Integration of environment and economy in product development gives opportunity for innovations

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October 2016
Gothenburg, Sweden

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Publication number: 2016:6

For press release see ivl.se

Summary

The project Integration of environment and economy in product development gives opportunity for innovations (IMP) has intended to strengthen the long-term competitiveness of the manufacturing industry through a pro-active risk management considering environmental and sustainability aspects, by developing methodologies for calculating the economic value of reduced environmental impacts from products, early in the product development phase.

The project activities have included: strengthening of the scientific basis regarding economic values; contribution to an ISO standard; and testing of methodologies in case studies and dissemination.

The case studies, carried out at AkzoNobel, SCA and Volvo Group, have shown different ways in applying a monetary value on environmental impacts, and in particular how these can assist decision-makers in their choice of for example materials. Different scenarios can provide useful input into this process.

The project has been coordinated by Swedish Life Cycle Center. Maria Lindblad, IVL Swedish Environmental Research Institute, has been the project leader.

Swedish Life Cycle Center ivl SVENSKA MILJÖINSTITUTET CHALMERS AkzoNobel SCA Care of Life VOLVO

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1. Introduction

The project Integration of environment and economy in product development gives opportunity for innovations (IMP) has intended to strengthen the long-term competitiveness of the manufacturing industry through a pro-active risk management considering environmental and sustainability aspects, and to stimulate to significant eco-innovation and not merely to incremental changes.

A Life Cycle Assessment (LCA) describes the use of natural resources and emissions of a product or service in quantitative terms throughout its life cycle (Baumann and Tillman 2004: chapter 1). Monetization of the LCA results means that an economic value is assigned to the different impacts that are covered within an LCA. This implies that a price is placed on the effects of different environmental damages.

The IMP project has aimed to contribute to more efficient product development by further developing, testing and establishing the Environmental Priority Strategy methodology (EPS) which makes environmental costs more visible early in the product development phase. It has also aimed at facilitating a change from a reactive to a proactive product development strategy with regards to environment and sustainability. In addition, it has aimed to contribute to the innovation process by making environmental and sustainability data more readily available.

Within IMP, the EPS methodology for calculating the economic value of reduced environmental impacts from products has been further developed. Activities within IMP have aimed at: strengthening of the scientific basis regarding economic values; contributing to an ISO standard; and testing of methodologies in case studies. The case studies have been carried out at the Volvo Group: *The Effect on Environmental Damage Costs and Eco-Efficiency of introducing Recycling of Sand in Volvo Group's Engine Plant in Skövde*, and *Environmental Cost and Eco-Effectivity Assessment of Copper and Aluminium High Power Cables*; at AkzoNobel: *4D P&L (4 Dimensional Profit & Loss Accounting)*, and at SCA: *Pilot weighting method for product development and innovations*.

The results from the IMP project have been disseminated via; Swedish Life Cycle Center; IVL Swedish Environmental Research Institute, the working group ´Get the prices right´; contributions to an ISO standard; workshops; conferences, and; publications in peer-reviewed journals. The project has been coordinated by Swedish Life Cycle Center.

Project title:

Integration of environment and economy in product development gives opportunity for innovations

Project leaders:

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Time period:

2013-11-01 – 2016-11-01

Funded by:

Vinnova Sweden's innovation agency, with in-kind contribution from AkzoNobel, SCA and Volvo Group.

2. Background

Business has long been a matter between seller and buyer. Transactions between them are based on the value a product or service has for the seller and buyer. But most products and services also create values and costs for third parties, so called externalities. Some of these externalities arise from changes in the environment.

Historically, there has been a difference between societal value creation and corporate value creation (KPMG 2014: 10). However, this is rapidly changing due to a number of megaforces, such as population growth, urbanization, digital connectivity, climate change and resource scarcity, which creates a new landscape for businesses to navigate in.

Already in 1972 the OECD Council adopted the Polluter Pays Principle (PPP), implying that "the polluters should bear the expenses of carrying out environmental protection measures decided by public authorities to ensure that the environment is in an acceptable state. In other words, the cost of these measures should be reflected in the cost of goods and services which cause pollution in production and/or consumption" (Sterner and Coria 2003, 2012: 118). At the Rio-conference in 1992 there was an international, political consensus about the "polluter pays principle" as it was written into the UN Declaration on Environment and Development, through principle 16. When EU, some years ago, launched their Integrated Product Policy initiative, the principle was transformed to "get the prices right", i.e. the price should include environmental costs. As a result, there are nowadays more precise requirements in the EU for including environmental costs in the energy and transport sectors (European Commission 2016). "Getting the prices right" is about correcting market failures and would imply emitters to bear the costs of the effects they have on the society (Fischer et al. 2012).

This new landscape implies that externalities are internalized, bringing both new opportunities and new risks to businesses and their revenues (KPMG 2014: 6, 11). Risks may include decreased earnings due to for example resource scarcity pushing prices to a higher level, while opportunities may include both increased revenues or decreased costs by proactivity on new markets or better control over the own value chain (KPMG 2014: 18).

A company often generates both positive and negative externalities through their operations, where a positive externality is "an economic, social or environmental benefit that a company creates for society for which it is not directly or fully rewarded in the price of its goods and services" and a negative externality is "an economic, social or environmental cost that a company inflicts on society for which it does not directly pay a price" (KPMG 2014: 7). Their internalization refers to the process of taking into account positive and negative externalities into the business model, meaning a business could either be rewarded or pay for their externalities (Ibid 2014: 7). Often, negative externalities are more directly internalized than positive ones (KPMG 2014: 18).

The increasing internalization of externalities brings a need for companies to better understand their externalities to be proactive and create value (KPMG 2014: 4, 6). The proactive companies are more likely to preserve their corporate value, although some internalization is announced and some unexpected (Ibid 2014: 50). By increasing positive externalities and decreasing negative externalities it is possible to grow revenues, including by cutting costs and reducing risks (KPMG 2014: 11). This brings a need to understand the externalities and to measure them (Ibid 2014: 4, 6).

Environmental impacts from products have so far been seen as negative features, which have been subject to minimization. However, innovation and product development is about value creation in a wider sense. In order to make this happen in an efficient way, there is a need to be able to describe the value of environmental change.

There are a number of published studies and projects quantifying environmental costs for emissions and resource extraction, many originally developed for use in connection with cost-benefit studies (Needs Project 2013, Ahlroth 2009; 2.-0 LCA Consultants 2013). In the 1990s, a research group, that later formed Swedish Life Cycle Center, started to use environmental damage costs for weighting of Life Cycle Data in the context of comparing the environmental impact of different product designs (Steen 1999).

There are several modern estimates of the environmental costs of climate-changing emissions (Stern 2006; Tol 2009), and there is ongoing research to value ecosystem services and estimate the value of natural capital of minerals (Steen and Borg 2002; de Groot et al. 2012). There is however no global consensus on one single methodology for integrating environmental costs into product development.

2.1 Why monetary valuation?

Defining the monetary value of environmental external costs requires subjective methodological choices. However, the decision to monetize the external costs is also a subjective methodological choice. As indicated above, monetization can help in decision-making by creating a common language that is used both for the environmental assessment as well as the economic aspects of an investment or technology update. The familiar nomenclature can help businesses better understand the magnitude of the impact. It becomes easier to relate different impacts to each other (KPMG 2014: 44), to the economic value of the products, and also to the economic costs of reducing the impacts.

Although the external costs are currently paid by the society, they might be internalized in the future through regulation and/or environmental taxes. The monetization thus helps the company estimate the financial risks associated with the environmental externalities. Assigning an economic value to environmental impacts can also assist environmental coordinators etc. in companies in making a persuading case for environmental improvements in internal communication and decision processes.

Despite these benefits, the idea of monetization has been met with scepticism and criticism in several environmental contexts, such as the global LCA community. The international standard for LCA, for example, stipulates that monetization or any other weighting across impact categories shall not be used in an LCA that aims to compare competing products, if the study is intended to be disclosed to the public (ISO 2006: 23).

The most common criticism towards monetization in the LCA community relates to the subjectivity and perceived lack of a scientific basis for monetization. However, many other arguments against monetization have been raised in the context of cost-benefit analysis (CBA). Several of these arguments points to the limitations of CBA itself, and is also relevant for LCA and other methodologies for quantitative environmental systems analysis. Pearce (2001) lists and discusses the following objections in relation to CBA:

Credibility: environmental impacts of an option, and their monetary value, are often highly uncertain. Wynne (1992) distinguishes four types of uncertainty; risk, uncertainty, ignorance and indeterminacy. If the possible outcomes can be defined and their probabilities can be assigned in a meaningful way, one is talking of risks. If the possible outcomes are identifiable, but their probabilities cannot be determined, one is faced with uncertainty. Ignorance refers to when we do not know what we do not know. Finally, indeterminacy is used to describe situations in which the complexity of the system is so large and so little is known about the relevant parameters and their relationships that modelling becomes a matter of hit and miss (Mickwitz 2003). Where ignorance and indeterminacy may be at play, and it will often be the case because of the complexity of social and environmental issues, decision-making will have to rely on other tools in addition to LCA or CBA. An LCA can, in principle, account for risk and, through sensitivity analysis, deal with uncertainty. However, if the full uncertainty is properly accounted for, monetized LCA results might encompass a level of uncertainty that makes them difficult to interpret and use. On the other hand, if the uncertainty is not properly accounted for, the study lacks in credibility.

Moral objections: a CBA or an LCA with monetization reflects utilitarian moral philosophy: it assumes that all types of negative effects can be compensated by positive effects. It can be argued that certain negative effects, e.g., the loss of human life or the extinction of a species, cannot be compensated for by positive effects. Furthermore, individuals that benefit from a policy or project typically do not, in practice, compensate the individuals that lose. As a result, the CBA or LCA should be complemented by an identification of negative (and positive) effects that are difficult to compensate (or off-set) by other effects; and by an analysis of the distribution of positive and negative effects for various groups in society.

The efficiency focus: an objective of monetization is to assess how efficient different options are when they are implemented in the current economic, technological and social context. Consumers and other decision-makers, however, often have additional objectives such as quality of life, fairness, long-term sustainability, etc. A full basis for a decision might require additional analyses to cover these issues.

Flexibility: decision-makers may feel that monetized LCA results, by indicating the most efficient option, usurp the freedom of choice from the decision-makers. Here, it is important to remember that the LCA is a decision-support tool, and that all relevant effects or political considerations may not be encompassed in the LCA.

Participation: CBA has been accused of not involving relevant stakeholders, and the same might be said for LCA.

By presenting one-dimensional results there is a risk that an LCA with monetization closes the door for debate. Stakeholder participation and debates are important to resolve conflicts of interest. Without them, important stakeholder groups might not accept the option selected by the decision-makers. This can be a significant problem for controversial options such as the construction of a waste incinerator or an expansion of the source separation scheme. Since LCA and CBA do not resolve conflicts of interest, they cannot replace the decision-process but only provide input to this process.

Capacity: expertise in both economics and environmental science is necessary to calculate monetized LCA results. A certain level of expertise is also necessary to interpret the results and to participate in a debate that is based on monetized LCA results.

Some of these problems can be alleviated through a few careful measures in the LCA:

- Generating and screening ideas for relevant options;
- Involve decision-makers and stakeholders as partners in the study, for example through an active reference group, to achieve mutual learning and increased acceptability of the final decision;
- Ensure that the methodology and case study are transparently reported, with important methodological choices and uncertainties highlighted; and
- Carry out or recommend complementary analyses to achieve an improved basis for discussion and/or decisions.

Even with these measures taken, it can be argued that monetization is a barrier rather than a path to good decision processes, at least democratic decision processes that involve stakeholders with conflicting interests. This barrier is related to the efficiency of communicating a one-dimensional monetized result. It is easy for the LCA practitioner to present the one-dimensional result, but much more difficult to produce and communicate a transparent presentation of all important methodological choices, assumptions and uncertainties. The difference is even greater for the audience of the study: it is easy to understand the one-dimensional monetized result; understanding the complex issues behind this result can be difficult even when the audience consists of LCA experts with plenty of time to spend. The sheer communication power of the monetized LCA results brings an apparent risk that the audience is tempted to accept these results without understanding what is behind them. This shuts the door for debate and makes the LCA more of a decision-making tool than a decision-support tool.

A decision-making tool that does not invite debate is not well suited for democratic decision processes; however, it can be useful in other contexts, particularly when environmentally relevant decisions have to be made rapidly by decision-makers that are not environmental experts. Such decision-makers can include consumers in a food store, engineers choosing materials for the components of manufactured products, managers making small and medium-sized investment decisions, etc.

The subjective nature of monetization can reduce the usefulness of the one-dimensional monetized result in some applications. Informed consumers or managers might trust the one-dimensional result only to the extent that they share their subjective values or trust the people that calculated the results. In some cases, however, monetization factors can be an efficient way to communicate subjective preferences. If a monetization methodology is consistent with the environmental preferences and perspectives of a company, the application of this methodology in product and process development will help operationalise the values of the company in the products and production processes.

When measures are taken to alleviate the problems of monetization, and when it is used in suitable applications, monetization will still reflect a utilitarian moral philosophy and a focus on efficiency. The choice to monetize environmental impacts remains subjective, because it is based on accepting utilitarian principles and on accepting efficiency as an important criterion for good decisions.

However, the choice to carry through an LCA at all is subjective in similar ways. Utilitarian principles are partly integrated into LCA even without monetization. When an LCA calculates, for example, the total particle emissions of the life cycle, it reflects the assumption that an increase in emissions at one place can be compensated by the reduction of emissions elsewhere, although these emissions will affect the health of different people. The focus on efficiency is also integrated in LCA even without monetization. An LCA does not calculate the total emissions of a system but the emissions per functional unit, which is an indicator of inefficiency.

This project has built on the idea that putting a price on products' total environmental impact will assist in integrating environmental aspects in product development more efficiently. Since the relationship between product design and environmental values is complex and often difficult to understand, standards that support such methodology are required for this approach to be accepted.

2.2 Eco-Efficiency

Measuring Eco-Efficiency can be a way to find out which environmental improvement that is achieved to the lowest cost. The idea is to include the concept of value when there are several alternatives to choose between, in order to not sub-optimize. When there is a limited budget for improvement, it is important that the choice does most good.

Eco-Efficiency can be measured in many ways, and the methodology chosen here is the ratio between the change in the environmental indicator and the change in the value or price indicator. In this way, we get a measure of the environmental load per investment cost and how this changes between different options.

2.3 The EPS Methodology

One common way to present LCA results is by looking at the life cycle impact in different impact categories. This implies looking at how much each resource use or emission contributes to for example acidification, global warming or ozone depletion. Each impact is measured in a standard unit, and all emissions are translated into this unit. One such unit is kg CO_2 equivalents, used for measuring global warming potential. 1 kg CO_2 is worth 1 kg CO_2 equivalents, while other greenhouse gases are worth more or less, depending on if they impact global warming more or less than carbon dioxide.

To show environmental impacts not on the level of impact categories, but aggregated in a single value ("single score"), a weighting of environmental impacts against each other is necessary. How important is for example acidification compared to global warming? This is often helpful for non-LCA practitioners, as it gives one result to consider and not several. There are different weighing methodologies available, and some of them based on monetary values of environmental impacts.

In comparison to the results of impact categories, which are based on scientific models, it is important to understand that "single-score"-methodologies always rely more or less on subjective value choices. Results are therefore dependent on subjective preferences integrated in respective methodology, and should be understood as valid in the context of these preferences only. If weighting is made on impact category indicators that are abstract in character, like "acidification potential" subjective values tend to vary highly in time and among individuals.

To increase the reproducibility of weighting, the EPS, Environmental Priority Strategy, methodology strives to apply subjective weighing of environmental impacts on utilities well-known to everyone, such as food and different human health conditions. This means that the impact models must follow the cause-effect chain past acidification and global warming to the actual consequences for human everyday life. The value of harm (for example lives lost) caused by different environmental impacts is taken from scientific studies, implying that this part of the assessment represents a "shared subjectivity". Compare this to evaluating the cost of CO2 emissions directly.

In the EPS 2000d methodology, the environmental impacts are evaluated, and expressed in terms of "willingness to pay" to hinder the damage on five safeguard subjects: human health, biological diversity, eco-system production, natural resources and aesthetic values. The calculation is based on an average OECD citizen.

The damage from different impacts is expressed in category indicators such as "years of lost life" (YOLL), "crop production capacity" or "oil reserves". These are then related to an economical value, and the entire effect over the life cycle is summed up to get the final result. As a guide for non-LCA practitioners it can be commented that the calculation of environmental impact in terms of cost is a way to both highlight the effect of emissions on current and future generations, but also a way to highlight what cost can be expected due to environmental legislation in the future (EPS 2015a and b).

For resources the overall principle is that the environmental cost of depleting a resource equals to the cost of replacing the resource from earth's average crust or another non-scarce rock. Similarly for fossil resources the cost to produce a bio-based equivalent gives the damage cost for resource depletion. For emissions, it is the added costs of impacts on safeguard subjects: Ecosystem services, access to water, biodiversity, and human health.

3. About the IMP project

The IMP project has been coordinated by Swedish Life Cycle Center, a national center of excellence for the advance of life cycle thinking in industry and other parts of society. In the Center, universities, industries, research institutes and government agencies are working together in research- and administrative projects, working groups and expert groups, and communication activities to develop, implement and share knowledge and experience in the life cycle field. The mission is to improve the environmental performance of products and services as a natural part of sustainable development. Current partners are Chalmers University of Technology (host of the center), KTH Royal Institute of Technology, Swedish University of Agricultural Sciences - Dept. of Energy and Technology, Swedish Environmental Protection Agency, AkzoNobel, NCC Construction, SCA, Sony Mobile Communications, SKF, Vattenfall, Volvo Cars Corporation, Volvo Group, IVL Swedish Environmental Research Institute and SP Technical Research Institute of Sweden.

The EU has within IPP (Integrated Product Policy) aimed to include environmental externalities in products prices, trying to 'Get the prices right'. This has been the focus in one of the working groups within the Center, called "Get the prices right". The working group has worked with the EPS-methodology, and together started the IMP pto investigate further monetization of environmental external costs.

The IMP project, Integration of environment and economy in product development gives opportunity for innovations, was funded by Vinnova Sweden's innovation agency, with in-kind contribution from AkzoNobel, SCA and Volvo Group. The IMP project was operated between November 2013 and November 2016. The project built on the pilot study Externalities in product development give possibilities for innovation (Vinnova ref: 2012-03841), and aims to promote a more effective product development concerning environmental and sustainability aspects.

The IMP project has strengthened the long-term competitiveness of the manufacturing industry through a pro-active risk management considering environmental and sustainability aspects. The IMP project has developed methodologies for calculating the socioeconomic value of reduced environmental impacts from products and to make it available early in the product development phase. A methodology has also been developed for estimating the economic risk for a company associated with its future environmental impacts. This gives businesses the opportunity to take on a more long-term planning in

development of new products and services.

Within IMP, the project group has contributed to;

- Continue to developing the EPS methodology for calculating environmental damage costs;
- The EPS methodology implementation, including: case studies, output from case studies, and methodology ISO standardisation;
- Dissemination, including: project management, coordination of the Working Group "Get the prices right", contribution to ISO standardization work, and dissemination.

Within the IMP project, work has been done to initiate development of an international standard on monetary valuation of environmental impacts. An ISO working group began working on a standard in February 2016. The group has held three meetings and a draft standard has been formulated. The standard, if it is accepted by voting of the member countries, will be called ISO 14008 - Monetary valuation of environmental impacts from emissions and use of natural resources. The work has led to another initiative from the UK to start a project on how to use monetary values of social costs in companies. That standard will be called ISO 14007 - Environmental management: Determining environmental costs and benefits. The IMP project group has participated also in this work. Describing the EPS methodology in terms of international standards will increase its credibility.

Three companies have been involved in developing case studies within the project, Volvo Group: *The Effect on Environmental Damage Costs and Eco-Efficiency of introducing Recycling of Sand in Volvo Group's Engine Plant in Skövde*, and *Environmental Cost and Eco-Effectivity Assessment of Copper and Aluminium High Power Cables*; Akzo-Nobel: *4D P&L (4 Dimensional Profit & Loss Accounting)*, and SCA: *Pilot weighting method for product development and innovations*. Below follow conclusions from the case studies, as well as interviews with their performers, while the case studies can be found in the appendices (1, 2, 3 and 4).

Swedish Life Cycle Center · ivl Svenska Miljöinstitutet · Chalmers · AkzoNobel · SCA Care of Life · Volvo

4. The history of the EPS methodology

The story of EPS

The EPS system was developed to meet the requirements of an everyday product development process, where the environmental concern is just one among several others. The development of the EPS system started during 1989 on a request from Volvo and as a co-operation between Volvo, the Swedish Environmental Research Institute (IVL) and the Swedish Federation of Industries. Since then it has been modified several times during projects, which have involved several companies, like in the Swedish Product Ecology Project (Ryding et. al 1995) and the Nordic NEP project (Steen et.al, 1996).

About EPS

EPS is a systematic approach to choose between design options in product and process development. Its basic idea is to make a list of environmental damage costs available to the designer in the same way as ordinary costs are available for materials, processes and parts. The designer may then calculate the total costs over the products life cycle and compare optional designs.

EPS includes an impact assessment (characterisation and weighting) methodology for emissions and use of natural resources, which can be applied in any Life Cycle Assessment (LCA).

The results of the EPS impact assessment methodology are damage costs for emissions and use of natural resources expressed as ELU (Environmental Load Units). One ELU corresponds to one Euro.

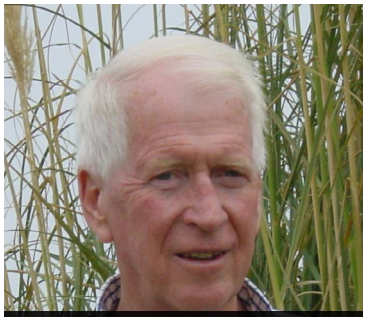
For more information:
The maintenance and updating of the EPS system is managed by IVL Environmental Research Institute. For more information see www.ivl.se/eps.

Dissemination

Many methodologies of varying quality have been proposed for green and sustainable development. In order to "market" the EPS methodology in this context, the IMP Project group has initiated and been active in an ISO working group on an international framework standard, ISO 14008 and has cooperated with LCA software companies with more than 10 000 users in order to integrate EPS data on monetary values of emissions and use of natural resources. The group also held an educational course for the Swedish Life Cycle Center network. There have been three ISO meetings and the ISO 14008 standard is now at Committee Draft level (about in the middle of the standardization process). The standard will create a language making it possible to communicate the basis for the EPS methodology and increase its credibility.

The EPS monetary values for emissions and natural resources is now integrated in the LCA softwares GaBi and SimaPro, which are used by partners in Swedish Life Cycle Center.

Bengt Steen & EPS



Bengt Steen, Chalmers

The latest version of EPS: www.ivl.se/eps

The work with EPS was initiated around 1989. How did the idea develop into what it has become today? Who requested the EPS?
- At Volvo there was a discussion on which material to choose for a front piece in their car model 850. Gunnar Westerlund, at Volvo's material lab, argued that this discussion was very costly and that they needed a methodology to calculate environmental performance of alternative designs. He therefore contacted The Swedish Industrial Board (Industriförbundet) who in turn contacted IVL, where Sven-Olof Ryding and I formed a working group together with Gunnar Westerlund. After a few years, we had developed the first version of EPS. Industriförbundet then contacted the CEOs of the five largest companies in Sweden and got their consent to start a larger project, the so called "Product Ecology Project". Soon, 15 companies were involved, and this paved the ground for CPM, presently Swedish Life Cycle Center, where the EPS system was maintained and developed further.

What would you say have been the biggest challenges and barriers for the development of EPS?
-The development of LCA methodology is dependent on academia, where it is more important to have high scientific quality than to deliver useful information when it is needed.

What is your biggest interest of developing and disseminating EPS?
- I want to contribute to making EPS an industrial standard. I think our philosophy on the use and value of EPS is outstanding in terms of broad system thinking. It is based on a good understanding of what sustainability is and how product development is made.

Who are the main users of EPS?
- Volvo and AkzoNobel use it regularly and several other companies have used it in special studies. It is used in education at Chalmers and MIT. EPS data are available in software like GaBi and Simapro and in the EcoInvent database.

What is your vision of the future of EPS? Which challenges does EPS face ahead?
- I am pretty convinced that the EPS principles of monetary valuation of environmental impacts will become a standard approach. It would be nice if we would still be at the stage then, so that wheels do not need to be invented again. Our main challenge is endurance.

How does the work with the ISO standard 14008 help drive the monetary valuation of environmental impacts ahead?
- It creates a language and gives credibility to the numbers, the quantified values, we produce. It offers a platform for dissemination of our results.

5.1 AkzoNobel

About AkzoNobel

AkzoNobel is a global paints and coatings company and produces specialty chemicals. The AkzoNobel headquarter is based in Amsterdam, the Netherlands, but the 45 000 employees are present in about 80 countries (AkzoNobel 2016: d). Ingredients produced by AkzoNobel are found within a wide range of different products (AkzoNobel 2016: b).

In Sweden, 2700 employees are spread out in 12 different cities. The global sustainability branch of AkzoNobel is based in Sweden (AkzoNobel 2016: a).

About the case study

The working group which has been involved in the case study within this project has been led by Klas Hallberg, Manager New Developments in Sustainability at AkzoNobel. The main participants were Karin Andersson Halldén, Caterina Camerani, Max Sonnen and Niek Stapel.

Results and conclusions

Where traditionally the impact of a company was solely measured in terms of the profit generated for its share-holders and its share price on the stock market, today, stakeholders demand increasingly more insight into a business' societal contribution in a broader sense. AkzoNobel has addressed this request by developing the 4 dimensional profit and loss (4D P&L) methodology.

The 4D P&L methodology takes into account not only our own company's costs and profit, but also the value creation (profits) and negative effects (losses) that take place in other links of the value chain, collectively called externalities. It does so in multiple dimensions: financial, environmental, human and social impacts are assessed. This is a totally new way of looking at a product's value chain, because the impact of a company on society at large can be assessed.

To assess the environmental impacts of a life cycle approach is used, together with the EPS in order to set a price on the environmental impacts. A comprehensive overview of all profits and losses throughout the value chain of a product is created by combining the results for each of the 4 capitals.

In this case study, AkzoNobel has taken a book as an example. The results show that per book, the combined overall increase in financial and human capital is more than 10 times greater than the loss of natural capital, and few social risks were identified. By using the model, AkzoNobel can identify where to focus their work in order to minimize the negative externalities, maximize the positive externalities, and decrease their environmental impacts.

Read more about the case study in Appendix 1

Klas Hallberg - AkzoNobel

Klas Hallberg, AkzoNobel

Read more about the work of AkzoNobel within sustainability at their website (AkzoNobel 2016: c).

What kind of benefits (and barriers) do you see when integrating monetary valued environmental impacts for materials and processes (EPS-values) in your product development process/organization?
- A benefit is that using monetary valuation enables us to speak the same language: monetary terms. But the benefit might also become a barrier, since the management is afraid to mix environmental costs with monetary terms, since they fear that financiers might think that the numbers are actual costs which might occur next quarter, or next year. It is necessary to explain how it works really carefully, but sometimes it is not enough.

What has been the most surprising result for your organization?
- The results are not so surprising for us, we are experienced within the field. My biggest surprise is that people are so positive to use the methodology, and this could be considered a result in itself. It is all about habits. People within our organization are now becoming used to this way of thinking.
- Given our type of business,we use a lot of fossil fuels, and climate impacts are of vital importance for us, which we are already measuring. Would we have another type of business, perhaps we would be more surprised with the results. One could be surprised over the high values of our climate impact, but to a large extent the reason for this is that we are using one methodology, EPS, and follow it stringently, instead of using different parts from different methodologies in order to steer the results.

Have there been any new lessons for your group while carrying out the case studies?
- Early in the process, we realized that in order to go beyond one case, and make it work for all products, it is necessary to integrate the data in an appropriate data processing tool.

What has been the biggest challenge during the work with the case studies?
- It has not such a big challenge for us, since we already have a lot of data. But for those who do not have a lot of data, it will be a big challenge. Perhaps our biggest challenge has been to explain why we should work with monetization of environmental impacts.

Do you have any ambitions to continue this work, and in that case, how?
- Yes, there are several examples. Pulp and Performance Chemicals AB have decided to do this annually. Also, we recently decided to make it on a general level for the whole organization and include it in the Annual Report. It will not be as detailed, and hence less substantiated, and the data we have varies in details in different parts of the organization. We will look at value chains which are representative for the whole organization.

What do you think is needed for more organizations to start to work with an integration of environment and economy through monetization of environmental damage costs?
- The organizations must have a well substantiated information data base regarding their value chains. They must start to measure and follow up their value chains and use a system for it. It is necessary to follow up the value chains, not only the own activities.

Do you have any recommendations to interested organizations about how they could get started with their work with an integration of environment and economy?
- It is necessary to have a few people focusing on this in their work, not just one person because it is necessary to have colleagues to discuss with. This is not easy if you are a small company, but you can collect data. It is also necessary to have the right competence, people who understand environment, but also has a holistic view, as it will be necessary to make simplifications and a well-balanced appreciation about how it could represent the whole organization. It is crucial to know what is important and which information that is available.

-To conclude, this work has functioned very well and it will be exciting to follow how it all develops further on.

5.2 SCA

About SCA

Based in Stockholm, Sweden, SCA is a global company operating in about 100 countries, producing hygiene products such as personal care and tissue, and forest products. It is also the largest private forest owner in Europe. SCA has 44 000 employees (SCA 2016: a).

About the case study

The project team has consisted of members of the Product Sustainability group at SCA, with Ellen Riise as the internal project leader. The whole team of seven persons have participated in general discussions around the internal weighting methodology. Out of that group, the LCA practitioners discussed and brought up suitable case studies to be used in the internal weighting tests. In addition, Madeleine Pehrson and Annica Isebäck from the group have run all additional evaluations where the EPS methodology has been used. These results were reported in a standard format for analysis and comparisons, which have been done by Ellen Riise.

Results and conclusions

SCA has used life cycle assessment (LCA) since the early 1990s. The methodology is used both to calculate the environmental performance of new innovations as well as to measure the improvements over time for product assortments. For many years SCA has had an interest in weighting as a support in complex interpretation of LCAs, and as a guide for strategic targets. In this project SCA has worked with both a development of an internal weighting methodology, and implemented, tested and started to evaluate the EPS methodology. A first step for development of an internal weighting methodology was the selection of environmental impact categories in a structured way. It was done with following basic principles like relevancy and scientific validity, as well as with a basis from a continuous stakeholder dialogue with SCA's stakeholders. The next step was to implement the EPS methodology in the way of working with LCA. Experiences from earlier work with EPS had made it clear that a sound technical solution for importing EPS data into LCA software was critical. With such a solution eventually in place, SCA has compared the internal weighting methodology with EPS values for the compared products. There is an overall agreement with the methodologies, explained by the focus on resource use in both methodologies. However, this focus is more explicit with the EPS methodology, whereas the internal weighting methodology has another priority for some emissions.

The possibility of further use of the EPS methodology will be evaluated after this pilot, where it is reasonable to believe that the internal implementation will take time. Communications of learnings and results will be an important part of the future monetarization work, and the upcoming international standard will support this work.

Read more about the case study in Appendix 2

Ellen Riise - SCA

Read more about the work of SCA within sustainability at their website (SCA 2016: b).

What kind of benefits (and barriers) do you see when integrating monetary valued environmental impacts for materials and processes (EPS-values) in your product development process/organization?

- We assess environmental and financial impact of our products in separate ways today. The integration of monetary values for environmental impacts gives an opportunity to evaluate the potential financial cost of environmental impacts. This will broaden the environmental assessment beyond direct environmental impact such as GWP (Global Warming Potential), acidification or eutrophication. Monetization has been researched for many years but is still a "new" assessment methodology for many people working with other financial tools. The internal implementation from the current pilot to integration will take time.

What has been the most surprising result for your organization?

- We perform environmental assessments with LCA of new innovations we have today a system for weighting the results of environmental impact categories. It turns out that the difference between products is about the same when comparing the difference between EPS values and the weighted environmental impacts.

Have there been any new lessons for your group while carrying out the case studies?

- Not so much of new lessons, but interesting to learn that our idea of resource efficiency at least has a corresponding methodology that seems to indicate in the same direction as we have chosen by our internal weighting methodology.

What has been the biggest challenge during the work with the case studies?

- Our pilot is focusing on integrating EPS in our LCA tool. It has been a practical issue, because the case study was depending on the update of EPS values in our software for LCA. Once the values were in place, and we had a template for the result interpretation out of the software, it has been very easy to run LCAs with an EPS result for many different products.

Do you have any ambitions to continue this work, and in that case, how?

- Our first step was to run the pilot. We will now evaluate the result and propose next steps for internal evaluation.

What do you think is needed for more organizations to start to work with an integration of environment and economy through monetization of environmental damage costs?

- Firstly, the companies need to anchor the purpose and value of adding the monetization of environmental and social aspects. Secondly, it is a very good foundation to have a good way of working with Life Cycle Management. You need good procedures, tools and data for handling environmental and social aspects in an efficient and credible way. Communication of learnings and result will be an important part of the monetization work.

Do you have any recommendations to interested organizations about how they could get started with their work with an integration of environment and economy?

- It is important to work based on life cycle management, with corresponding good knowledge about the processes and products. It is necessary to be able to analyze and find hot spots along the value chain such as different life cycle stages, environmental impacts, and down to single processes since the important outcome is to find where to work to reduce the environmental impacts.

5.3 Volvo Group

About Volvo Group

With 100 000 employees, production in 18 countries and markets in 190 countries, the Volvo Group is a large, global manufacturer of trucks, buses, construction equipment and marine and industrial engines. The Volvo Group headquarter is located in Gothenburg, Sweden (Volvo Group 2016).

About the case studies

Volvo Group made two case studies within the IMP project.

1. The Effect on Environmental Damage Costs and Eco-Efficiency of introducing Recycling of Sand in Volvo Group's Engine Plant in Skövde: The case study was initiated by Maria Böös, Director CSR and Public Affairs at Volvo Group Operations. Lisbeth Dahllöf collaborated with Johan Ålander, a manufacturing technology specialist at Volvo Group Trucks Operations at the foundry in Skövde where he is planning investments. Other information around the hypothetical case was given by the references in the report. The LCA study was performed by Lisbeth Dahllöf and the report was reviewed by Mia Romare, Bengt Steen and Johan Ålander.

2. Environmental Cost and Eco-Effectivity Assessment of Copper and Aluminium High Power Cables: All involved people in the study are from Volvo Group trucks advanced technology and research. Mattias Dalesjö, Senior technology specialist, is responsible for the development of the aluminium cable project on which the case study is based and has contributed with data for the LCA. Marasami G, system engineer, is also part of the development project and has provided data for the eco-efficiency calculation. Mia Romare and Lisbeth Dahllöf have been involved in the LCA modelling and report.

Results and conclusions

1. The Effect on Environmental Damage Costs and Eco-Efficiency of introducing Recycling of Sand in Volvo Group's Engine Plant in Skövde

This study investigates how the information of environmental damage costs can be calculated and presented for investment in a production facility.

Volvo Group Trucks Operations, Powertrain Production in Skövde needs large amounts of sand for their foundries. They have a new and an old foundry. The old one has no recycling of the used sand and it becomes more and more difficult to get new sand, because of the specification and the unwillingness to start new sandpits due to environmental reasons. Also Volvo has high costs for deposition of the used sand although it is used for filling of ground for industrial areas, and thus avoiding the landfill fee.

Recycling of the sand would reduce the need for virgin sand. There is technique for this that is mechanical which was hypothetically calculated with in this report. There are also other possibilities to reduce the need of virgin sand, such as using synthetic bauxite (a common ore) sand or natural clay. Both solutions are, however, expensive.

The environmental damage costs for the current situation and a hypothetical future with recycling were calculated and compared. It serves as an example of how environmental damage costs would be changed in comparison with hypothetical investment costs. The damage cost/kg of the natural sand had been calculated earlier. A theoretical calculation was also made for the case if the foundry is using bauxite sand and considers recycling. 96 % of the environmental costs for the hypothetical case of natural sand recycling would be due to the sand itself and not the transports involved.

The hypothetical introduction of recycling of the natural sand is eco-efficient, thus both environmental damage costs and direct costs decrease, given a payoff time that is shorter than the probable usage time for the investment and that current sand price stays the same. It is however probable that the sand price increases, which makes the recycling option even more eco-efficient.

Bauxite sand does not give an

environmental benefit compared to natural sand even if it would be used afterwards in the aluminium industry. To use bauxite sand or other minerals with a content of a useful resource but not reusing them after the foundry, would however cause very high environmental costs as illustrated in this study in a case where the bauxite sand is not reused in the aluminium industry.

For bauxite sand, the cost for CO2 emissions are mainly from sand making. For calculations of risk in investments it is recommended to subtract the CO2 emissions where the society has internalized the costs (tax or fees) and in this case the truck transports in Sweden and Norway pay CO2 tax. However, still the natural sand would have the highest risk, because its dominance in the environmental damage costs result. It can thus be the fossil energy use causing CO2 emissions in synthetic sand production that has the highest internalization risk.

If the energy use in the world would come from sustainable sources, then the CO2 emission problem in this study would be solved and if the sand can be made from rock without scarce minerals, nearly all the environmental risk would have disappeared. In the meantime it is recommended to invest in energy and sand efficiency.

To summarize, with the recycling rate assumption in this study, it is a risk not to invest in recycling of natural sand, since it is a limited resource and the synthetic alternatives are expensive and environmentally impacting with current production technology.

2. Environmental Cost and Eco-Effectivity Assessment of Copper and Aluminium High Power Cables

Volvo Group made life cycle assessments of two different high power cable alternatives: copper based cables and aluminium based cables.

The results indicate that the environmental cost of the copper cable is significantly higher than that of the aluminium cable. This is due to the fact that copper is much more scarce than aluminium in the earth's crust, and thus the cost of using it in a sustainable way is much higher.

The lower weight of the aluminium cable is beneficial in the use phase, but this has a much smaller impact on the environmental cost than change of material. If the efficiency of the copper recycling can be improved, the losses will decrease, and the total impact over the life cycle due to the material can be decreased.

It is important to note that the results indicate the long term issues and environmental cost of the different cable alternatives. When choosing, also short term considerations must be made, where the use phase might be more important. As the choice of aluminium is beneficial both in the long term, as well as for the energy consumption in the use phase, it can be recommended as the alternative with least environmental cost.

As the results are presented in monetized terms, the environmental gains of the change of cable material can be weighed against the investment cost. This can help decision-makers evaluate how sizable the gain is in terms that are already familiar within decision-making.

Main conclusions and recommendations:

- The copper alternative holds the highest environmental cost.
- In this case a good choice of sustainable material is more important in the long run than the potential weight reduction for the environmental performance.
- Recycling is critical in order to minimize the total life cycle cost. Proper collection, separation and processing to secure quality is essential.
- It is clear that the difference between internal and extern cost is very large in the case of the copper cable input material. This indicates a risk that the price of this cable alternative might increase. End of life value might also increase accordingly.
- The eco efficiency assessment shows that the change from copper to aluminium is an investment that will decrease the environmental cost with 1-10ELU per invested € depending on if the end of life if included.

Read more about the case studies in Appendices 3 and 4

Lisbeth Dahllöf and Mia Romare - Volvo Group

Lisbeth Dahllöf, Volvo Group

Mia Romare, Volvo Group

Read more about the work of Volvo Group within sustainability at their website (Volvo Group 2016: b).

What kind of benefits (and barriers) do you see when integrating monetary valued environmental impacts for materials and processes (EPS-values) in your product development process/organization?

- A benefit we can see is that by integrating monetary values, environmental aspects will be taken into consideration more when it comes to decision making. This because they now can be evaluated on the same basis.

- A barrier is that the environmental damage costs are not allowed to be included in the normal balance sheet, thus the costs are not tangible in the short perspective.

- The time perspective is also a real barrier. Abiotic resource depletion has a high environmental cost, but it is not a visible problem for businesses today. Because of this the results can be hard for decision makers to take into consideration. Many unborn generations have to be considered in order to work with sustainable development, which is not common in economic decisions today.

What has been the most surprising result for your organization?

- Surprising for the foundry was that the sand resource has a high environmental damage costs. There had been a high focus on CO2 emissions and the direct costs for alternative synthetic sand, not the environmental impact of the synthetic sand.

- The results from the comparison of the aluminium and copper cables showed the predicted results, where aluminium is more environmentally beneficial. The surprise was that the difference was very large.

Have there been any new lessons for your group while carrying out the case studies?

- Yes, definitely! In the LCA team we got to test the effect of GaBi's economic allocation on EPS, increasing our knowledge on how LCA method assumptions impact the EPS results. We also learned a lot about the updated EPS and how our results changed when using it.

- We also learned good ways to use economical valuation to calculate eco efficiency. Eco-efficiency can be defined in different ways, and we found one that could help us as a company to optimize our environmental investments. Additionally, we got the change to argue for the benefits of using EPS, with its long term sustainability focus.

What has been the biggest challenge during the work with the case studies?

- The big question to understand was; when can we use EPS. The answer ended up being that we can use it to look at future risks.

- When looking at EPS as a measure of future risk it is important to subtract the already implemented environmental cost, in order to only see future risks. Understanding, clarifying and conveying this presented a challenge, for example in the case of CO2 tax or in the case of emissions without EPS index.

- It is also interesting that plants struggle with environmental goals for

emissions that may not cause proven environmental damage for that concentration level (EPS index=0). In that case EPS does not add any extra information, since the limits are from a precautionary standpoint. It was a challenge to differentiate these types of cases from cases where EPS is applicable.

Do you have any ambitions to continue this work, and in that case, how?
- Yes, we would like it to become a common practice. We already have EPS in the product development but the monetary values are not used. The indices are only used as relative umbers, not as monetary values, which we would like to include.

- We hope we can find other case studies and so that we can continue to do calculations for environmental costs as a part of investment evaluations.

What do you think is needed for more organizations to start to work with an integration of environment and economy through monetization of environmental damage costs?
- It requires that the companies set aside specific time and resources for this accounting-process. It is important that the company not only does it to confirm the investment they already have decided to do, because they see the damage cost as "not real money". It needs to be considered as a risk in the same way as other risks.

- EPS can be used as a communication tool, but also as a part of development and business decision making. In a real integration the environmental damage cost should be known as early as the direct cost, and of course it should be minimized.

- Policies (internal and external) and long-term perspective is also desirable in companies, as well as a will to include long term risks.

Do you have any recommendations to interested organizations about how they could get started with their work with an integration of environment and economy?
- It requires that the companies set aside specific time and resources for this accounting-process. It is important that the company not only does it to confirm the investment they already have decided to do, because they see the damage cost as "not real money". It needs to be considered as a risk in the same way as other risks.

6. Results and conclusions

The case studies have showed different approaches and examples of how companies can use the EPS methodology for integration of economically valued environment impacts in product development. EPS can be used to compare two scenarios with each other and to choose between design options in product and process development.

In AkzoNobels case study on a book, they worked with a model to assess the impact of the product life cycle on society at large, using a 4 dimensional profit and loss accounting methodology. The model assesses financial, environmental, human and social impacts. The model has been developed by AkzoNobel as a response to the society's demands on companies to address and explain how they work with externalities. The four dimensions are assessed using different methodologies, where a life cycle approach has been used when assessing the environmental impacts of a product. Using the EPS has subsequently allowed AkzoNobel to set a price on their environmental impacts in the study.

In the case study, AkzoNobel has identified that, per book, the combined overall increase in financial and human capital is more than 10 times greater than the loss of natural capital, and few social risks were identified. AkzoNobel believes that the loss in natural capital can be (further) reduced by using their technology and value chain cooperation.

In the SCA case study, SCA compared the EPS results with an internal weighing method they have used for several years. SCAs weighing method mirrored the concern they had experienced from their stakeholders and society on their releases and use of natural resources. The comparison showed similar ranking of their alternative product life cycles, but differed in terms of the weight it gave to single emissions and resources. The difference may be explained by the difference between local aspects in permit contexts (SCA's internal method) and global or regional resource aspects in sustainability assessment (EPS). In permit contexts, for instance for water emissions, safety marginal are often used, resulting in zero impacts. The SCA internal method therefore gave significant weight to water emissions that was given no weight in the EPS method as it as global averages gave no or negligible impacts. The SCA case study clearly showed that not all environmental management of a company can be handled through product policy. The permit process and the environmental concern on the product levels are complimentary.

The integration of monetary values for environmental impacts gave an opportunity to evaluate the potential financial cost of environmental impacts. The possibility of further use of the EPS methodology at SCA will be evaluated after this pilot, where it is reasonable to believe that the internal implementation will take time.

The Volvo Group made two case studies within the IMP Project: *The Effect on Environmental Damage Costs and Eco-Efficiency of introducing Recycling of Sand in Volvo Group's Engine Plant in Skövde*, and *Environmental Cost and Eco-Effectivity Assessment of Copper and Aluminium High Power Cables*. The study on recycling of sand, investigated how the information of environmental damage costs can be calculated and presented for investment in a production facility. The results showed that with the recycling rate assumption in this study, it is a risk for future costs if they do not invest in recycling of natural sand, since sand is a limited resource and the synthetic alternatives are expensive and impacting with current production technology. The study shows an example of how one can work to handle future risks. It shows different scenarios and their associated costs, and can assist decision-makers in taking decisions based on these scenarios.

Regarding the case study on copper and aluminium high power cables, the results indicate that the environmental cost of the copper cable is significantly higher than that of the aluminium cable. This is due to the fact that copper is much scarcer than aluminium in the earth's crust, and thus the environmental cost (and in the long run economic cost) of using it in a sustainable way is much higher. As the results are presented in monetized terms, the environmental gains of the change of cable material can be weighed against the investment cost. This can help decision-makers evaluate how sizable the gain is in terms that are already familiar within decision-making. EPS could in this case assist in determining the best long-term decision, but also for the short-term.

To conclude, the IMP project has been able to meet the aims decided in the beginning of the project. By updating the EPS methodology, and further on testing the methodology in the case studies, the IMP project has contributed to the aim of achieving a more efficient product development by making environmental costs more visible early in the product development phase. Using EPS in the case studies enabled a showcase of how companies can work with the methodology, and has hence contributed to facilitating a change from a reactive to a proactive product development strategy regarding environment and sustainability.

The update and further development of the EPS has contributed to making environmental and sustainability data more readily available, which can be used in an innovation process.

Within IMP, the project group has contributed to;

- Continuing to developing a methodology for calculating environmental damage costs and for estimating degree of internalisation;
- Methodology implementation, including: case studies, output from case studies, and methodology standardisation;
- Dissemination, including: project management, coordination of the Working Group ´Get the prices right´, contribution to ISO standardization work, and dissemination.

7. Lessons learned and way forward

Monetization can help in decision making by creating a common language that is used both for the environmental assessment as well as for the economic aspects of an investment or technology update. Monetary valuation can also help us better understand the magnitude of the impact. Another potential benefit of discussing the environmental impact in terms of money is that we better understand if the price we pay includes the external cost, a cost that is paid by society. The external costs, externalities, are a potential business risk as they may become internal due to for example regulations and taxes. The case studies in this project have shown how companies can use monetary valuation to handle these risks, by using the EPS methodology.

Communications of learnings and results will be an important part of the future monetarization work, and the upcoming international standard will support this work.

7.1 ISO standard and the future of EPS

Valuing environmental impacts in monetary terms is a complex issue, and users of the EPS methodology seldom have the time to understand all models and data. Therefore, credibility is crucial so that new users will be reluctant to start using it, and learn gradually about its different features.

Our strategy will be to fulfil the work within ISOs environmental management committee and to maintain the EPS impact assessment data, so that it always represents latest knowledge on environmental issues.

One of the lessons learned in the project is how much work that is needed to implement and disseminate a new methodology that has been developed. Even if we spent much time in the planning of the project and during the project work to implementation and dissemination, the world is big and lots of efforts remain.

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Appendix 5: IMP Workshop

On October 10, 2016, a joint workshop was conducted with 22 participants from the project group and other interested. Apart from presentations about EPS, ISO and the case studies, including a panel debate, two sessions were devoted to discussions. The workshop took place at IVL, Swedish Environmental Research Institute, in Gothenburg.

First discussion session

The first discussion session made a swot analysis on monetization of environmental damage costs.

On *strengths*, the groups identified:
- Monetization creates a common language – "everybody understand money"
- Monetization clarifies where in the supply chain environmental damage costs occur
- Facilitates risk management
- Facilitates communication about environmental aspects and environmental risks
- Facilitates portfolio steering on a strategic level
- Creates a long-term view in strategic decisions
- Knowledge about future costs
- EPS is widely and systematically used in the environmental impact categories
- Enables concrete measurement of environmental costs
- Enables comparison of different types of environmental impact in the economy

On *opportunities*, the groups identified:
- Easier to compare products
- Creates benefits for the society
- The use of risk management tools are already practiced regarding environmental cost estimates
- Risk management - long-term strategy - finance
- Risk management and risk management communication
- Communication
- Enables proactivity by activity early in the decision process
- Enables CO2 estimates
- Creates goodwill
- Make companies' "hot spots" visible
- Long-term competitive advantage
- Opportunity to visualize the company's improvements - targeted initiatives

On *weaknesses*, the groups identified:
- Difficulty in weighting long-term risks against short-term risks
- The time perspective, and it can create misconceptions
- Trade-offs can be (almost too) clear - which can also be good.
- The issues where there are no factors will not be accounted for, how do we cover those?
- (Preventive) legal requirements vs. environmental costs can be tricky - both to weigh between and to explain
- Hypothetical cost
- Not "real" money (yet)
- Requires a lot of knowledge and competence, also for its communication
- Founded on subjective valuations
- Do not follow the usual calculations
- Provide the right information to the costumers

On *threats*, the groups identified almost the same issues as for weaknesses, why these are not repeated in this text.

To summarize, many strengths and opportunities, and especially weaknesses and threats are similar to each other. While monetization of environmental damage costs provides many strengths and opportunities in the strategic area regarding the ability to calculate for future risks and costs, as well as facilitation in communication, these are at the same time both weaknesses and threats as it requires a high knowledge to manage the methodology and also to communicate its results. Similarly, the time perspective provides both a strength and a weakness.

Second discussion session

In the second discussion session, the groups discussed different questions.

Question: To what extent are environmental costs (materials and resources) involved in your decisions today? Why are/ why are environmental costs not involved?

- Example 1: In investment decisions and in product development for comparison between two products. As a complement to LCA.
- Example 2: LCC at the project level. EPS again. Involve EPS for help with decisions to complement the CO_2 calculations, for set environmental targets. Set the direction in the long term.
- Example 3: Carbon dioxide and risk; in product development. Customer needs. Customer savings for major development projects.

Question: Who in your organization has an interest in including environmental costs in decision making?

- Whoever has the interest - must also have a mandate (interest is not enough for action)
- The person may be limited in what they believe are economic demands on them.

Question: What is missing to be able to involve environmental costs in decisions today?

- Pressure from customers, management, the rest of society
- Major general interest
- Knowledge

Question: Are there any barriers to include environmental costs in decisions today? Which are they?

- Too many steps in the organization
- Disconnection - strategy & expertise - procurement competence
- Environment must be involved earlier, now we analyze in retrospect. Environment must become closer to strategies. Lifecycle management - key issues
- The organization - can we even receive the results now?
Who and Where? That must be the first step.
- Many demands already – those come at the first place
- Wrong competence in management groups

Appendix 4: Volvo Group, Environmental Cost and Eco-Efficiency Assessment of Copper and Aluminium High Power Cables

Appendix 4: Volvo Group, Environmental Cost and Eco-Efficiency Assessment of Copper and Aluminium High Power Cables

Appendix 3: Volvo Group, The Effect on Environmental Damage Costs and Eco-Efficiency of introducing Recycling of Sand in Volvo Group's Engine Plant in Skövde