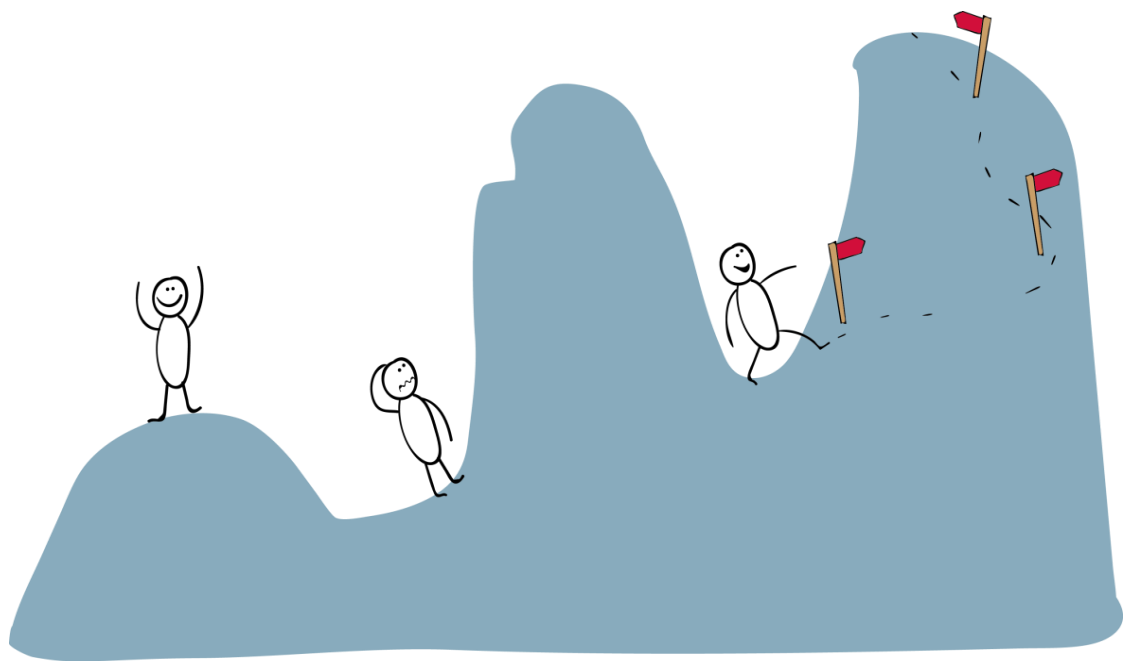


Energy efficiency along the value chain

Ways of working for increased competitiveness



Emma Rex, Birgit Brunklaus, Katarina Lorentzon

Swedish Life Cycle Center. Report number 2015:6

Energy efficiency along the value chain.
Ways of working for increased competitiveness.

Emma Rex, SP Technical Research Institute of Sweden
Birgit Brunklaus, Chalmers University of Technology
Katarina Lorentzon, SP Technical Research Institute of Sweden

Swedish Life Cycle Center. Report number 2015:6
Also published as SP Report 2015:78

Illustrations by Louise Quistgaard and Juhanni Rex-Karlsson

Summary

This report presents a project with the aim to develop methods for large companies on how to work with energy efficiency that stretches along the value chain. By studying organizational conditions and physical effects on energy and climate for six cases in three companies, recommendations are given to businesses and governments on how to work for increased life cycle energy efficiency.

The results point to a range of organizational and economic challenges, but also to enablers. Four strategies for progress were identified: A) Find and share the life cycle benefits, B) Get focus and priorities in line C) Enable and encourage understanding and action, and D) Seek or create a way forward.

The study points to the need to be strategic, and to translate this strategy into priorities and operational work. Yet, it must be recognized that life cycle thinking is not the work by one company and there is a call for cross-actor arenas to discuss and develop governance of value chains beyond the act of single companies.

Sammanfattning

Denna rapport summerar ett projekt med syfte att utveckla metoder för hur stora företag kan arbeta med energieffektivisering genom hela värdekedjan. Genom att studera organisation och fysiska effekter på energi och klimat för sex fall i tre bolag, har rekommendationer för hur näringsliv och myndigheter kan arbeta med energieffektivitet i ett värdekedjeperspektiv tagits fram.

Resultaten visar på organisatoriska och ekonomiska utmaningar, men också på möjliggörare inom följande områden: A) Identifiera och dela energivinster i värdekedjan, B) Se till att prioriteringar stämmer överens, C) Möjliggöra och uppmuntra förståelse och handling, och D) Söka eller skapa vägar framåt.

Studien visar på behovet av att arbeta strategiskt och att översätta strategin i prioriteringar och operativt arbete. Energieffektivitet i värdekedjan kräver också samarbete mellan aktörer, och projektet efterlyser arenor där industri- och samhällsaktörer gemensamt kan diskutera och utveckla styrning och förändring mot mer energieffektiva värdekedjor.

Foreword

This report presents the results of the research project “Energy efficiency throughout the value chain”, run within the Swedish Life Cycle Center from January to October 2015. The project was funded by the Swedish Energy Agency, and made in collaboration with industry and academia. The project was led by SP Technical Research Institute of Sweden and the following people were part of the project group:

- Emma Rex, SP Technical Research Institute of Sweden (project lead)
- Birgit Brunklaus, Chalmers University of Technology
- Katarina Lorentzon, SP Technical Research Institute of Sweden
- Cecilia Bengtsson, Volvo Real Estate
- Klas Hallberg, AkzoNobel
- Lennart Swanström, ABB
- Anna Wikström, Swedish Life Cycle Center

The project also had a reference group, consisting of

- Amir Rashid, KTH Royal Institute of Technology
- Fredric Norefjell, SP Technical research institute of Sweden
- Tomas Rydberg, IVL Swedish Environmental Research Institute

The authors would like to express their gratitude to the Swedish Energy Agency, participating company representatives and interviewees, and the reference group for their commitment, support and fruitful discussions throughout the course of this project.

Table of Contents

Introduction.....	1
Aim and scope.....	3
Method.....	4
Industrial context.....	6
Guide for readers.....	6
A value chain perspective on energy efficiency.....	7
Drivers, barriers and enablers identified in the literature.....	11
Energy efficiency in value chains.....	11
Life Cycle Assessment.....	16
Life Cycle Management.....	17
Green/sustainable supply chain management.....	20
Green lean, operations management and energy efficiency.....	23
Summary of literature.....	26
Case studies.....	28
Volvo Group.....	30
ABB group.....	43
AkzoNobel.....	52
Analysis.....	67
Find and share the life cycle benefits.....	68
Get focus and priorities in line.....	71
Enable and encourage understanding and action.....	74
Seek or create a way forward.....	77
Impact on energy efficiency.....	80
Impact on competitiveness.....	88
Implications for policymaking.....	88
Discussion and further work.....	90
Conclusions and recommendations.....	93
Recommendations to industry.....	93
Potential for life cycle energy efficiency – theory and practice.....	96
Recommendations to policy.....	96
Next step.....	97
References.....	98
Appendix.....	107

Introduction

Large multinational corporations active in Sweden have an important role to play to achieve both energy policy objectives and environmental targets. ABB has, for example, adopted a target of reducing energy consumption in the Group by 2.5% per year, the Volvo Group has adopted an environmental challenge that all sites should have a plan for how they will be CO₂ neutral, and AkzoNobel has set a target to reduce carbon footprint by 25% in a value chain perspective. To use the power of such voluntary efforts is important to achieve national goals such as efficient use of energy, renewable energy, non-toxic environment and reduced climate impact.

An important contribution is enterprises' development of their own products and services. AB Volvo could with the production of its hybrid truck show 30% lower fuel consumption (Volvo Trucks, 2014) and the ABB paint robot FlexPainter reduced carbon dioxide emissions in automotive finishing by half (with 2,000 tonnes less carbon dioxide and 3.4 million SEK lower energy costs in a normal-sized car factory (ABB, 2014). Development can also be achieved through incremental improvements, where for example the SCA during the period 2008-2011 reduced the overall carbon footprint of hygiene products such as diapers and sanitary napkins by up to 18% (CPM, 2013).

A common denominator of the examples above is that the companies to reach these potentials improved energy and resource efficiency not only within its own operations, but in the entire value chain - by reducing the need for energy and resources throughout the life cycle of the product, from raw material extraction to use and end of life. Such a "lifecycle perspective" on what should be optimized, opens up for much stronger impacts on resource and energy efficiency, than measures made in own operations alone. IKEA Group's latest sustainability report shows that the group saved 40 million Euros through energy efficiency improvements in department stores and warehouses 2010-2013. Simultaneously, the sales of LED lights has enabled more than twice as large energy savings among customers - the equivalent of 86 million euros - only in 2013 (IKEA Group, 2014), as illustrated in Figure 1.

Historically, Swedish industry has been successful in increasing general productivity while also improving energy efficiency. From 1993 to 2010, energy intensity (final energy use per added value) has decreased by 36%, mainly through the introduction of new processes or new plants (IVA, 2013a), but also through conversion to more electricity based processes and production. However, the study does not present any evidence that energy efficiency from a life cycle perspective has increased; lower final energy use in manufacturing does not necessarily result in overall lower energy use.

Despite promising energy and economic potentials, a life cycle perspective of products and businesses is yet unusual in practice. Larsson and Gebert (2008) have studied supply chains and customer requirements for energy efficiency among a range of companies in different sectors: Volvo, Schenker, SSAB, Cascades, Stora

Enso, IKEA, ICA, Perstorp, ABB, Alfa Laval, and Statoil. At the time of the study, only a few companies with direct customer contact, such as IKEA and ICA, put pressure on energy on their suppliers. In 2013, a survey of environmentally innovative actions among the 100 largest Swedish companies showed that measures so far had focused primarily on energy efficiency, renewable energy and materials within own operations. Measures in the value chain was found to be rare (Brunklaus et al. 2013, see also Arnfalk et al. 2008).

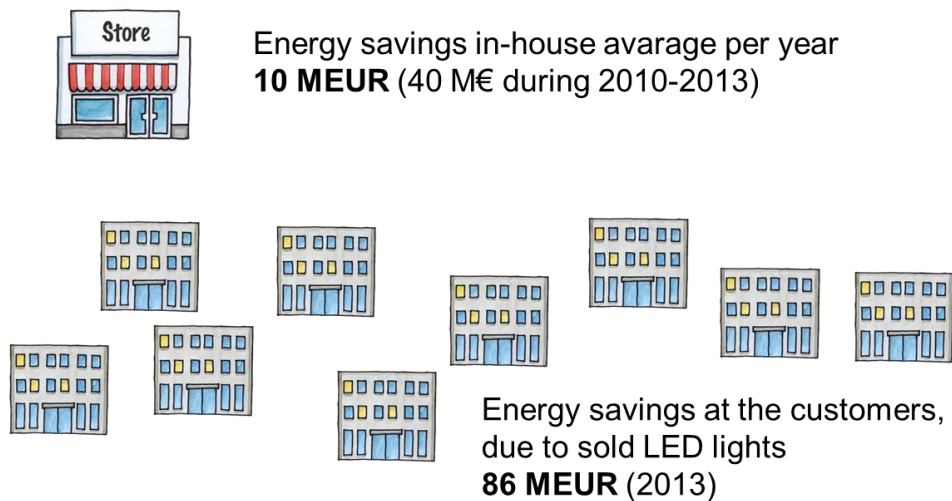


Figure 1. Energy savings at IKEA due to efficiency projects in-house, compared to savings at their customers due to sold LED lights.

Yet for companies to proceed in their sustainability ambitions, this is where many of the solutions have to be sought. Now that many of the "internal" measures have been implemented, further implementation of a life cycle approach is regarded necessary. In a study on resource efficiency in European manufacturing industries, optimization at individual company level was found to save about 10% of the studied firms' resource consumption at best, while value chain optimization had the potential to reach 20% - over the entire value chain - by using best available technology (Greenovate!Europe, 2012). Also the Swedish Energy Agency identifies the life cycle perspective as central to achieve the Swedish environmental objectives in areas such as non-toxic environment, reduced climate impact and sustainable energy systems (Statens Energimyndighet, 2011, Energimyndigheten 2015).

Further implementation of the life cycle approach involves major challenges: Established norms of what system to optimize, and how risk and profit are distributed in the value chain is challenged. A change may require new ways of looking at whose responsibility it is to manage and develop environmental and energy issues, or new ways to organize and manage business practices. Today, a life-cycle analytical approach is often limited to corporate environmental or research and development departments (Winnes, 2013; Rex and Baumann, 2006). Large groups such as SCA, ABB, AkzoNobel, SKF and Volvo Group have, for example, all in house expertise in environmental or development departments, at the same time as they recognize that life-cycle thinking needs to have a greater

impact on decisions and practices in more parts of the organization, as well as in the value chain, to achieve new business, products and services with significantly less environmental impact (CPM, 2012).

In this project we study how large companies can work to bring energy and resource optimization across the entire value chain. The aim is to highlight impacts and identify ways of working to encourage energy and resource-efficient solutions throughout the value chain - from raw material supply to end of life. The project is a cross-industry and interdisciplinary study providing recommendations for companies' internal work, while still recognizing that structures and incentives outside of the specific firm may also have an impact. By increasing awareness of the opportunities and methods for wider use of environmental life cycle, the project aims to help Sweden achieve environmental and energy policy objectives at the same time as contributing to increased industrial sustainability and competitiveness.

Aim and scope

The purpose of this project has been to develop methods for, and disseminate results on, how large companies can work with energy efficiency that stretches across actors in the value chain. By studying both organizational conditions and physical effects on resources, energy and climate for a number of cases, recommendations are given on how businesses and governments can include or encourage life-cycle actions in industry.

The long term goal is increased competitiveness through energy and resource efficient production and consumption systems. The project contributes to this by highlighting how companies and governments can facilitate and benefit from increased value chain perspectives in their energy efficiency work.

Delimitations

This report focuses the individual firm's ability to adopt energy efficiency along value chains. We specifically study aspects that affect the individual company, or actions that this company can do, although recognizing that a firm is influenced by and interacts with a wider context.

Focus in this study is on ways of working for large companies who want to develop in the direction toward more life-cycle thinking. We do not go into detail what kind of companies should or might want to do this kind of work. Also the case studies focus voluntary measures, over and above current regulations by law. All case studies are made in large multi-national groups with strong brands and extensive experience in life cycle thinking.

The case studies look at life cycle of work based on barriers and drivers experienced within the studied companies. Focus is on how people within the companies perceive his/her work and its relation to other actors. Other stakeholders and actors in the supply chain, such as suppliers and customers, have not been interviewed. The aim with the case studies has been to pin-point aspects beyond

technology and data, such as organizational and motivational aspects, with a focus on difficulties and possibilities perceived in large organizations.

Method

This project is interdisciplinary and combines interpretative research on organizational and business perspectives on product and business strategy with the calculations of effects on resources, energy and climate.

Procedure

The project is based on six case studies to gain in depth understanding of different approaches and ways of working in large companies, and their effects on energy and resources through the value chain. The case studies were complemented with a literature review, and preliminary results were analyzed and discussed with a broader group of industry and government representatives to jointly develop and disseminate conclusions and recommendations of high validity and relevance.

The work was divided into five work packages (WP), which both build on each other and were part of an iterative process.

WP1 – Project management

The project was managed through a project group consisting of researchers as well as representatives from the Swedish Life Cycle Center and the participating companies. A reference group was also selected with expertise in complementary fields including production, law and life cycle management. The reference group provided inputs on e.g. findings from the literature, means to analyze data, preliminary empirical results and possible connections to related studies.

WP2 – Establishment of framework

A practically oriented framework was developed to capture the internal and external dynamics of different working practices in the upcoming case studies. This work included a compilation of previous literature on the drivers, barriers and enablers for life cycle based energy efficiency and business solutions. Together with screening interviews with company representatives, this compilation formed the basis for the design of interview guidelines and analysis.

WP3 – Case studies

Six case studies were made in three large production companies representing different industry sectors ABB (engineering), AB Volvo (automotive) and AkzoNobel (chemical). The case studies aimed at illustrating the interaction between strategy/organization and concrete effects on energy and the environment. Organizational conditions and potential impact on competitiveness were identified through documents and interviews. Data was collected through interviews and workshops with representatives having both environmental and energy efficiency

positions, as well as people from product development, business strategy, sales and marketing. Impact and potential for improvement of environmental and energy effects in a life cycle perspective were quantified by the researches from document studies and additional information from the respondents.

WP4 – Analysis and validation

The literature studies (WP2) and the results from case studies (WP3) jointly formed the base for the analysis to provide deeper understanding of ways of working and incentives internally and externally. To validate and strengthen the analysis and develop practical viable recommendations and methods, a workshop was made on the preliminary results. In this workshop both people from the case study companies and additional business representatives from the Swedish Life Cycle Center took part, as did a representative from the Swedish Environmental Protection Agency.

WP5– Dissemination of results

Results from the project are reported on in this report, which for sake of wider dissemination also is part of the report series of both the Swedish Life Cycle Center and SP Technical Research Institute of Sweden. Preliminary results of the project have also been presented at the 7th International Conference on Life Cycle Management in Bordeaux, September 2015, and discussed in a workshop within the Swedish Life Cycle Center.

It became very clear during the project that there is a general need for increased corporate and policy understanding of the life cycle perspective. As a result it was decided to complement this final report with a power point targeting functions other than the environmental. An illustrator was engaged to assist in framing the message in an inspiring and easily understandable way. The resulting power point is intended to be used within agencies and large companies as a point of departure for discussion and further work.

Data collection

The results in this report are based on scientific literature, company reports as well as primary data collected from interviews and workshops.

Literature studies

The literature review has been made on a range of research scholars, on drivers, barriers and ways forward to increase energy efficiency along the life cycle. Literature on life cycle assessment (LCA) and life cycle management (LCM) are complemented with previous research in green supply chain management, operations management, green lean, and energy efficiency. These provide additional insights on organizational and commercial challenges and limitations when attempting to apply a life cycle energy perspective, such as lack of motivation and discord incentives in the value chain. As this project mainly have been empirically based, the literature review shall not be considered exhaustive,

and is more of a screening focusing the intersection between "traditional" energy efficiency and the management of life cycles and value chains.

Interviews and document studies

The case studies were selected together with the project representative of each participating company. After selection, in depth interviews were made with selected people with large involvement and knowledge in each case. 1-3 people were interviewed per case. In all, 11 interviews were made in the study. Each interview lasted about 1,5 h. Direct notes were taken in all interviews, in addition most of the in depth case interviews were also recoded with permission for internal notes. Case interviews were complemented with document studies such as company webpages, sustainability reports and internal documents. Interview template for the case study interviews can be found as Appendix A.

Preliminary results were discussed in workshops with both the reference group and peer life cycle experts in the Swedish Lifecycle Center.

Industrial context

The project was carried out within the Swedish Life Cycle Center (SLC, formerly CPM), a cross-industry center of excellence focusing on the implementation of life cycle thinking in industry and other parts of society. Partners in SLC are ABB, AkzoNobel, SCA, SKF, Volvo Group, Volvo Car Group, Vattenfall, NCC Construction, the Swedish Environmental Protection Agency, SP, IVL, Chalmers, SLU – Department of Energy and Technology and KTH. Within SLC, a wider distribution of the life-cycle concept, both within businesses and through value chains, has been identified as crucial for taking the knowledge we already have about how products and services can become more resource and energy efficient to use in society (CPM, 2012; CPM, 2013).

Guide for readers

This report is fairly comprehensive in describing procedures and results, since much of the results are based on understanding and context in each of the studied cases. The different chapters are, however, designed to be possible to read relatively independently, and can be selected based on the interest of each reader.

The concluding chapter, *Conclusions and recommendations*, may well be used as an executive summary of the entire report for those wanting a shortcut to the main results of the study.

A value chain perspective on energy efficiency

Energy efficiency in-house is a well-known win-win activity. The next step is to reduce energy and resources throughout the value chain, from raw material to end of life. Energy efficiency can be related to much more than energy used in production. In fact, most operations in a value chain directly or indirectly affect energy use.

The merit of a value chain perspective is to avoid sub optimizations across actors and processes. It encourages people to focus on how the different parts of the production and consumption system are interlinked and the fact that measures in one part of the chain have effects in other parts. For example a company that contracts out an energy intense process to a supplier decreases its own impact, but in terms of the entire system no improvement has occurred. However, with a value chain perspective such sub optimisations can be avoided and optimisations made over the whole system of actors. This is sometimes referred to as life cycle thinking.

Life cycle thinking

The life cycle concept deals with energy and materials efficiency over the entire life of products or services “from cradle to grave”, i.e. from raw material extraction, all the way through production, transportation, retail and use to disposal or to new products and services. It takes as its starting point physical flows of energy and material and emphasise the need to broaden the scope from optimizing a single operation or actor to optimize energy and resources throughout the entire value chain (Figure 2).

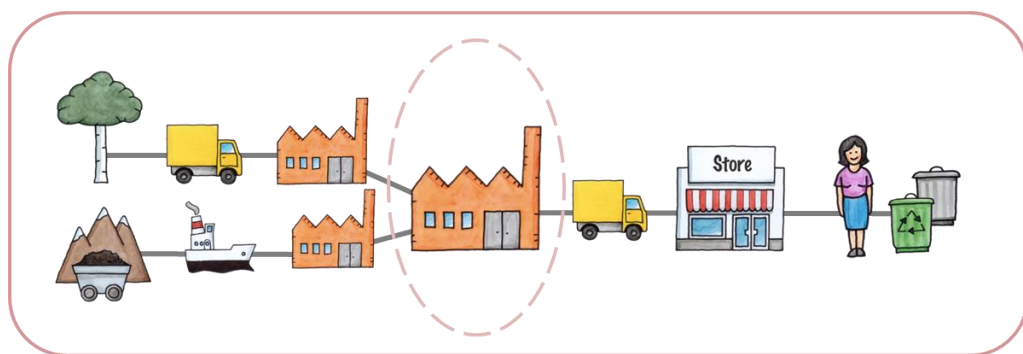


Figure 2. With life cycle thinking, the scope of optimization of energy and resources extends from a single site to the full value chain.

Some characteristics of the life cycle perspective include:

- It considers all impacts associated with a product or service, irrespective of where they occur.

- It optimises across systems of actors instead of inside the boundaries of a company or function
- It focuses measures on where the greatest impact occurs seen over the entire life cycle, not only on processes within the company's direct control.

With this as the starting point for action, re-focusing takes place, such as:

- An increased focus on collaboration, coordination and communication of across actors in the value chain
- An altered view of responsibility and scope of action, e.g. the producing company acknowledging the importance of influencing raw material suppliers or the use phase
- A higher degree of systems solutions, e.g. the idea of comparing value chain against value chain or of completely redefining business models
- A higher awareness of risks in the entire value chain, including changes in future conditions of e.g. predicted resource scarcity or uncertain social and environmental effects.

Life cycles stretches across actors and nations

As stated above, life cycle thinking considers all impacts associated with a product or service, irrespective of where they occur. Many large corporations have global supply chains and products sold on international markets. Thus it is seldom feasible to discuss national boundaries or effects of life cycle actions (see figure 3).



Figure 3. Most life cycles are global, and include activities and effects beyond a specific nation.

Products and processes can be part of many life cycles

When talking about a life cycle perspective, it is important to recognize that both products and processes often are part of many life cycles, in which the relative contribution can differ significantly.

For the life cycle of a truck, for example, the main impact in a life cycle perspective is related to the use phase of the product (Volvo Group Sustainability report, 2014), as seen in figure 4. The direct environmental impact from production made by the truck manufacturer is but a few percent.

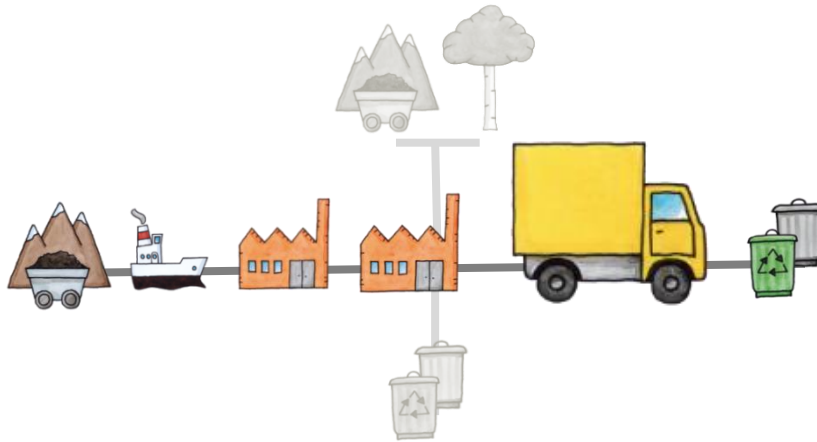


Figure 4. In the life cycle of a truck, the use phase represents the major environmental impact.

Yet when looking at the life cycle of the production site, energy use during operation of the site may well be a very important part of the life cycle of the plant (Figure 5).

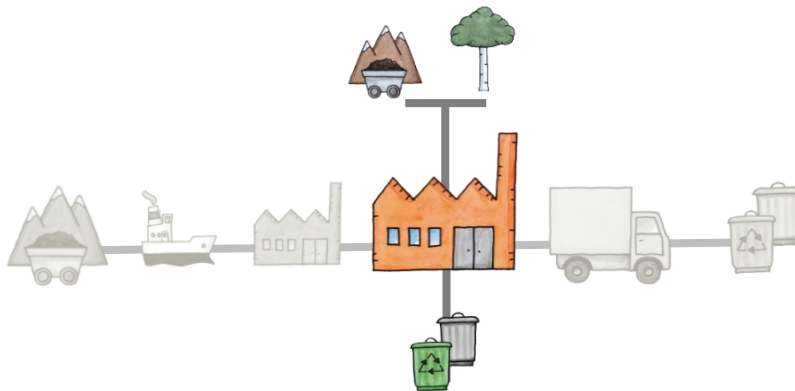


Figure 5. Production sites are also part of the life cycle of the building. Here the use of the building has a major share of the total environmental and energy impact.

Another example of the relative importance of different life cycle phases is transportation. Taken together, the transport sector is a very important contributor to global warming worldwide (UNECE, 2015). Yet in life cycle assessment studies (LCA) of specific products, transportation often show to have very low impact compared to other processes in the life cycle. Similarly, building and construction contributes a large share to energy use worldwide (UNEP, 2009; UNECE, 2015), although seldom even included in LCA of specific products.

Thus, in a company it can be a pedagogical challenge to make employees see their part in the big picture, especially as this picture can vary with perspective used.

Policy interest in life cycle thinking

The life cycle perspective has influenced several initiatives in European policymaking (see eg Finkbeiner, 2014; Dalhammar, 2007), standardization (e.g. ISO 2006 a and b) and handbooks (e.g. European Commission, 2010). Examples include the Ecodesign directive and the current work of the European Union to develop product environmental footprints (PEF). This interest in life cycle thinking in policy seems to persist. Sonnemann et al. (2015) conclude that “there seem to be high expectations of the future use of LCA in SCP policy areas such as sustainable public procurement and eco-design directives as well as consumer information” (p 20).

Drivers, barriers and enablers identified in the literature

Theories about the energy efficiency in the value chain can be linked to several different research scholars. On the one hand, there is a body of literature on energy efficiency in industry and the link to the value chain. On the other hand, there is the LCA literature and the link to energy, as well as the LCM literature and the link to energy in value chains. In the following, these research scholars are briefly explored and complemented with previous research in green supply chain management, operations management, green lean, and the link to energy efficiency. These provide additional insights on organizational and commercial challenges and limitations when attempting to apply a life cycle energy perspective.

Thus, this section provides examples of actions, barriers and solutions regarding energy efficiency identified in the literature on:

- Energy efficiency in value chains
- Life Cycle Assessment
- Life Cycle Management
- Green/Supply Chain Management
- Green lean/operations management

Energy efficiency in value chains

Literature on energy efficiency in industry (processes as well as production sites), dwellings, offices, service buildings, and for transportation and distribution is extensive, and it mainly runs back to the first oil crisis in the beginning of 1970s. Nowadays, there is also a considerable stock of literature on energy efficient products and services from slightly more recent periods. The purpose of the literature review below, however, is not to account for these two, both quantitatively important, scientific areas – this would be far beyond the scope of the study and of limited value for it, related to the required effort. Instead, it gives some examples from literature that address, or has the ambition to address, the intersection between energy efficient production and energy efficient products and also includes elements of a life cycle perspective.

In IVA (2013a), The Royal Swedish Academy of Engineering Sciences (IVA) has examined current energy use in Swedish industry. Three different aspects on industrial energy efficiency are identified:

- Operations – optimizing of current operations
- Products and development – production and process development for higher production efficiency, more energy efficient products.

- Cooperation with the external environment – cooperating in systems can further increase energy efficiency through the utilization of residual products and residual energy.

Since the study is limited to process and manufacturing industry and measures needed to increase energy efficiency *in industry*, recommendations and proposals to industry and policy makers address mainly industrial operations and processes. Nevertheless, industry is also recommended to *look beyond own activities*, considering energy efficiency also in the next steps in the supply chain, and policy makers are suggested to *support cooperation* in a systems' perspective in order to encourage e.g. energy recovery in streams across organizations. The authors call for instruments to overcome barriers and create incentives for this kind of extended cooperation along supply chains (IVA, 2013a).

Likewise, the building sector is encouraged to increase the systems' perspective in its value chains, e.g. through the establishment of a *R&D program* for renovation and energy efficiency improvements in the building sector (IVA, 2012).

Though it is not an important direct energy user, the service sector has surprisingly strong influence on indirect energy use through *procurement criteria* on suppliers and products, and decision makers in the service sector and policy makers are encouraged to increase incentives between the actors in the service value chains (IVA, 2013b).

The link between energy efficiency and energy efficiency in value chains

IVA (2013a) points out that an isolated, strictly national focus on the use of energy and other resources in industry may prove counterproductive; a globally more energy efficient product manufactured with a relatively high energy use in one country may result in lower final energy use in another country. This aspect is valid also for other sectors where goods and services cross national borders.

In Helldal & Tenne (2009), products are classified from an end user perspective in active and passive products (*Figure 6*):

- Active products: require input and/or influence other products during the use phase
- Passive products: do neither require important input nor influence other products during the use phase.

The life cycle impact assessment profile differs between these product groups, and efforts to reduce the environmental impact and use of resources, e.g. energy, should be focused accordingly. The efforts to reduce environmental impact and resource use from passive products should be concentrated to manufacturing, raw material production and end-of-life, while measures to reduce impact and resource use from active products should be focused on the use phase and its optimization (Lindahl 2000 in Helldal & Tenne, 2009). The categorization in active and passive products can be used as a “shortcut” to a hot-spots analysis based on a full or screening LCA, and also in combination with e.g. eco-design tools such as the Eco-strategy wheel (Norrblom *et al* 2000 in Helldal & Tenne, 2009) and or Design for Environment (DfE).

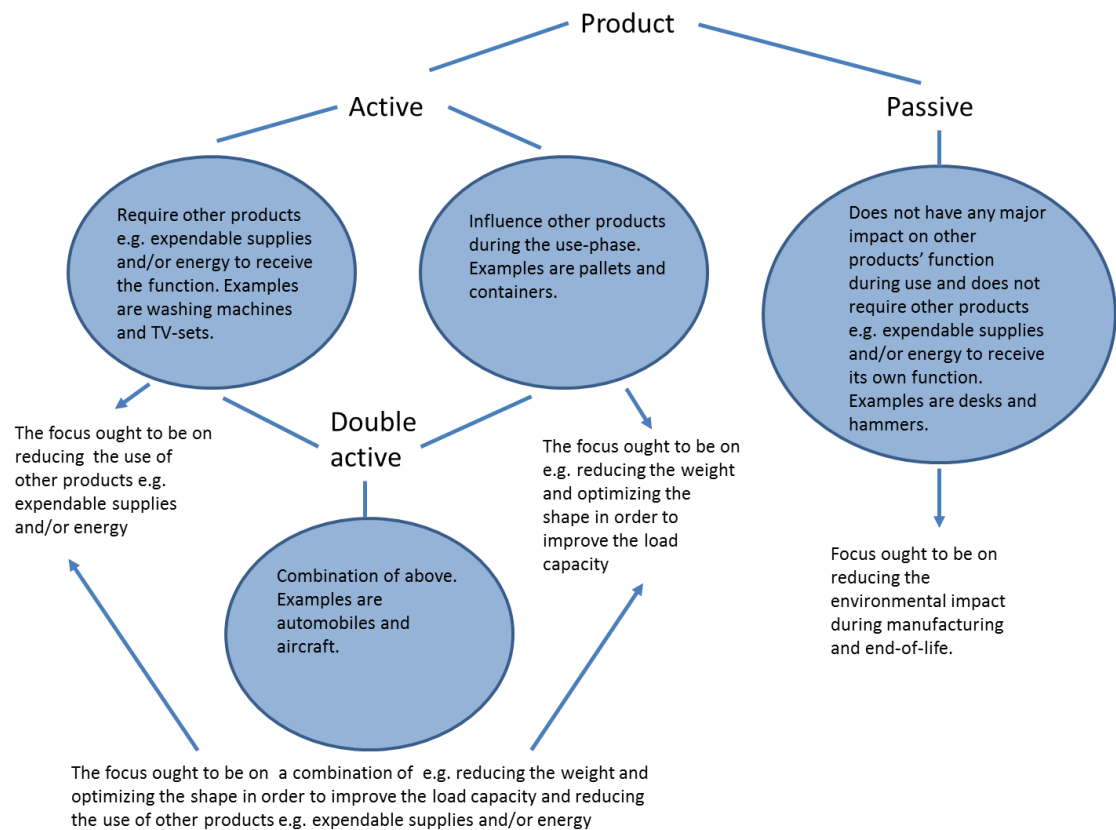


Figure 6. Active and passive products (from Lindahl et al. 2000, modified in Helldal & Tenne 2009)

Barriers

IVA (2013a) identifies the following barriers to cost-efficient energy efficiency measures in industry:

- Competition for limited resources within companies (time and money) – priority to core business
- Lack of or insufficient knowledge
- Financial calculations that do not take life cycle costs into account, combined with separate budgets for investments and operations
- Little external pressure (customers, owners, shareholders, governments etc.) on increased energy efficiency

Although the authors point out that an isolated, strictly national focus on the use of energy and other resources may prove counterproductive (see above), the summary of current political drivers and barriers addresses mainly either industrial operations and processes or energy efficient products and processes, which illustrates the risk for suboptimisation mentioned above.

Neij (2007) (in Larsson et al. (2009)) also lists a number of barriers to increasing energy efficiency in organizations, including limited and asymmetrically distributed knowledge and information on energy efficiency, split incentives for energy efficiency between budgets, and availability of energy efficient technology. IVA (2012) further highlights that the connection and coordination between long term

goals and political/societal instruments are insufficient, and presents a set of recommendations to correct these shortcomings (see below).

In the service sector, the interest in energy efficiency measures and investments are fairly low, since energy costs are modest compared to other costs (IVA 2013b).

Drivers

The drivers for increased energy efficiency in industry mentioned in IVA (2013a), IVA (2012) and, to some extent, IVA (2013b) are:

- The national energy efficiency goal (20% less energy input per GDP in 2020 compared to 2008)
- The energy efficiency directive (see below)
- The eco-design directive (minimum energy performance requirements and energy labeling)

The energy efficiency directive was implemented in Swedish law in 2014, when the Swedish parliament decided that (Sveriges Riksdag, 2015):

- Large companies (at least 250 employees and annual sales of over 50 million SEK or a balanced sheet total exceeding 43 million EUR per year) shall carry out an energy survey every fourth year. The survey shall include cost efficient measures for energy efficiency improvements.
- Suppliers of electricity shall invoice the customers for the metered consumption of electricity, if the supplier has access to measurements.
- Requirements are tightened on the public sector to be more energy efficient.

Industries and district heating companies planning to build larger electricity production facilities, industrial plants or district heating networks shall carry out a cost-benefit analysis, taking available surplus low grade heat into account.

Most of the provisions entered into force June 2014.

The Environmental Code is an overarching driver for increased energy efficiency in industry. This piece of legislation contains a number of general rules of consideration that express, for instance, principles regarding resource management, recycling and suitable localization of activities and measures. Supervisory and licensing authorities have the power to base their decisions on these general rules of consideration concerning e.g. permit conditions (IVA, 2013a).

Specifically for the building sector, IVA (2012) mentions the Swedish implementation of the directive on energy performance of real estate, according to which all new buildings are to be “very low energy buildings” from 2020 (for official buildings, the provision is applicable already in 2018). Initiatives for energy effective office buildings are found within Belok (2015) and STIL (ES 2015:05).

Enablers

Current enablers for increased energy efficiency in industry reported in IVA (2013a) include energy mapping cheques and regional planning. The energy

mapping cheques address companies with an energy use exceeding 500 MWh per year or 100 animal units, and a cheque entitles the company to a subsidy of 50% (maximum SEK 60 000) of the costs for mapping the energy use. All Swedish counties develop regional development plans that include coordination of processes of importance for sustainable regional development and facilitate cooperation across counties. Well-functioning processes may bring about the integration of growth and energy efficiency.

Since the study is limited to process and manufacturing industry and measures needed to increase energy efficiency in industry, recommendations and proposals to industry and policy makers address mainly industrial operations and processes:

Industry

- Demonstrate leadership, set goals and evaluate them
- Ensure knowledgeable and committed employees
- Create structures and systems, e.g. management systems
- Be proactive and allocate funds
- Create sustainable visions for the future

Policy makers and public authorities

- Show that energy efficiency is prioritized
- Support knowledge growth and provide tools
- Focus in particular on SMEs
- Facilitate financing
- Support “the voice of the customer”
- Invest in the future

Nevertheless, industry is also recommended to look beyond own activities, considering energy efficiency also in the next steps in the supply chain, and policy makers are suggested to support cooperation in a systems’ perspective in order to encourage e.g. energy recovery in streams across organizations. The authors call for instruments to overcome barriers and for incentives for this kind of extended cooperation along supply chains.

IVA (2012) gives a series of recommendations to decision-makers in the real estate sector, e.g. stricter construction regulations for renovation and new construction to encourage the application of solutions with higher energy efficiency, and an R&D programs in energy efficiency in buildings, e.g. to encourage the application of a systems perspective in the real-estate sector.

In IVA (2013b), the energy use in the service sectors (consulting sector, restaurants, hotels and supermarket) has been also investigated. The authors point out, that due to an advanced position in the value chain, service companies are in a good position to influence the energy consumption of suppliers and customers in their value chain by procurement, setting standards and developing business concepts.

Since the service sector is less exposed to competition from abroad than manufacturing industry, higher energy prices would probably be the most efficient

measure to increase interest for energy efficiency in the service sector (IVA, 2013b). However, in order to achieve the greatest possible energy efficiency gains in the service sector, it is often necessary to involve subcontractors and customers in energy-saving initiatives, and the authors recommend increased incentives for cooperation between players in service sector organizations' value chains.

Life Cycle Assessment

Life cycle assessment (LCA) is a systems-oriented methodology for the assessment of material and energy flows and their environmental impacts related to a product or a service, all the way from raw material extraction, to disposal (Baumann and Tillman, 2004). LCA studies are recognized for their ability to identify hotspots of environmental impact along the value chain, including direct and indirect energy usage and resource flows. LCA is often considered a prerequisite of life cycle management (see e.g. Rebitzer, 2005) although some scholars argue that full quantitative LCA studies are not essential for life cycle thinking and management in general (Baumann and Tillman, 2004).

The link between energy efficiency and LCA

The LCA literature focuses on the performance of LCA studies of different levels of detail (screening or full) to know and learn, find hot spots etc. These studies are then argued to be applicable for learning and decision making in a range of corporate functions such as marketing, sourcing, product and process development (see e.g. Baumann and Tillman 2004, Sonnemann et al 2015). Energy sources, energy efficiency and their environmental implications in terms of e.g. global warming potential are often very important parts of an LCA study.

Drivers

There are many reasons for performing LCA studies. Increased knowledge and reduced risk through the assessment of own impact and hot spot analysis of what are the main contributing processes in the value chain are important driving forces. There could also be direct and indirect market advantages such as data for information and labelling, increased legitimacy or as a response to marketing claims from competitors (Rex and Baumann, 2004).

Barriers

The LCA literature as such seldom focus managerial or relational issues. Identified barriers regards most often constraints of undertaking LCA studies, rather than implementing LCM in the organization (Mortimer, 2010).

Identified barriers for undertaking LCA studies primarily focus on tools and methods, and related time and money needed to perform the studies, (see e.g. Rebitzer, 2005, Rex and Baumann 2008, Baumann and Tillman, 2004). Common barriers identified include:

- Takes time
- Costs money
- Lack of data
- Lack of specialist competence
- Lack of developed methods
- Lack of standardized methods

Enablers

The LCA literature has put much effort into facilitating the “technical conditions” of performing LCA, in order to reduce identified barriers. A lot of efforts have been made to *develop the LCA methodology*, both to be more “accurate”, and to make the act of performing LCA more easy and rapidly usable with less resources (Baumann 1998, Rebitzer 2005).

Another line of action has been to *work with data availability*, through data bases, data formats etc. A lot of progress has also been made on both data formats and availability in the last decade. Related to this is the *development of tools and guidelines*, such as the ILCD handbook, for example (European Commission 2010). Based on the notion that different types of companies seems to adapt LCA differently, *sector-specific recommendations and guidelines* is also common approach (Mortimer, 2010).

A smaller stem of research has been focusing organizational aspects such as how to encourage and *ease the institutionalization and individual adaptation* of LCA as an environmental technique within the company (see e.g. Rex and Baumann 2007).

Life Cycle Management

The life cycle management (LCM) literature is not any uniform scholar of theory. It often has its roots in life cycle assessment, and has evolved by seeking inspiration from a range of other knowledge fields such as organizational theory, (Baumann 1998, Heiskanen 2002), knowledge management (Nilsson-Lindén 2014), operation management (Löfgren 2012) and social practices (Schmidt, 2013).

Possible actions in life cycle management are countless and can be classified in many ways. A common practice is to present actions related to different functions of the company, such as product development, purchasing, marketing etc. (see e.g. Baumann and Tillman 2004, United Nations Environment Program 2007).

LCA (life cycle assessment) is a central method in LCM, as one of the most common tools used to monitor status quo and potential improvement options. Other related methods and tools include social LCA, life cycle costing (LCC), and various footprints, among others (cf. e.g. UNEP/SETAC 2009, Sonnemann et al. 2015).

The link between LCM and energy efficient value chains

A central idea in life cycle management is the shift in focus from optimizing one actor's own production processes, to extend the scope and improve environmental (or sustainability) performance based on the full value chain, from raw material to waste handling (c.f. e.g. Sánchez, Wenzel et al. 2005, Rebitzer 2015). Depending on the type of product and the company's role in the value chain, small changes in one part of the value chain may have substantial effects in another. This is valid not least for energy efficiency, which is one aspect among others dealt with within LCM.

Drivers

Life Cycle Management (LCM) has been described as making life cycle thinking and product sustainability "operational", in a dynamic, voluntary and step-wise process (United Nations Environment Programme, 2007). Rationales for taking on such an approach includes improved image, visibility and stakeholder relations, increased shareholder value, and an increased awareness and preparedness for changing regulatory contexts (United Nations Environment Program 2007). It has also been argued to be an opportunity to differentiate through sustainability performance on the market place, a way to work with all departments of a company, and a way to enhance collaboration with stakeholders along the value chain (Sonnemann and Margni 2015).

Barriers

There are many tools and methods associated with LCM, with LCA as a prominent yet not the only tool emphasized, as seen above. Parts of the barriers to LCM are associated with the *lack of availability and success when trying to implement and use such tools* (see e.g. Sánchez, Wenzel et al. 2005). Another barrier is *the complexity of considering and/or organizing entire value chains* (Rebitzer 2015, Nilsson-Linden 2014, Mortimer 2010). What more is, the responsibility for who should take on this approach is not clear, e.g. what actor in the value chain could or should take lead to optimize the entire system? Sonnemann et al 2015 suggests that the sustainability departments of large multinational companies often are in a position to coordinate the implementation of LCM. Yet this seems mainly to regard the internal implementation in each company.

Mortimer (2010) makes a comprehensive literature review and list 32 enablers and barriers to undertaking LCM associated to four different levels:

- Individual: e.g. narrow technical or organizational skills or low access to authority.
- Organization: e.g. inflexible management programs, high direct and transactional costs, lack of commonly defined visions and goals, commitment, training and resources.
- Organizational field (supply chain): e.g. lack of data, increased risk due to increased dependency, customer resistance or limited understanding, lack of influence in the value chain
- Broader system (society and institutions): e.g. low or lack of market demand and constraints from current production and consumption system and culture.

When it comes to internal implementation of LCM, several researches in life cycle management have observed *divergent interpretations among employees on what environmental and life cycle related actions and ambitions means for the organization and for their work practices* (Heiskanen 2000, Rex 2008, Schmidt and Remmen 2013). Actions and responsibilities related to environment or life cycle thinking are typically regarded as technical issues related to the responsibility of the environmental department alone (Rex and Baumann, 2006; Schmidt and Remmen, 2013). There is also a lack of translation to operational action over and above the environmental departments (Rex 2008).

Enablers

Life cycle management aims to affect entire value chains, in themselves embedded in a wider societal and institutional system. As such increased stakeholder demand beyond end of pipe focus, and the emergence of strategic and cooperative approaches across actors in the value chain has been identified as enablers for LCM adoption (Mortimer 2010), along with internal integration within each firm.

To this end, most research of LCM focuses on internal resources and practices in organizations as enablers or barriers of life cycle management. Based on a review of LCM literature, Nilsson-Lindén et al. (2014) identified the main critical success factors for LCM found in the literature to be (c.f. also e.g. Sonnemann et al. 2015):

- Top management support
- Communication and interaction
- Integration across functions
- Part of everyday practice
- Alignment with business strategy
- Knowledge of LCM
- Holistic environmental approach
- Collaboration of product chain actors

Nilsson-Lindén et al. (2014), conclude that LCM literature mainly identify factors that ought to be considered, and even tend to have a "feeling of utopian descriptions" encompassing holistic management in the entire product chain with all actors and function included. To this end, the list above could be seen as reflecting a desired state of *reaching "optimal conditions"* for LCM. Examples of LCM work can also be found aimed at inspiring companies to adopt LCM (see e.g. UNEP/SETAC 2009). The question largely remains on how to achieve this in practice.

One line of research in LCM takes a descriptive approach to LCM, usually following internal company practices through the use of case studies. Identified enablers in this literature often relate to the understanding of human and organizational factors, some examples being:

- Providing communities of practice to exchange experiences among practitioners across industries (Rex and Baumann 2008, Mortimer 2010)
- Finding a framing that makes a broader group of employees concerned about the question. Schmidt and Remmen (2013), for example, found that

employees in their case study more easily got involved in aspects framed as sustainability than environmental.

- Having a life cycle champion, entrepreneur, or pioneer, assuming the responsibility to drive the issue forward, and translating and adapting the practice to the individual context of the company has also been continuously recognized as important for LCM adoption (see e.g. Baumann 1998, Rex and Baumann 2007, Sonnemann et al. 2015).

Organizational challenges for LCM, preferably with greater influences from management science, are increasingly recognized as important to study in order to assist in the development for increased capacity building and mainstreaming of life cycle management in practice (Sonnemann et al. 2015).

Green/sustainable supply chain management

Just like the life cycle management literature, the supply chain management literature is not a uniform scholar of theory. Some researchers have described different scholars of theories and analyzed the conceptualizing of global supply chains and sustainable development (Boons, Bauman and Hall, 2012). The conceptualizing are influenced by mainstream sciences, such as economics and management sciences, sociology and organizational science, as well as described as social networks in governance studies, and environmental systems engineering.

The main body of literature is related to *management science*, such as the leadership and management of supply chains (Zakris, 2002), as well as the role of a focal company and the power in the supply chain (Seuring, 2004; Kogg, 2009). There is another body of literature based on *organization theory*, such as descriptions of product chain organizations PCO, and combined with environmental systems engineering (Bauman, Brunklaus, et al 2015). Descriptions of *social networks and governance* are found in studies on green public procurement (EU, 2015; CSR Vast, 2011) and auditing (Zanden, 2015; Locke et al 2013).

According to the council of supply chain management professionals (Jaggernath, 2015) *supply chain management SCM* has been described/defined as “integration of planning, analyzing, coordinating and scheduling of every activity involved in *sourcing and procurement, conversion and logistics management activities*. SCM encompasses all *logistics management activities and manufacturing operations*, as well as *marketing, sales, product design, and finance and information technology*”.

Green supply chain management GSCM has been described/defined as SCM with environmental awareness, an emphasis on green productivity and decrease in environmental impact (assessed by LCA) during each link in the value chain by *reducing energy consumption, reducing consumption of natural resources, reducing pollution related problems and increasing recycling to harness the future use of raw materials and supply* (Jaggernath, 2015). In the 80s the drive towards sustainability had three focus areas: dematerialization, detoxification and de

carbonization which led to the *4Rs* (*reduce, reuse, recycle and redesign*), and activities like *green procurement, energy efficiency, and reduction of GHG emissions and waste, promoting recycling and biodegradables* (Jaggernath, 2015).

Challenges facing GSCM practitioners and implementations (Jaggernath, 2015):

- incompetent use of information,
- lack of collaboration due to companies being too busy or intellectual property concerns
- cost containments,
- lack of SC visibility,
- risk management,
- increasing customer demand for SCM,
- globalization

GSCM includes organizational performances requirements (cost, quality, time, flexibility), and green supply chain alternatives (TQEM, ISO14000, ISO 9000), according to Sarkis (2002). Lately the focus from energy and materials in green SCM (Sakris, 2002) has been changed to sustainable supply chain management, and social issues have become popular, especially in textile and food supply chains (Seuring, 2004; Seuring et al 2008; Kogg, 2009, Chkanikova and Koog 2011, RSCN 2012). Kogg and Mont point out the degree of coordination and power in supply chains (2012).

Figure 7 shows a framework to conceptualize different approaches to implement upstream CSR (Kogg, 2009).

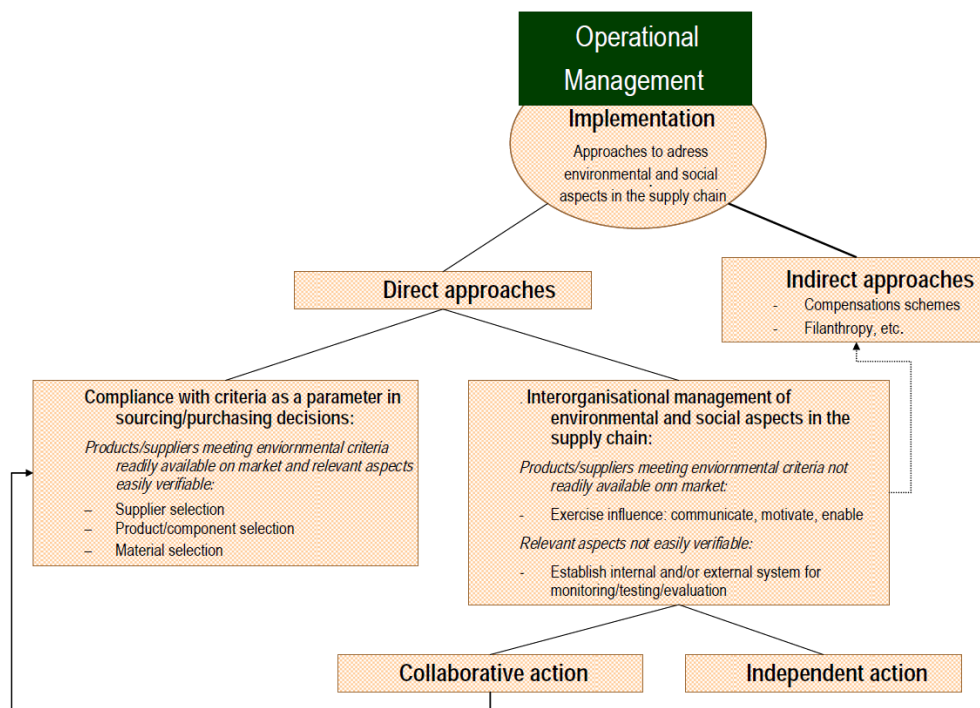


Figure 7. A framework to conceptualize different approaches to implementation of upstream CSR (Kogg, 2009)

Possible actions in green/sustainable supply chain management are mostly related to information and material flows (Seuring, 2004), while energy issues are more seldom addressed specifically (Sakris, 2002). A common practice is to present actions related to different functions of the company, such as purchasing, procurement, logistics, marketing etc. Compared to LCM that do not have a function on its own in companies, sustainable supply chain management often has a more expressed function, although focusing more on social and health issues.

The link between energy efficiency and SCM

A central idea in green supply chain management is to improve the efficiency of the whole supply/value chain. GSCM include activities like *green procurement, energy efficiency, and reduction of GHG emissions and waste, promoting recycling and biodegradables*. Regarding sustainable supply chain management, a central idea is to visualize the supply chain and create trust for the customer regarding social issues and risk (Jaggernath, 20015).

Drivers

The green/sustainable SCM literature as such seldom focuses energy efficiency issues. Identified barriers regard most often collaboration and sharing of information within the global supply chain, rather than implementing energy efficiency measures.

A central reference is the article by Walker et al (2008), which includes drivers and barriers to environmental supply chain management, as well as measures to overcome these barriers.

Identified **drivers** for undertaking SCM include internal and external drivers:

- *Internal drivers* are organization-related (skillful policy entrepreneurs, desire to reduce costs, pressure from investors, manage economic risk, improve quality, values of founder/owner, managers improving position in company, employee involvement)
- *External drivers* are regulatory (legislative and regulatory compliance, proactive action pre-regulation, ISO14000), customers (pressure by customers to green supply chain, collaborate with customers, E-logistics and environment, marketing pressures), competition (gaining competitive advantage, improve firm performance), society (stakeholders can encourage environmental strategy, potential for receiving publicity, public pressure, reduce risk of consumer criticism, non-economic stakeholder, pressure by advocacy groups), and suppliers (collaborate with suppliers, supply integration).

Barriers

Identified barriers for undertaking SCM in the study by Walker et al (2008) include:

- *Internal barriers* are costs, lack of training and commitment, lack of understanding of how to incorporate green into buying, lack of buyer awareness, lack of legitimacy and greenwash.

- *External barriers* are regulations inhibiting innovations, poor supplier commitment unwillingness to exchange information and different sectors have different challenges.

In her dissertation, Kogg (2009) studies the implementation of upstream CSR and describes the following challenges:

- going beyond first tier supplier,
- inter-organizational and intercultural communication,
- motivating change in supplier activities and monitoring,
- willing/ability to change sourcing,
- lack of competence in the focal firm and at suppliers.

Enablers

The green/sustainable SCM literature as such seldom focus on solutions to overcome barriers. A central article is the article by Walker et al (2008), which includes measures to overcome SCM barriers. The following solutions to overcome internal and external barriers, have been identified:

- *Internal solutions:* regarding cost and unawareness, training has been recommended. Another solution is to make people sympathetic for the problem and thus more motivated to work with the issue.
- *External solutions:* regarding regulations, flexible best available techniques BAT is used. To overcome external poor supplier commitment, close supply chain relations and cooperative customer-supplier relationship is used. To overcome sector specific barriers, awareness has been used.

Green lean, operations management and energy efficiency

Lean production, or in short Lean, is an interpretation of the successful production concept and "philosophy" first developed and adopted by Toyota, based on continuous improvement, flexible and low input processes adapted to customer requirements (e.g. Helldal & Tenne 2009).

As mentioned in Löfgren (2009), taking only parts of the life cycle into account when investigating a decision makers' influence on environmental performance and use of resources introduces the risk of sub optimisation. However, despite its process perspective, Lean does not take the whole life cycle into account, but focuses more on the production or steps before distribution, which has been pointed out by Larson and Greenwood (Helldal & Tenne, 2009), EPA (2003) and Larsson *et al* (2009). To address this shortcoming, the integration of environmental aspects and Lean production has been suggested (e.g. Helldal *et al* 2009), which below is denoted Green lean.

Mollenkopf *et al.* (2010) report that Wal-Mart has recognized that aligning green and lean practices drives the financial performance of the firm and earns respect from customers (Friedman, 2008, in Mollenkopf *et al.* 2010), and that General Motors, Andersen Corporation, Intel, 3M, and Com Ed have saved significantly by integrating green and lean initiatives (United States EPA, 2000, in Mollenkopf *et al.* 2010). Similar examples of compatible green and lean supply chain strategies can be seen in the furniture industry (Handfield *et al.* 1997, in Mollenkopf *et al.* 2010). However, it is not explicitly mentioned whether these examples and effects represent assessments taking the whole life cycle perspective into account and whether energy efficiency has contributed to the results. Similarly, Helldal & Tenne (2009), studying the truck and bus manufacturer Scania, Sweden, showed increased energy efficiency, and attributed to waste elimination. Whether energy efficiency increased also from a life cycle perspective was not reported.

The link between energy efficiency and green lean

Mollenkopf *et al.* (2010) give an account for a literature review covering the interface between green, lean, and global supply chain strategies. The authors refer to “green supply chain strategies” as efforts to minimize the negative impact of firms and their supply chains on the natural environment. A green supply chain focus requires working with suppliers and customers, analysis of internal operations and processes, environmental considerations in the product development process, and extended stewardship across products’ life-cycles (Corbett and Klassen, 2006; Mollenkopf, 2006, in Mollenkopf *et al.* 2010). The authors state that causal relationship between lean processes and environmental sustainability has been much debated in literature (King and Lenox, 2001, in Mollenkopf *et al.* 2010) and refer to research that suggest that lean and green practices may not always be compatible, which is supported by a survey on emissions of organic compounds from manufacturing plants. Furthermore, lean manufacturing and mass customization require more setups, which generate more waste and use more energy (King and Lenox, 2001, in Mollenkopf *et al.* 2010). However, innovative firms with continuously improving manufacturing processes seem to be more likely to take on environmental innovations (Florida, 1996, in Mollenkopf *et al.* 2010).

Drivers

According to Mollenkopf *et al.* (2010), the integration of lean supply chain processes and environmental practices is driven both by internal and external factors. The authors mention *cost reduction* and *profitability* from gaining new market segments, *commodity risk management*, and the preservation of a *corporate culture* as examples of internal drivers (Friedman, 2008; Kleindorfer and Saad, 2005; Kleindorfer *et al.* 2005, in Mollenkopf *et al.* 2010), while external drivers include *governmental* (Hansen *et al.* 2004; Cole, 2008; Kleindorfer *et al.* 2005, in Mollenkopf *et al.* 2010), *customer and environmental pressures* (Cole, 2008; Hall, 2000; Vachon and Klassen, 2006a, in Mollenkopf *et al.* 2010), a similar focus on *continuous innovation and process improvement* (Florida, 1996, in Mollenkopf *et al.* 2010), and the potential for further *profitability* through added customer value (Kleindorfer *et al.* 2005, in Mollenkopf *et al.* 2010).

Barriers

Among the barriers to implementing green and lean supply chain strategies, Mollenkopf *et al.* (2010) mention *lack of environmental awareness* (Rothenberg *et al.*, 2001, in Mollenkopf *et al.* 2010), *lack of metrics* (Mollenkopf *et al.* 2010) the common belief that environmental practices *do not pay* (Porter and van der Linde, 1995, in Mollenkopf *et al.* 2010), and the perception that green initiatives are *time consuming and expensive*.

Enablers

Mollenkopf *et al.* (2010) point out the demand for high levels of *information sharing*, *rapid performance improvements* with suppliers and *minimal transaction costs* (Dyer, 1997; Lamming, 1993, in Mollenkopf *et al.* 2010) as necessary for lean supply arrangements, and conclude that this type of relationship may provide the incentive firms need to bridge the lean and environmental supply chain practices of their suppliers (Simpson and Power, 2005, in Mollenkopf *et al.* 2010).

In Helldal & Tenne (2009), the truck and bus manufacturer Scania in Södertälje, Sweden, claimed that *dedicated management, resources, competence*, established and implemented *working routines* and *tools*, and, finally, *visible results* that are evaluated are the key to better environmental performance indicators, such as energy efficiency.

Using the limitations of LCA as a support for decision making in daily work and the success of total quality management (TQM) as starting points, Löfgren (2009) proposes three methods of “manufacturing LCM”:

- Relating environmental impact and resource use to a particular manufacturing industry actor (instead of relating them to a life cycle step);
- Relating environmental impact and resource use to a manufacturing process, omitting the material that is actually delivered as product leaving the system;
- Using discrete-event simulation (DES) combined with LCA to capture the dynamics of the manufacturing system to help manufacturing decision makers find ways to improve the environmental performance of processes for which they are responsible.

In the discussion on advantages and disadvantages with these proposals, the first method adds little additional information compared to relevant scenarios applied to an ordinary contributions analysis. The second method identifies *own* manufacturing processes influencing the environmental performance in a conventional cradle-to-gate analysis - no assessment of overall environmental impact is carried out. Hence, there is a risk of sub optimization, and the method should be used in combination with an ordinary LCIA. While including the most “operations management” and dynamic aspects of the three methods, the third method is time consuming since it requires environmental performance data corresponding to specific simulation parameters. In the discussion of further research, Löfgren (2009) points out that more research is needed to allow manufacturing decision makers to assess the business consequences of a decision that will change the environmental performance of a process for which they are responsible.

Summary of literature

The studied bodies of knowledge all have their perspectives on energy efficiency in value chains, although with different starting points and actions in focus. Energy efficiency as such is most pronounced in the energy efficiency and operations management literature, although the life cycle perspective cannot be considered prominent in this literature. The LCA, LCM and (green) supply chain management literatures has a stronger value chain focus, but here energy efficiency is but one aspect among others.

Within both life cycle management and green/sustainable supply chain management, a central idea is to improve the efficiency of the whole supply/value chains, through better information, collaboration and material flows. The LCA and LCM literature centers on optimizing material flows, and have been rather normative in its character with a strong focus on tools, data and procedures. In sustainable supply chain management focus is more on the organizational practices and relations, where for example collaboration, motivation and power in the supply chain seems to be important. While in supply chain management, the companies and suppliers and customers are in focus, the governance studies focus on external help, such as NGOs. However, more studies are dedicated to social and health issues, while energy efficiency is seldom included. (Notably there was a general lack of studies showing the practical effects of measures taken in terms of actual energy improvements achieved).

Drivers

Within green/sustainable supply chain management, there are a large number of internal and external drivers identified. Internal drivers include reduced costs, pressure from investors, management of economic risk, improved quality, values of founder/owner, managers improving position in company and employee involvement. External drivers are related to regulation, customer, competition, society, and suppliers. Similar driving forces can be found in the LCA/LCM literature, although with additional emphasis on learning, hot spot analysis, environmental risk and sustainability differentiation on the market.

Notably energy efficiency literature is the area where legal requirements are the most pronounced as driver for action. The national energy efficiency goal, the energy efficiency directive and the eco-design directive are emphasized as the main drivers for increased energy efficiency in Swedish industry. Yet these directives rarely ensure energy efficiency from a life cycle perspective.

Barriers

Energy efficiency literature emphasizes the requirements of cost-effectiveness of energy measures and points out competition for limited resources within companies (time and money), insufficient or asymmetrically distributed knowledge, financial calculations not accounting for life cycle costs combined with separate budgets for investments and operations, and finally little external pressure on increased energy efficiency as main barriers to cost-efficient energy efficiency measures in industry.

In the LCA and to some extent also LCM literature lack of tools, standardizations and data are further enhanced, as is the top management support for life cycle action. Within green/sustainable supply chain management, barriers regards similarly sharing of information within global supply chains, but also relate to collaboration, lack of training and understanding of how to incorporate green into corporate functions such as purchasing.

Enablers

In energy efficiency literature, energy mapping cheques (i.e. financial support for energy surveys) and administrative instruments (e.g. regional planning) are current enablers for increased energy efficiency in process and manufacturing industry. Furthermore, leadership, organizational structures and commitment are also mentioned as important enablers in industry, while policy makers are suggested to support cooperation in a systems' perspective along and across organizations. Since the service sector is less exposed to competition from abroad than manufacturing industry, higher energy prices would probably be the most efficient measure to increase interest for energy efficiency in this sector.

In line with identified barriers, enablers found in the LCA and LCM literature include development of tools and methodologies, the set-up of databases and data formats, and identification of recommendations and best practices in different industries. In comparison, green/supply chain management, has a greater focus on supply chain relations, cooperative customer-supplier relationships and training. Such more organizational and procedural aspects of management has historically been less prominent in the LCM literature, although it starts so be more recognized as important in order to make LCM more "mainstream" (Sonnemann et al. 2015). Possibly, in this ambition, a greater exchange between LCM and green supply chain management would be fruitful.

Case studies

The case studies are based on projects in three large multinational production companies active in Sweden: Volvo AB, ABB and AkzoNobel. The companies are part of the Swedish Life Cycle Center, and the case studies provide examples of actions, barriers and enablers regarding energy efficiency in the value chain.

The purpose of the case studies is to illustrate the interaction between strategies and organization, and concrete effects on energy and the environment. Organizational prerequisites, and potential impact on competitiveness, were mapped through documents and interviews with representatives from different functions (environment, market, business, product, and process development). Calculations of theoretical and practical effects on energy and carbon were made by the researchers based on data found in each case study.

Selection of case studies

The selection of case studies was made based on screening interviews with environmental managers in each of the studied companies. We particularly asked for cases that either had an energy efficiency focus, or were examples of life cycle thinking with energy implications throughout the value chain.

Six cases of energy efficiency were chosen, two in each company:

- Energy efficiency at production – idle electricity reduction per plant. (AB Volvo)
- Energy efficiency at building - demand of 25% energy reduction on new buildings. (AB Volvo)
- Group objective on energy efficiency in production. (ABB)
- From selling energy efficient motors to selling energy services. (ABB)
- Target on reduced carbon footprint across the value chain. (AkzoNobel)
- The Intersleek eco-premium solution in marine coatings. (AkzoNobel)

The case studies were selected to reflect different levels in the organization, such as production level, product level, and strategic level.

The screening interviews were complemented with semi-structured in depth interviews with project leaders and other central personnel related to each case, as well as company webpages, sustainability reports and internal documents. Interview template for the case study interviews can be found as Appendix A.

Aspects of interest

The case studies have been created based on the categories drivers, barriers, enablers, effect on energy and effect on competitiveness:

- **Drivers** - are related to the initiation of the energy efficiency project studied.
- **Barriers and enablers** - are related to the process of the energy efficiency project.
- **Effects on energy** - are related to the theoretical and practical effects, basically kWh and CO₂ emissions.
- **Effects on competitiveness** - are related to impact on economic results, as well as company image, credibility, stakeholder relations etc.

In the next sections each company and their sustainability strategies are described in general, the selection of the cases are described for each company, as well as the barriers and enablers for each studies case. At the end of each case, the effects on energy (and carbon emissions) are calculated and the effect on competitiveness is described.

Volvo Group

The Volvo Group is one of the world's leading manufacturers of trucks, buses, construction equipment and marine and industrial engines. The Group also provides complete solutions for financing and service. The Volvo Group, with its headquarters in Gothenburg, employs about 100,000 people, has production facilities in 19 countries and sells its products in more than 190 markets. In 2014 the Volvo Group's net sales amounted to about SEK 283 billion. The Volvo Group is a publicly-held company, AB Volvo, and shares are listed on Nasdaq Stockholm (Volvo Group 2015a).

Sustainability and energy efficiency at Volvo Group

The Volvo Group's vision is to become the world leader in sustainable transport solutions by: creating value for customers in selected segments, pioneering products and services for the transport and infrastructure industries, and driving quality, safety and environmental care working with energy, passion and respect for the individual (Volvo Group 2015a).

The company is divided into several business areas, where group truck operations account for almost two-thirds of the Group's total turnover (Volvo Group 2015b):

- **Volvo Group Trucks** – all sales and marketing in Volvo Group Trucks Sales, all production is grouped separately in Volvo Groups Trucks Operations, all product development is gathered together in Volvo Group Trucks Technology
- **Construction Equipment CE-** Manufactures a number of different types of equipment for construction applications and related industries.
- **Buses** - City and intercity buses, coaches and chassis.
- **Volvo Penta** - Market leader in marine and industrial engines
- **Governmental Sales** - Sales to government agencies and organizations.
- **Volvo Financial Services-** Delivers competitive financial solutions to Volvo Group customers.

The Volvo Group is taking a strong value chain approach:

“As one of the world's leading manufacturers of heavy commercial vehicles, the Volvo Group bears a responsibility for responsibly managing sustainability throughout our value chain. The Volvo Group takes a full value chain approach to sustainability, extending our influence beyond the immediate scope of our own operations to drive economic, environmental and social sustainability through our supply chain, distribution and service networks, customer base and commercial partnerships. Close collaboration with our key stakeholders strengthens our company and value chain, helping us to achieve our vision of becoming the world leader in sustainable transport solutions.” (Volvo Group Sustainability Report 2014).

Volvo Group product development and LCAs

According to the sustainability report 2014 (Volvo Group Sustainability Report 2014), the Volvo Groups “future success” of becoming the world leader in sustainable transport solutions depends on the ability to deliver innovative and financial viable products and service. In 2014 the Volvo Group operated from a “strong product portfolio” following the groups’ most extensive product renewal during 2013. According to the sustainability report 2014 the Volvo Groups product development is driven by the cost and availability of fuel, environmental legislation and new technologies. The long-term research and development that improve the sustainability on products has led to investments in CO₂ and energy efficiency among others. The Volvo Groups product development focus lies on energy and resource efficiency as well as conducting whole life cycle assessments (LCAs):

“Focusing our product development on using resources and energy more efficiently simultaneously reduces the overall environmental footprint of our products while supporting our costumers’ profitability.” ... “We conduct whole life cycle assessments (LCAs) for our products, taking into account all environmental impacts from the production and use of raw materials, energy and water consumption and the creation of waste, as well as emissions to air and water.” (Volvo Group Sustainability Report 2014).

According to the sustainability report 2014 (Volvo Group sustainability report 2014), the environmental impact is calculated according to the EPS 2000 (Environmental Priority Strategies in product development) method based on willingness to pay. The Volvo Groups LCAs demonstrate that more than 90% of a products environmental impact results from its use. One example is the environmental impact of a Renault Truck, as illustrated in figure 8: where impact is divided into production (+49%), fuel consumption (+59%), emissions (+28%), maintenance (+7%), and recycling (- 43%).

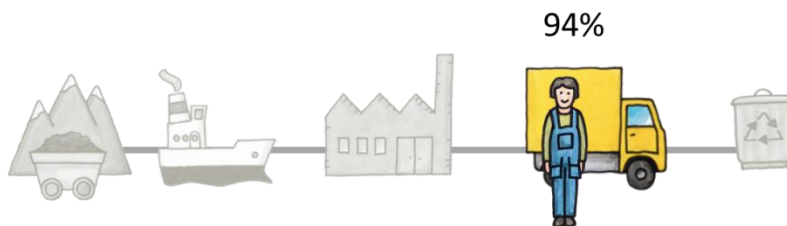


Figure 8. In the Volvo Group, the largest share (about 94%) of the products’ environmental impact is associated with the use phase.

Means to increase energy efficiency - environmental footprint, energy programs and targets

The Volvo Group has 66 production sites in 19 countries around the world. In 2014, the Group delivered 203,100 trucks 8,800 busses, 61,300 units of construction equipment, 17,400 marine equipment, and 15,300 engines for industrial applications. The Volvo group has reported detailed environmental data and related KPIs (key performance indicators) since 1991. The latest values in 2014 are absolute values and related to net sales for Volvo production plants in industrial operations (Volvo Group Sustainability Report 2014):

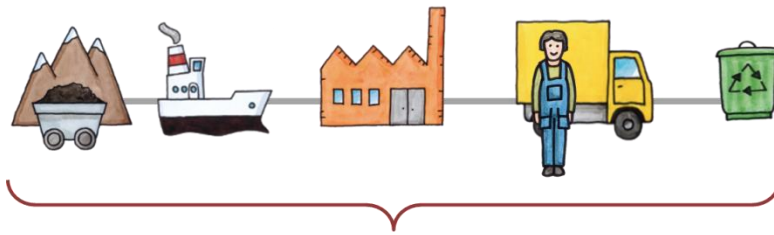
- Energy consumption 2,176 GWh (7.9 MWh/SEK M) reduced from 2,536 GWh in 2013
- CO₂ emissions 231,000 tons (0.8 tons/SEK M) reduce from 280,000 tons in 2013

The Volvo Group has reached the reduced energy consumption in large parts due to an *energy reduction program* in truck manufacturing. The operations in different countries like in Brazil, USA and Sweden have reduced their energy and CO₂ emissions. An example from Sweden is the transmission factory in Köping, where geothermal cooling reduced electricity and heating by 5,000 MWh per year. Overall, the truck manufacturing plants in Sweden reduced energy by 38,000 MWh (Volvo Group Sustainability Report 2014).



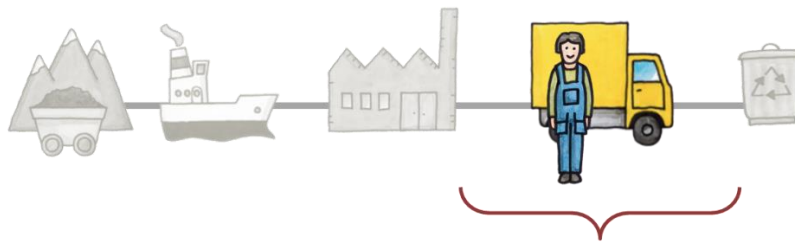
Figure 9. Examples of results from Volvo Group energy reduction program in plants in Brazil, USA, and Sweden.

In parallel to energy reductions on site level, Volvo Group has also targeted CO₂ emissions over the lifetime of their products. A part of this work has been a commitment to the *WWF Climate savers program during 2009-2014*. During the 2009-2014 program, one objective was a 30M ton reduction in CO₂ emissions over the total lifetime of the truck, construction equipment and busses manufactured between 2009 and 2014, compared to the baseline year 2008. Already in 2013, the emissions were reduced by 40Mton achieved through improved fuel efficiency as Volvo Group launched three prototype demonstrators with improved fuel efficiency by 20% (Volvo Group Sustainability Report 2014), see figure 11.



Objective 2014: - 30 Mton CO₂

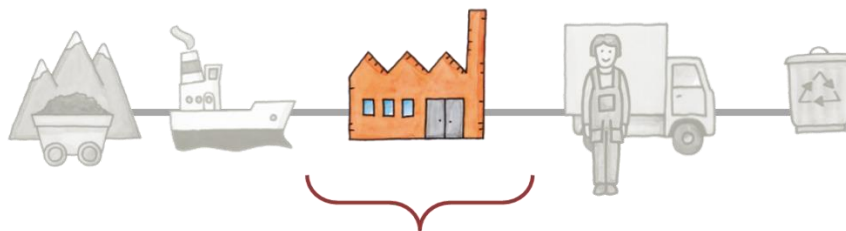
Figure 10. Volvo Groups recent WWF Climate Saver commitment 2009-2014 is to reduce emissions over total lifetime with 30M ton CO₂, compared to 2008.



Result 2013: - 40 Mton CO₂

Figure 11. Already in 2013 Volvo Group achieved 40M ton CO₂ reduction in the product development due to improved fuel efficiency by 20%.

Volvo Group has continued to work with WWF. One part of the new WWF Climate savers 2015-2020 commitment is to improve energy efficiency in production by identifying and executing energy saving activities, leading to a reduction of energy with 150 GWh by 2020, which means 8% energy savings in production sites compared to baseline in year 2013, as illustrated in figure 12 (Volvo Group Sustainability Report 2014).



Objective 2020: 8% energy savings

Figure 12. One part of Volvo Groups new WWF Climate Saver commitment 2015-2020 is to achieve energy savings of 150GWh in production, which is 8% less than in 2013.

In 2014, the CO₂ emissions from the Volvo Groups production facilities decreased from 279,900 tons to 230,700 tons due to reduced energy use and renewable energy. About 800 GWh, or almost 37% of the total energy consumption were

renewable including hydropower and biomass heating. This includes that the Volvo Group has *carbon neutral facilities* at several plants (see figure 13). The first plant was a Volvo Trucks plant in Ghent 2007, in Belgium. The other plants are Swedish plants: Volvo Trucks plant in Tuve 2011, Volvo Penta plant in Vara 2011, and a Volvo Construction Equipment plant in Braås 2013 in Sweden. The long term ambition is to make all production facilities carbon neutral. Energy is used from renewable sources such as solar, hydro, wind and biomass. Under the WWF Climate savers 2015-2020 program, a study of sites in Asia for switching to renewable energy use will be made, including discussions with government about regulations and the availability of renewable energy. These discussions are called “magnifier” in the WWF climate savers program to push the development of more renewable energy. The program will also take up problems and possibilities in renewable energy investments.

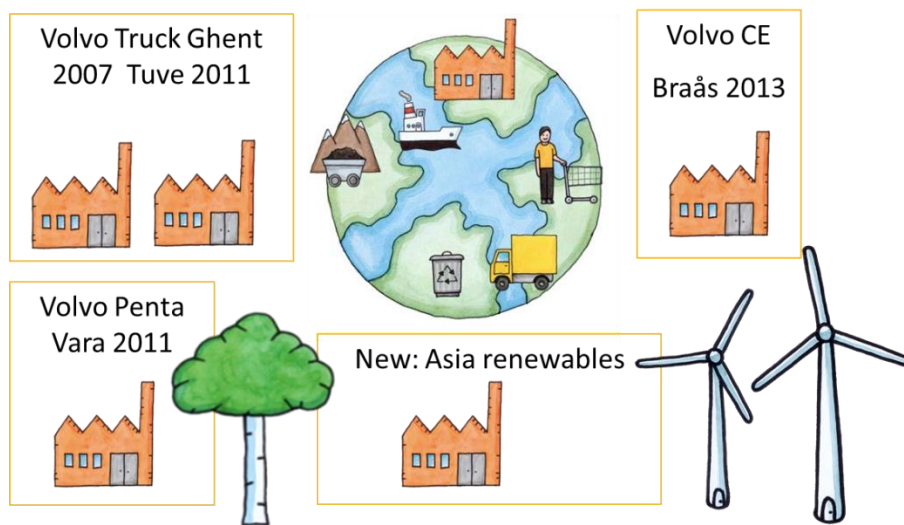


Figure 13. Volvo Groups Carbon neutral production sites can be found in Volvo Trucks, Penta and Construction equipment.

Apart from energy savings and renewable energy, the Volvo Group is also aiming to *reduce downstream environmental impacts*. The company is teaching in eco-driving, which means 5-10% fuel reduction and societal life gain from CO₂ reduction by 10,000 EURO calculated from EPS200.

Further, the Volvo group is *supporting circular economy*. The remanufacturing business increased by 18% with 7 manufacturing centers worldwide: Sweden, France, Japan, Brazil US, Shanghai, and China (compared to 2% in 2013). A re-manufactured engine saves up to 80% production energy compared to the production energy of a new engine. A truck is largely recyclable, since almost 85% of its weight consists of metal.

Selection of case studies

The purpose of the case studies is to illustrate the interaction between strategies/organization and concrete effects on energy and the environment. The case studies provide examples of actions, barriers and enablers regarding energy efficiency in the value chain. Selection of the case studies was based on a screening interview with the environmental manager at Volvo Group Real Estate Services (Bengtsson, 5 Maj 2015). There are a number of initiatives and goals that are related to energy efficiency in the value chain within the Volvo Group. There is for example the Volvo Group challenge of 50 % energy reduction between 2003 and 2009, and Volvo Real Estate goal of 25% improvement of energy performance of new buildings compared to national legislation introduced in 2013. There are also production site and building related initiatives like energy efficiency measures, CO₂ neutral sites, and installation of energy monitoring equipment.. In the following, two cases of energy efficiency, one at Volvo Construction Equipment and one at Volvo Real Estate Service within the Volvo Group have been chosen:

1. *Energy efficiency at production – idle electricity reduction per plant.*
2. *Energy efficiency at building - goal to develop new buildings to use 25% less total energy compared to the national building legislation.*

The screening interview was then complemented with in depth interviews with a project leader at Volvo Group Trucks Technology (9 September 2015), a technical specialist at Volvo Group Real Estate Services (20 august 2015) and the environmental manager at Volvo Group Real Estate Services (27 august 2015), as well as company webpages, sustainability reports and internal documents.

Energy efficiency at production – Idle electricity reduction

The Volvo Group is owning and managing a large number of buildings on a global level, both office buildings and production facilities. In this case we looked at a production-related energy project at Volvo Construction Equipment (Volvo CE), starting up with idle electricity reduction, but also including actions like CO₂ neutral sites and installation of energy monitoring equipment.

Volvo CE get started with a global energy project

In line with the overall energy efficiency ambitions of Volvo Group, such as the group challenge of energy reduction and the WWF Climate Savers Program, Volvo Construction Equipment started at the beginning of 2014 a global energy efficiency project among production plants (Sjögren 2015). The project was initiated within the environmental organization of Volvo CE. A global project team was set up including representatives from each of the participating production plants.

The rationale to start the project was energy and cost reduction and to prioritize areas where the largest waste of energy was identified. The project concerned total energy consumption and costs for Volvo CE, and the contribution of each individual plant, with a focus on plants with the largest electricity consumption (together representing 90% of the electricity use).

The energy project started to focus on electricity, since it was the largest energy use and the largest cost. The first goal for the project was “idle electricity reduction”. It was considered as a relatively “easy” thing to start with. Results were expected without any larger investments, but with behavioral measures like turning down the lights and shutting down equipment when not in use. Thus, the overall strategy of the energy project became to start with idle electricity during 2014-2015, continue with production energy during 2016-2018, and to finish with CO₂ neutrality.

A new KPI (key performance indicator) was chosen for this work, defined as relative idle electricity in % (i.e. idle electricity in kWh during 10 h idle divided by production electricity in kWh during 10h of production). The target for relative idle electricity was set based on one of the best performing plants at the time, and based on their performance, “a reasonable but possible level” was chosen. Thereafter the target was set to reduce relative idle electricity to less than 15% in all plants.

Progress of the project was followed up monthly. Energy and cost for each plant was calculated and specified in a “Cost breakdown” where the relative idle status, weekly consumption, potential savings and potential implemented was presented in an A3 for each plant, and reported to the Volvo Construction Equipment globally.

Previous experience from e.g. the Volvo Group “energy challenge” 2003-2009 indicated that energy issues many times had been interpreted as an “environmental activity” in the organization, and thus as being a responsibility for the environmental managers. In addition, the energy challenge had not been a binding target and thus not considered compulsory to react upon. To realize effects in production, energy efficient measures had to be integrated at the plants. This was not always an easy task as energy efficiency is one of many, sometimes conflicting goals, along with financial ones for example. Thus progress had mainly been made when energy efficiency and (short term) profitability had gone hand in hand.

For the energy project in the studied case, representatives of each participating plant were appointed to run the work locally. An important part of the project was to involve the operators on site to find ways to improve energy efficiency, both technical and behavioral, for example by together identifying and implementing new routines for turning down machines and lightning. In this process, the project representative monitored results and continuously acted to coach the operators. In some cases so called “night walks” or “treasure hunts” were arranged, where the project representative for the plant, together with e.g. the plant manager walked around the plant at the end of the day or during weekends to identify energy saving potentials at times of no production.

Barriers and enablers

When it comes to barriers and enablers for the global energy project, one first reflection is on the measurement of status and progress. Volvo has a culture of measuring and using KPI in management: The project members measured the electricity during idle and during production. Progress of the project was also decided on to be reported through KPI every month. There were sufficient data on a global level. However, there was in some cases a need of additional measuring equipment to get more detailed data on local level in order to visualize effects.

Important enablers for the entire project have been the support and commitment all the way from Volvo CE globally to plant managers on site. The organizational setting of having a global project, not only a local national one, contributed to rise the importance of the project, as well as the continuous reporting and follow up to Volvo CE management.

The different plants involved in the project showed divergent results, partly due to the possibility to find time for continuous engagement in the project at each site. Contextual aspects such as current work load, change of personnel and reorganizations had a strong impact. The existence of personnel with environmental knowledge that could add and relate environmental arguments, to other type or argumentations used at the plant, such as budget arguments, was also identified as supporting progress.

An important aspect for success, recognized by the project leader, was *behavioral change* among the plant operators, e.g. in terms of turning down machines and lightning when not in use. Behavioral changes take time and people to encourage and motivate the operators, a time that do not always exist. Energy efficiency is part of the responsibility for the sites, along with many other tasks such as health issues and handling of chemicals etc. It is also not always evident for the operational level how headquarter strategies of energy efficiency translate to operational work in production.

Practices identified as enablers for behavioral change included the set-up of the project to start with a relatively “easy” task like idle electricity that also engaged everybody from operational personnel to plant managers. The global project leader’s coaching of the team members was also essential. The project leader used many means to coach and pay attention to the work of the team members, such as encouraging talks, spread of good examples, and make sure results were asked for in the organization, for example through weekly contact with the team members and the A3 format for weekly and monthly follow ups. Informal competitions between plants or among work stations, spurred by e.g. the weekly comparisons, or the earth hour to shut down all equipment, had a positive effect as well.

Another example on how to gain commitment from plant managers and production operators was found in relation to the “treasure hunts”, where the active participation of plant managers and sometimes also the environmental manager of Volvo Real Estate helped in gaining and demonstrating priority for the issue. Pictures from these walks were also published on the intranet and in internal newspapers to further shed light on the activity.

For the *technical improvements*, investments were sometimes made to get more energy efficient machines and lightning, or in new monitoring equipment to make follow ups easier. Even in these cases, the project leader recognized that the personnel needed time to evaluate the measurement results.

In all, personal engagement of the project team, as well as the systematic work and follow up, was enablers during the project and made the energy project a success so far. Idle electricity formed the start of the energy project, characterized by small technological investments and mainly behavioural changes at plant level. The next

steps in the energy project, production energy and CO₂ neutrality, are more investment related. In these steps, the WWF climate savers program (2009-2014, new 2015-2020) with its commitment for energy in form of reduced GWh, might further support and motivate investment decisions in this project.

Effects on energy and resources

From the start in 2014, the plants had up to 40% relative idle electricity and the goal was to reach 15% at the end of 2015. The relative idle electricity is defined as idle electricity (kWh during 10 h) per production electricity (kWh during 10 h production). The target to reduce “idle electricity” for all plants to less than 15% between 2014 and 2015 was based on one plant that was quite good at reducing their idle electricity, and that it would be also possible for the other plants to reach.

At the end of 2013, before the global energy project started, six factories together had a potential of reducing energy use with approximately 16,800 MWh / year if they reduced their idling consumption on the weekends, from Friday afternoon to Monday morning (58h) to 15% of consumption during production.

The project is still under way and actual savings will be followed-up at the end of the year. However, major improvements have been made to approach the target. Result so far for the studied energy project, shows that that two plants already have exceeded the goal to reach 15%, and even got down under 10 % (spurred by each other to do even better than plan).

Implications for competitiveness

Energy efficiency has been one of Volvo Groups interest for some years. Internally, the energy efficiency project (so far the idle electricity reduction) seems to be perceived more of interest for Volvo CE as a company and the competitive advantage of individual plants, and less so for increasing the competitive advantage of specific products. Other advantages are possibly the contribution to Volvo Groups Environmental profile and contribution to the fulfillment of the WWF program.

Energy efficiency at building - demand of 25% energy reduction on new buildings

The Volvo Group owns and manages a large number of buildings on a global level, for both office and production. In this case we looked specifically at Volvo Group Real Estate Services and a target they introduced in 2013 to have 25% less energy use in new buildings compared to legal standard in each country of operation (illustrated in figure 14).

- 25% energy use

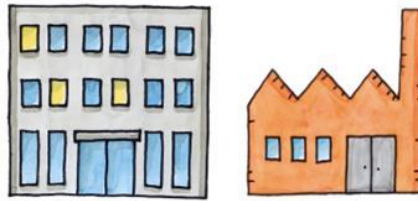


Figure 14. Volvo Real Estate has a goal that all new buildings shall use 25% less energy than legal standard in each country.

Volvo Group Real Estate Services

Volvo Group Real Estate Services is the Group's property management unit and it focuses on optimizing the value of the Volvo Group's real estate and on contributing to the company's growth. Its operations include both property management and workplace service (Volvo Group Real Estate 2015b). The mission of Volvo Group Real Estate Services is to provide commercial properties, optimize synergies and a high degree of standardization regarding all real estate and facility management services within the Volvo Group, on market terms (Volvo Group Real Estate 2015a)

Volvo Real Estate Services is a group function and part of the Volvo Group with around 500 employees across the globe. The headquarters is situated in Gothenburg, Sweden. The company was established in 2007 when the Volvo Group decided to collect the responsibility for ownership and lease agreements of their estates, offices as well as production sites, in one part of the organization. The main aim of this centralized practice was to have better control over the real estate portfolio throughout the group (Volvo Group Real Estate 2015b, Bengtsson 2015)

The Volvo Group has an environmental committee responsible for driving the environmental strategy on a global level. Besides the central environmental committee, and the environmental directors for each business areas and managers for business functions, there are persons with environmental/energy responsibilities under quality management on each production sites. The environmental manager from Volvo Real Estate is for example driving the questions of energy standards for new buildings, such as the 25% reduced energy goal for all new buildings at the Volvo Group.

Since 1991 the Volvo group has reported detailed environmental data (among others energy consumption and CO₂ emissions). Data is collected and available for each of the Volvo Groups production sites, and summarized in an environmental or sustainability report each year (Bengtsson 2015)

The responsibility for production related energy lies at the site manager while responsibility for building related energy lies at the Volvo Real Estate. While responsibility is split, the sites often do not have split energy measurement equipment. Responsibility for budget and investment in general lies at the production site or the business areas it belongs to.

New office

When Volvo Group Real Estate Services built a new office, they decided to make a building that were highly energy efficient, and allowed the testing of alternative technologies. The building was finalized in 2009, with particularly well insulated windows with automatic opening function, special ventilation solutions and sensor-regulated lighting among the solutions. Heat pumps were installed for heating and cooling of the estate (Bengtsson 2015, Volvo Global Magazine Nr 1, 2011)

The new office was a success when it comes to implementing new technologies and reduced energy consumption, reported both internally in the Volvo Global magazine (Volvo Global Magazine, 2011) and externally in the Swedish Radio P4 (2011). One of the reasons for the success of the office building was, according to Bengtsson (2015), the small Real Estate organization responsible for both owning and management of buildings. The project was initiated in the line-organization, where also the investment decisions were made. The goal was to reach a 50% reduced energy demand compared to Swedish building sector in average (with reference to Swedish average of 202 kWh/m² and EU Green Building Program for new buildings with 75 kWh/m², Volvo Real Estate 2015).

Barriers and enablers for the new office

In order to reach the goal “50% lower energy demand compared to normal office buildings”, and implement new energy efficient technologies in the office building, a number of barriers and enablers affected the final outcome. Some of the challenges included to identify energy efficient technologies for office buildings, involve the plant manager and project manager for internal support, handle investment decisions about different parts (to integrate the energy efficient technologies into the building process), follow up the energy consumption and the office user satisfaction, and communicate results internally and externally.

During the set up and planning of the new office there was reasoning in the team that they wanted to take the opportunity to try some “new solutions” now when they built something new and had the chance. They aimed at half of the average values in Sweden. During that time there was no explicit strategy or examples for how to reduce energy in buildings at the corporation. However, the building had some importance since the office building would serve for the central functions of the Volvo corporation (Bengtsson 2015).

It was probably rather different project decisions that led to the results in energy efficiency terms, than an expressed corporate strategy. The project management took investment decisions on each measure; some things were approved and others not. LED, for example, was only installed in the staircase, as it was both an expensive and fairly immature technology at the time. Other investment decisions that were approved included, for example, especially well insulated windows, natural ventilation, thermal pumps and temperature control system (Bengtsson 2015, Volvo Global Magazine, 2011). In most cases the resulted solution worked very well. However, some measures, such as an automatic opening function of windows, were less easy to accept by some tenants.

In all, the construction costs for the office became about 5% higher than a traditional building on the same type, a cost that was paid back in less than a year due to the lower energy use in operation (Volvo Global Magazine, 2011).

Effects on energy and resources – new office

In order to reach the goal of 50% lower energy demand compared to Swedish average values, a number of energy efficient technologies were implemented in the above described office. As a result, energy consumption for the office building in 2010 was 65 kWh/m² which is less than half of the compared Swedish average of 202 kWh/m², and less than EU Green Building Programme of 75kWh/m² (Volvo Real Estate 2015). With a total area of the office building of about 7 000 m² (Weber, 2015), this means 945 MWh less energy ((7 000 * 200) – (7 000 * 65) = 945) compared to a traditional building of the same type.

Implications for competitiveness

Environmental care is a core value for Volvo Group and the ambition to have high energy efficiency in buildings is in line with this value, rather than a means of gaining direct market advantages for Volvo Group products. In terms of media attention, it was less news value of implementing a range of existing energy efficient technologies in the case of the office, compared to for example presenting the world's first carbon dioxide neutral automotive factory in Gent in 2007 (see Volvo Group Global 2014).

The energy efficiency work for the office building has yet got attention internally and to some extent externally. The success of the project was used in different occasions like in the Volvo newspaper as well as power point presentations with the message: “If we are building a new house why don't try some new energy efficient technology”, and “50% lower energy demand compared to normal office buildings”. The success was even communicated outside in radio P4.

New demand of 25% energy reduction for new buildings

In 2013, Volvo Group Real Estate Services decided to introduce a goal to develop all new buildings and major renovations to use 25% less total energy than national targets. At the time, environmental certification systems on buildings like BREEAM and LEED were discussed in the Swedish building sector more generally. Volvo Real Estate decided not to place specific demands on following such particular standards; this could be a voluntary choice in each situation. Yet it was decided to use categories that were also of importance in these standards, such as energy performance and chemicals. These were both areas that Volvo Group traditionally had been working with, and that could be directly linked to environmental gains.

Further implementation of the energy goal has been communicated to the whole RE organization but also to other organizations within the Volvo Group. Currently, Volvo Real Estate also supports project managers in implementation, and runs RE internal training with focus on the building standard.

Barriers and enablers in implementing demand of 25%

There were many aspects needed to be taken into account when formulating the building standard in general and the 25% energy target in particular. Volvo Real Estate operates globally and the target had to be defined to be applicable in all countries and types of buildings. There are different local climates, as well as local practices and standards. Therefore, national legislative demands were used as baseline, and the target was set relative to national legislation. In this way, the same target is valid for the whole Volvo Group (Heikkilä, 2015).

It is not only the countries and the buildings that are complex. Also the building development is a complex process, and it can take a long time. During that process, constant revisions and adaptations to function and budget are made. Volvo Real Estate is responsible for the entire building process from planning to construction and can assist in discussions with clients. Yet final decisions of how the building is constructed are made by the project management in each case. The role of Volvo Real Estate is to set requirements on specific projects, and to inform about the advantage of having better energy performance than legal when applicable. Thus better energy performance is more seen as an ambition than a hard target.

It is common in the building industry that construction and maintenance are performed by different actors, with different budgets. Within Volvo Group, investments in new buildings are often the role and responsibility of each production site, with their specific budgets, while Volvo Real Estate is responsible for continuous management of the building once up and running. To reduce the risk of sub-optimizations between initial investments and long term maintenance Volvo Real Estate recommends using an energy calculation to identify different cost effective energy measures leading to better energy performance in the long run (Heikkilä, 2015).

Effects on energy and resources – 25% demand

The new demand on energy reduction for new buildings was introduced in 2013, and since new buildings takes years to construct and are evaluated first after 2 years in operation the real effects on energy and resources effectiveness is yet to be evaluated.

Although the energy target is in place and valid for the entire Volvo Group, this is not to say that all Volvo Group buildings uses 25% less energy than national standard. The building standard relates only to new buildings, and the number of new builds is quite small compared to existing building stock. (In the building sector typically no more than 10 %.)

Implications for competitiveness – 25% demand

The new demand on energy reduction for new buildings has little effect on the overall company energy result, since new buildings are a small share within Volvo Group.

ABB group

ABB provides power and automation technologies to utility, industry, and transport and infrastructure customers. The ABB Group of companies operates in roughly 100 countries and employs about 140,000 people (ABB, 2015).

ABB's operations are currently organized into five global divisions:

- Power Products
- Power Systems
- Discrete Automation and Motion
- Low Voltage Products
- Process Automation

These are in turn are made up of specific business units focused on particular industries and product categories.

From January 2016, the Power Products and the Power Systems divisions will be combined into a new Power Grids Division (Nordström, 2015).

ABB sustainability objectives

In the end of 2013, the Executive Committee endorsed a new sustainability strategy, including nine sustainability objectives that apply to the whole ABB Group and impact all areas of the value chain (ABB 2015b). The new sustainability objectives, aiming for 2020, were the result of a thorough review of existing programs and challenges, and extensive stakeholder consultation both inside the company and externally. During this process, it was concluded that the five sustainability focus areas that originally were selected for 2013 had evolved and that the new objectives should cover a broader range of material issues. These conclusions were then discussed and refined with senior business, region, country and function heads within ABB (ABB, 2015a).

The value chain perspective was found to be vital, in strategy, in human resources and for overall commitment, and the new sustainability strategy takes sustainability as an integral part of the overall strategy, not a matter for campaigns (Swanström, 2015).

Individual sustainability targets and key performance indicators are being developed and rolled out in the company, and progress will be reported in the annual Group Sustainability Performance Report (ABB, 2014a). Many different levels and dimensions are addressed by these targets: divisions, business units, local business units and the sustainability organization (Swanström, 2015). For efficiency reasons, sustainability objectives have traditionally been communicated through the country organization, not through the business organization, since sustainability policy is most often country specific. However, most of the resources are found in the business organization. From about a year ago (autumn 2014), division HSE¹ managers are in place to help facilitate the implementation of

¹ Health, safety, environment

sustainability measures. The degree of organizational complexity has, as a consequence, increased, but the commitment from the business organization is very important. The country organization is currently still the most important for sustainability matters (Nordström, 2015).

ABB sustainability objectives related to energy efficiency

Two of the sustainability objectives are related to energy efficiency, on the one hand energy efficient *products and services*, and on the other energy efficient *production* (ABB, 2015b):

- Power and productivity for a better world: ABB is a world leading supplier of innovative, safe and resource efficient products, systems and services that help customers increase productivity while lowering environmental impact
- Energy efficiency and climate change: ABB is an industry leader in energy efficiency, use of low-carbon fuels and renewable energy. We cut greenhouse gas emissions. ABB to reduce its energy use by 20% by 2020.

ABB addresses the first objective e.g. by working closely with customers to increase their productivity and energy efficiency (e.g. software in steel production and algorithms for automation and control of ventilation in mines). Customer projects like these have seldom targets and/or follow-up on increased energy efficiency, but they are sometimes used for communication (Swanström, 2015). Systematic interaction with suppliers from an energy efficiency perspective is less well developed; the two internal sustainability programs focusing on suppliers are about environmental aspects (audits on major suppliers to address provisions in ISO14001) and sustainability in the supply chain (risk assessment from social and labor law perspectives) (Nordström, 2015).

The 20% reduction target was set in 2013 as a development of the previous one, stipulating 5% reduction per two-year period, which had been well-established and accepted since long. The aggregation to a more challenging, yet realistic, and long-term target was considered in line with ongoing efforts and easier to communicate (Nordström, 2015).

The two objectives above seem independent and equally prioritized, and none of them are conditioned by the other, i.e. overall energy efficiency from a value chain perspective cannot be taken for granted. However, as we will see, considerations take place and instruments are used with the intention to prevent sub-optimizations.

The objective on energy use reduction is to be compatible with a reduction in greenhouse gas emissions, i.e. measures for either of the two components in the objective must not be detrimental to the other. This is stated in the ABB Sustainability Performance Report 2014 (ABB, 2015b):

“As well as working to improve the efficiency of our energy consumption, ABB also seeks to reduce the carbon intensity of our energy sources.”

Hence, there is no separate target for greenhouse gas emissions, but an ongoing discussion about whether it would be reasonable to introduce a target of 20% reduction. The reason for not having a target for greenhouse gas emissions is that

the figures on emissions from own fleet are based on estimations, and that monitoring and follow-up of such figures includes large uncertainties.

Selection of case studies

The two sustainability objectives related to energy efficiency above were used as the basis for the selection of the following short case studies:

1. Group objective on energy efficiency in production
2. From selling energy efficient motors to selling energy services

A screening interview, where the two cases were identified, was carried out with Lennart Swanström, Senior Principal Scientist, ABB AB (telephone interview 27 May 2015). The two cases were investigated during an interview with Anders Nordström, Group Head of Environment, ABB (telephone interview 11 September 2015) and Tommaso Auletta, Global Energy Solutions Manager and Energy Efficiency Manager, ABB (face to face interview 8 September 2015). These interviews have been complemented with company information from e.g. sustainability report and websites.

Group objective on energy efficiency in production

In the sustainability strategy, endorsed by the Executive Committee in the end of 2013, ABB has committed to reducing energy intensity by 20% *per dollar of revenues in its own operations* by 2020 from a 2013 baseline. This target includes both direct fuel consumption and the use of electricity and district heating for manufacturing processes and to operate buildings. More than 200 energy efficiency projects were under way at ABB facilities during 2014 to address this objective, which resulted in reduced energy intensity by 1.6 %, equivalent to 34.4 GWh of energy savings (ABB, 2015b). However, a yearly reduction by 1,6% will not be enough to reach the 20% target unless revenues increase significantly.

Energy efficiency efforts and measures are “owned” by the production sites – they have to assume the costs. The group environmental organization can support and “nag” but does not interfere in the implementation details. The best results are obtained when business management ask for results and participate also in the “nagging” (Nordström, 2015).

The energy intensity was 66 MWh per million US dollar sales. In absolute values, the total energy use decreased by 6% between 2013 and 2014, as well as the energy use per energy carrier (fuels, electricity and district heating) (ABB, 2015b). Approximately one third of the absolute reduction in energy use was due to business divestments, which influenced mainly electricity and gas consumption. Most common and cost effective measures included energy-efficient lighting solutions, but also optimizing heating, ventilation and cooling processes, investments in more efficient equipment, investigating and optimizing compressed air systems, behavioral change programs, and implementing or updating heat recovery from machines and processes (ABB, 2015b).

The production of ABB is generally considered as low energy intense manufacturing, with the exception of the production of transformers which represents the most energy intensive business area of the group (Nordström 2015).

To implement the objective on energy efficiency in own operations, the most energy-intensive sites have been required to undertake energy audits and all sites have been required to develop an energy saving program (ABB, 2015b). ABB has introduced a green building policy allowing for longer pay-back periods for energy efficiency investments to encourage production sites and business units contribute to the group sustainability objective on energy efficiency

In ABB, the real estate function is a key player in the efforts to reduce energy use in own operations – it has resources and capacity, but it is also subject to profit requirements. The real estate function in Germany, considered as an internal “frontrunner”, is developing a concept for the implementation of ISO 50001² to comply with the Energy efficiency directive (EU, 2012) which, in Germany, requires an energy management, such as ISO’s, at production sites of a certain size. However, profound insights in production engineering are also essential when improving energy performance in production and processing equipment and/or utilities. The current sustainability manager of the transformer business area worked earlier within operations of excellence, which makes the identification of measures that are both sustainable and profitable easier (Nordström, 2015).

Below, the transformer production plant in Ludvika in Sweden is used as a case for the energy calculations. However, the description of drivers, barriers and enablers are examples that apply to operations’ energy efficiency measures in ABB in general, based on Nordström (2015).

Description

As mentioned above, the most energy-intensive sites have been required to undertake energy audits to identify possible energy savings that would help implementing the objective on energy efficiency in own operations. The site in Ludvika, which is one of the top five energy intensive facilities with more than 2,800 employees on-site, carried out such an energy audit in 2013 and developed a multi-year program of measures that will continue into 2015. Thanks to a cross-functional coordination between real estate, environment and production engineering, functions that already have been mentioned as vital for energy efficiency improvements in ABB; a step-by-step improvement plan was adopted. Upgrading lighting systems, repairs and upgrades in the compressed air systems, installation of energy metering, introducing timers on drying ovens and significant training for employees have been implemented, and in 2015, the installation of heat recovery in the painting area, additional energy metering and further lighting upgrades were expected to increase savings even more. (ABB, 2015b; Nordström, 2015).

Drivers

In ABB, the environmental management system objectives addresses some of the non-deniable realities facing industry e.g. climate change and lack of resources. As mentioned above, two of them are related to energy efficiency, driving ABB to

² ISO 50001 :2011 Energy management systems -- Requirements with guidance for use

increase energy efficiency performance, both from a production and a products'/services' perspective (ABB, 2015b; Nordström, 2015).

Customers' energy efficiency targets and the role of ABB on the market are other drivers mentioned by an ABB official. Customers want to increase energy efficiency, and in order to gain own experience for better understanding and communication, ABB has to "practice what you preach". This aspect is also relevant for the relation to investors, whose growing interest for sustainability and ranking systems is increasing (Nordström, 2015).

Barriers

Barriers to increased energy efficiency in own operations include the competition in space for investments, which necessitates some kind of ranking, most likely according to pay-back period (Nordström, 2015). In a situation where a production site has to choose between investments in increased production capacity or marketing programs that both increase revenues, energy efficiency measures, that "only" reduce costs, are less easily defended.

The group sustainability objectives on energy efficiency are perceived as more or less relevant for different parts of the group, which sometimes is manifested in a slight reluctance to apply energy efficiency measures; in the trade-off between different efforts, on-site energy efficiency measures are less prioritized (Nordström, 2015). The logic behind this attitude reflects insights in energy use from a value chain perspective: to put effort in reducing energy use in an ABB office selling components for European wind power mills replacing coal fired power plants risks simply turn out as being counterproductive if these efforts reduce the office's selling capacity, at least from a life cycle GHG emissions perspective. Hence, organizational and national energy efficiency targets can compromise energy efficiency in a value chain perspective because of system boundaries that are too narrow.

Enablers

Commitment from the business organization, often providing additional motives for investments and/or measures alongside energy efficiency targets, such as increased productivity, increased quality and/or shift in technology, was a main contributor to the necessary investments and successful energy efficiency program in Ludvika (see above) (Nordström, 2015).

Another major enabler described was the cross-functional coordination, engaging people with profound know-how in production, real estate and sustainability. Thanks to this cooperation, a well-balanced step-by-step improvement plan was adopted and implemented.

Longer pay-back periods for energy efficiency investments have been introduced as part of ABB's 'green building policy to encourage production sites and business units contribute to the group sustainability objective on energy efficiency (Nordström, 2015).

Effects on energy and resources - in theory

When applied to the facility in Ludvika specifically and (using a conservative approach) assuming constant sales, the target on 20% less energy use per million dollar sales would correspond to a reduction in energy use from about 72,000 MWh electricity, 7,100 MWh fuel and 7,700 MWh district heating 2013 to 58,000 MWh, 5,700 MWh and 6,200 MWh in 2020 respectively. The corresponding reduction in GHG emissions is about 1,052 ton CO₂eq, based on emission factors from Gode *et al* (2011).

Effects on energy and resources - in practice

Already implemented parts of the energy efficiency program in Ludvika described above resulted in a reduction in use of electricity by 1,287 MWh, not including upgrade in lighting system (no data provided), corresponding to about 1.8% reduction (fuel and district heating were not affected). This corresponds to a reduction in GHG emissions of 47 ton CO₂eq, based on emission factor from Gode *et al* (2011). The payback period for different measures varied between 5 months and 7 years.

Implications for competitiveness

As the operations' energy efficiency objective is reduced energy use per sales volume, energy efficiency is tied to maintained competitiveness - energy efficiency measures are not allowed to affect sales negatively. Hence, costs for efficiency measures cannot be compensated for by radically higher prices.

It is difficult to quantify the non-tangible effects from energy efficiency measures on goodwill, but there are competitive gains from enhanced company image such as being perceived as a sustainable, innovative and responsive company that "practices what it preaches" (Nordström, 2015).

From selling energy efficient motors to selling energy services

The objective "products and services for a better world" targets 20% revenue increase from energy efficiency-related products, systems and services by 2020 from a 2013 baseline. In 2014, 51% of ABB revenues were related to energy efficiency and renewable energy, which was the same level as in 2013. The global savings in electricity from using ABB drives were assessed to 445 TWh. Innovations released in 2014; updated Health, Safety and Environment checklists and guidelines for Research and Development were expected to contribute to increased revenue from energy efficiency and renewable sales (ABB 2015b):

"In the coming year, we will work to expand the scope of this portfolio, further formalizing processes and definitions for the methodology, and investigating ways to assess the portfolio's contribution to the environment, the economy and society."

As a supplier of energy transforming equipment and electricity using machines, energy efficiency has always been a guiding principle in ABB's activities. In order

to support a full range of products and services, ABB's energy efficiency services started off in 2011, when the former CEO initiated the group Energy Efficiency within the After sales service unit, independent from the divisions organization. Tommaso Auletta was recruited as manager of the group of initially four consultants, based in Sweden but cooperating with energy specialists all over the group, with the mission to offer energy efficiency audits and reviews for larger industry companies and real estate, aiming at reducing their energy use (ABB, 2012).

Below, the energy analysis at Sapa Heat Transfer (Auletta 2013) is used as an example of the ABB approach to address the target above. The description of drivers, barriers and enablers are examples energy efficient products and services in ABB in general, based on Auletta (2015).

Description

Sapa Heat Transfer is a leading company in the production of aluminum band mainly used in the manufacturing of heat exchangers for cars and trucks. In 2013, ABB was commissioned to carry out a survey of the energy use in one of Sapa's cold rolling mill with a focus on the supporting systems. The project was initiated to address the commitment to continuously increase energy efficiency in equipment and buildings, expressed in the energy policy. Since several parts of the manufacturing equipment were old, they were suspected to use large amounts of energy. ABB found that the cold rolling mill could cut its electricity use by 3%. In addition, heat losses, cooling water and compressed air demands could be reduced (ABB 2013). The financial savings amounted to 1.7 million SEK per year, the energy savings to 2 GWh/year, and the payback time varied from 0 to 1.2 years for different measures (Auletta, 2013).

Drivers

The environmental management system objective on increased sales of energy efficiency-related products, systems and services is one driver for increased energy efficiency. In addition, customers' own energy efficiency targets are other drivers mentioned by ABB officials (Nordström, 2015; Auletta, 2015). From a sustainability perspective, sales are easier today than, let's say, ten years ago, when customers would not ask for e.g. an EPD. To put it simple: today, they tend to buy more efficient equipment from ABB and take credit from it - in some years, it is time for ABB to charge for it (Nordström, 2015).

Naturally, the interest for energy efficiency measures follows energy prices. For example electricity prices in Indonesia increased by 15% in 2013 (EIA, 2015) which contributes to a growing interest for ABB's services and products (Auletta, 2015).

The European energy directive (EU, 2012) is another driver. The implementation of the directive varies between European countries. Especially in Germany, where non-compliance may incur fines, the directive has required large efforts since it includes energy "audits" on every site of a certain size (Nordström, 2015).

Barriers

As mentioned above, barriers to increased energy efficiency in ABB's own operations include the competition in space for investments and short pay-back periods. This is also true from a products' energy efficiency perspective: although energy measures may have payback periods below 2-2.5 years (theoretical potential), only about 20% of this potential will be implemented (practical potential) because of customers' priorities to other aspects. Payback period is a function of energy prices, and where these are low, e.g. in the US, the interest for energy efficiency measures is poor. Sometimes, customers are inclined to recruit students to carry out energy analyses, instead of commissioning ABB, but these studies are likely to come up with only easily implemented measures rather than exhaustive and technically more challenging ones (Auletta, 2015).

Enablers

For a successful implementation, it is vital that the customer has incorporated an energy strategy including an organization that ABB can communicate with and with a clear mandate (Auletta, 2015). Figure 15 illustrates the building blocks forming an entity in such an energy strategy (Auletta, 2013).

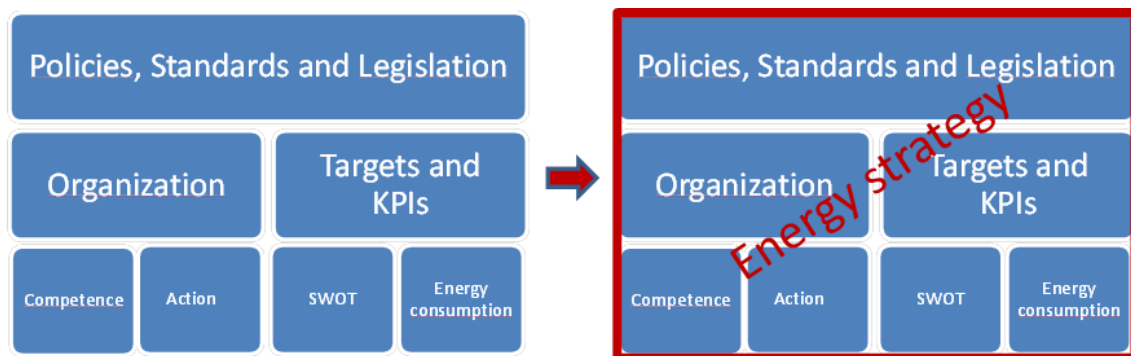


Figure 15. Energy strategy – a cornerstone in energy work (based on Auletta (2013))

As mentioned above, innovations released in 2014, updated Health, Safety and Environment checklists and guidelines for Research and Development were expected to contribute to increased revenue from energy efficiency and renewable sales (ABB, 2015b).

Effects on energy and resources – in theory

ABB has a global market, and, as mentioned above, the global savings in electricity from using ABB drives were assessed to 445 TWh in 2013 (ABB, 2015b). From experience, the actually realized savings generally correspond to about 20% of the theoretical potential (Auletta, 2015), which thus would amount to, roughly, 2,200 TWh. If the revenues related to energy efficiency and renewable energy increase by 20% in 2020, and assuming the current rate of global savings in electricity from additional products and services, this would correspond to an increase in theoretical electricity savings globally from about 2,200 TWh per year in 2013 to about 2,700 TWh per year in 2020. With a GHG emission factor corresponding to a European electricity mix, this would reduce GHG emissions with additionally 206 Mton CO₂eq per year.

Effects on energy and resources - in practice

As already mentioned, the global savings in electricity from using ABB drives were assessed to 445 TWh in 2013 (ABB, 2015b). If the revenues related to energy efficiency and renewable energy increase by 20% in 2020, and making the same assumptions as above, the use of ABB drives would correspond to an increase in electricity savings globally from 445 TWh to 534 TWh per year. With a GHG emission factor corresponding to a European electricity mix, this would reduce GHG emissions by another 41 Mton CO₂eq per year.

Implications for competitiveness

Apart from providing solutions that both ABB and its customer benefit from, the energy efficiency services business is vital for ABB as being perceived as a sustainable, innovative and responsive company, both by investors and employees, both today and tomorrow.

AkzoNobel

AkzoNobel is a global paints and coatings company, with around 50 000 employees in 80 countries. The headquarters is situated in Amsterdam, the Netherlands (AkzoNobel, 2015a). AkzoNobel business is divided into three business areas: decorative paints, specialty chemicals and performance coatings (AkzoNobel, 2015b). They produce a wide range of brands, for business to business as well as to consumer markets.

Sustainability at AkzoNobel

AkzoNobel has had an active sustainability work for many years, and are very proud to be in top three position of Dow Jones sustainability index in the Materials industry group for the last nine years, with a top ranking the last three years. (AkzoNobel, 2015c). According to the Annual report 2013, this position has been achieved by “being committed to the concept that we shouldn’t make separate business and sustainability decisions” (AkzoNobel, 2014a page 17).

In 2013, AkzoNobel announced a new vision, strategy and targets related to sustainability (AkzoNobel, 2014a). In the six strategic targets communicated in the 2013 Annual report, three were directly related to sustainability, as seen in figure 16.

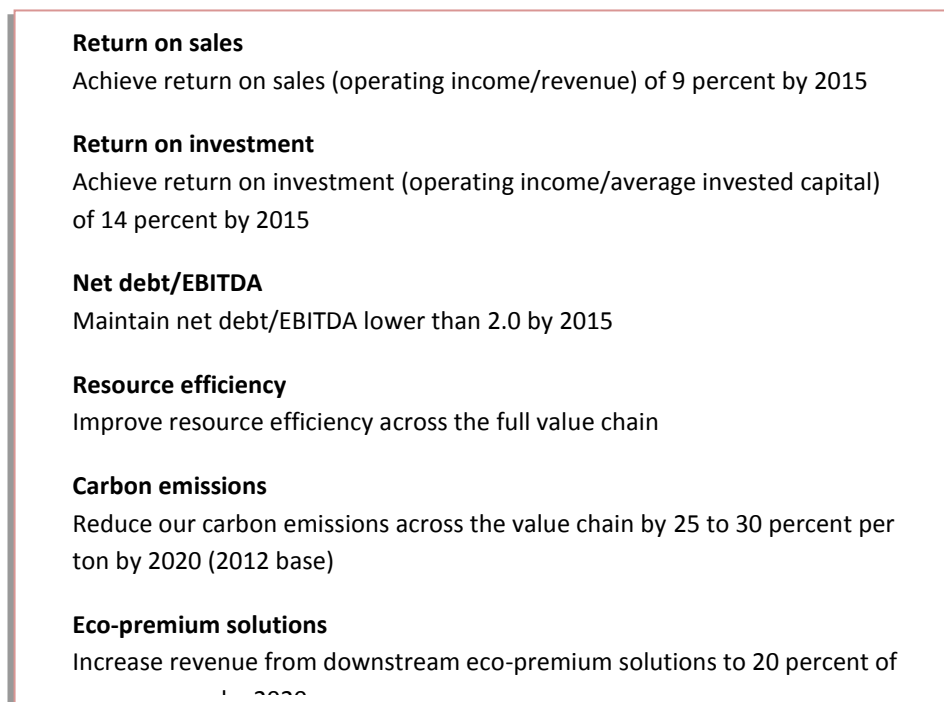


Figure 16. AkzoNobel strategic targets 2013 (AkzoNobel 2014a)

A novelty in this strategy was a strong value-chain focus, including “significant reduction in specific greenhouse gas emissions across the value chain” (AkzoNobel, 2014 b).

The value chain focus was however not new internally. The group AkzoNobel Sustainability had been working with the value chain in terms of taking a life cycle

perspective on environmental work for many years. For example, they have been members of the Swedish Life Cycle Center since the 90's, and have an experienced team of LCA specialists in house. To date about 500 LCAs have been made on corporate products (Hallberg, 2015a).

Selection of case studies

In AkzoNobel, two case studies have been selected for this study, linked to the carbon emission and the eco-premium solution targets respectively;

1. The process itself to set and meet the target on reduced carbon footprint across the value chain
2. The Intersleek® eco-premium solution in marine coatings.

The case studies were selected and initially explored in a telephone interview with Klas Hallberg, Manager Developments in Sustainability, May 7, 2015. For the value chain target case, and additional in-depth telephone interview was made with Derek Rance, Director Research and Innovation for Performance Coatings at AkzoNobel, June 26, 2015. The Intersleek case was mainly covered through an in-depth telephone interview with Trevor Solomon, September 7, current market manager for Intersleek, with previous position as both product and business manager of the Intersleek product range. A complementary interview for both cases was held with Klas Hallberg October 7, 2015. Primary data from the interviews has been complemented with Annual reports and other company related documents and websites in both cases.

Target on reduced carbon footprint across the value chain

Since 2013, the corporate target of resource efficiency has been formulated to include carbon footprints of the entire life cycles of their products, from cradle to grave. In average in AkzoNobel, 15% of carbon footprint throughout the full life cycle of the products stem from the company's own operations. The rest occur either upstream at the suppliers and raw material production, or downstream among retail, use and waste handling (AkzoNobel, 2015c). The target to reduce carbon footprint with 25-30 % thus implies that operations outside of AkzoNobels own control, such as actions among suppliers and customers, also has to change to reach the target (see figure 17).

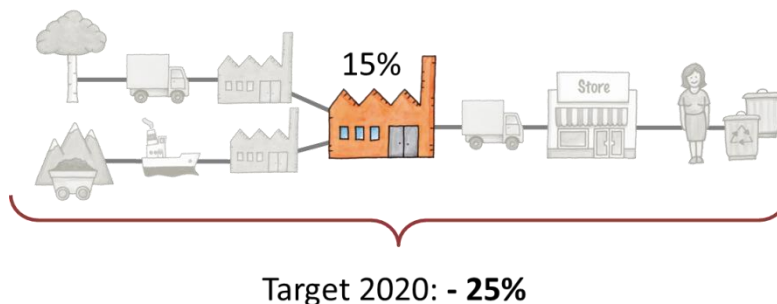


Figure 17. AkzoNobel has a strategic target of reducing carbon footprint of the entire value chain with 25-30% per ton of sales, from 2012-2020, although their own operations only make up 15% on average.

Introduction of a goal on value chains

The decision to adopt a corporate target encompassing the entire value chain was a result of years of work in the area of life cycle thinking in the AkzoNobel Sustainability team (Hallberg, 2015a). The team had gradually extended the scope of assessment for environmental considerations within the company, from own operations to a wider life cycle perspective. First, by assessing and discussing cradle to gate in one business unit showing the most interest, gradually extending this practice to more business units. Later on including also cradle to grave in environmental assessments, and slowly spreading also this practice among the business units.

The Manager for Developments in Sustainability were in the early 2010s able to argue to the Sustainability Director and other managers that the practice of measuring performance of entire value chains was “already there” and thus no major changes needed to assess and follow up a potentially forthcoming value chain strategy (Hallberg, 2015b).

In 2012, Ton Büchner was appointed as new CEO of AkzoNobel, (AkzoNobel, 2015d). He wanted to put strategies on the value chain “forward to the external world”, and it was decided to also define a quantitative target (Rance, 2015). The target was expressed in the new corporate strategy in 2013, as described above.

Defining the range/scope of the target

Once the decision was made to have a target on the entire value chain, it was a fairly rapid activity to identify the scope. Within 1-2 months, a number was to be set that each business area in AkzoNobel felt comfortable to sign up to (Rance, 2015).

Sustainability work of AkzoNobel is executed through a Sustainability Leadership Team, chaired by the director of sustainability, holding one representative from each business area. This group became responsible for recommending a target level, and also implementing what was finally agreed. The three business areas are very different in nature, and thus also in their focus and possibility to affect the carbon footprint of their respective value chains. Thus it was *no easy task to set one common target for the entire corporation (Rance, 2015)*.

For *specialty chemicals*, the own operations contributes with a large component of their total footprint (38%), as illustrated in figure 18. For *decorative paint*, energy efficiency strongly relies on the amount of high energy containing components in their products, and upstream operations account for 64% of all footprint (figure 19). In *performance coatings*, the acts of customers are the main contributions of carbon footprint. The application and curing process and end of life roughly constitutes two thirds of the footprint (64%), and a very small share in own operations (as illustrated in figure 20). (Data from AkzoNobel, 2015c).

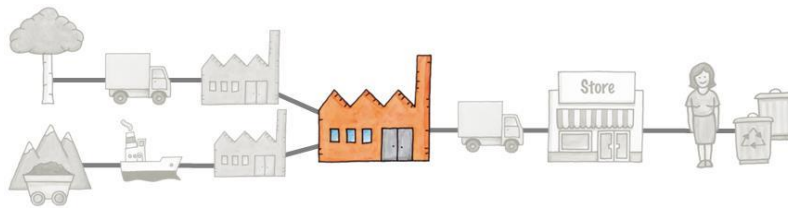


Figure 18. In specialty chemicals, an important part of the carbon footprint is associated with the company's own operations.

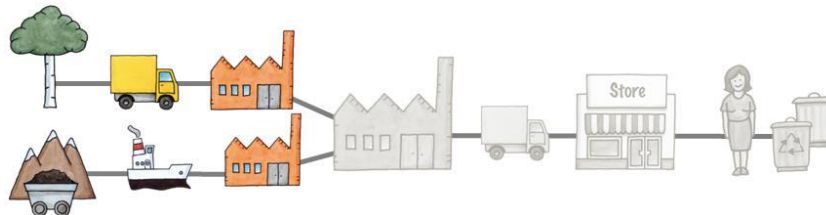


Figure 19. For decorative paint, a lot of energy is used upstream, and reducing carbon footprint is mainly about reducing the need for energy intensive components.

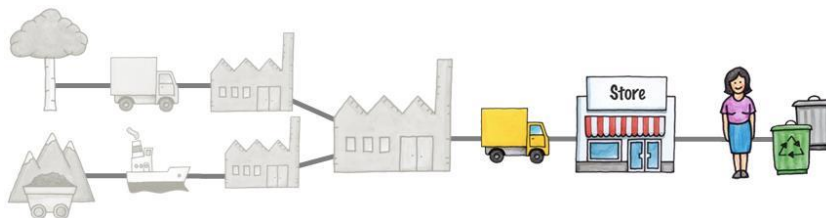


Figure 20. In performance coatings, about 2/3 of the carbon footprint is within downstream operations.

Each business unit was asked what target they could manage, and the business managers seemed keen on providing strong ambitions. Performance coatings gave the lowest bid of the three. They thought they were too dependent on their customers' behavior to target any more radical changes: "You can't tell a customer that is has to do something" (Rance, 2015).

After consultations with the AkzoNobel Sustainability group and internal discussions, Performance Coatings finally set 20% as the maximum limit, and that would "really be a stretch". The other two, decorative and specialty chemicals, said 30 % is possible. So the target was formulated as "25-30%" for the corporation as a whole (Rance, 2015).

The AkzoNobel Sustainability team was a bit surprised by the ambitions expressed by the business units. They thought even 15% would be a challenging target to reach for. Possibly, the units did not fully grasp the amount of changes needed in processes outside of own operations? (Hallberg, 2015 b).

Means to meet the target

Different business units have been working differently to meet the target. In performance coatings, for example, progress have been made in the area of

influencing suppliers to reduce energy and waste, and in shifting to more renewable materials in existing products and processes. The act of customers, and how this can be influenced by AkzoNobel, has also been increasingly recognized in the company. Some internal ways of working put forward by Mr Rance (2015), the director Research and Innovation for Performance Coatings, include:

Conversations with key suppliers – Introducing a dialogue with key suppliers delivering high volumes or share of material, pointing out that if they could help reducing the carbon footprint along the value chain, they will be valued as a better supplier internally. However, in order to do so, suppliers also needed to share information on reductions made, so AkzoNobel could include it in the carbon assessment models. Some suppliers were willing to do that, others thought it was not Akzo Nobel's business. Some suppliers were also afraid of haggling, for example that if they showed reduced energy use, then AkzoNobel would ask them for price decrease. Thus, Mr Rance conclude, *“You have to have element of trust in the value chain to save the planet. That you see in the world today: The collaboration in the value chain is really important to make changes for the future.”*

Align with customer(s customer) – The recognition that 2/3 of the footprint in performance coatings were downstream has led to a more customer based way of working with sustainability. Yet, also among customers, the maturity and interest differ considerably. A way forward used in performance coatings, has been to specifically target customers, or even customers' customers, that explicitly see sustainability as a core value and themselves trying to reduce their carbon footprint. These customers are often well-known global players generally recognized as leaders in sustainability. Looking for sustainable solutions together with these customers, and help them reduce their footprint, provides a mutual benefit.

The practice of “jumping” in the value chain, to talk directly to the customer of the customer, was according to Mr Rance a “sort of a forbidden thing” many years ago. However, the perception today is that the 1st tier customers are now recognizing that their customers often can have a better dialogue directly with the producer on what they want. The customers' customers are the ones driving the product specifications. Large companies closer to end products are also often more experienced in e.g. regulatory affairs and how to change them than their suppliers, and often they also have a deeper knowledge of the specific chemistry and performance needed in their particular application.

To this end, a strategy seems to be to team up with “likeminded” when it comes to both suppliers and customers. *“What we try to do is to align ourselves with major global players that are minded like us.”* (Rance, 2015)

Managing the product portfolio from a carbon perspective – A recent idea in performance coatings, following from the carbon target, is that the product portfolio might need to be managed, not only from a financial perspective, such as gross margin, but also from a carbon footprint perspective. A way to reach the target might be to promote value chains with low footprints: If you can grow the sales of these low footprint products, and reduce the sales of products associated to value chains with high footprint, you can reduce the footprint all in all. This is a fairly new discussion within performance coatings, and “a concept that we are

playing with still”. Mr Rance tries to promote the idea internally among business leaders when he has the opportunity. So far, initial interest has been strongest within performance coatings, the business units having the main impacts downstream in the value chain.

Evaluation and follow up

The target to reduce carbon footprint along the value chain is followed up twice a year (Hallberg, 2015a). Every part of the business has identified “generic key value chains”, covering at least 80% of their sales volume. With support from AkzoNobel Sustainability, these key value chains are translated into carbon footprint along the entire value chain. For this, different downstream scenarios are assumed, as there are many possible applications of products made.

Calculations are based on data from the about 500 LCA studies made in the organization throughout the years. Along with sales figures for different product groups, an estimation can be made on the cradle-to-grave carbon footprint per ton of sales for the entire corporation.

The carbon footprint target is per ton of product, as it was not considered possible to relate to functional unit as these differ so much in the organization (Hallberg, 2015a). Impacts during use phase are calculated based on operations directly related to the use of the AkzoNobel product as such, such as heat for application or removal. Any potential impact on related life cycles, such as reduced fuel use of a ship due to the use an AkzoNobel coating, does not affect the AkzoNobel cradle to grave footprint according to current practices (Hallberg, 2015b).

Responsibility for meeting the target is distributed in the organization. The managing directors within each business area have the accountability for supporting the sustainability dashboard, in which the carbon footprint target is one part. The functional directors have the accountability for delivering their part of the deal through various key performance indicators they are responsible for (Rance, 2015).

Enablers and barriers

The Manager Developments in Sustainability recognizes that although there is often a willingness to reach the value chain target, from there to understand what action to undertake is a long step away (Hallberg, 2015a).

There is an internal *lack of understanding of the life cycle perspective*, resulting in, for example, business and middle managers focusing the wrong processes. A common mistake is to overestimate the potential of efficiency measures in own operations. Also, not all managers know their value chains in enough detail to be able to see what actions or part of the life cycle to target (Hallberg, 2015a,b).

Also among employees and business units recognizing the need to engage all stakeholders in the company, reduction of carbon footprint along the value chain turned out to be tricky. The *maturity of customers and suppliers vary a lot*, and conversation with many suppliers, even some key ones, are not as fruitful as they would like them to be (Rance, 2015). There is also a *lack of coordinated market strategy* in the corporation, as AkzoNobel has been built up around a range of

separate businesses, organized with market managers for different product groups but no central marketing department (Hallberg, 2015a).

Another potential barrier is the practice in the company to stick to core operations and not extending the scope of business outside the production of products. An example is in the area of powder coating in which it takes a lot of energy to add energy to apply the paint. Many customers use very old technology for application. In theory, AkzoNobel could be able to help the customer to find new technologies for application, and perhaps share the investment and profits. But this is not normally regarded as the responsibility of AkzoNobel as it is not perceived as core business. However, there are also examples where such collaboration exists. Within AkzoNobel EKA for example, there already is a tradition of selling technology solutions and services to customers, for example helping customers to operate their own mills. This unit has so far also showed results in improving carbon footprint in a life cycle perspective (Hallberg, 2015).

Apart from stakeholders and business structures, internal priorities also repeatedly came through as major barriers in this case, i.e. *sustainability not being top priority* for business. The general *ambition is clear in theory*: to increase profitability of the company while still decreasing energy consumption. Also there is an understanding that it is up to the business units to create products that do create value for their customers that they then will be rewarded by financially. However, how to do it in practice is not easy (Rance, 2015).

There indeed are *tradeoffs between financial and non-financial targets*, and often up to the managers to find the right balance between financial and non-financial targets (Rance, 2015). Financial targets are often the overriding thing among many managers and thus often get priority in terms of time and resources. For many managers it may well be that carbon footprint reduction is something that is “nice to have in the back on your mind”, but when it comes to return on sales opposite return on carbon, then driving financial performance to competitive levels is “the overriding priority” (Rance, 2015). It also seems that business leaders have the opportunity to make (but also be exposed of) more drastic measures to achieve economic objectives than environmental, such as closures and layoffs (Hallberg, 2015b).

A new combined “resource efficiency index”, defined as “gross margin divided by cradle to grave carbon footprint” might, according to Hallberg 2015, provide more guidance in the relation between finance and energy, and assist in enhancing supply chains with high profit but low climate impact. The index is however not associated with any target at the moment, but it is included and monitored in the Annual Report 2015 (AkzoNobel, 2015c).

Mr Rance (2015) further recognizes that progress also depends on the *agenda of individual managers* leading different functions. Getting alignment across a huge corporation is a huge task, and focus of (middle) managers can have an extensive impact on how fast a process is progressing.

It might also be so that *other aspects of sustainability have higher priority in the organization*. It is much more focus on reducing potential emissions of dangerous substances than on energy efficiency. Similarly, there is more focus on the target for eco-premium solutions than that on reducing carbon emissions across the value

chain. Mr Rance explains this with the interest of customers: It is only a very small share of the customers focusing carbon. Toxicity is more relevant for a broader set of customers. Taken together, there is a *very small part of the organization that explicitly works with the carbon reduction target* (Rance, 2015).

Energy implications – theoretical potential

In 2014, AkzoNobel had a total carbon footprint of 26.9 million tons CO₂, of which 4 million tons was in own operations (AkzoNobel 2015c). A reduction with 25%-30% of the carbon footprint would then imply reduced carbon footprint with around 7 million tons CO₂e per year (6.7-8,1 million tons based on 2014 numbers) from 2020 on (assuming the same sales volumes 2020 as in 2014).

The target to reduce carbon footprint with 25-30% along the value chains are very much related to energy efficiency. Approximately 90% of the carbon footprint corresponds directly to energy use (Hallberg, 2015a).

Energy implications – practical potential

With 5 years left to reach the target to reduce the cradle-to-grave carbon footprint per ton of sales by 25–30 %, from 2012 to 2020, it is clear that it is yet a long way to go. 2013 resulted in 2% reduction of carbon footprint cradle to grave per ton of sales, but in 2014, the result was an increase in carbon footprint with 4% compared to the 2012 baseline (AkzoNobel, 2015c).

According to the Manager Developments in Sustainability, there are several reasons for the slow progress (Hallberg, 2015a, b).

- The target was set in conjunction with a shift in CEO. Previous sustainability targets had been *regarded more as visions* in the company. Possibly this culture was still dominant when the business units were asked to set the target. The succeeding practice of treating it a hard target became a bit of a surprise in the organization.
- *The target is indeed very high.* To reach such levels there is a need for radical shifts in technologies, resource base or energy supply, not only in own operations or among 1st tier suppliers, but in the full value chain of the products. Also the target is for the entire corporation and sustainability improvements made in some areas could well be outweighed by actions in other areas with opposite effect.
- A lack of understanding of the life cycle perspective among both AkzoNobel and suppliers has led to misunderstandings in what requirements and actions are to be made. As a result, a promised value chain reduction of 20% from one supplier may become 20% reduction in the suppliers own operations (at best). This leads to a lot of frustration within AkzoNobel at follow up, when advances made turn out to have much less effect than anticipated on the value chain target.
- Global megatrends, such as interest in general of renewable energy, indeed help AkzoNobel to reach the target, but may also counteract it. Today's

low oil price is devastating for the very development of renewable energy and raw material supply.

- The major impacts on the target is not related to sustainability considerations in each value chain, but from changes in the product mix, acquisitions, divestitures, new markets, global business cycles, etc., which normally not primarily have to do with any environmental strategy.

According to the sustainability leadership team representative of one of the three business units, the challenge is also not only to “do enough”, but also to do it fast enough to reach the goal. The performances of new products are very important for the customer, and there are a lot of testing and criteria to be met to convince the customer of a new product. It may well take 5 years before any sales of a new product get going. Thus, product development starting now will not affect the target for 2020 (Rance, 2015).

Despite dismal figures in 2014, it has been decided to maintain the set target (Hallberg, 2015b). Although there is an emerging awareness in the organization that more radical structural changes are needed to reach the target, a lot of the responsibility remains on the individual business units.

Competitive advantage

When the new CEO of AkzoNobel started in 2012, he clearly showed that the strategy of AkzoNobel working with the entire value chain was an important message to external stakeholders (Rance 2015).

Internally, this goal seems to have been perceived more as of interest for AkzoNobel as a company, and less so for increasing the competitive advantage of specific products or business units: “If it provides value for AkzoNobel, then we do it” seems to have been a common reaction among managers (Rance, 2015). In the short run, the carbon reduction target across the value chain was expected to add a competitive advantage (only) when aligned with other value propositions of the company. For some customers, the joint ambitions towards some common goal, such as carbon reduction along the life cycle, may pose an additional feature and get business relations that all in all resulted in a deal.

Yet such deals can be very substantial also in economic terms. For some products and segments, the environmental profile of AkzoNobel is a vital contributor to win certain major contracts, such as the Olympics, and may even allow for price premiums of up to 30-50% (Hallberg, 2015b).

Intersleek – Ship coating that reduces fuel consumption



Intersleek® is a range of products in the International paint brand. It is part of the so called marine coatings in the business area performance coatings of AkzoNobel. Intersleek belongs to the “eco-premium solutions” of the company, and it’s sales are thus affecting the AkzoNobel strategic target to increase the sales of eco-premium solutions sold to 20% in 2020.

There are basically two types of coatings in the marine and shipping industry; “antifouling” and “foul release” (Criminna and Pagliaro, 2015). Antifouling are biocide containing coatings, emitting controlled amounts of biocides continuously during operation. Intersleek® belongs to foul release coatings, which are biocide-free. Instead, the chemical components are chosen to provide a particularly smooth surface on which organisms have difficulties to attach (hence the name “sleek”) (Solomon, 2015). However, it also happens to have the positive life cycle benefit of making the ship run even more smoothly in the water, leading to less fuel needed during operation.

Development of the Intersleek product

Intersleek products have a positive environmental profile due to the absence of biocides and smooth surface resulting in lower fuel consumption. The first Intersleek product, Intersleek®425, was launched in 1996. Since then, development has mainly been directed towards increasing the possible market for the product by developing the coating to suit ships at lower speeds (Solomon, 2015). Luckily, this aim for higher market penetration has also gone hand in hand with better fuel efficiency for the ship.

Intersleek®900, launched in 2007, was AkzoNobel's first fluoropolymer coating, suitable for vessels above 10 knots, such as tankers, bulk and general cargo vessels. Compared to silicone-based systems, such as Intersleek®700, (launched in 1999), this type of coating provided, among else, an even more smooth surface, resulting in up to 10% less fuel needed in operation (International Marine, 2011). The latest member of the Intersleek family, Intersleek®1100SR was launched in 2013, being even more effective to combat growth on a wider range of organisms.

Market reactions

Intersleek has been relatively well received on the market. The products in the range have surpassed each other, and Intersleek®1100SR is now the fastest growing foul release product of AkzoNobel (AkzoNobel 2015e).

Although quite successful, the product has yet but a small share of the total market opportunity. Reasons why customers hesitate to use Intersleek® include (Hallberg, 2015a; Solomon, 2015):

- Marine and shipping is a *conservative industry*. There is a high degree of *skepticism* among the customers to invest in new technology. A new coating is an investment that will last for at least the next 5 years. Many

customers are uncertain about the consequences and hesitant to changing away from familiar coating system.

- *Uncertainties in actual effect.* Physical conditions at the time of operation of the vessel, such as operation speed, water temperature, geographical position etc. makes the fuel reducing effects vary and a certain effect and payback time difficult to guarantee.
- The coating has a higher purchase price, as well as a higher cost for application, than conventional alternatives. *Total investment cost for the coating is 2-3 times higher than conventional coatings.* Payback time depends on physical conditions, as mentioned above, and varies normally between 6 and 18 month. *A typical payback time is around 12 month* before the larger investment cost is paid back in less fuel consumption.
- *Industry/ownership structure* is also a barrier. Approximately 80% of all large ships are "on charter", i.e. there are different actors owning and operating the ship. This means that there most often is one actor providing (and paying for) the coating, and another actor accounting for continuous operation, including paying for the fuel use.

Development of a carbon credit program

In 2009, two years after the launch of Intersleek 900, the R&D Director at the time attended a presentation from a consultant on carbon offset programs. He had the idea to determine whether carbon credits could be used in the marine industry. AkzoNobel had already methods and calculations to assess the reduction of greenhouse gases with Intersleek. However, assessments from an independent reliable actor, as would be the case of an established carbon credit provider, were assumed to provide much more legitimacy for the environmental claims made (Solomon, 2015).

By the end of 2009, the Intersleek business team started to investigate the possibility to introduce an offset program for the carbon saved when using Intersleek products (Solomon 2015). The idea behind such program is that one credit represents the removal of a tonne of carbon dioxide equivalent from the atmosphere, and after being issued by an accredited agency, this credit can be traded on a voluntary carbon market (International Marine, 2015)

The Gold Standard was chosen as partner in this work. There was a lot of work to assess the internal feasibility, as well as comply with all the requirements of the program (Solomon, 2015). There were extensive requests for background data on both technical and environmental aspects. What more is, procedural and legal aspects such as customer agreements and auditing partners needed to be settled. Also, carbon offset principles in more general terms needed to be further developed, as marine industry was a brand new application for offsets. It was for example the first carbon-credit generating methodology for "moving articles" (International Marine, 2015).

After years of preparation, the two people at AkzoNobel had green light internally to go for the carbon credits program in 2013 (Solomon, 2015). In 2015 the first two pilots for credits were launched, with a range of customers already waiting to be part of the program. The Intersleek customers can choose how credits should be transferred; either in cash or as carbon credits. In the two pilot cases one customer wanted cash and the other credits. However, 34 more customers are in line for the program, and a majority of these (about 80%) has shown most interest in the cash solution. AkzoNobel assists in the sales of the credits by the use of an external broker for carbon offsets (Solomon, 2015).

Barriers and enablers

The improved life cycle performance of the ships seems to have been a positive “bi-effect” to other targets of AkzoNobel, thus not leading to any major trade-offs of internal priorities. Improved fuel efficiency for the ship owner co-developed with properties needed in the hunt for greater potential market share of the product. Increased sales have been in line with the strategy to sell more eco-premium solutions and profit margin of the product has also been relatively high throughout the years.

A potentially more controversial route in the company might have been the decision to engage in the carbon offset program. This was a new type of business for International paint. As a matter of fact, it was also a new type of sector for the offset industry. Yet the engagement in the carbon offset program did not induce any major obstacles internally, such as getting approval and acceptance for developing the idea, according to one of the managers behind it. At this specific point in time, Intersleek was run more autonomous than other brands, due to the importance and profitability of the products. As a result, Intersleek product and business managers had more direct access to top managers and were in this way able to “linestep” some levels of middle managers to get approval for the carbon offset work (Solomon 2015). Fortunately, these top managers also showed interest in the idea. The project duo of the offset program still needed to follow routines such as making calculations of business case etc. but with the more direct access, they did not have to convince so many people than would have been the case in a more “normal” organizational setting.

It also helped that business was good. Intersleek was successful and profitable in itself, and the idea of carbon credits was rather an initiative to enhance already good sales, than to “save” an unsuccessful product (Solomon, 2015).

For continuous further development and sales of the product, the current Intersleek market manager has identified uncertainty of the sales force as one of the main barriers (more than R&D for example) (Solomon, 2015). An internal survey of perceptions of sustainability goals and targets within AkzoNobel, partly initiated by the market manager, shows that the salesmen are uncomfortable in how to speak to the customers about the Intersleek benefits. They request e.g. more sales support and materials, as they perceived it as “a different way of talking” (Solomon, 2015)

Although yet a long way to go before full market acceptance, the carbon offset program has several characteristics that may contribute to ease some of the initial market reluctance. A trustworthy third party actor approving the environmental gains of using the product reduces customer’s uncertainty of the actual effect and

provides important legitimacy for the claims made. The offset program is also a way to mediate financially between the owners of the ship and the operator leasing it. The credits are given to the one buying the coating, which contribute to outweigh the higher investment cost. Discussions are even held to find a deal where cash can be transferred already before actual sales of the credit, to reduce the delay in time for pay back of the investment (Solomon, 2015).

Energy efficiency effects - Theoretical potential

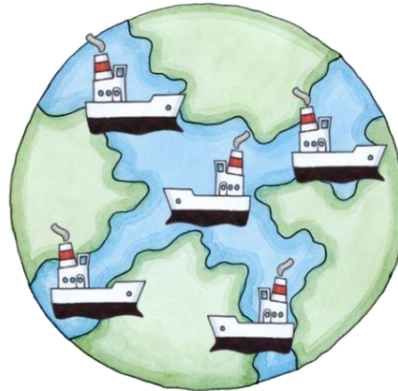
Intersleek is developed for vessels such as tankers, bulk carriers and general cargo vessels, and may potentially provide considerable improvements in energy efficiency during operation. Fuel and emissions savings are typically around 7-9% in average for Intersleek®900 compared to previous in-service periods using other coatings (International Marine, 2011; CPM 2013). AkzoNobel estimates that one single Very Large Crude Carrier (VLCC) could save 9,000 tonnes of fuel, 31,000 tonnes of carbon dioxide emissions, and 3.6 million USD over a five year period when using Intersleek 900 instead of a self-polishing copolymer antifouling (International Marine, 2011), resulting in a reduction of 6,200 ton CO₂ yearly as illustrated in figure 21.



- 6,200 ton CO₂/year

Figure 21. A single large crude carrier may reduce its carbon dioxide emissions with 6,200 tonnes carbon dioxide per year by using Intersleek®900

Own calculations of AkzoNobel show that if all ships (that the coating is suitable for) were coated with Intersleek, CO₂ emissions worldwide could be reduced by 90 million tons each year (International Marine 2011, see also figure 22). This is 50% more than the amount generated annually by the population of Sweden (CPM, 2013), and 3 times the full cradle to grave carbon footprint of AkzoNobel in 2014 (AkzoNobel 215c).



- 90 000 000 ton CO₂/year

Figure 22. If Intersleek®900 were used on all suitable ships worldwide, CO₂ savings could amount to 90,000,000 tonnes a year

Energy efficiency effects – practical potential

The theoretical potential of Intersleek®900 is substantial, as seen above. The estimated value of 7-9% fuel savings in average is based on measures on ships in operation and can thus be seen as the practical potential technology wise. In-service measures show that for beneficial conditions, the actual effects may even be considerably higher than this (International Marine, 2011).

Nevertheless, the realized effect is much less than the potential 90 Mtons CO₂ per year stated above. This is mainly due to the limited market uptake of the product. According to the market manager of Intersleek, current market uptake is about 5% (Solomon 2015). Assuming that the 90 Mtons saving represent 100% of the possible market, a 5% uptake would lead to savings of 4,500,000 tones CO₂ annually. Although considerably lower than the 90Mtons, this is still on pair with the carbon footprint of all AkzoNobel's in-house operations worldwide (4 Mton 2014 according to AkzoNobel Annual Report 2014). A more conservative calculation on Intersleek 900 alone, based on the information that at least 350 large ships were coated with Intersleek®900 in 2014 (Criminna and Pagliaro, 2015), gives about 2 Mton CO₂ savings achieved ($350 \times 6,200 = 2,170,000$ ton).

The limited market uptake is associated to a number of aspects, as seen above, such as reluctance of customers, changed cost-benefit distribution in the value chain and sales people not confident with communicating the new business rationale. The carbon credit program is expected to address many, yet not all of these obstacles.

Implications for competitive advantage

Possible implications on competitiveness for the Intersleek case can be found at both product and company levels. At product level, Intersleek has many characteristics that are beneficial to the customers, and thus pose a competitive advantage in potentially higher market share and profits:

- The use of Intersleek may lead to *costs savings* at customer level, due to lower fuel consumption and reduced costs of treatment and disposal of

wash water and blasting abrasives at drydocking (because of absence of biocides) (International Marine, 2011).

- Interleek may, according to AkzoNobel, *improve CSR and environmental performance* and contribution to reach environmental goals of the vessel owner (International Marine, 2011).
- The *carbon offset program* adds a potential environmental or economic benefit to the customer. Indeed the offset program adds a major cost for AkzoNobel (e.g. for data collection, referees etc.). However, these costs are assumed to pay back in higher sales of Intersleek (Solomon, 2015).
- Apart from sales at a specific point in time, the carbon offset program may also provide *more loyal customers*, according to the director research and innovation for performance coatings at AkzoNobel (Rance, 2015).

The actual market impact of carbon credits is too early to evaluate, as it is in its infancy. But according to the market manager of Intersleek, it seems very positive. They receive much interest and many questions from customers regarding the carbon credits and related matters. However, it is too early to say if the greater sales they have seen lately, is due to a profound interest of the product as such, or a result of more general ups and downs on the market (Solomon, 2015).

In addition to having customer benefits that allows for a price premium and increased market share, Intersleek may also strengthen the competitiveness of AkzoNobel as such.

- Intersleek is frequently used by AkzoNobel globally as an example of sustainable solutions and innovations (AkzoNobel 2015f). This *strengthens the image* of AkzoNobel as an innovative and responsible company, and sends a message to stakeholders that AkzoNobel is working actively in the area.
- According to Hallberg (2015), such *good examples of innovations in the area of sustainability is also very important for shareholders and investors, for example pension funds*, in their assessment of the sustainability and future position of the company.
- The Intersleek development also serves as internal inspiration for employees as an example of a successful product that is both profitable and more sustainable: *"Everybody within AkzoNobel wants to be part of it."* (Solomon, 2015).

Analysis

The results from the case studies were analyzed using a grounded and iterative approach, where the results were categorized, classified and grouped to find common themes and phenomena emerging from the cases. Detailed notes from each case study interview were classified into drivers, barriers and enablers found in each case. A table was made where all these data were introduced, grouped and compared between all the cases. Further classification and grouping were made by the researchers in an iterative manner, resulting in the emergence of four more or less explicit “strategies” to which most of the barriers and enables could be classified:

- Find and share the life cycle benefits
- Get focus and priorities in line
- Enable and encourage understanding and action
- Seek or create a way forward

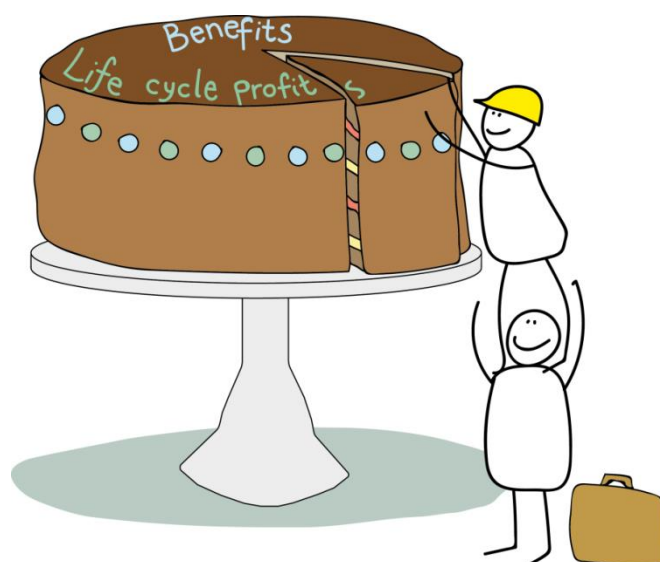
The above themes were presented and discussed in a workshop with experts in industry and academia including participating companies and researchers as well as peer experts in other industry and academic environments. Focus of this workshop was on ways of working and recommendations to policy.

In the subsequent analysis, results for each of the four themes based on case studies and workshop were compiled and related to what was found in the literature. An analysis was also made on the theoretical and practical effects of the studied cases.

In the following, the four identified themes will be described in more detail as identified ways of working. Many aspects may belong to multiple themes, but have been presented only in one to avoid repetitions. The analysis ends with effects on energy, competitiveness and implications for policy.

Find and share the life cycle benefits

Under this theme we have collected concerns and examples related to how to extend the scope of optimization from a single company to entire value chains, and what implications this extended scope will have on business models and practices, including the sharing of risks and benefits in the value chain.



Barriers and enablers

In most of the case studies where the companies offered products or service to a market, the revenues of the companies depend on selling products or services defined in physical terms. In some of the case studies, benefits from an energy life cycle perspective were found to be both “unlocked” and “locked in” because of business models, targets and mindsets. Space and power in negotiations, cost-benefit distribution and integrity aspects were also described as barriers and enablers for energy life cycle efficiency.

Examples of barriers identified in the study:

- The trend of outsourcing and sticking to core operations
- Perception of what is the role of each actor (not our business /role to provide services e.g.)
- Divergent views on what system to optimize, e.g. own operations, or various part of the value chain.
- Suppliers unwilling to reveal energy information (e.g. perceived risk of prize haggling, energy-price-related contracts etc.)
- Lack of trust from suppliers
- Changed distribution of costs between purchase and operation
- Split ownership/responsibility of actors investing in and benefitting from energy effects (e.g. leasing)

- Difficulties in sharing business information between certain actors within a supply chain
- Business agreements on confidentiality of certain data
- Legal barriers on trade and/or integrity hindering dialogue that may relate to forthcoming commercial collaborations.

Examples of enablers identified in the study:

- Targets set on the entire value chain
- Business practices including sales of services
- Third party actor mediating profits or information along the value chain

Financial calculations not accounting for life cycle costs combined with separate budgets for investments and operations is a barrier to finding and sharing life cycle benefits also mentioned in energy efficiency literature.

The extended scope from optimizing energy efficiency in one unit to a full value chain is really central in the LCA and LCM literature, as the main premise on which all work is based. The business case of such work is a presumption found in some LCM literature, although with limited back up in concrete examples.

Ways of working in industry

Finding and sharing life cycle risks and benefits may require new methods for making business and the recognition of so called value chain stewardships, which is established when economic incentives and environmental impact coincide (see e.g. Cerin 2006). Energy efficiency in a life cycle perspective is one aspect that would need consideration by the value chain steward. Below, we suggest how to come about these new ways of working.

Optimize a broader system

Life cycle energy use is a concept that needs to be introduced in product and process development along with new business models. Optimizing life cycle energy use implies calculating energy use upstream and downstream your own activities and possibly sharing and “trading” information that, today, is either considered confidential or commercially regulated.

Dare to target energy/greenhouse gas targets outside your own control – Setting and following up quantitative energy use and greenhouse gas targets for the entire value chain challenge existing roles and practices and encourage ideas on how to reach a more holistic approach to energy use in value chains.

Who manages the life cycle – you? Energy efficiency throughout value chains assumes a life cycle “agent”, actively trying to manage the life cycle impacts in this respect. Who is, or could be, this agent of change?

Identify or create a ”broker” for information and profit – To overcome legal or business barriers that may compromise trade regulations or integrity, sensitive information required for optimizing a broader system would need a function for

sharing and “trading” information – a “broker” – and a system that enables sharing profits and deficits.

Challenge existing business models

Existing contracts, business models and business logic may hinder life cycle energy efficiency. Established practices such as outsourcing can be questioned from a life cycle perspective. Promising examples in literature and in the case studies are rather found where companies extend their business scope or control larger shares of the supply chain.

Embrace the need for changes in markets or product mixes – Recognizing the need to manage the product portfolio from an energy/resource use or carbon perspective is a challenging insight, leading to a discussion about the possibility and responsibility to induce market changes for the sake of carbon footprint and consequently setting up new market and product strategies.

Rethink scope of business – The practice of developing profitability and efficiency together with partners oppose the trend in many companies to outsource everything but core business. Examples from the case studies show indications that business units offering services together with products seem to be more successful in implementing a life cycle perspective than those with a single focus on selling products. A step in this direction identified in the workshop is to offer competence in life cycle impacts related to the product as a sales argument, to differentiate the sales offer.

Explore new business models – Business models based on sales of functions or services has the potential to shift incentives, profits and logics to more life cycle based use of resources. Such service-related business models must be translated to economic results, so that the economic model is not still only based on selling products, and profit might have to be allocated in the value chain. Due to the inertia of large existing production systems, new business models are mainly an opportunity in early business planning, e.g. when introducing new products, new technologies or new offers.

Deal with changed cost-benefit distribution in the value chain

New business models might change power balances in the value chain, such as the relation between supplier and customer. To succeed, trust has to be maintained, insecurity and uncertainty have to be discussed and managed and new solutions have to be agreed upon.

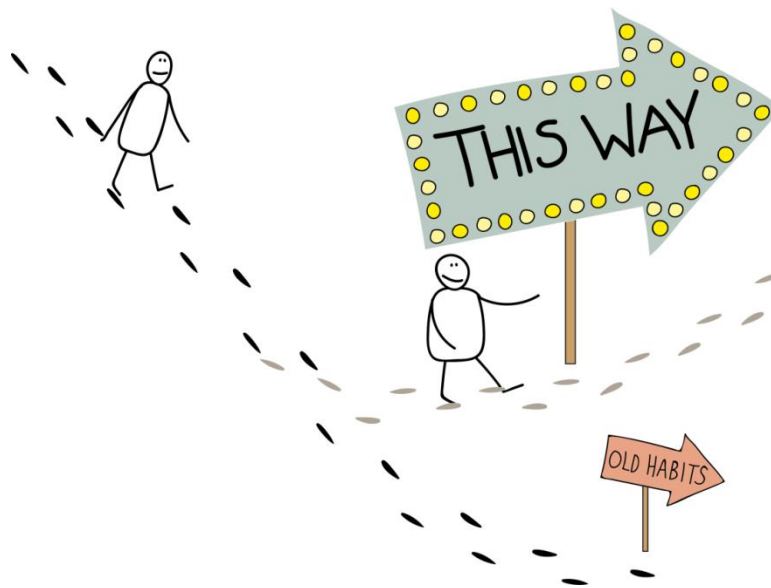
“Translate” benefits to each stakeholder’s own language – Context, background and culture are parameters that influence perceptions and interpretations also in business. One of the conclusions from the project workshop was that these parameters have to be addressed to get stakeholders in a supply chain committed to changes in the distribution of costs and benefits. A translation of any new business practice or model to a “what’s in it for me” in the appropriate stakeholder’s own language was found crucial.

Get support from a third party – The use of an trustworthy NGO or other third party actor may assist in providing financial structures, legitimacy for claims made

and a predefined transparency. Examples from the case studies include a carbon trade certification body (Gold standard) ensuring an arena for an independent, systematic process for carbon offsetting, and WWF helping the setting and commitment to life cycle targets for the reduction of GHG emissions and energy use.

Get focus and priorities in line

This theme is about how to deal with diverging priorities in-house, as well as among suppliers and customers. It also includes the formulation and use of appropriate key performance indicators and the responsibilities for their follow-up.



Barriers and enablers

An organization does not only have one but plenty of voices and priorities. The case studies showed quite important barriers to consistent and concurrent priorities; focuses sprawled both within the companies and along the supply chains. Enablers were relatively few and addressed mainly how complexity had been managed. Highly emphasized during the project workshop was the need to recognize life cycle thinking to influence strategic decisions and to analyze the costs for the customer and for the customers' customer as input to prioritization.

Examples of barriers identified in the study:

- Energy efficiency targets (national and organizational) with too narrow a boundary, possibly resulting in sub-optimizations
- High level of complexity and wide internal range of products and practices (different products, different countries, different operations)
- Focus, resources and follow-up not aligning life cycle
- Other goals/actions (financial, other sustainability goals/actions) having higher priority in the competition for space for investments
- Lack of coordination of different strategies

- Diverging personal engagement of internal (middle) managers
- Sustainability/energy targets perceived as the responsibility of environment department alone, only engaging a very small part of the employees and/or organization
- Lack of requirements with respect to energy efficiency
- Customers' and own limited space for investments (priority to other investments than energy efficiency measures)
- Customers having higher focus and priority on finance/price than sustainability in the purchasing situation
- Customers' lack of an energy strategy including organization to communicate with and with a clear mandate

Examples of enablers identified in the study:

- Group sustainability objectives highly prioritized and of common interest
- Formulation and follow-up of targets
- Setting targets on life cycle energy use
- Continuous follow up of and attention to results
- Combined environmental and financial KPI (for example in reporting)
- Adaptation to complexity of organization (for example global)
- Adaptation to complexity of product (for example different products)

In LCM literature the management support, integration in functions and alignment with strategies are generally recognized as important for progress, although not going into detail on how to achieve this in practice. Energy efficiency literature more specifically points to separate budgets, competition of internal resources and calculations not taking cost into account in a life cycle perspective as barriers (IVA, 2013a), and green lean to the perception that green initiatives are time consuming and “do not pay” (Mollenkopf et al. 2010).

Ways of working

Getting focus and priorities in-line is a matter of managing complexity, but also about making life cycle thinking, both in environmental and economic terms, influence strategic decisions, prioritization, targets and KPIs. It is also vital to make also middle- managers committed to these metrics.

Dare be strategic!

Setting targets beyond your own operations is most certainly challenging for the majority of companies. Still, for true life cycle energy efficiency it is required.

Recognize the need for life cycle thinking – Setting targets on life cycle energy use requires not only courage but also long term commitment from owners and management at all levels. Using science based targets, such as “our contribution to the two-degree target”, may increase relevance and legitimacy to life cycle thinking in strategic decisions.

Support and/or introduce incentives. - To convey messages and in order to “make things happen”, management on different levels may need to explore existing incentives and practices and make appropriate adjustments to support the

new direction in sustainability objectives such as energy efficiency targets. One example found in the cases was longer pay-back periods for energy efficiency investments to encourage production sites and business units contribute to the group sustainability objective on energy efficiency.

Regular follow up and sanctioning by top management – All strategic targets must be followed up by top management. If they are seen as strategic for the company this must also show in tradeoffs made.

Manage potentially conflicting goals

A single organization has to relate to a plethora of goals, some of which might be contradictory, either seemingly or truly. Some energy goals may require measures that coincide with commercially motivated actions – these measures represent the “low hanging fruits” that could be prioritized.

Identify harmonizing goals – The environmental or sustainability organization is not solely responsible for achieving sustainability goals - the business organization may find additional motives for investments and/or measures alongside energy efficiency targets, such as increased productivity, increased quality and/or shift in technology, which facilitates financing.

Scrutinize seemingly conflicting goals - The case studies show several examples of conflicting goals, between financial and environmental goals, but also between different sustainability objectives (e.g. toxicity vs carbon) or between national/in house energy efficiency targets and targets along the life cycle. Furthermore, customers and other stakeholders may have different focus and prioritize goals differently, e.g. price. Consider whether changed cost-benefits internally could unlock additional possibilities. Another example from the case studies on how to handle the relation between environmental and financial goals was combined KPIs, such as “gross margin divided by cradle to grave carbon footprint”.

Identify truly conflicting goals - Trade-offs between truly conflicting goals will be necessary, e.g. between short term financial results and long term environmental goals. The functions may need assistance or clear guidelines to make these tradeoffs meet strategic targets.

Formulate KPIs and ensure follow up

Development must be monitored and result must be asked for. Relevant KPIs, driving development towards the target, without creating any “leakage” or rebound effects, regularly followed-up is a useful way of working.

Find the energy life cycle hot-spots – To put effort where it is the most effective, information about what contributes most to life cycle energy use is needed. However, since most products occur in several life cycles, the energy hot spots may differ depending on context. A set of screening LCAs could do for a start. Hot spots on a national level can also be identified by governmental agencies, according to ideas put forward in the project workshop.

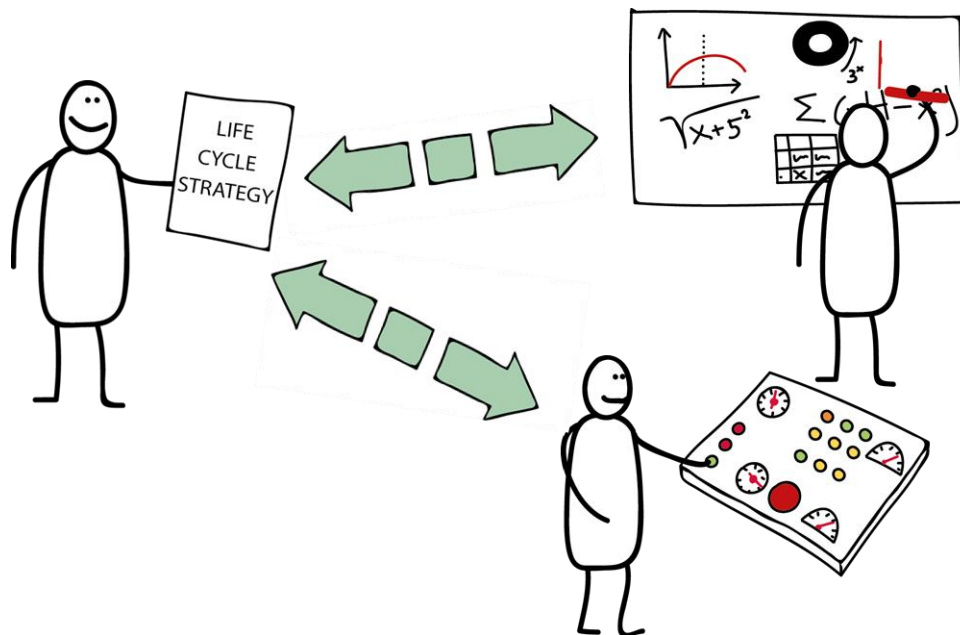
Set measurable targets and formulate KPIs – Quantified targets and appropriate KPIs, reflecting life cycle ambitions, are valuable for monitoring and follow up.

This was stressed especially during the project workshop. Yet this is not always straightforward to formulate in a multinational corporation with many products and markets. Sometimes a pragmatic target such as kg carbon per kg or dollar product sold is more feasible than relating to a functional unit, for example. Relative goals may also be a way to relate to complex realities, such as 25% below legal requirements in each country.

Follow-up on KPIs –A conclusion from both studied cases and the project workshop is that follow up of KPIs is important to maintain focus and interest from the organization, yet it is often neglected.

Enable and encourage understanding and action

In this theme we have included knowledge and understanding that enable life cycle action in that employees in different functions understand the life cycle perspective and its implications for own operation. We also include the encouragement of such action; how to boost motivation and commitment among the employees.



Barriers and enablers

The studied companies are all multinational groups with life cycle related targets and in house competence and experience in life cycle thinking and assessment. Yet they witness on lack of understanding of the life cycle perspective in general in the organization, and particularly a lack of translation to operational implications for relevant functions and employees. Enablers found in the case studies mainly regarded how project and case leaders used various ways to encourage action by boosting attention and commitment in the organization.

Examples of barriers identified in the study:

- Low in-house understanding and knowledge of the life cycle perspective
- Lack of translation from strategic to operational level
- New role/unaccustomed sales organization
- Lack of data
- Lack of time, resources and attention to life cycle work, e.g. energy efficiency measures
- Lack of time and money to motivate operators to change behavior

Examples of enablers identified in the study:

- Capacity building internally, such as internal education
- Internal attention to positive results and contributions by individual employees or groups
- Provision of support to specific functions, e.g. documents and checklists, but also on how to meet stakeholders with additional arguments
- Find arguments in line with the organization (for example budget, time, environment, long term, etc)

It is a major challenge to redirect current practices among the tens of thousands of people in multinational corporations to extend the scope from own operations to entire value chains. Even if the LCM-literature appoints itself as the means to make sustainability and life cycle thinking “operational” in industry (United Nations Environment Programme, 2007) there is notably little focus in literature on how to ensure this in practice. Within green/sustainable supply chain management, lack of training and understanding of how to incorporate green into ordinary practices are discussed, for example in sourcing. A smaller stem of research in LCM has also emphasized the importance of individual adaptation, interpretation and translation in each organization (e.g. Heiskanen, 2000; Rex and Baumann 2007; Schmidt and Remmen 2013).

Ways of working

Ways of working in relation to then enabling and encouragement of understanding and action particularly focus on how to achieve the translation from strategic ambitions to everyday work. Case studies and workshops very clearly show that this translation is not only vital to do, but also that it is made in a language familiar to each target group, and attention is given to progress made at all levels.

Support in-house capacity and understanding

In-house capacity and knowledge needs to be sought on many levels. There is a need for education and capacity building on the main characteristics of the concept as such, as well as in relation to own operations. What more is, understanding relates to both physical effects, and rationales for engagement.

Provide a reason – People at both strategic and operational level often do not understand in what way they may affect the life cycle and reasons for doing so. Thus it is important to find arenas to mediate or discuss possibilities and rationales for each function to engage, i.e. to determine “what is in it for me” also among

internal stakeholders. (Notably, this is as of today often anticipated to be done in economic terms.) Arenas for such discussions may be educational occasions but it also comes natural when life cycle targets are set in the organization. Similarly a discussion needs to be held on who is expected to be actively involved.

Advance knowledge and understanding – A common understanding of the life cycle perspective cannot be taken for granted, a fact that has been shown in both studied cases and previous research. Understanding is necessary on the life cycle perspective in general, but also more specifically on the nature of the own products' life cycles, something that might be missing even among appointed product managers. Knowledge can be supported through hands on educations as well as knowledge sharing and exchange of experience among internal and external actors.

Make knowledge possible – Surprisingly few technical barriers or enablers were put forward in the case studies. Those still stressed regarded mainly means to know and follow up on progress due to e.g. lack of separate energy measuring equipment, but also inadequate access to supplier or customer specific data, or internal data systems not adapted to report on a suitable format for life cycle actions. The availability of such feedback is important to learn and improve from previous work.

Assist in the transition from strategic to operative

It is not unusual that life cycle targets are set in the organization on a strategic level, without further guidance on how to get there. Thus the ambition is “clear in theory” but not what needs to be done in everyday practice.

Invest in translation – and translators – It is repeatedly seen in the case studies that life cycle work is not operationalized outside the environmental departments, despite ambitious targets set. One reason being corporate functions not recognizing their roles and responsibilities. Another reason is lack of understanding how strategic ambitions translate to operational action. The case studies point to the importance of dedicated translators, taking on the role of mediating from strategy to operation. Most successful is when this translator has the time and mandate to work specifically with this translation in collaboration with affected units. In particular, behavioral changes need both a translation to operational work, and sustained coaching to set the new behavior.

Talk the right language – A company has many voices, cultures and motives. To speak the “right language” to different functions in the organization is considered essential to reach out in the organization. This include to translate ambitions and effects in terms central to each function, such as market shares, kWh or m tons produced, but it is also about knowing and using the technical and cultural way of talking in each department. The understanding and adaption to each target groups' rationales and ways of talking was one of the most stressed enabler for life cycle action emphasized at the industry workshop.

Provide visual examples – Examples of actions and effects can have great pedagogical potential in showing what is possible in a context close to the employee. If internally or externally monitored, it can be increasingly motivational, if externally exhibited. Internal examples can be made as examples and test pilots

of suggested practices. “Bad examples” are less accepted, but may well be as illustrative on effects of different actions.

Boost motivation and commitment

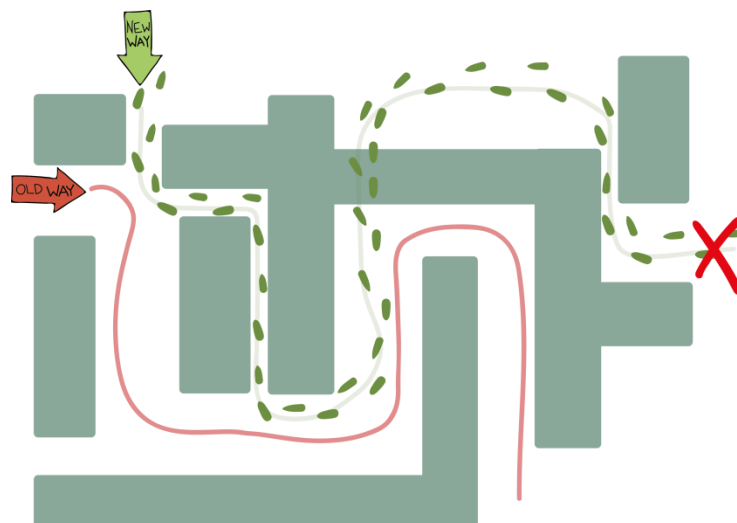
Knowledge and understanding is in many cases not enough for action. Formal and creative ways to create and increase attention has shown to be effective in achieving higher performance and commitment.

Ensure frequent follow up – Frequent follow up helps keep focus and commitment to a specific task. This can be achieved through hard targets and KPI, as discussed above, but also through softer means such as continuous reconciliations and pep-talks by project leaders and specialists.

Create attention – In the case studies we saw several examples of how attention to achievements made were created over and above corporate wide targets and KPI. A reoccurring example was more or less formal competitions and awards, spurring employees and groups to increase their ambitions (for example the best energy saver is awarded). Being the first in some respect, e.g. the first carbon-neutral site of its kind, also has the potential to increase motivation in the entire organization, from operation managers to public relation officers.

Seek or create a way forward

With an unclear immediate business case, divergent priorities and lack of shared understanding and commitment in the organization, it is surprising how much progress is still made. In the case studies made this can mainly be derived to devoted people constantly seeking their path through the organizations, advancing where it is possible for the time being, rather than acting on a predefined strategy.



Barriers and enablers

Organizational settings such as how people are arranged in departments, levels in the hierarchy, what collaborations to start with, the set up and manning of projects

and strategies etc. were seldom explicitly mentioned by the respondents as being barriers for energy efficiency in value chains. Yet, such aspects were commonly referred to when the respondents talked about how they managed to proceed in their respective project. A large share of the enablers identified in the case studies were about how to make use of, or manage to walk around, existing organizational set ups and interests to be able to step by step “create” a way forward in the organization.

Examples of barriers identified in the study:

- Other focus and /or lack of interest in various parts of the organization.
- Reluctance among existing functions to change the way they work.
- Insecurity among staff, e.g. sales force uncertain in how they talk with customers about life cycle benefits.
- Complex product chains or multitude of functions and products
- Immature (1st tier) suppliers and/or customers not willing to discuss life cycle strategies and improvements.
- Nedprioritringar och omstarter i organisationen
- Legacy in existing structures; there is already a set of production facilities competences etc. optimized in another logic (from workshop).

Examples of enablers identified in the study:

- The set-up of good examples and/or pilots internally showing a certain direction is possible.
- Favorable conditions or room for action (by chance): just enough to do at a certain period of time, profitable product, managers showing interest etc.
- Ability to find a “fast lane” in the organization, e.g. reduced levels of middle managers or the creation of specific project associated with time, resources and follow up.
- The use of “islands of interests” in the organization, wherever they turned out to be.
- Personal interest among employees

Our case studies show that acts of life cycle thinking still often has the character of ad-hoc work, even in well experienced and ambitious companies. Identified barriers and drivers point to the importance of a champion that finds resources in different ways, and adapt to the realities in different parts of the organization. Similar phenomena have early on been recognized in relation to LCA practice, (see e.g. Baumann 1998), and can be interpreted as life cycle thinking still not being institutionalized in the organization.

Ways of working

Ways of working related to seeking and creating a way forward emphasize the importance of devoted people passionate about making progress, but also how they find their way forward in the organization, like in a labyrinth, using existing and created stepping stones to proceed.

Anticipate and meet reluctance

Change leads to uncertainty in both the value chain and the organization as such. An important piece of the puzzle is to anticipate and keep barriers low, and not at least talking the right “language” to suit different functions.

Meet internal and external concerns and uncertainty – Particular functions and department might need technical support through guidelines, data, checklists and education to include energy efficiency aspects in their work. They may also need assistance in formulating arguments for changed practices against their respective internal and external stakeholders. Examples being sales people or project managers needing assistance in arguments other than price and performance. The use of a third party actor may help provide credibility and legitimacy in this process.

Keep initial investments low - Low initial investments in e.g. time and commitment decrease reluctance and perceived risk in the organization and may allow for some internal learning and testing before any formal statements.

Seek beneficial conditions

A bit of “luck” or beneficial circumstances such as co-development with other goals, interested managers, just enough to do or profitable products seems to have enabled many forms of progress in the studied cases. In an organization you can either search for the beneficial conditions, or try to create them.

Bypass or redefine organizational structures –There may sometimes be a need for new thinking in company organisational structure in order to allow life cycle-based innovations. In a previous study by Rex (2007), AB Volvo’s work to develop a hybrid truck turned out to require a reorganization of technological development units, since production of the powertrain could no longer be divided up as before. Suggestions of new practices and ways of thinking can also have difficulties to survive many levels of middle managers with their specific (and divergent) context and motives. Temporal project settings bypassing existing structures, and ultimately new ways of organizing in line with extended life cycle thinking might be needed.

Formalize the function of a sustainability leader – Literature as well as the case studies all show the importance of a devoted life cycle entrepreneur. Instead of waiting for such informal champion to emerge, a company can specifically appoint a role with this specific mission. Preferably such “sustainability leader” should have both business and environmental background to manage the challenges of translation and adaption to diverging contexts as previously discussed.

Recruit managers based on core values – The interest and priority of managers at different levels were repeatedly seen in the case studies as enablers to proceed with life cycle actions. In the workshop it was pointed out that this interest can also be proactively managed, for example by ensuring core values as part of the personal profile in (top) management recruitment.

Start where it is possible

Notably progress in the studied cases is not necessarily made where it has the main environmental or economic impact. Rather progress is made where it is possible to progress.

Team up with likeminded in the value chain – Many customers and suppliers are reluctant to challenge existing routines, and a way forward seems to be to align with companies showing similar green ambitions even if these are found among your 2nd or 3rd tier suppliers or customers.

Team up with likeminded in the organization – Similar to approaching likeminded actors in the value chains, life cycle champions in the companies seems to use islands of interest internally to set examples and show possible practices, for example first introducing a specific measure in small test scale in an interested business unit.

Recognize that change takes time – Life cycle thinking in practice may induce quite radical changes in both the company and the society at large. Not least changes in behavior take time as well as sustained patience and support. There might also be a great inertia in existing technical and personal infrastructure, such as production capacity or competence profiles, making existing systems very reluctant to change.

Impact on energy efficiency

Each of the cases described above include assessments of potential for reduction of energy use. Below these potentials are summarized and commented. Finally, some conclusions are drawn.

Theoretical, practical/semi-empirical and actual improvements

In the case studies, different types of efforts to increase energy efficiency (in one case climate impact reduction) in product life cycles were described and, to some extent, quantified. Some cases are about already (or almost already) implemented measures, while others are about targets that reflect ambitions and directions, though details on implementation is lacking or left out. The approach in all cases was to identify a theoretical potential, reflecting a situation where the full potential of the target is achieved, a practical (or semi-empirical) potential, based on experience or assessments on what improvements that usually or probably can be expected, and finally (where applicable) actual reductions achieved in the specific case.

The distinction between theoretical and practical potential has also been made in the building sector, for example, where studies e.g. point to a theoretical reduction potential of CO₂ emissions of 60-70% for buildings (Mata, 2013; O'Brian 2012), while others show the practical reduction potential for property managers to be about 40% energy reduction (Dalenbäck et al 2005).

In our calculations, input data on the specific case has been taken from the case studies described on page 28-66, with complementary information for the assumptions and calculations made sought from literature or other sources. Effects are expressed in energy units, and corresponding CO₂ equivalents have been calculated by means of life cycle based emission factors for related energy carriers. In the case where climate impact reduction was the target parameter, the energy use was calculated correspondingly. These figures are summarized in Table 1 - 6, which also indicate where in the supply chain that GHG emissions reductions (and reduction in energy use) take place in relation to the case company, using the categorization in three broad scopes described in e.g. the GHG protocol® (WRI/WBSCD, 2015):

Scope 1: All direct GHG emissions.

Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.

Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. transmission and distribution losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

Table 1-6 is only aimed at illustrating examples and order of magnitude for the effect of different types of actions. Although the figures in the tables below are based on actual case studies, it must be emphasized that they represent rough estimates of yearly reductions in energy use and with assumptions made on actual energy carriers. Furthermore, the time for implementation differs, causing temporal asymmetries between different cases. Finally, the conversion between energy use and GHG emissions and vice versa is based on emission factors from literature or commercial LCA software, and not on case-specific data.

Conclusions

Although the quantification of the impact on energy efficiency estimated in the cases are very case-specific and includes many assumptions, they support the following conclusions:

- In the production of active products (i.e. products that require input and/or influence other products during the use phase), energy efficiency measures beyond own activities generally have a (much) higher energy efficiency potential than measures in own activities.
- The actual and/or semi-empirical potential is generally very much lower (10 % or even less) than the theoretical potential.

Table 1 Case "15 % idle electricity". Summary of estimated potential for reduction in energy use and greenhouse gas emissions. Case- specific input data extracted from the case study (page 35-38), other input data from literature or other sources.

Case: "15% idle electricity", energy project within Volvo CE		
Data for the calculations below:		
<p><i>Theoretical reduction potential:</i> At the end of 2013, before the global energy project started, six factories together had a potential of reducing energy use with approximately 16,800 MWh per year if they reduced their idling consumption also on the weekends, from Friday afternoon to Monday morning (58h) to 15% of consumption during production. Data for actually realized reduction is not available.</p> <p>For the calculation of the targeted reduction in GHG emissions, emission factors for average European electricity mix (ESU services, 2015) of 462 g CO₂eq/kWh (Gode et al 2011) have been used.</p>		
Yearly reduction	GWh	kTon CO₂eq
Theoretical reduction potential (target)	16.8	7.8
Practical/semi-empirical reduction potential (target)	Not available	Not available
Actually realised reduction	Not available	Not available
Relation between empirical or (where available) actual reduction and theoretical Potential	---	---
Reduction in life cycle stage(s)	Scope 1 and 2 ³	

³ Scope 1: All direct GHG emissions. Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.

Table 2 Case "Office building". Summary of estimated potential for reduction in energy use and greenhouse gas emissions. Case- specific input data extracted from the case study (page 38-42), other input data from literature or other sources.

Case: Office building, Volvo Real Estate		
Data for the calculations below:		
<i>Actually realized reduction:</i>		
The office building described in the case had an energy consumption in 2010 of 65 kWh/m ² . The average energy of a comparable office building has been estimated to around 200 kWh per square meter and year (Volvo Global Magazine 2011). In the office building project the aim was to reach half of this, i.e. 100 kWh/m ² .		
Assuming a floor area for the office in question of about 7 000 m ² (Weber 2015), the practical improvement aimed for was: (200 * 7 000) – (100 * 7000) = 700 000 kWh		
In practice, the final energy consumption was better than expected (65 kWh/m ²), and the actually realized improvement was: (200 * 7 000) – (65 * 7000) = 945 000 kWh		
<i>Theoretical reduction potential:</i>		
Since there is no data available for total office area of Volvo Globally, we are using data for office buildings in Sweden as a theoretical comparison. According to SCB (2012), there is about 28,100,000 m ² of office buildings in Sweden. Assuming 10% being (re)built every year, and the current average value being 121 kWh/m ² (ES 2015:05), the theoretical improvement if these offices went from 121 kWh/m ² to 65 kWh/m ² corresponds to: 0,1*(28 100 000)*(121-65) = 157 360 000 kWh		
For the calculation of the targeted reduction in CO ₂ eq, we approximate all energy use to be district heating in Sweden, using an emission factor of 88,6 g CO ₂ eq/kWh (Gode et al 2011).		
Yearly reduction	GWh	kTon CO₂eq
Theoretical reduction potential (10% of all offices in Sweden)	(157)	(13.94)
Practical/semi-empirical reduction potential (target for one single building)	0.7	0.06
Actually realized reduction (one single building)	0.9	0.08
Relation between empirical or (where available) actual reduction and theoretical potential	Not applicable	Not applicable
Reduction in life cycle stage(s)	Scope 1 and 2 ⁴	

⁴ Scope 1: All direct GHG emissions. Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.

Table 3 Case "Group objective on energy efficiency in production". Summary of estimated potential for reduction in energy use and greenhouse gas emissions. Case- specific input data extracted from the case study (page45-48), other input data from literature or other sources.

Case: "Group objective on energy efficiency in production" Ludvika plant, ABB Group		
Data for the calculations below:		
<p><i>Theoretical reduction potential:</i> ABB has committed to reducing energy intensity by 20% per dollar of revenues in its own operations by 2020 from a 2013 baseline. This target includes both direct fuel consumption and the use of electricity and district heating for manufacturing processes and to operate buildings. The figures below represent the theoretical target for 2020 and onwards for the energy use at the plant in Ludvika, based on energy use in 2013 (72,000 MWh electricity, 2,200 MWh natural gas, 4,800 MWh oil and 7,700 MWh district heating), using current mix of energy carriers and a conservative approach of constant sales:</p> <p>$0,2 \times (72,000 + 2,200 + 4,800 + 7,700) = 17,400$</p> <p>For the calculation of the yearly reduction of GHG emissions, emission factors from Gode et al (2011) have been used: Electricity mix Sweden 36,4 g CO₂eq/kWh Natural gas 248 g CO₂eq/kWh Oil Eo1 288 g CO₂eq/kWh District heating Sweden 88,6 g CO₂eq/kWh</p> <p><i>Actually realized reduction:</i> The actually realized reduction so far is 1,287 MWh electricity and refers to 2014 with 2013 as a baseline. For the calculation of the yearly reduction of GHG emissions, the emission factor for Swedish electricity mix above has been used. The payback period for different measures varied between 5 months and 7 years.</p>		
Yearly reduction	GWh	kTon CO₂eq
Theoretical reduction potential (target 2020)	17.4	1.1
Practical/semi-empirical reduction potential (target)	Not available	Not available
Actually realised reduction	1.3	0.05
Relation between empirical or (where available) actual reduction and theoretical Potential	7%	4%
Reduction in life cycle stage(s)	Scope 1 and 2 ⁵	

⁵ Scope 1: All direct GHG emissions. Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.

Table 4 Case “From selling energy efficient motors to selling energy service”. Summary of estimated potential for reduction in energy use and greenhouse gas emissions. Case- specific input data extracted from the case study (page 48-51), other input data from literature or other sources.

Case: “From selling energy efficient motors to selling energy efficiency service” ABB Group		
Data for the calculations below:		
<p><i>Theoretical reduction potential:</i> The global savings in electricity from using ABB drives has been assessed to 445 TWh in 2013 (ABB, 2015b). From experience in ABB, the actually realized savings generally correspond to about 20% of the theoretical potential, which thus would amount to a theoretical reduction of, roughly, 2,200 TWh per year. If the revenues related to energy efficiency and renewable energy increased by 20% in 2020, and assuming the current rate of global savings in electricity from additional products and services, this would correspond to an increase in theoretical electricity savings globally at customer level to about 2,670 TWh per year in 2020.</p> <p><i>Semi-empirical reduction potential and actually realized reduction:</i> If the revenues related to energy efficiency and renewable energy increase by 20% in 2020, and making the same assumptions as above, the use of ABB drives would correspond to an increase in electricity savings globally from 445 TWh to 534 TWh per year.</p> <p>For the calculation of the corresponding GHG emissions, emission factors for average European electricity mix (ESU services 2015) of 462 g CO₂eq/kWh (Gode et al 2011) have been used.</p>		
Yearly reduction	GWh	kTon CO₂eq
Theoretical reduction potential (target 2020)	2,670,000	1,234,000
Practical/semi-empirical reduction potential (target 2020)	534,000	247,000
Actually realised reduction (2013)	445,000	206,000
Relation between actual reduction and theoretical potential	20%	20%
Reduction in life cycle stage(s)	Scope 3 ⁶	

⁶ Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

Table 5 Case “Target on reduced carbon footprint across the value chain”. Summary of estimated potential for reduction in energy use and greenhouse gas emissions. Case- specific input data extracted from the case study (page 53-60), other input data from literature or other source

Case: Target on reduced carbon footprint across the value chain, AkzoNobel		
Data for the calculations below:		
<p><i>Theoretical reduction potential:</i> One of AkzoNobel’s sustainability targets is to reduce the carbon emissions across the value chain by 25 to 30% per ton by 2020 (2012 base). In 2014, AkzoNobel had a total carbon footprint of 26.9 million tons CO₂, of which 4 million tons was in own operations. A reduction with 25%-30% of the carbon footprint would then imply reduced carbon footprint with around 7 million tons CO₂e per year from 2020 on (assuming the same sales volumes 2020 as in 2014). Approximately 90% of the carbon footprint corresponds directly to energy use.</p> <p>In the calculations below, the energy mix in the value chain is assumed to consist of European electricity: 7 million tons CO₂eq out of which 90% is related to energy => 6.3 million tons CO₂eq Emission factor for European electricity = 0,462 kg CO₂eq/kWh 6 300 000 000 kg CO₂eq / 0, 462 kg CO₂eq/kWh = 13 600 000 000 kWh</p> <p><i>Actually realized reduction:</i> 2013 resulted in 2% reduction of carbon footprint cradle to grave per ton of sales, but in 2014, the result was an increase in carbon footprint with 4% compared to the 2012 baseline of 26.9 million tons of CO₂. This would imply a net increase of approximately 2% net increase compared to the 2012 baseline of 26.9 million tons CO₂:</p> <p>Carbon footprint reduction (26.9-26.9 x 0.98 x 1.04) million tons CO₂eq = - 516,480 tons CO₂eq 90% is related to energy => 465,000 tons CO₂eq Emission factor for European electricity 462 g CO₂eq/kWh Realized reduction in 2014 = 465 000 000 / 0,462 = 1 006 000 000 kWh</p> <p>For the calculation of the corresponding reduction in yearly energy use, emission factors for average European electricity mix (ESU services, 2015) of 462 g CO₂eq/kWh (Gode <i>et al</i> 2011) have been used.</p>		
Yearly reduction	GWh	kTon CO₂eq
Theoretical reduction potential (target 2020)	13,600	7,000
Practical/semi-empirical reduction potential (target 2020)	Not available	Not available
Actually realised reduction (2014)	-1,006	-516.5
Relation between empirical or (where available) actual reduction and theoretical potential	-7%	-7%
Reduction in life cycle stage(s)	Scope 1-3	

Table 6 Case “The Intersleek® eco-premium solution in marine coatings”. Summary of estimated potential for reduction in energy use and greenhouse gas emissions. Case- specific input data extracted from the case study (page 61-66), other input data from literature or other source

Case: Intersleek® marine coatings, AkzoNobel		
Data for the calculations below:		
<p><i>Theoretical potential:</i> One scenario made by AkzoNobel shows that if all ships (that the coating is suitable for) were coated with Intersleek, CO₂ emissions worldwide could be reduced by 90 million tons each year (International Marine 2011).</p>		
<p><i>Semi-empirical potential:</i> Current market uptake was estimated in the case study to be about 5%. Assuming that the 90 Mtons saving represent 100% of the possible market, a 5% uptake would lead to savings of 4,500,000 tons CO₂ annually.</p>		
<p><i>Actually realized potential:</i> A more conservative calculation on Intersleek 900 alone, based on the information that at least 350 large ships were coated with Intersleek®900 in 2014 (Criminna and Pagliaro, 2015), and that a single large crude carrier may reduce its carbon dioxide emissions by 6,200 tonnes CO₂ per year by using Intersleek®900, gives about 2 Mton CO₂ savings achieved.</p>		
<p>For the calculation of the corresponding energy use, an emission factor of 317 g CO₂eq/kWh for ship fuel from Gode <i>et al</i> (2011) has been used.</p>		
Yearly reduction	GWh	kTon CO₂eq
Theoretical reduction potential	284,000	90,000
Practical/semi-empirical reduction potential	14,200	4,500
Actually realised reduction	6,850	2,170
Relation between actual reduction and theoretical potential	2%	2%
Reduction in life cycle stage(s)	Scope 3 ⁷	

⁷ Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

Impact on competitiveness

The potential competitive advantage of having a value chain perspective is often emphasized in literature (see. e.g. CPM, 2013; Greenovate!Europe, 2012, Sonnemann Margini, 2015), the rationale being cost savings in reduced energy, resources and emissions as well as enhanced image and possibilities of differentiation. Yet in each specific business case direct benefits are not always evident.

In the cases of this study, a general contribution to the overall companies' image and stakeholder relation was more pronounced than direct benefits on the market. Still, we have seen that image could be substantial for success in major contracts and sustained positions on the market. Interviewees also point to the (growing) importance of demonstrating value chain actions and ambitions to investors and shareholders.

Taken together, a value chain perspective on energy efficiency seems to be of great importance for long term competitiveness in industry, yet still a challenge to identify and motivate in specific business situations.

Implications for policymaking

In the analysis above, we have seen several examples of barriers to life cycle energy efficiency. Some of them may be overcome by enablers found or created within the company – these are described in the “ways of working” above. The elimination or at least reduction of other barriers was found to call for policy action. However, the literature review, the case studies and the project workshop made it obvious that current national energy efficiency target and national climate impact targets do not account for energy use and climate impact in a life cycle perspective. Below, recommendations for policy making that came up during the project workshop are listed.

Most policy recommendations related to the theme of *finding and sharing the life cycle benefits*:

- Put legal requirements on life cycle energy efficiency on the relevant step in the value chain, and relate them to output (products or services provided) rather than production plants or units;
- Form platforms for long term cooperation; where industry, academia, NGO and policy actors can discuss, identify and create new ways for governance of value chain;
- Support (verbally and financially) global initiatives in the life cycle area e.g. between US and Europe such as global LCAccess, and involvement and support in standardization;
- Consult business before new regulations are developed and adopted, and harmonize regulation across authorities for consistency.

When it comes to the area of *getting priorities in line*, the following areas of recommendations for policy making were put forward:

- Make economic incentives and environmental impact coincide as described by Causean theory and the concept Value chain stewardship (see e.g. Cerin 2006)
- Transform or complement national targets on environment and energy use to life cycle based targets.
- Set up processes for innovation procurement based on energy performance in a life cycle perspective

The two themes *Enable and encourage action, and seek or create a way forward* both represent mainly internal processes in the organization, on which policymaking might not be expected to provide so much direct influence. Yet, many of the suggestions of the other themes, such as demanding life cycle goals, facilitating sharing of risk and profit, creating forums for governance in supply chains etc. will also most likely have an impact on life cycle thinking being higher on the agenda of companies, indirectly facilitating the possibilities to find ways forward.

The act of policy can also be important in creating the sustainability leaders needed in industry, by encouraging life cycle thinking to be part of higher education curricula. It is also important to recognize that change takes time, and that policymakers are patient in their efforts, for example support not only research but also implementation/demonstration, and provide long term arenas for exchange and further development.

Additional recommendations to policy thus include:

- Support implementation and demonstration of research results
- Seek ways to integrate life cycle thinking in higher education, not only in science based curricula.
- Recognize that transition of large industries and systems takes time

Discussion and further work

This report points to the premises for large companies to further their role in extending the scope of optimization of energy use from a single operation to a full value chain. A range of different ways of working has been identified, in particular on how to proceed in the internal work of multinational corporations.

Practical implications

Although studied companies are knowledgeable in life cycle thinking since many years, and with strategic targets in place, many life cycle actions still show an ad-hoc nature. To take the next step, the results point to the need for truly making life cycle thinking a strategic issue, with the consequences that call for e.g. rethinking about collaborations in the value chain, key performance indicators, recruitment strategies and business models. To date many strategic ambitions exist in theory, but its operationalization is left to be performed by each unit separately within current priorities and practices, and in an organization with divergent contexts and deficient understanding of the implications for daily work.

Large multinational companies with strong brands are sometimes seen as having particular good conditions for life cycle management (Sonnemann et al. 2015). Yet it must be remembered that among thousands of employees, there are thousands of understandings, contexts and priorities. A company does not have one voice, but many, and changing logic takes time. The recommendation to express, or jointly develop, “what is in it for me” is as valid for actors in the value chain as it is for different functions of an organization.

Over and above these internal premises, that have been in focus in this study, is a need for a wider discussion in society, on who or what could and should coordinate entire value chains, and possible need for societal incentives for such development. What are the responsibilities, possibilities and rules of game to go from product and process improvement to changing sub-systems such as value chains, and, ultimately, changing the entire system in a socio-economic perspective, illustrated in figure 23.

Such a development will most likely require a discussion about who manages the life cycle, sustained arenas for joint development among industry, academia and policymakers, and further research on how to share risks and benefits within and across actors in the value chain.

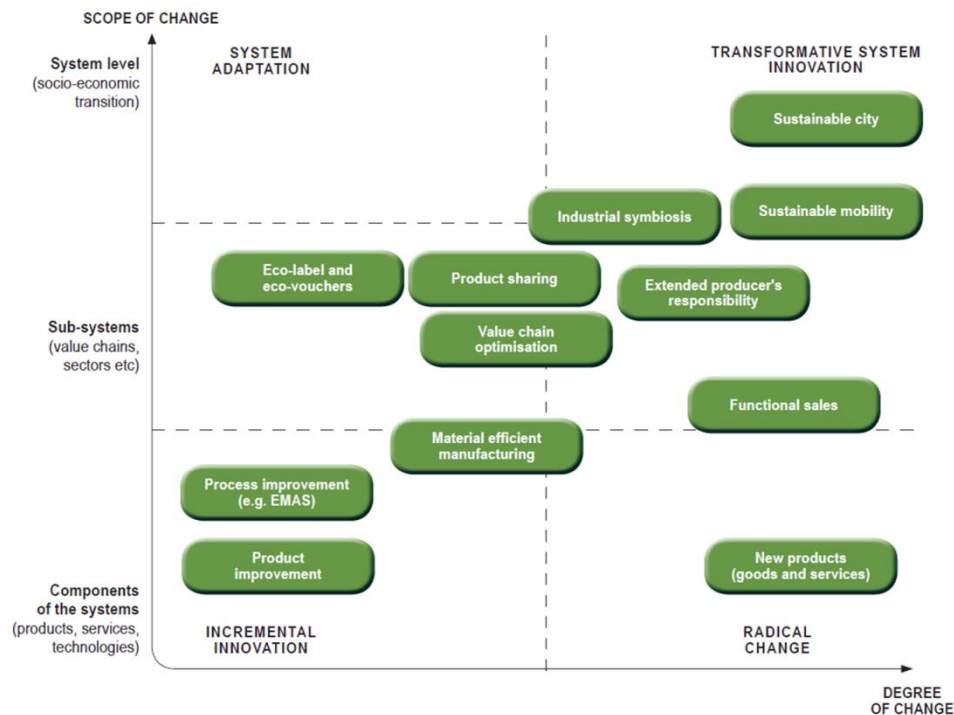


Figure 23. “From product improvement to transformative system innovation”, from Meidzinski (forthcoming) in Ecoinnovation Observatory (2013).

Reflections in relation to literature

The studied companies in this report are all well experienced in LCM, with strategic capacity in top management support, strategies and goals for their life cycle ambitions, organizational capacity in senior LCA experts and tools in in-house sustainability departments and, finally, a key position in their value chains, all of which are important aspects for success according to the literature. And although many good examples can be reported on, there are still major barriers and obstacles for systematic action and radical results.

Life cycle thinking competes with many logics of a company and the utopian image of a common direction is hard to find. This is something that the literature often seems to overlook. We welcome more research on practical integration and adaptation of life cycle thinking in different kinds of corporate functions, as well as a discussion on who needs to know and do what in multinational companies: What roles and functions are most critical to address?

A wider understanding of the life cycle perspective is often claimed as important for progress, this report included. However, what is important in one life cycle is not necessarily so in another, and companies are part of many life cycles. In fact, operators’ understanding of the life cycle perspective of one product may even reduce the perceived need to work with issues less important in this life cycle, but vital in another context. Such discussion of intersecting life cycles, and of the mix of products and processes a company contributes to, is rarely found in the literature.

Literature on energy efficiency in value chains also needs to better describe and demonstrate the business benefits of this work. Such benefits are most often just taken for granted, but may be difficult to quantify and motivate in practice, not least with today's low energy prices. Governmental agencies indeed have a role in providing incentives, but researchers and businesses also need to come together to develop methods for finding, demonstrating and sharing life cycle benefits.

Finally, the above discussion on who are, or could be, the brokers and leaders for system innovation in entire value chains (or systems of life cycles), would also benefit from a further transdisciplinary exploration. There are a range of concepts touching upon this issue from different perspectives including e.g. focal companies (see e.g. Seuring, 2004; Kogg, 2009; Kovács, 2008), product chain organizations (see e.g. Baumann, Brunklaus, et al 2015), product stewardship (Hart, 1995; Hart and Milstein, 2003; Hart and Dowell, 2011), value chain stewardship (see e.g. Cerin, 2006) and governance of supply chains (see e.g. EU, 2015; CSR Vast, 2011; Zanden, 2015; Locke et al 2013).

Conclusions and recommendations

By studying organizational challenges for companies working with energy efficiency in value chains, this study has sought better understanding of why many companies still struggle with implementing life cycle management, despite good intentions to do so. With life cycle assessment (LCA) experts and tools in place, challenges may yet relate to intra-organizational aspects (like translations, tradeoffs and budgets) or lack of incentives and trust along the value chain. This study further explores such challenges, with particular interest in energy efficiency along the value chain, illustrated in figure 24.

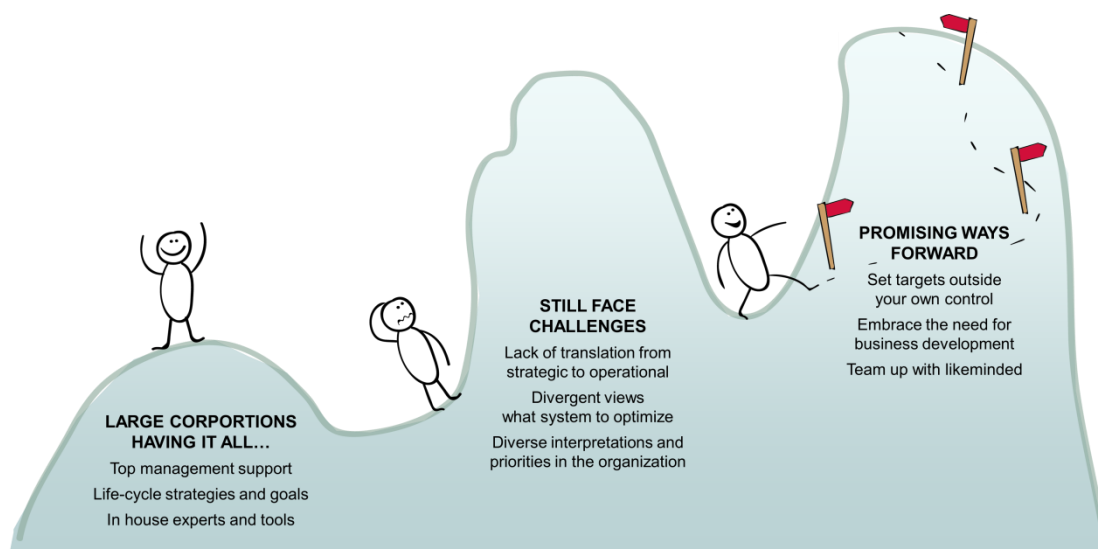


Figure 24. Some examples of premises, challenges and ways of working found in the study.

Despite favorable conditions, many challenges exist. Strategic challenges include lack of translation from strategic to operational levels, and divergent views on what system to optimize. Intra-organizational challenges include diverse interpretations and priorities of the many employees, with their respective context and trade-offs. Examples of challenges along the value chain are split motivations and weak stakeholder interest. In the study a range of promising ways forward was identified, further explored below.

Recommendations to industry

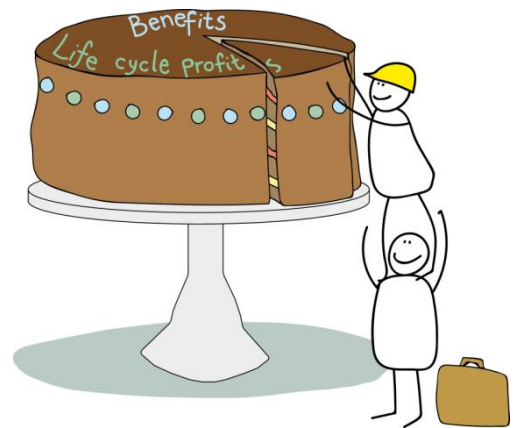
There is no single way of working for increased energy efficiency in value chains, but many. Therefore, there is a need to work on many levels simultaneously, and at the same time adapt to the specific premises for each company. Although all case

studies in this project were unique in their specific settings and results, similarities could be found in barriers and enablers experienced, resulting in four strategies for progress in which identified ways of working could be categorized.

Find and share the life cycle benefits

Find and share the life cycle benefits relates to the procedure of extending the scope of optimization from a single company to entire value chains, and what implications this extended scope will have on business models and practices. This includes both a rethinking of the practices and scope of business of today, and how to deal with the sharing of risks and benefits with related actors. Identified ways of working relate to how companies can:

- **Optimize a broader system**, e.g. through setting energy efficiency targets on the entire value chain.
- **Challenge existing business models and practices**, including outsourcing, product portfolio strategies, and sales of products vs services
- **Deal with changed cost-benefit distribution**, in the value chain, through new models for the sharing of risk and profit, possibly with the assistance of a third party.



Get focus and priorities in line

Getting focus and priorities in-line is based on the observation that many divergent focuses and priorities exist today acting as a barrier to life cycle work. Ways of working include managing complexity, as well as making life cycle thinking, both in environmental and economic terms, influence strategic decisions, prioritization, targets and KPIs.

- **Dare be strategic!** Life cycle thinking will not permeate company action in a systematic way unless strategic targets also show in company incentives and follow up.
- **Manage potentially conflicting goals**, such as possible tradeoffs between financial and environmental targets, but also among potentially competing environmental goals e.g. internal efficiency vs. life cycle improvements.

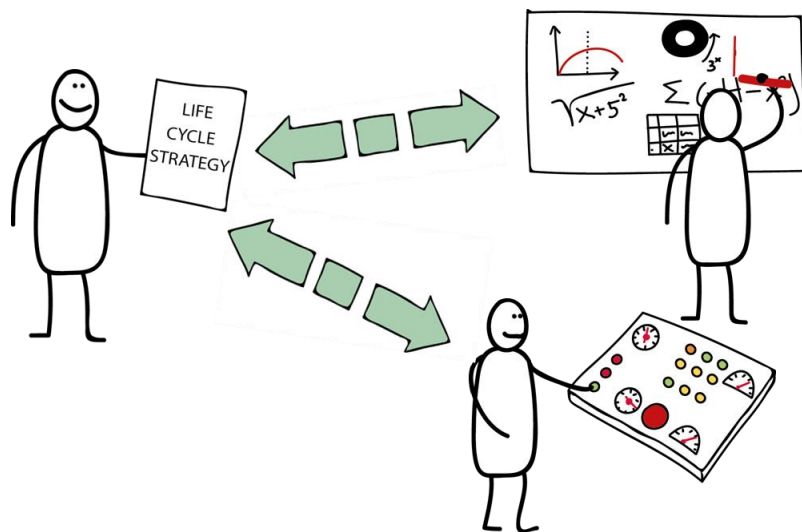


- **Formulate KPI and ensure follow up**, a challenging task that is surprisingly often neglected but powerful if performed well.

Encourage and enable understanding and action

The strategy of encouraging and enabling understanding and action points to the need of increasing knowledge and understanding of the life cycle perspective within the different functions of the organization, including the translation of strategic ambitions into operational work at different levels. Identified ways of working were:

- **Support in-house capacity and understanding**, by discussing rationales for engagement, invest in education and knowledge sharing and provide data for follow up and learning.
- **Assist in the transition from strategic to operative**, by recognizing the need for appointed translators, and adapting language and support to each function.
- **Boost motivation and commitment**, through e.g. pointing out what is unique, frequent follow up and appreciative attention to achievements made.

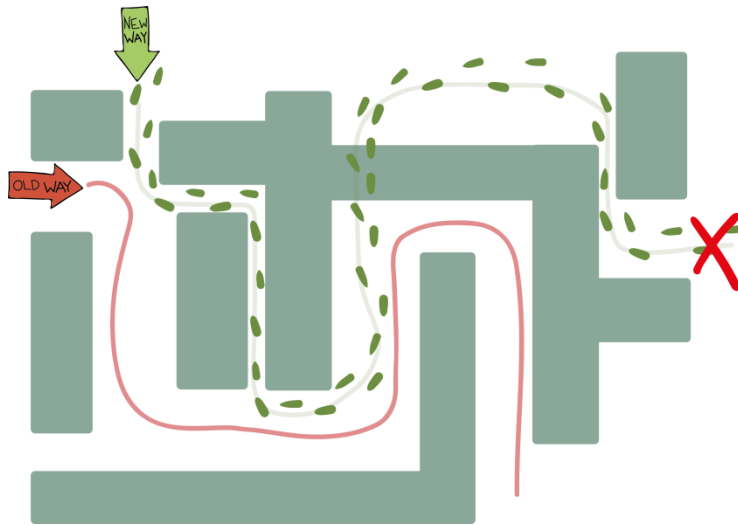


Seek or create a way forward

Seek or create a way forward is primarily about how to proceed internally when priorities, incentives and structures are not supportive enough as is. Identified ways of working to progress before formal structures are set include to:

- **Anticipate and meet reluctance and insecurity**, by proactively assisting with rationales and arguments, possibly with the use of third party actors.
- **Seek beneficial conditions**, such as a “fast lane” to interested managers, resources to a specific project, or co-development with other goals.

- *Start where it is possible*, e.g. by teaming up with partners showing interest, internally as well as in the value chain.



Potential for life cycle energy efficiency – theory and practice

From the quantification of life cycle energy efficiency measures and climate impact reductions in the case studies it was concluded that energy efficiency measures beyond own activities generally have higher energy efficiency potential than measures in own activities in the production of active products (e.g. products that require input and/or influence other products during the use phase). However, policy making is needed to unlock these more important energy efficiency potentials.

It was also concluded that the actual and/or semi-empirical energy efficiency potential is generally very much lower (10 % or even less) than the theoretical potential.

Recommendations to policy

From a national authority point of view, it would be desirable to optimize the use of financial and other resources targeting increased energy efficiency and reduced greenhouse gas emissions. In this project we have shown that the potential for improvements often is higher in value chains than in single operations. However, as life cycle stretches across actors and countries, policymaking need to consider how to transform national environmental targets and national energy use targets to life cycle environmental and energy use targets. Legal requirements can e.g. be set on life cycle energy efficiency, applied on the relevant step in the value chain,

rather than production plants or units. Also policy can support global initiatives in the life cycle area such as standardization, incentives and regulations.

Policymakers have an important role to play in “getting priorities in line”, through making economic/market incentives and environmental impact coincide. One example is processes for innovation procurement based on energy performance in a life cycle perspective. Finally national and international governments can act as catalysts for wider system innovation by hosting forums for governance in supply chains, support not only research but also implementation and demonstration, and seek ways to integrate life cycle thinking in higher education.

Next step

This report points to the needs and premises for companies to elaborate on their role in extending the scope of optimization of energy use from a single company to a value chain. A range of different ways of working has been identified, in particular on how to proceed in the internal work of multinational corporations. A PowerPoint presentation illustrating ways of working identified in this project has been developed to assist in the internal dialogue in industry and other interested organizations.

To this end, it must also be recognized that change in value chains is not the work by single actors. More profound changes are needed in the entire system of actors, to go from product or process improvement to system innovation. Important questions to discuss include who can and should be the “agent of change” for such development, how risks and profits can be demonstrated and shared and what societal incentives might be needed. These are hopefully areas for further research and joint developments between industry, academia, institutes and governmental agencies.

References

ABB (2014). Robot för billackering. <http://new.abb.com/se/om-abb/teknik/sa-funkar-det/robot-for-billackering> Besökt 2014-02-06

Arnfolk, P. T Brorson, Å Thidell, R Almgren (2008). Miljöarbete inom teknikföretag – utvecklingstendenser samt jämförelser med annan tillverkande industri. Internationella Miljöinstitutet IIIIEE, Lund.

Bauman, Brunklaus, Lindkvist, Arvidsson, Linden, Hildenbrand (2015). Populating the life cycle perspective: methods for analyzing social and organizational dimensions of product chains for management studies. ISIE Conference 2015. 7-10 July 2015 in Surrey, UK.

Baumann, H. (1998) *Life Cycle Assessment and Decision Making: Theories and Practices*. Göteborg : Chalmers University of Technology 1365.

Baumann, H. and Tillman, A. (2004) *The Hitch Hiker's Guide to LCA. An orientation in life cycle assessment methodology and application*. Studentlitteratur. Lund.

Belok (2015). Effektiv energi i lokaler. <http://belok.se/totalmetodikens-utbredning/> downloaded 4 August 2015.

Boons, Bauman and Hall (2012). Conceptualizing sustainable development and global supply chains. *Ecological economics* 83, page 134-143.

Brunklaus B., Hildenbrand J. and Sarasini S. (2013). Eco-innovative measures in large Swedish companies An inventory based on company reports. Vinnova analysis VA 2013:3.

Cerin, P. (2006). Introducing Value Chain Stewardship (VCS). *International Environmental Agreements* (2006) 6:39-61. DOI 10.1007/s10784-005-2193-4.

Chkanikova and Kogg. (2011). Greening food supply chains: Greening food supply chains: Analyzing the potential role of retailers in triggering/ensuring environmentally and socially responsible production of food. 1st CR3 Conference, Hanken School of Economics.

CPM (2012), CPM The Swedish Life Cycle Center, Operational plan stage 7, www.lifecyclecenter.se, Göteborg.

CPM The Swedish Life Cycle Center (2013). Life Cycle Based Innovation (LINN). CPM Report 2013:3

CSR Väst (2011). Hållbara inköp slutrapport. CSR Väst. <http://www.slideshare.net/csrvast/hllbara-inkp-slutrapport-2011>

Dalenbäck et al (2005). *Åtgärder för ökat energieffektivisering i bebyggelse*. Chalmers Energi Centrum report 2005:1.

Dalhammar, C. (2007). An emerging product approach in environmental law incorporating the life cycle perspective. Ph.D. thesis. International 62 Institute for Industrial Environmental Economics. Lund University, Lund, Sweden

Eco-innovation Observatory (2013) Europe in transition Paving the way to a green economy through eco-innovation Annual Report 2012. January 2013

Energimyndigheten (2015). *Bråttom med insatser för en hållbar energiomställning. Redovisning av uppdrag att utarbeta underlag inför kommande beslut om forskning och innovation.* Report Dnr 2015-2434
<http://www.energimyndigheten.se/globalassets/nyheter/2015/brattom-med-insatser-for-en-hallbar-energiomstallning.pdf>

ES 2015:05 (2015) Energistatistik för lokaler 2014 <https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=5512>

ESU-services (2015). Public LCI reports and datasets. <http://www.esu-services.ch/data/public-lci-reports/> visited October 2015.

EU (2015). Green public procurement EU level.
http://ec.europa.eu/environment/gpp/index_en.htm

European Commission (2010). European Commission - Joint Research Centre - Institute for Environment and Sustainability: *International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance.* First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union

Finkbeiner (2014). Product environmental footprint – breakthrough or breakdown for policy implementation of life cycle assessment? *International Journal of LCA* 19:266-271

Greenovate!Europe (2012). Guide to resource efficiency in manufacturing: Experiences from improving resource efficiency in manufacturing companies

Gode, J., Martinsson, F., Hagberg, L., Öman, A., Höglund, J., Palm, D. (2011). Miljöfaktaboken 2011 - Uppskattade emissionsfaktorer för bränslen, el, värme och transporter. Värmeforsk rapport 1183.

Hart, S. (1995). A natural-resource-based view of the firm. *Academy of Management Review*. 20(4): 986–1014.

Hart and Milstein (2003). Creating sustainable Value. *Academy of Management Executive*. vol. 17 no. 2 56-67.

Hart and Dowell (2011). *Invited Editorial: A Natural-Resource-Based View of the Firm Fifteen Years.* *After Journal of Management*. vol. 37 no. 5, 1464-1479.

Heiskanen (2000). Managers' interpretations of LCA: Enlightenment and responsibility or confusion and denial? *Business Strategy and the Environment*, 9, 239-254.

Heiskanen (2002). The institutional logic of life cycle thinking. *Journal of Cleaner Production* 10 (2002), p427-437).

Helldal, M. and S. Tenne, (2009). Positiva miljöeffekter i kölvattnet av lean produktion. Examensarbete, Institutionen för ekonomisk och industriell utveckling, Linköpings universitet, Tekniska högskolan. LIU-IEI-TEK-A-09/00551-SE.

Helldal, M., Tenne, S., Lindahl, M. (2009). Environmental benefits riding the coattails of lean production: can an integration of environmental aspects and lean production result in synergies and a reduced risk of sub-optimisation. Proceedings of EcoDesign 2009: 6th International Symposium on Environmentally Conscious Design and Inverse Manufacturing. EcoDesign 2009, 6-9 December in Sapporo, Japan.

IKEA Group (2014). IKEA Group Sustainability Report FY13

ISO (2006a). 14040:2006 Environmental management - Life cycle assessment – Principles and framework

ISO (2006b). 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines

IVA (2012). Energieffektivisering av Sveriges bebyggelse. Hinder och möjligheter att nå en halverad energianvändning till 2050. ISBN 978-91-7082-859-1.

IVA (2013a). Energieffektivisering av Sveriges industri. Hinder och möjligheter att nå en halverad energianvändning till 2050. ISBN 978-91-7082-865-2.

IVA (2013b). Energieffektivisering av Sveriges tjänstesektor. Hinder och möjligheter att nå en halverad energianvändning till 2050. ISBN 978-91-7082-870-6.

Jaggernath (2015). Green supply chain management. Journal of entrepreneurship, management and sustainable development. Vol 11, No 1.

Kogg (2009). Responsibility in the Supply Chain: Inter organizational management of environmental and social aspects in the supply chain - Case studies from the textile sector. Dissertation 2009:2 IIIIEE, LTH.

Kogg and Mont (2012). Environmental and social responsibility in supply chain: The practice of choice and inter-organizational management. Ecological economics 83, 154-163.

Kovács G. (2008). Corporate environmental responsibility in the supply chain. Journal of Cleaner Production 16 sid 1571-1578

Larsson and Gebert (2008). Leveranstörskedjor – förstudie kring kundkrav på energieffektivitet hos leverantörer. IUC Skåne, DNr 2008-001296.

Larsson, M., Cerin, P., Swanström, L., & Gottberg, A. (2009). Methods to improve energy efficiency in supply chains, Supply chain conference 2009.

Locke, R. M., Rissing, B. A., & Pal, T. (2013). Complements or substitutes? Private codes, state regulation and the enforcement of labour standards in global supply chains. British Journal of Industrial Relations, 51(3), 519–552.

Löfgren, B. (2009). Capturing the life cycle environmental performance of a company's manufacturing system. Environmental Systems Analysis, Department

of Energy and Environment, Chalmers University of Technology, Göteborg, Sweden. ESA-report 2009:13, ISSN 1404-8167.

Löfgren, B. (2012). *The green engineer as an enabler of life-cycle management in manufacturing: models and practices*. Göteborg: Chalmers University of Technology (Report - Department of Environmental Systems Analysis, Chalmers University of Technology, nr: 2012:22).

Mata (2013). *Modelling of energy conservation and CO₂ mitigation in the European Building Stock*. Dissertation energy and environment. Chalmers.

Mortimer (2010). Literature review of Enablers and Barriers to Adoption of Life Cycle Management. Landcare research Contract report LC010/022. New Zealand. http://www.landcareresearch.co.nz/publications/researchpubs/LCM_Literature_review_2010.pdf

Mollenkopf, D., Hannah Stolze, Wendy L. Tate, Monique Ueltschy, (2010). "Green, lean, and global supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 Iss 1/2 pp. 14 – 41.

Mollenkopf, D.A. (2006). *Environmental Sustainability: Examining the Case for Environmentally-sustainable Supply Chains*, Council of Supply Chain Management Professionals, Lombard, IL.

Nilsson-Lindén (2014). A knowledge management perspective on environmental life cycle management A manufacturing company example, Chalmers University of Technology, 2014

Nilsson-Lindén H, Baumann H, Rosén M and Diedrich A (2014). Organizing Life Cycle Management in practice: challenges of a multinational manufacturing corporation. *International Journal of Life Cycle Assessment*, DOI 10.1007/s11367-014-0818-y

O'Brien (2012). *Modelling energy demand in the building sector, within EU*. Dissertation energy and environment. Chalmers.

Rebitzer (2015). Introduction: Life Cycle Management, in Sonnemann, Margini (Eds) *Life Cycle Management*. Springer.

Rebitzer, G. (2005). Enhancing the Application Efficiency of Life Cycle Assessment for Industrial Uses. *The International Journal of Life Cycle Assessment*, (THÈSE NO 3307 (2005)). doi:10.1065/lca2005.11.005

Rex, E. och Baumann, H. (2004) *Expanding the green practice of LCA - The first decade of life cycle assessment activity in the Swedish forest products industry*. Göteborg : Chalmers University of Technology (Rapport - CPM - Centrum för produktrelaterad miljöanalys, Chalmers tekniska högskola, nr: 2004:1).

Rex E, Baumann H, (2006). Interpretations of Corporate Environmental Policy: Challenges for Environmental Communication and Action. 13th International Conference of Greening of Industry Network, July 2-5 2006, Cardiff Wales UK.

Rex (2007). Produktens eller samhällets miljöproblem? Om miljöfrågans hantering och kommunikation inom Volvo Lastvagnar. Chalmers Tekniska Högskola. ESA-rapport 2007:19

Rex and Baumann (2007). Individual adaptation of Industry LCA practice: Results from two case studies in the Swedish Forest products industry. *International Journal of LCA* 12(4) p. 266-271.

Rex (2008). *Marketing for Life Cycle Thinking*. Chalmers University of Technology. Nr 2835.

Rex and Baumann (2008). Implications of an interpretive understanding of LCA practice, *Business Strategy and the Environment* (0964-4733). Vol. 17 (2008), 7, p. 420-430.

RSCN (2012). *Workshop: Responsible Supply Chains and Networks: Challenges for Governance and Sustainability*, Stockholm, Sweden, 22-24 November 2012

Sakris (2002). A strategic framework for green supply chain management. *Journal of Cleaner Production*, 11, 397-409.

Sánchez, Wenzel and Sjøgaard Jørgensen (2005). Models for defining LCM, monitoring LCM practice and assessing its feasibility. *Greener Management International* (45) Spring 2004

SCB (2012) Bostads- och byggnadsstatistik årsbok 2012.

http://www.scb.se/statistik/publikationer/BO0801_2012A01_BR_BO01BR1201.pdf

Schmidt and Remmen (2013). Images of environment and management practice: Conflicting priorities or platform for organizational learning? Paper presented at ERSCP-EMSU 2013 Istanbul Turkey

Schmidt, (2013). Social Practices – A new focus area in LCM. *Proceedings of the 6th International Conference on Life Cycle Management* (pp. 51-54) Chalmers Tekniska Högskola.

Seuring (2004). Industrial ecology, life cycles, supply chains: difference and interrelations. *Journal of business strategy and the environment* 13 (5) 306-319.

Seuring, Sakris, Müller, Rao (2008). Sustainability and supply chain management – An introduction to the special issue. *Journal of Cleaner Production*. Vol 16, Issue 15. Sonnemann, Demise Gemechu et al. (2015) *Life Cycle Management: Implementing Sustainability in Business Practice* in Sonnemann, Margini (Eds) *Life Cycle Management*, Springer.

Sonnemann, Margini (Eds) (2015) *Life Cycle Management*. Springer.

Statens Energimyndighet, (2011). *Energimyndighetens roll i miljömålssystemet*. ET 2011:35

Sveriges Riksdag, (2015). Betänkande 2013/14:NU18 Genomförande av energieffektiviseringsdirektiveth<http://www.riksdagen.se/sv/Dokument-Lagar/Utskottens-dokument/Betankanden/Arenden/201314/NU18/> Downloaded the 4 August 2015.

UNEP/SETAC, (2009). *Life Cycle Management: How business uses it to decrease footprint, create opportunities and make value chains more sustainable*. United Nations Environmental Programme Division of Technology, Industry and Economics. <http://www.unep.fr/scp/publications/details.asp?id=DTI/1208/PA>.

United Nations Environment Program (2007) *Life Cycle Management a business guide to sustainability*.

http://www.unep.org/publications/search/pub_details_s.asp?ID=3960

UNEP (2009). Buildings and climate change. <http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf>

UNECE (2015). United Nations Economic Commission for Europe.
www.unece.org.

Volvo Trucks (2014). "Leder vägen fram"
<http://www.volvotrucks.com/trucks/sweden-market/sv-se/trucks/volvo-fe-hybrid/Pages/volvo-fe-hybrid.aspx> Besökt 2013-02-03

Walker, Sisto, McBain (2008). Drivers and barriers to environmental supply chain management practices: Lessons from public and private sectors. *Journal of purchasing and supply management*. 14, 69-85.

Weber (2015). Volvo ARCE, Arendal i Göteborg
<http://www.weber.se/golvavjamning/rad-anvisningar/referenser-golvavjamning/volvo-arce-arendal-i-goteborg.html>.

Winnes, K. (2013). Användning och behov av energi- och miljösystemanalys – sex företagsberättelser om forskningens betydelse för strategiskt beslutsfattande inom energi- och miljöområdet, CPM The Swedish Life Cycle Center - Report No 2013:5; SP Rapport 2013:29.

WRI/WBCSD (2015). *GHG protocol*. <http://www.ghgprotocol.org/calculation-tools/faq>, visited November 2015.

Zanden (2015). Responsibility boundaries in global supply chains. Forthcoming: *Journal of Business Ethics*. The original publication is available at www.springerlink.com.

References case studies Volvo Group

Bengtsson C (2015). Environmental manager at Volvo Group Real Estate Services. Screening interview and in-depth interview, 5 Maj and 27 August 2015.

Heikkilä K. (2015). Technical specialist at Volvo Group Real Estate Services, In depth interview 20 august 2015.

Sjögren B. (2015). Project leader at Volvo Group Trucks Technology, In depth interview 9 September 2015

Swedish Radio P4 (2011). Få kontor klimatsmarta. 22 february 2011.
<http://sverigesradio.se/sida/artikel.aspx?programid=104&artikel=4362997>

Weber (2015). Volvo ARCE, Arendal i Göteborg
<http://www.weber.se/golvavjamning/rad-anvisningar/referenser-golvavjamning/volvo-arce-arendal-i-goteborg.html>

Volvo Global Magazine Nr 1, (2011). Climate-smart construction pays for itself.
Volvo Global Magazine Nr1 , 2011.

<http://www3.volvo.com/investors/finrep/sr11/pdf/Climate-smart%20construction%20pays%20for%20itself%20.pdf>

Volvo Group Real Estate (2015a). Volvo Group Global – Volvo Group Real Estate
http://www.volvogroup.com/group/global/en-gb/contact_us/VolvoGroupRealEstate/Pages/business_functions.aspx

Volvo Group Real Estate (2015b). Volvo Group Global - Other entities.
<http://www.volvogroup.com/group/global/en-gb/volvo%20group/our%20companies/otheroperations/Pages/default.aspx>

Volvo Real Estate (2015). ARCE - Internal Power Point presentation, Volvo Real Estate. 27 August 2015.

VolvoGroup (2014) Volvo Group Global – CO₂ neutral factories.
[http://www.volvogroup.com/GROUP/GLOBAL/EN-GB/RESPONSIBILITY/MOVING_SOCIETY_FORWARD/ENVIRONMENTAL_CARE/PAGES/CO₂_NEUTRAL_FACTORIES.ASPX#sthash.BIe1gVFv.dpuf](http://www.volvogroup.com/GROUP/GLOBAL/EN-GB/RESPONSIBILITY/MOVING_SOCIETY_FORWARD/ENVIRONMENTAL_CARE/PAGES/CO2_NEUTRAL_FACTORIES.ASPX#sthash.BIe1gVFv.dpuf)

VolvoGroup (2015a) Volvo Group Global – About us – A Global Group
<http://www.volvogroup.com/group/global/en-gb/volvo%20group/Pages/aboutus.aspx>

VolvoGroup (2015b) Volvo Group Global – Our Operations – Volvo Group Organisation
http://www.volvogroup.com/group/global/en-gb/volvo%20group/our%20companies/Pages/business_structure.aspx

VolvoGroup Sustainability Report (2014).
http://www3.volvo.com/investors/finrep/sr14/pdf/SR_2014.pdf

References case studies ABB

ABB (2013). Energianalys visar på besparingspotential i miljonklassen- Sapa Heat Transfer optimerar energianvändningen.
http://new.abb.com/docs/librariesprovider51/energieffektivisering-filer/see_referenscase-sapa_lr.pdf?sfvrsn=2 Visited October 2015.

ABB (2015). ABB in brief 2015. <http://new.abb.com/about/abb-in-brief>

ABB (2015a). <http://www400.abbext.com/sustainability-report-2013/governance/sustainability-objectives-2014-2020.html> Visited September 2015.

ABB (2015b). Group Sustainability Performance Report 2014.
http://new.abb.com/docs/default-source/investor-center-docs/sustainability-performance-reports/2014_abb-group-sustainability-performance-report.pdf
Visited September 2015.

Auletta, T. (2013). Energy Energy Efficiency, a key question for business success. Presentation at Chalmers Energy Conference 2013.
<http://www.chalmers.se/en/areas-of-advance/energy/Documents/Chalmers%20Energy%20Conference%202013/Presentations/Tommaso%20Auletta.pdf>

Auletta, Tomaso (2015). Global Energy Solutions Manager and Energy Efficiency Manager, ABB, face to face interview 8 September 2015

EIA (2015). International energy data and analysis: Indonesia. U.S. Energy Information Administration.
http://www.eia.gov/beta/international/analysis_includes/countries_long/Indonesia/indonesia.pdf Visited October 2015.

EU (2012). DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. <http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX%3A32012L0027> Visited October 2015.

Gode, J., Martinsson, F., Hagberg, L., Öman, A., Höglund, J., Palm, D. (2011). Miljöfaktaboken 2011 - Uppskattade emissionsfaktorer för bränslen, el, värme och transporter. Värmeforsk rapport 1183.

Nordström Anders H. (2015). Group Head of Environment, ABB, telephone interview 11 September 2015.

Swanström, Lennart (2015). Senior Principal Scientist, ABB AB, telephone interview 27 May 2015

References case studies AkzoNobel

Criminna and Pagliaro (2015). Ecofriendly Antifouling Marine Coatings, ACS Sustainable Chemistry & Engineering, March 2015

Hallberg (2015 a). interview with Klas Hallberg, Manager Developments in Sustainability, May 7, 2015

Hallberg (2015b). complementary interview with Klas Hallberg, Manager Developments in Sustainability, October 7, 2015

Solomon (2015). Interview with Trevor Solomon, Market Manager Intersleek, International Marine, September 7, 2015.

AkzoNobel (2014a). Akzo Nobel Annual report 2013

AkzoNobel (2014b). Value Chain
<http://report.akzonobel.com/2013/ar/sustainability/value-chain.html>

AkzoNobel (2015a), Akzo Nobel – About us. <https://www.akzonobel.com/aboutus/>

- AkzoNobel (2015b). Akzo Nobel – Our business areas
https://www.akzonobel.com/our_key_markets/our_business_areas/
- AkzoNobel (2015c). AkzoNobel Annual report 2014
- AkzoNobel (2015d). Ton Büchner's Profile,
https://www.akzonobel.com/news_center/news/news_and_press_releases/ton_buchners_profile.aspx, Accessed 2015-10-14
- AkzoNobel (2015 e). Slime shall be released,
https://www.akzonobel.com/innovation/our_innovations/intersleek/, accessed 2015-10-14
- AkzoNobel (2015f). Examples of our innovations,
https://www.akzonobel.com/innovation/our_innovations/ accessed 2015-10-14
- International Marine (2011). <http://www.international-marine.com/Literature/Intersleek900GiveLongTermEnergyEfficiencyImprovementsMercatorLines.pdf>
- International Marine (2015). Carbon Credits a Marine Industry First,
<http://www.international-marine.com/carboncredits/default.aspx>, accessed 2015-10-14
- CPM (2013). Life Cycle Based Innovation, CPM the Swedish Life Cycle Center, CPM report 2013:3.
- Rance (2015). Interview with Derek Rance, Director Research and Innovation for Performance Coatings at AkzoNobel, June 26, 2015.

Appendix A – Interview guide

The interview guide includes an introduction to the research project, cases, and publishing issues, as well as the following areas and questions:

Interviewees' relation to the case

- What do you do as xxx / what do you normally work with?
- In what way were you involved in the particular case?

Initiative and drivers

- What prompted this project? Why did you make the change / project?
- Who took the initiative? Why did it come from this person / group?
- Who made the case progress?
- What did you achieve?
- Was it linked to any goal or strategy in the company?
- Did the project have any explicit environmental or energy ambitions?
- Did you have management support? If so, how?

Actions/process including barriers and drivers

- Tell us about the process of running the case.
- What decisions, events etc. were part of the case?
- Did you make use of any tools, process descriptions etc.?
- Which actors and departments / functions were involved?
- Was this the right constellation? What other constellation would have been better?
- Over what time period of time did the case run?
- Who appreciated and supported the project? What were the reasons for this support?
- Was there any resistance? From whom and why?
- How did you handle difficulties?
- What was successful and what was not possible to implement?
- Affected the case any KPIs? Which ones and how?

Recommendations

- (How) would you like to work with similar issues in the future?
- Do you have any Suggestions of changes if it would be done again?
- What would make management more motivated to work with this type of action? (What guidance is intended to have in mind?)
- What would make employees more motivated to work with this type of action? (Which aims to have in mind?)

- What would encourage more employees to participate?
- Would it be desirable? If so, why?

Effects on energy and environment:

- What were the de facto impacts on resources, materials, emissions to air and water, waste, energy, type of energy, etc. in a life cycle perspective?
- What would the potential results have been (on energy and environment) if everything went as expected?

Effect on competitiveness

- (How) has this case affected the company's competitiveness such as financial result, company credibility, relationships with stakeholders, changed business models, conditions for sustainable competitiveness and possibilities of meeting customer demand in the future?
- Did the case have any impact on the competitiveness of other actors in the value chain?

Appendix B – Workshop results

Results from workshop October 21, 2015, on preliminary results with participating companies and additional industry and governmental representatives.

Numbers in parenthesis are an indication of the relative importance of each aspect *within* each category, as signaled by the workshop delegates.

Find and share the life cycle benefits

Identified ways of working

- Target targets outside your own control (2)
- Find or create a “broker” for information and profit (5)
- Rethink scope of business (3)
- Embrace the need for changes in markets or product mix (1)
- Identifying “What is in it for me” (2)
- Translate it to the appropriate stakeholder’s own language (12)
- Early business planning for LCT (Easier to include in new products, new technologies, new business) (4)

Recommendations to policymakers/agencies

- Find hot spot areas
- Stimulate for LCT (1)
- Incentives for life cycle entrepreneurs (2)
- Be a platform for long term cooperation (7)
- Support implementation of research (4)

Enable and encourage understanding and action

Identified ways of working

- Frequent follow up and attention (2)
- Education/capacity building (2)
- Translators
- Get visual examples (also need of “bad” examples internally”)
- Translation to “What is in it for me” expressed in a language familiar to the receive such as economic terms (11)
- Sustainability should be an own function in the company (and will be followed up as such) (1)
- Regular follow up by top management (4)
- Embed in existing processes/business models (1)

- More education in society at large
- Apply science based targets (2)
- Assure that the new service-related business models relate to economic results (e.g. so the economic model is not still only based on selling products) (5)
- Core values should be part of personal profile of top management (recruitment) (2)

Recommendations to policymakers/agencies

- Put legal requirements on the relevant place in the value chain (focal company, consumer organisations may also be stronger than single customers)(7)
- Relate demands to products/services rather than production units (7)

Get priorities in line

Identified ways of working

- Recognize the need for life cycle thinking to influence strategic decisions (5)
- Adopt KPI and responsibilities to a LC system (4)
- Get help from outside NGOs, standards, etc (2)
- Find hot-spots; what makes best use (3)
- Find the appropriate value chain/value cluster
- Risk perspective: analyze costs for the customer and the customers' customer (6)
- Look at science-based targets (1)
- Clear goals and targets for KPI (5)

Recommendations to policymakers/agencies

- Innovation/procurement based on environmental performance (in a life cycle perspective) (1)
- Make economic incentives and environmental impact coincide (Value chain stewardship (VCS), Cousean Theory)) (6)
- National environmental targets => National life cycle environmental targets (4)
- Life cycle thinking aspects in higher education not only in science based curricula (3)

Seek or create a way forward

Identified ways of working

- Start where it is possible (6)
- Team up with likeminded, even if you need to "jump" among the actors in the value chain
- Anticipate and meet uncertainty (1)
- Harmonize goals and how work is done in companies (6)
- Formalize the function "sustainability leader" should have business and environmental background (2)
- Use a selling language
- Understand that change takes time: Factories are made, investments, people have their jobs...
- Sell function, many profit has to be allocated through the supply chain (8)
- Have the language of the purchasers and the sellars
- Education and knowledge sharing (5)
- Forward questions and wishes up to sales persons and marketing people (1)

Recommendations to policymakers/agencies

- Collaborate with companies before new laws are set (4)
- Better life cycle perspective in e.g. GRI, Dow Jones et (5)
- Authorities collaborate so that you have the same message/approach to companies so we can be proactive for future legislation (1)
- Authorities support (verbally and in cash) global initiatives in the life cycle field e.g. between US and Europe such as global LCA access, involvement and support in ISO/SIS etc. (4)