board of Fisheries[44] shows an example of reduced fish recruitment due to emissions of nutrients[45]. Using this data is here assumed to have the similar uncertainty as the Skälderviken data when applying it to other parts of the world.

In 1995 the total emissions of nutrients to the Kalmar coastal water body was 5000 ton of nitrogen/year. The catch of perch decreased in the period 1990 to 1997 with 12 percent per year. An empirical model can thus be made for the decrease of fish production due to nitrogen emissions, where the characterization factor **CF** = decrease in fish recruitment [kg fish/year] / emission of nitrogen [ton/year].

The decrease of fish production due to emissions of COD and phosphorous can be modelled with an equivalence method just as with the EPS characterization factor for COD and phosphorous impact on NEX.

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[40] Steen B (1999b): "A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – Models and data of the default method"; CPM report, Chalmers University of Technology, Sweden, page 268

[41] Samuelsson (1993): "Life cycle assessments and eutrophication – a concept for calculation of the potential effects of nitrogen and phosphorous"; IVL Report B 1119, Stockholm

[42] Jonsson, Alanärä (2000): "Svensk fiskodlings närsaltsbelastning – faktiska nivåer och framtida utveckling, Vattenbruksinstitutionen rapport 18, Umeå

[43] Steen B (1999b): "A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – Models and data of the default method"; CPM report, Chalmers University of Technology, Sweden, page 267

[44] Jan Andersson et al. (2000), "Recruitment failure and decreasing fish stocks in the coastal areas of Kalmarsund", Fiskeriverket rapport 2000:5

[45] Johansson (2000):"Åtgärdsanalys av övergödningsproblemet i Kalmar läns kustvatten", Meddelandeserien nr 2001:18, ISSN 0348-8748

5.4.3 Nature data needed for local characterization models

Below are some examples of nature properties (in the models for eutrophication above) that are dependent on the local conditions, and where it is possible to find information. An inventory of nature system data sources can be found in the report "Local environmental impact"[46].

4.2.3.1 Oxygen concentration in fresh water bodies

Data about oxygen concentration in the reference water courses (50), river mouths (50) and lakes (95) can be found and downloaded for free at the website of the Environmental Assessment department[47] at the Swedish University of Agricultural Sciences. The location, year, month, day, depth [m], oxygen concentration [mg/l] is specified in the data set. If the fresh water area in a specific study is not a reference area, it has to be estimated with one.

High phosphorous content is another indicator of that the water area is eutrophicated if no reliable data about oxygen concentration can be found. For lakes, a list of the lakes that had a concentration of phosphorous of more than 100 µg/litre (yearly average) and thus regarded as hypertrophic was compiled in 1990 from a questionnaire to the County Administration[48].

4.2.3.2 Oxygen concentrations in marine water bodies

National monitoring programme data can be downloaded for free from the SHARK database (Svensk HavsARKiv)[49]. Regional data about marine concentrations of oxygen can be found and ordered at the Swedish Meteorological and Hydrological Institute for an administrative fee[50].

4.2.3.3 Anthropogenic emissions of nutrients

The anthropogenic emissions of phosphorous and nitrogen in Sweden can e.g. be found at the Swedish Meteorological and Hydrological Institute [51] or the Swedish University of Agricultural Sciences [52]. Emissions of phosphorous and nitrogen in Europe can be found in the European Pollutant Emission Register (EPER)[53], which is a European-wide register of industrial (which includes e.g. agriculture) emissions into air and water (Norway and Hungary are also included).

4.2.3.4 Normal extinction rate of species (NEX)

The extinction rate of species due to eutrophication is not known. In EPS it has been estimated with the fraction of red listed species that are assumed by science expertise to be threatened by eutrophication. In Scandinavia, 10% of the red listed species are assumed to be threatened by eutrophication[54]. On a global scale it is supposed to be 1% as warmer regions are less sensitive to excess nitrogen[55]. This empirical way of modelling does not suit adaptation to too small areas, and using the fraction of red listed species to smaller areas than Scandinavia is therefore not recommended.

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[46] Häggström S.; "Local environmental impact - Local nature system data availability and local characterization modelling"; CPM Report 2005:5
[47] http://www.ma.slu.se/IMA/dv_program.html
[48] http://www.ma.slu.se/Miljotillst/Eutrofiering/Hypertrofikarta.ssi
[49] http://www.smhi.se/oceanografi/oce_info_data/shark/home_download_sv.html?language=s (My attempt to download data did not succeed however.)
[50] http://www.smhi.se/oceanografi/oce_info_data/shark/home_search_sv.html
[51] Brandt, Svensson, Winqvist (2005): "Källfördelning av näringsämnen på vattendistrikt. Tilläggsrapport till SMED&SLU rapport: Klassificering av påverkan av näringsämnen på rapporterings- och havsområden", SMHI
[52] http://info1.ma.slu.se/db.html
[53] http://www.eper.cec.eu.int/eper/
[54] ArtDatabanken, "Rödlistade arter i Sverige", http://www.artdata.slu.se/
[55] Steen B (1999b): "A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – Models and data of the default method"; CPM report, Chalmers University of Technology, Sweden, page 267

6 Upgrading of prototype software tool

A prototype software tool called EMS@CPM that support work with the policy controlled environmental management methodology was developed in the project "Policy controlled environmental management work". One of the objectives with starting this sub project was to improve the prototype so that it can be used in practice.

6.1 Improvements made

The improvements performed of the tool EMS@CPM within IMPRESS sub project 8, are based on requirements from users of the tool. The most important requirements that were identified in the end of the project "Policy controlled environmental management work" were the following:

- Possibility to update the policy after it has been created
- Possibility to update the processes after it has been created
- The policies need to load faster in order for users to work with the tool

The first one of these requirements was met by implementing functionality to edit and store information related to a policy. The second of these requirements was met by establishing a connection to the functionality to edit LCI data which is used by the tool LCA@CPM. This work included generalisation of the functionality which also will make it possible for other tools to use the same functionality. The last one of the requirements was the one which required most resources to solve. The reason for the long time required to load a policy is that a search is performed for existing characterisation parameters and which of them that are linked to aspects in the processes for each indicator. This is a procedure that involves a lot of queries to the database. This was solved in two steps. In the first step functionality for matching of characterisation parameters was optimized, where the highly optimized functionality for calculation of impact assessment used in LCA@CPM was generalised and integrated within EMS@CPM. In the second step functionality for storing of information was implemented, which was made to guarantee that this time-consuming matching is only performed once each time a user is logged in.

EMS@CPM is integrated within the IMI portal[56] which is a platform where a lot of functionality is shared among the different tools on the portal (see 6.2). This means that enhanced functionality in one tool can be utilized also by the other tools if the functionality is implemented in a generalized way. In the IMPRESS project there have been a lot of improvements performed on especially LCA@CPM (see report from IMPRESS sub project 10) which has also implied improvements of the functionality of EMS@CPM. For example the functionality for aggregation of processes and editing of processes in general has been enhanced. The same applies to the management of users of the tools in the portal. Moreover, improvements of the data conversion functionality facilitates easier import and export of data in the EMS@CPM tool.

The prototype tool EMS@CPM did not become ready enough for use in practical tests etc. The work with the tool EMS@CPM has however not been in focus for the work performed within sub project 8 of IMPRESS, as other tools with a lower complexity has met the needs of the users for some of the implementation work performed in the project, see the chapter about low technology solutions in the results from sub project 3 "Maintenance of integration".

[56] The IMI Portal – http://databases.imi.chalmers.se/imiPortal/

6.2 Integration with other environmental information systems

The environmental management system is a tool for controlling all activities with environmental relevance and see to that the environmental goals expressed by the company management are fulfilled. The environmentally relevant activities can be performed in the production process, the product development process, the procurement process or be included in transports and logistics. All these parts of the company deliver information to the EMS and thus all the different information systems gain on being integrated with the EMS.

An example of a performed integration work is the use of life cycle assessment (LCA) information in environmental management systems (EMS). A weak point in the EMS method is the valuation of different environmental aspects and it is sometimes suggested that LCA methodology can be used in order to calculate the relative severity or significance of the environmental aspects[57]. LCA on the other hand is based on inventories of all the processes included in a product's life cycle, and life cycle inventory data can therefore be acquired from EMS. These are strong reasons to integrate EMS and LCA, but to do this, there are some intrinsic differences between EMS and LCA that has to be managed.

EMS and LCA differ in the system boundaries. The LCA information is based on products, and the quantitative data are normalised to the functional unit while the EMS information is usually based on processes, and the quantitative data are normalised to one year. The same allocation rules are seldom used. This puts demands on the documentation if the same information is going to be used for both applications. The allocation methods used must be described in detail.

The LCA information contains both an inventory of the operational performance indicators (OPIs) and a link to their impact on nature in terms of environmental condition indicators (ECIs) while EMS handles usually only the OPIs.

The tool EMS@CPM is integrated within the IMI portal[58], 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, that is further described in the Final report from the IMPRESS project "Implementation of integrated environmental information systems"[59].

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[57] http://www.infra.kth.se/fms/pdf/smb_forsvarsdepartementet.pdf

[58] The IMI Portal – http://databases.imi.chalmers.se/imiPortal/

[59] 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

7 Conclusions

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.

Together with SCA Personal Care, an exercise of extraction of indicators in practice was performed in order to make the methodology step clear. 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. The work is with great advantage started with creating a draft set of environmental indicators that are possible to calculate in practice. The definitions of the indicators need to be thoroughly made before the feasibility and relevance of and indicator definition can be apprehended. The draft indicator set gives the possibility to start discussions in the organization about what is actually relevant to measure, how the measurement is best performed and how much it will cost. The draft set of indicators and the definitions of the indicators are intended to be modified later on. The resolution of the indicators for e.g. each function, each product, different packaging and/or material can also be increased with time.

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 drawback of not having defined environmental condition indicators representing the policy is that environmental performance indicators cannot be weighted based on the impact on the environment. The impact on the environment from environmental performance indicators is not independent from the product, the process, the geographical site and the modelling of the life cycle scenario. The different EPIs can instead be prioritized from other perspectives, e.g. technological, economical and market potential perspectives. The EPIs and their results can however 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 work with controllability connects all tools used in a company to reach the environmental goals. 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. The scope of the environmental management system is however limited to comprise the environmental aspects that can be influenced by the organization's activities. The scope of the policy controlled environmental management work is also limited to comprise the environmental aspects that are indicated in the policy, or required due to laws and regulations. If the policy does not mention a certain environmental area or impact and no regulation etc. demands it, this means that the environmental aspects with such impacts should not be considered in the environmental work in other way than that a proposal of changes to the policy should be made.

The other step in the methodology pointed out to need further support in the project "Policy controlled environmental management work" was the adaptation of characterization methodology to local conditions. 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; 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). A methodology for local adaptation of EPS 2000 was chosen to be the most feasible solution. This work was performed in parallel with an investigation of available local data about the condition of the environment that was made in sub project 2 "General method development" and it was found that the local nature data needed for adaptation was accessible.

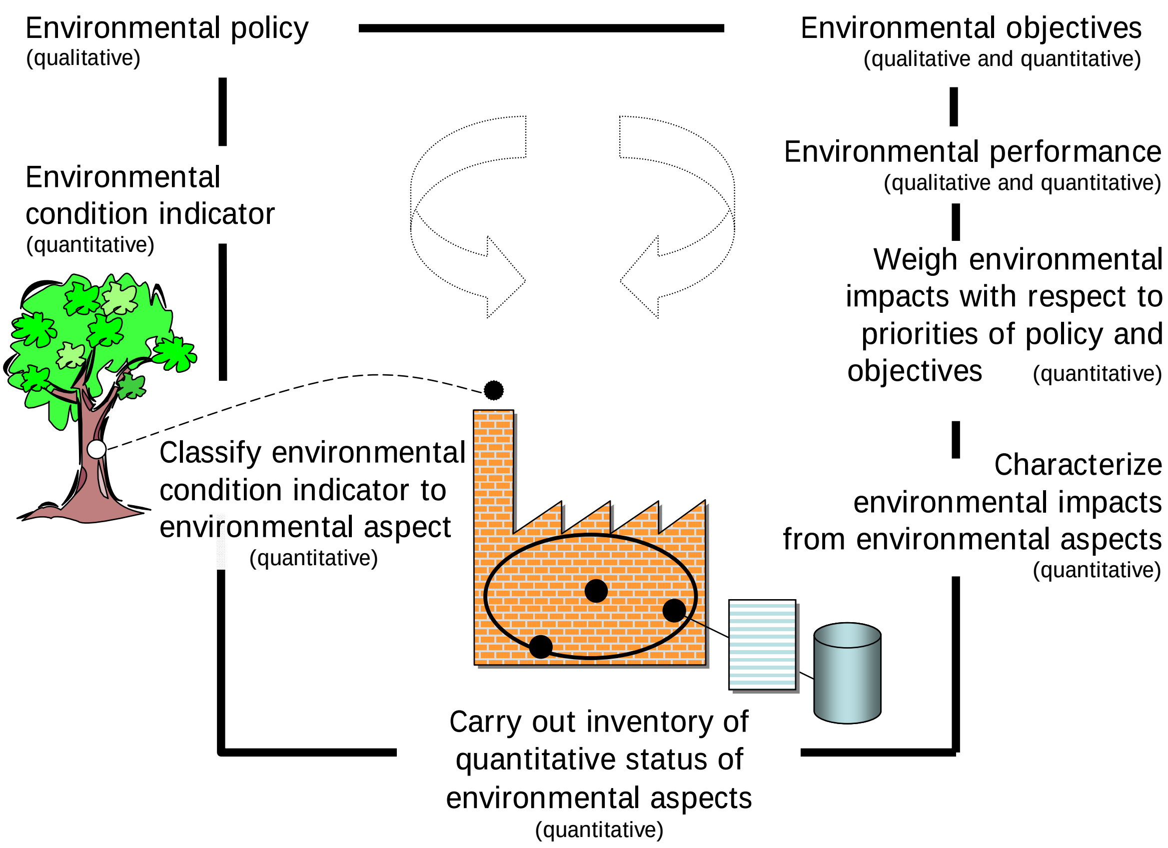
One of the objectives with starting this sub project was to improve the prototype software tool EMS@CPM, that supports work with the policy controlled environmental management methodology so that it can be used in practice. The work with the tool EMS@CPM has not been in focus for the work performed within 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. The prototype was improved in this sub project in terms of increased possibilities to update the information and more robustness and it was also integrated with other environmental information tools within the IMI portal. The tool has also been integrated in VIEWS, the Visualization of Integrated Environmental Work Spaces, that is further described in the Final report from the IMPRESS project "Implementation of integrated environmental information systems".

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.

Appendix I
Policy controlled environmental management work methodology

The methodology provides a structured procedure for connecting the environmental policy with the everyday environmental management work. A conceptual analysis is made of the environmental policy to find the relevant environmental condition indicators. The impact on the indicators from the company's environmental aspects is calculated by means of quantitative cause-effect models. These models have been borrowed from LCA methodology where they are called characterization models. A prototype software tool has also been developed to support the methodology.

The policy controlled environmental management work is divided into eight steps as can be seen in the picture below.



The work can be started at any of the steps and in either of the directions as the arrows suggests. Starting from the top left corner of the picture, the steps are:

- **Environmental policy**
  The environmental policy is formulated.
- **Environmental condition indicator**
  A conceptual analysis is made of the policy i.e. an analysis of what is actually stated in the policy about environmental responsibilities. In the analysis are extracted environmental condition indicators, as defined in ISO 14031, as consequences of the statements of the environmental policy.
- **Classify environmental condition indicator to environmental aspect**
  The identified environmental condition indicators are translated into environmental aspects. This step is compatible with the classification step in the ISO 14042 standard.
- **Carry out inventory of quantitative status of environmental aspects**
  The inventory of the quantitative status of the environmental aspects involves acquisition, processing and reporting of numerical environmental data and modelling of the production system based on the environmental aspects of interest. The list of environmental aspects from the previous step may be complemented with aspects that are not explicitly covered by the policy but are still needed because of laws and regulations, customer/supplier demands, internal use etc. This step corresponds to the environmental review and the general measuring and monitoring according to ISO 14001.
- **Characterize environmental impacts from environmental aspects**
  The impact on the environmental condition indicators from the company's environmental aspects is then calculated by means of quantitative cause-effect models. The methodology for these models has been borrowed from life cycle assessment (LCA) methodology where they are called characterization models.
- **Weigh environmental impacts with respect to priorities of policy and objectives**
  A quantitative subjective prioritization is made of the effects on the environmental condition indicators. The method with which this will be made is chosen in this step. The priorities shall be based on the policy and can also be used to identify the company's significant aspects.
- **Environmental performance**
  The current status of the environmental performance of the company is measured in terms of impact on the environmental condition indicators from the activities performed by the company. The characterization factors and the priorities from the two previous steps are used.
- **Environmental objectives**
  The results from the calculation of the environmental performance are used to set environmental objectives and targets. The environmental objectives are set at company level to avoid sub-optimizations at individual sub-units.

Appendix II
EPS characterization factors for eutrophication

Below are the specific expressions of the characterization factors (CF) in EPS 2000.

N-tot impact on NEX
Modelled with empirical method
CF = A*B/C

A = relative size of n-polluted (ocean) water area
B = ratio of extinction of species caused by eutrophication [NEX]
C = global emission of nitrogen to water [kg]

N-tot impact on fish and meat
Modelled with mechanistic method
CF = -A*B*(C-D)/(D*E)

A = share of nitrogen emissions ending up in areas where the growth rate is limited by nitrogen
B = average fish production in Swedish waters [kg/hectare*year]
C = weight of bottom fauna 1984 [g/m^2]
D = weight of bottom fauna 1912[g/m^2]
E = anthropogenic added nitrogen [kg/hectare]

COD impact on NEX (determined by an equivalency method using N-tot as a reference)
Modelled with equivalency method with N-tot as reference
CF = A*B*C

A = part of COD mineralized
B = relative rate of consumed oxygen for COD/N-tot
C = CF for N-tot

P-tot impact on NEX
Modelled with empirical method
CF = A*B/C

A = relative size of P-polluted (lake) area
B = ratio of extinction of species caused by eutrophication [NEX]
C = global emission of phosphorous to water [kg]

Suggestions for local impact modelling

Models for impact on NEX
The geographical scope for this model is Scandinavia.

N-tot impact on NEX
Modelled with empirical method

CF = A*B/C = 0.9*0.1 NEX/8.6 E6 kg = **1.05 E-8 NEX/kg**

A = relative size of n-polluted (ocean) water area
B = ratio of extinction of species caused by eutrophication [NEX] = 0.1 NEX (1990?)
C = Scandinavic emission of nitrogen to water [kg] = 8626 ton (2001)[60]

P-tot impact on NEX
Modelled with empirical method
CF = A*B/C = 0.1*0.1 NEX/0.9 E6 kg = **1.1 E-8 NEX/kg**

A = relative size of p-polluted (lake) water area
B = ratio of extinction of species caused by eutrophication [NEX] = 0.1 NEX (1990?)
C = Scandinavic emission of phosphorous to water [kg] = 899 ton (2001)[61]

COD impact on NEX
Modelled with equivalency method with N-tot as reference
CF = A*B*C = 0.5*0.102*1.05 E-8 NEX/kg = **5.36 E-10 NEX/kg**

A = part of COD mineralized = 0.5
B = relative rate of consumed oxygen for COD/N-tot = 0.102
C = CF for N-tot = 1.05 E-8 NEX/kg (see above)

Models for increase of fish production

The geographical scope for the nitrogen model is Skälderviken, but it is assumed that the figures can be applied also at other locations where no eutrophication exists. The use of the results in other parts of the world introduces an uncertainty, which is assumed to be in the order of a factor of 4[62].

N-tot impact on fish increase
Modelled with empirical method
CF = -A/B = -25/56.1 = **-0.446 kg fish/ kg N-tot**

A = increased fish production = 25 kg/hectare*year
B = anthropogenic added nitrogen = 56.1 kg/hectare

P-tot impact on fish increase
Modelled with equivalency method with N-tot as reference
CF = -A*B = -0.446*7 = **-3.122 kg fish/kg P-tot**

A = CF for N-tot = 0.446 kg fish/kg N-tot (see above)
B = relative rate of nutrient need kg N-tot/ kg P-tot = 7[63]

60 EPER, http://www.eper.cec.eu.int/eper/

61 EPER, http://www.eper.cec.eu.int/eper/

62 Steen B (1999b): "A systematic approach to environmental priority strategies in product development (EPS). Version 2000 – Models and data of the default method"; CPM report, Chalmers University of Technology, Sweden, page 264.

63 According to Matts-Ola Samuelsson [Samuelsson (1993): "Life cycle assessments and eutrophication – a concept for calculation of the potential effects of nitrogen and phosphorous"; IVL Report B 1119, Stockholm], 1 mole of P equals 16 moles of N in eutrophicating effect and translated to kilograms 1 kg of P equals 7 kg of N. This figure corresponds to the content of nutrients in fish fodder where there are 8 times as

Models for decrease of fish production

The geographical scope for the nitrogen model is Kalmarsund, but it is assumed that the figures can be applied also at other locations where eutrophication exists [64]. The uncertainty is assumed to be the same as for increased fish production (see above).

N-tot impact on fish decrease
Modelled with empirical method
CF = A/B = 12/5 = **0.0024 kg fish/ kg N-tot**

A = decreased fish production = 12 ton/year
B = anthropogenic added nitrogen = 5 000 ton N-tot/year

P-tot impact on fish decrease
Modelled with equivalency method with N-tot as reference
CF = A*B = 0.0024*7 = **0.0168 kg fish/kg P-tot**

A = CF for N-tot = 0.0024 kg fish/ kg N-tot (see above)
B = relative rate of nutrient need kg N-tot/ kg P-tot = 7[65]

COD impact on fish decrease
Modelled with equivalency method with N-tot as reference
CF = A*B = 0.0024 *0.102 = **0.00024 kg fish/ kg COD**

A = CF for N-tot = 0.0024 kg fish/ kg N-tot (see above)
B = relative rate of consumed oxygen for COD/N-tot = 0.102

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much P to N [Jonsson, Alanärä (2000): “Svensk fiskodlings närsaltsbelastning – faktiska nivåer och framtida utveckling”, Swedish University of Agricultural Sciences, Umeå]. The reliability of the figures is however not guaranteed.

64 Andersson et al. (2000), ”Recruitment failure and decreasing fish stocks in the coastal areas of Kalmarsund”, Fiskeriverket rapport 2000:5 and
Fiskeriverket (2001), “Småskaligt kustfiske och insjöfiske – en analys”

65 According to Matts-Ola Samuelsson [Samuelsson (1993): “Life cycle assessments and eutrophication – a concept for calculation of the potential effects of nitrogen and phosphorous”; IVL Report B 1119, Stockholm], 1 mole of P equals 16 moles of N in eutrophicating effect and translated to kilograms 1 kg of P equals 7 kg of N. This figure corresponds to the content of nutrients in fish fodder where there are 8 times as much P to N [Jonsson, Alanärä (2000): “Svensk fiskodlings närsaltsbelastning – faktiska nivåer och framtida utveckling”, Swedish University of Agricultural Sciences, Umeå]. The reliability of the figures is however not guaranteed.

Appendix III
Svanen coefficients

Calculation of coefficients, kg / ton of paper

Quantity of bleached chemical pulp, ton of 90% pulp/ton of paper	K1
Quantity of unbleached chemical pulp, ton of 90% pulp/ton of paper	K2
Quantity of CTMP, ton of 90% pulp/ton of paper	M1
Quantity of TMP / ground wood, ton of 90% pulp/ton of paper	M2
Quantity of recycled fiber, ton of 90% pulp/ton of paper	R
Quantity of bleached mechanical pulp, ton of 90% pulp/ton of paper	B

COD coefficient = 30K1 + 15K2 + 15M1 + 6M2 + 12R + 4B
P coefficient = 0.05K1 +0.015K2 + 0.01(M1 + M2) + 0.015R
S coefficient = 0.8K1 + 0.7K2 + 0.2M1 + 0.15M2 + 0.5R
NOx coefficient = 2.0K1 + 1.8K2 + 0.6(M1 + M2) + 1.0R

The total points rating for each individual parameter is then calculated as:
C = COD emission to water kg O_2 / ton P_C = COD total / COD coefficient
P = P emission to water kg P / ton P_P = P total / P coefficient
S = S emission to air kg S / ton P_S = S total / S coefficient
N = N emission to air kg NO_2 / ton P_N = N total / N coefficient

Each of the parameters P_C, P_P, P_S and P_N individually must not exceed 2 points.
The total emission rating for the paper product is finally calculated by adding together the total scores for the individual parameters.
$\Sigma P = PC + PP + PS + PN$
Where the requirement for ecolabelling is
$\Sigma P \leq 4.0$

Appendix IV
Template for extraction of environmental indicators from the environmental policy

The work is with great advantage started with creating a draft set of environmental indicators that are possible to calculate in practice. The definitions of the indicators need to be thoroughly made before the feasibility and relevance of and indicator definition can be apprehended. The draft indicator set gives the possibility to start discussions in the organization about what is actually relevant to measure, how the measurement is best performed and how much it will cost. The draft set of indicators and the definitions of the indicators are intended to be modified later on. The resolution of the indicators for e.g. each function, each product, different packaging and/or material can also be increased with time.

Documentation of the environmental policy

Company/Organization

- Name
- Included units subordinated this policy

Policy description

- Description of the level of the policy:
    - References to mother policy and if possible documentation of how the mother policy was broken down to the policy in question
    - References to existing sub-policies
- Policy version
- Date completed
- Valid time and geography span
- Demographic range

Environmental policy

- Environmental policy: Text or reference
    - References to indicators in the text, e.g. using the indicator numbers
- Drawing/outline of the physical reference (the site) with the inputs and outputs that are relevant for the environmental indicators.

Documentation of the indicator set

Environmental indicators

- List of the extracted quantified indicators and their units

Indicator name	Number	Unit	Impact category	Short description of indicator

- For each indicator, document the following:
  - Complete definition/description of indicator
    - Is the indicator an MPI, ECI or OPI according to the ISO 14031 definitions?
    - Reference to original IIP if the indicator definition is chosen among already existing ones (from impact assessment methods, quality management system)
    - Unit explanation if necessary
    - Choice of impact category
    - Dependency of or influence on other indicators
    - Included units in the company contributing to the value of the indicator
    - Comparability (in case of comparisons between years and/or units, does the indicator provide a fair measure?)
  - Formula
    - The physical or economical inputs and outputs that are the input for the calculation
    -
  - Input - intended data acquisition procedure
    - Intended data acquisition
    - Expected data availability and quality
    - Economical feasibility
  - Output - intended use of the indicator
    - The company unit that can influence the indicator together with the top management will receive the indicator result.
    - The output can be used as:
      - Comparison between company's units
      - Comparison between years of the company's aggregated environmental performance
- Check again the motives for including the indicator in the list:
  - Interpretation of the policy
  - Connected legal requirements

Documentation of the working method

The context and the choices that were made during the work with extracting the indicators are obvious at the time but will not be after time has passed. To prevent misinterpretations in the future, it is good to also document how the work was performed.

Work description

- Who performed the work? (Competences/roles)
- For what purpose was the indicators extracted? (Intended use)
- Scope/indicator level (chosen end-point for environmental impact)
- Time consumption

Difficulties and obstacles

- What was most difficult? How was it solved?
- What are the main obstacles to performing this kind of analysis?

Benefits

- What benefits were gained by the work? (Increased understanding of the policy, increased knowledge…)

Further comments

- Detail level for maximum controllability?

Example of documentation of an EPI:
OPI 1 - Name: Hazardous chemicals

Definition/ description of function:

Monitor the use of hazardous chemicals in proportion to the total amount of chemicals used. The classification of chemical substances as hazardous is made according to the EC Directive 67/548/EEC. This indicator can be divided into two for higher resolution; one that monitors the chemicals used for the product and one that monitors the chemicals used for the production process.

Formula:

If Y is the substances purchased by the company and $i \in Y$
If X is the substances classified as hazardous purchased by the company and $j \in X$

Hazardous chemicals = $$100 * \frac{\sum_{\forall j \in X} Purchased\_weight_j}{\sum_{\forall i \in Y} Purchased\_weight_i}$$

Unit:

[weight%]

Input

From purchasers and production managers:
Name and weight of each chemical substance purchased
From environmental coordinator:
Risk classification of each chemical substance.

For higher resolution:
From designers:
Name and weight of each chemical substance in the product specifications.

Output:

To top management:
The weight of hazardous chemicals used in the company in relation to total weight of chemicals used.
To designers and production managers:
The weight of hazardous chemicals used in the products/processes in relation to total weight of chemicals used.

Comments:

The environmental impact from this environmental aspect depends on the kind of chemical that is used. The classification according to Directive 67/548/EEC can be substituted with e.g. cause-effect modelling.