Application of Life Cycle Assessment in the Truck Industry

Master's Thesis for Civil and Environmental engineering

PÄR NORDHALL

Department for Energy and Environment
Division of Environmental System Analysis
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg 2007

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Användning av Livscykelanalys inom lastbilsindustrin

Examensarbete inom Civilingenjörsprogrammet Väg och Vattenbyggnad

PÄR NORDHALL

Institutionen för Energi och miljö

Avdelningen för Miljösystemanalys

Chalmers Tekniska Högskola

Sammandrag

Mycket av dagens miljödebatt handlar om transportsektorns bidrag till utsläppen av klimatförändrande växthusgaser. I arbetet med att minska utsläppen av andra miljöpåverkande ämnen såsom kväveoxider, svaveldioxid och kolväten har man kommit långt. När det gäller utsläpp av koldioxid, däremot, ökar utsläppen kontinuerligt och en förändring är nödvändig. En av de största delarna av utsläppen från transportsektorn kommer ifrån användandet av tunga lastbilar. Lastbilar påverkar naturen under hela dess livscykel, och framförallt under användandefasen. Det gör att frågan om vad lastbilsindustrin gör för att minska miljöpåverkan från att livscykelperspektiv blir väldigt intressant.

Studiens fokus ligger på om företagen i lastbilsindustrin använder livscykelanalyser, LCA, för att utvärdera miljöprestandandan och för att göra förbättringar på produkterna. Vilka, om några, användningsområden ser de största aktörerna i Europa för LCA nu och framtiden?

Frågeställningarna studeras genom att kartlägga fyra av de sex största aktörerna på den västeuropeiska marknaden: DaimlerChrysler, Volvo, DAF and Scania. Information om företagen har samlats in genom att studera rapporter (interna angående LCA och externa årliga miljörapporter) och genom kontakt företagsrepresentanter. De svenska företagen har ägnats lite extra uppmärksamhet där intervjuer med tre personer på varje företag genomförts för att komplementera informationen.

Användningen av LCA kartlades och resultatet visar på likheter och skillnader i användningsområden. Tre av fyra företag använder LCA. Samtliga företagen i studien som använder LCA ser fördelar med LCA arbete i R&D och dimensioneringsprocesser. En annan användning som verkar vanlig är för att underbygga företagsstrategier. Användningen av LCA för marknadsföring (genom miljövarudeklarationer eller liknande) och hur man använder LCA för interna lärandeprocesser är lite oklart, även om företagen framhäver nytta med LCA för interna ändamål. Studien visar att lastbilsindustrin inte använder LCA för att utvärdera upphandlig eller produktion.

Studien visar en tydlig spridning av LCA-användandet mellan företagen. Samtliga företag har kommit i kontakt med konceptet i någon utsträckning, men förtroendet sviktar i vissa fall. Några företag är hängivna och har visat tålamod med LCA, och andra är inte lika övertygade om nyttan.

I analysen studeras anledningen till skillnaderna. Det visar sig att skillnaderna verkar ha starka samband mellan de inledande drivkrafterna för att börja använda LCA. Institutionaliseringsteori verkar stämma överens med praktiken i detta fall när det gäller uppfattningen om interna och externa drivkrafter: när man kan identifiera starka interna drivkrafter visar företaget prov på tålamod och uthållighet i institutionaliseringsprocessen (i fallet med DaimlerChrysler och Volvo). Å andra sidan, när drivkraften är tveksammare karaktär t ex isolerat ledningsbeslut eller för att konkurrenter använder LCA visar det sig att risken för att överge LCA är stor. Det visar sig även finnas skillnader inom samma institutionaliseringsfas. När det gäller DaimlerChrysler och Volvo har dem båda nått sedimentationsfasen, men DaimlerChrysler har kommit längre när det kommer till forsking och utvärdering av deras LCA användning.

Att förutse hur LCA användningen i lastbilsindustrin kommer att se ut i framtiden är svårt. Men, baserat på resultaten från studien och tolkning av målsättningen med företagens LCA användning har en individuell uppskattning av framtiden för LCA i varje företag gjorts.

Studien är intressant för de som är intresserade av hur LCA kan användas av företag, i olika syften och användningsområden. Studien kan också användas till att beskriva hur företag tar emot ett ”nytt” verktyg, och hur man kan förklara den inställningen.

Nyckelord: Livscykelanalys, lastbilsindustri, LCA tillämpningsområden

ABSTRACT

When it comes to the environmental debate the contribution to climate change from the transport sector is a popular topic of discussion. The sector has come a long way in lowering emission levels of nitrogen oxides, sulphur oxides and hydrocarbons. However, on the issue of climate change carbon dioxide emission levels are increasing continuously and there is need to break this trend. One of the most important contributors in the transport sector is the use of trucks, and especially heavy trucks. The trucks have impact on the environment throughout its life cycle, and especially from its use phase. This raises the question of what truck industry do to lower environmental impact from a life cycle perspective.

This study focus on if truck industry use Life Cycle Assessment, LCA, for evaluating environmental performance and make improvements to their products. What, if any, applications do some of the biggest truck industry actors in Europe see for LCA, now and in the future?

The questions posed above were addressed by mapping of four of the six largest truck industry actors in Western Europe: Daimler Chrysler, Volvo, DAF, and Scania. Information on the companies was gathered through reviewing of reports (internal reports on LCA and external environmental reports) and contact with company representatives. Special attention was paid to the Swedish truck industry were additional interviews were held with 3 employees versed in their environmental efforts at each company.

Application of LCA was mapped and the result show differences and similarities in the areas of LCA applications. Three out of four companies make use of LCA in their organisation. The companies in this study that applies LCA, all use it in R&D and design processes. Another, seemingly, popular application is to support strategic decision making. The use of LCA in marketing (through EPDs or other environmental declarations) and for internal learning purposes are somewhat unclear, but are still considered important by the companies. The study shows that truck industry make no use of LCA in neither evaluating production processes nor in purchasing.

The study clearly shows great diversity in LCA use within the European Truck industry. All companies have used LCA some extent, but the continuous commitment to LCA varies. Some companies are devoted to using LCA, and some started using LCA but later abandoned the concept.

In the analysis, reasons for this diversity are further explored. The diversity seems to be directly linked to the initial driving force for adopting LCA. In terms of institutionalisation theory, the practice in this case seems to support the notion of internal and external driving forces: when strong internal driving forces can be recognised, there seem to be patience and endurance in the institutionalism process (in the case of Daimler Chrysler and Volvo). On the other hand, when LCA is adopted because of management decision or because of competitor actions the driving forces are somewhat vague and there is an evident risk of abandonment of the LCA concept (in the case of DAF and Scania). Regardless, of institutional phase there are also other differences that are discussed in the report. For instance, Volvo and DaimlerChrysler both have reached the sedimentation phase. However, Daimler Chrysler has gone further with research and careful evaluation of the benefits of using LCA.

To predict the future development of application of LCA in truck industry is difficult. However, based on the results from the study and interpreting the aim of LCA use individual appreciation of the company's future use of LCA has been made.

The findings of the study are interesting for those interested in how companies can make use of LCA, for different purposes and applications. The report can also be used as an example of how companies can position themselves to a 'new' tool, and explains why the company takes that position.

Key words: Life Cycle Assessment, truck industry, LCA applications,

Contents

Foreword

This study has been conducted at in the division for Environmental Systems Analysis at Chalmers University of Technology during the period between September 2006 and May 2007, with a pause during October 2006.

The work has been supervised and guided by lic. Emma Rex and dr. Henrikke Baumann has been responsible for the examination process. I would like to take this opportunity to show my appreciation for the help they have given me throughout this project.

The participating companies should are also acknowledged. Without their help data collection would have been impossible. Also, special thanks to Thomas Rydberg that has been helpful in supplying contact and LCA information. Last but certainly not least, I would like to thank my loving family and friends for their support.

Göteborg, May 2007

Pär Nordhall

1 Introduction

When it comes to the environmental debate today there are some popular topics of discussion, the environmental impacts from products and services being one. The need for improvements in environmental performance is a great challenge and the responsibility for change lies on all parts of the society, thus making it very complex. Different actors in society have to support the development towards a sustainable society. Governments, industry actors and market forces all have to pay attention to the challenges that lies within the issues connected to sustainability. It can be argued that if a market does not demand a green product there is no need to produce it. On the other hand, if there are no green products available, there are no conditions for environmental decision-making for consumers. Having a sustainable society as the ultimate goal, there is a need to create conditions for sustainable production, as well as for consumption and demand.

An important sector that is discussed frequently when it comes to environmental issues, is the transport sector. The contribution to global issues is undisputable, and one example is the issue of climate change. The transport sector's contribution to the total emissions of green house gases, GHG, shown is increasing:

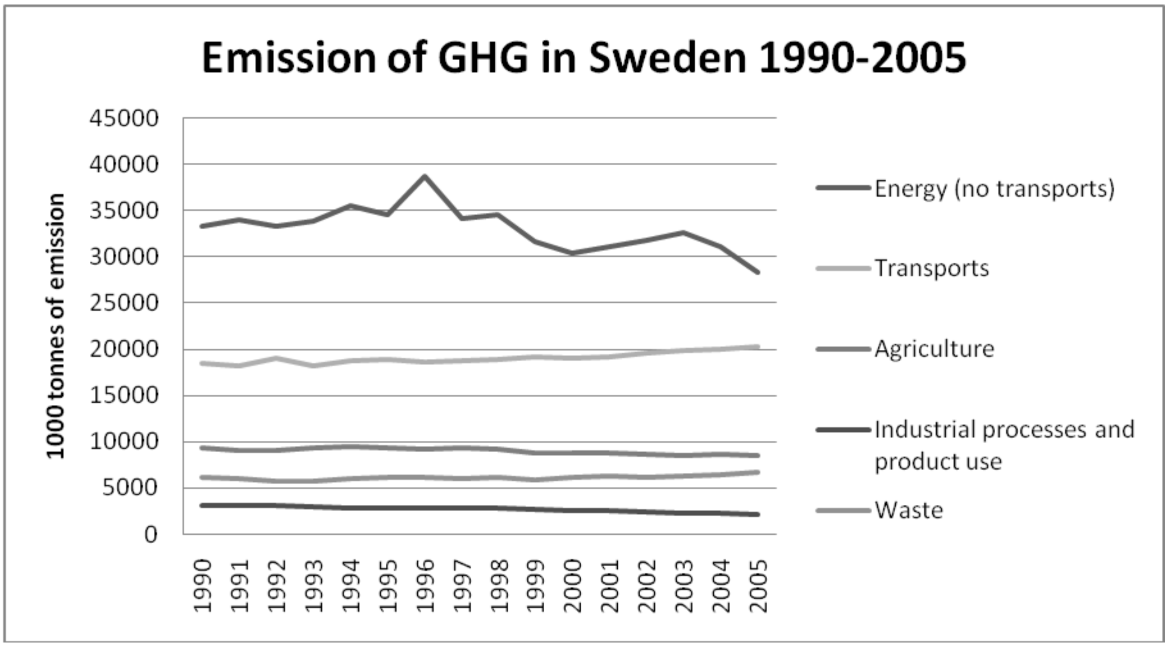

Figure 1. Development of GHG emission in Sweden 1990-2005 (Naturvårdsverket, 2007).

Figure 1 shows the development of different sectors' emissions of GHG from 1990-2004. It shows that transport, energy industry and industrial processes are the three most important sectors on this issue. The total emissions have practically been on the same level since 1990, and so has the contribution from the transport sector (Statistiska Centralbyrån, 2007) However, there is an expected increase in emission levels during the period 2005 until 2020 (Vägverket, 2005).

Climate change is not the only issue that the transport sector influence, air quality is also an important issue. There are goals established, by the Swedish Government, on different types of emissions from the transport sector. Goals on emissions of sulphur dioxides, nitrogen oxides and hydrocarbons are expected to be achieved. Air quality in urban areas is slowly improving. These emissions are includes in the European emission classification of engines, the Euro system. The EURO standards are sets of exhaust emission levels from the engines and have been applied in Sweden since 1993 (EURO 1). The standard has been updated continuously with toughened emission levels, and has contributed to the positive development in these areas (Vägverket, 2007).

However, carbon dioxide emission levels from engines have not yet been included in any standards. Still this is recognised as a very problematic area. Along with the United Nations (UN) the Swedish government has established a long term goal on the emissions of green house gases (GHG). The goal from the generation perspective is to lower the emissions of carbon dioxide-equivalents to 4,5 tonnes until 2050. The emission in 2004 were 7,9 tonnes. Also, a short term national goals have also been established on climate impact (Naturvårdsverket, 2007):

- For the period 2008-2012 the levels should have been lowered with 4% from the 1990 levels.

Vägverket strives towards the following goals set for the transport sector (Vägverket, 2007):

- By 2010 the emission levels should have been stabilised on the 1990 levels;
- By 2020 the emission levels should have been lowered with at least 10%.

As one can make out from the goals listed above the transport sector cannot fully support the national environmental goals. Fossil fuels dependency and the growing vehicle mileage development makes it too tough, especially for heavy duty trucks (16 tonnes and above). Vägverket realises that the short term goals will be difficult to fulfil, but the mid- and long term goal are within sight (Vägverket, 2007).

The contribution of GHG emissions from the transport sector is undisputable and the prognosis for the road traffic's contribution does not foresee much improvement. The emission of carbon dioxide is going to increase from the sector as a whole, and from all vehicle groups (Vägverket, 2005).

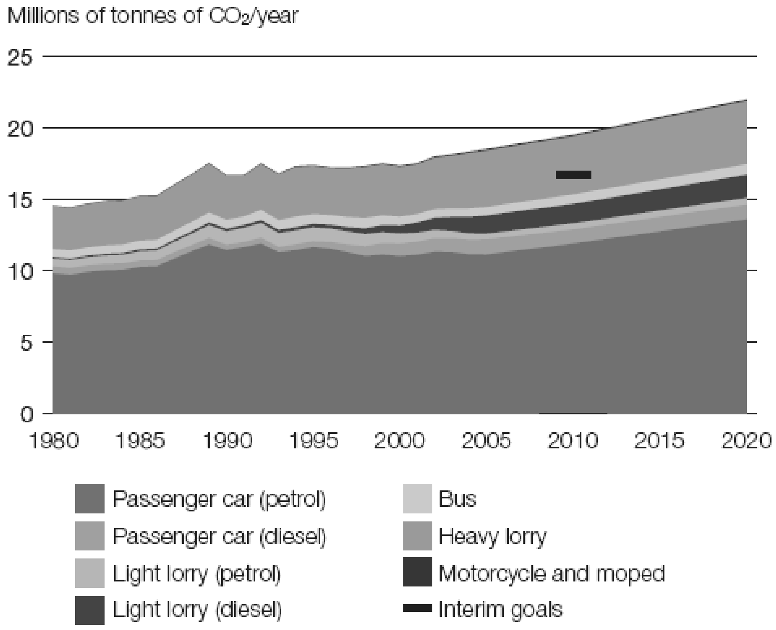

Figure 2. Estimated emission of carbon dioxide from Swedish road traffic (Vägverket, 2005).

Figure 2 shows the estimated growth in carbon dioxide emission until 2020. The interim goal, as mentioned earlier, is not within reach at this point of time. The most important vehicle groups besides passenger cars is heavy trucks (heavy lorry). Vägverket appreciates that the increase from heavy trucks will continue, due to increased vehicle mileage, and improvements in fuel efficiency and controlled traffic growth are needed to be able to reach these goals (Vägverket, 2005).

Sweden currently has two major producers of trucks. Looking at the Swedish truck manufacturers', Volvo and Scania, environmental policies they indicate that are committed to lowering their impact on the environment. How is this put into practice?

To structure and to organise environmental work in companies implementation of an Environmental Management Systems (EMS) can be helpful. An EMS is a strategic management tools applicable on organisational or site levels. EMS was developed to simplify and make environmental work more effective in the organisations that use them. The EMSs are voluntary and are often used to communicate active environmental work, and to create reliability when it comes to environmental issues. The most common EMSs are ISO 14001 and EMAS (Ammenberg, 2004). ISO 14001 and EMAS are site-level management systems that focus on continuous on-site environmental improvements rather than on the actual emission levels or potential impacts. The standards promote a holistic environmental view for an organisation and may include life cycle thinking in the activities they are applied to.

Trucks' main impact on environment comes from the use phase of the product, not from the production. For instance, Volvo estimates that 80-90 % of the impacts from trucks occur during its use phase (Volvo Trucks, 2003). Mostly due to its fuel consumption; carbon dioxide and other emissions are the main challenges. The fact that the truck consists of a great number of components and that 10-20% of the total impacts comes from other life cycle stages further motivates taking on a life cycle perspective of assessing products. The idea of life cycle thinking and incorporating all product related processes when evaluating impacts from the individual products is to describe the whole surrounding technical system and the products total use of resources throughout its lifetime, the cradle-to-grave perspective.

Trucks are complex products, and to have a relevant environmental evaluation would imply that you include all stages from the life cycle. Considering that the truck has environmental impact not only from the use phase, but through the whole supply chain and its production. EMS is supposed to include life cycle perspectives, but often it is not the reality. To evaluate products environmental performance, companies can use Life Cycle Assessment, LCA. It is a scientifically recognised method that has been under development for a long time. The general methodology is described in the ISO-standards 14040-43.

1.1 Problem definition

This project aims to investigate the current use of LCA in European truck industry, with focus on the Swedish truck manufacturers. By studying the historical development of LCA use in truck industry an appreciation of the future outlook for further LCA use will be made.

1.2 Problem discussion

How truck manufacturers use LCA is not clear. The report will clarify the sector’s specific use of LCA, and the applications associated with LCA. Different application fit different types of organisations and purposes. The report will establish the most relevant business application for the truck manufacturers today.

To find the solution to the problem defined three sub-questions were identified:

1. Does truck industry use LCA? In what business applications?
2. What are the perceived benefits and obstacles of using LCA?
3. Will companies use LCA in the future? How?
4. Can you have both LCA and EMS work in the same company?

The report presents LCA use in the Swedish truck manufacturers Volvo and Scania in detail. For comparisons to the situation on the European market in general the German truck manufacturers DaimlerChrysler and DAF has been studied more briefly.

The first questions were addressed by asking the companies, in interviews and by collecting documents. However, the business applications are not always direct, thus a personal interpretation to the business applications will be communicated in the report.

The historical use of LCAs can be of interest for a general view of the companies' commitment to, and belief in, LCA. Together with the general view of LCA, some indication on how the companies will use LCA in the future can be presented to discuss the third question.

The last question has been a subject of a passive study, if the companies mention any problems related to EMS and LCA.

1.3 Limitations

The theoretical review of LCA application is focused to literature on production industries, because Volvo and Scania are assembly and production companies. Economics for LCA have been neglected, due to an assumption that all companies studied would be able to afford LCA if they made the effort. For the same reason technical knowledge is not considered a valid reason for not using LCA.

The focus on Volvo and Scania is due its Swedish heritage and a screening comparison will be made to the most important competitors, by Western European market share. The European perspective is also motivated because all the manufacturers are situated in EU countries and affected by EU legislation and directives.

Time limitation is the main factor why not all companies have been studied in detail. Subsequently, the companies selected in the case study Volvo and Scania are the only companies where driving forces may be studied properly, and used in the analysis and discussion.

1.4 Methodology

The study of relevant literature is focused on LCA methodology, business applications and industry use. The main sources have been educational literature, academic articles and studies on industry use of LCA. A few aspects of making LCA implementation successful in companies have been studied, to be able to describe the most obvious differences between the companies.

Data on the Swedish truck manufacturers Volvo and Scania was collected from documents available on their homepages, in articles and reports and completed with qualitative interviews with versed people in the companies and on LCA. The following people were available for open and semi-structured interviews:

Volvo:

Rolf Willkrans, Director of Environmental Affairs, Volvo Group.

Lars Mårtensson, Director of Environmental Affairs, Volvo Trucks.

Cecilia Gunnarsson, Environmental Coordinator, Volvo 3P.

Information on Volvo's LCA work has been updated with information from email correspondence with Annika Gunnarsson, LCA Coordinator, Volvo Environment & Chemistry.

Scania:

Anna Henstedt, Regulation & Certification, RDR, Scania AB.

Urban Wästljung, Public and Environmental Affairs, CA, Scania AB.

Per Johansson, Dismantling & Special tools, RFKP, Scania AB.

DAF and DaimlerChrysler's homepage information has been completed with information from email correspondence with:

DaimlerChrysler:

Matthias Finkbeiner, Manager Design for Environment, Mercedes-Benz Passenger Cars.

DAF:

Wilma Margry, DAF Environment.

Information on LCA and truck industry sector in general was supplied in email-contact with:

Thomas Rydberg, IVL Swedish Environmental Research Institute.

Based on the interviews and other material estimations on how the company has taken a position towards LCA. Their current position and general attitude towards is important to be able to say something about any future aspects.

The empirical results were put in an analytic framework context, which has been important in creating understanding of the current situation. The chosen model for analysing the companies' use of LCA is the Product Development Chain defined in an international survey on industry's use of LCA (Frankl & Rubik, 2000), and their views of the application areas. The framework was chosen based on its well defined application areas and its focus on product development companies.

The analysis part of the report will deal with the questions asked in the problem discussion. An analysis of the companies' LCA use and the relation between level of implementation and the driving forces for using LCA will create understanding for the current position of each company and serve as a basis for thought on the future role of LCA.

1.5 Disposition

The first chapter, Introduction, aims to clarify and motivate the problem and the report. It explains the challenges for truck industry and introduces the key concept of LCA.

The second chapter, Life Cycle Thinking and LCA, is a deeper explanation of the theories of Life Cycle Thinking and the concepts derived from it. LCA is also presented, firstly in general and then more thoroughly.

The third chapter, LCA Applications, presents the analytic framework chosen for this study. It also presents the application areas recognised and used in the framework.

The fourth chapter, Aspects of successful LCA implementation, presents some theories of what make LCA implementation successful in companies. In this report theory on EMS integration, driving forces and institutionalisation is presented. The chapter is ended with a list of obstacles for further use of LCA.

The fifth chapter, European Truck industry, is a presentation of the study of the European truck manufacturers, DAF and DaimlerChrysler chosen as base for comparison to Volvo and Scania. It includes the companies' use of LCA, Application of LCA, and how well LCA is integrated in the organisation, Level of implementation.

The sixth chapter, Swedish truck industry, is the presentation of the Swedish companies, Volvo and Scania. The presentation of each company includes: Environmental image presentation, LCA application, Driving forces and Level of implementation.

The seventh chapter, Comparison & analysis, is the analysis part of the report. It deals with the results from all companies. It is completed with a further analysis of Volvo and Scania. The initial analysis is completed with a driving force analysis.

The eighth chapter, Explaining the differences, discusses the most important differences between the companies. Trends to estimate future direction in LCA use is also presented.

The ninth chapter, Conclusions, presents the most important conclusions and findings made from carrying out the study.

The tenth chapter, Personal thoughts and recommendations, includes thought on the results and some recommendation to each company, as well as some suggestions to further academic studies. It also contains personal thought on the process and methodology of this study.

The tenth chapter, References, is a list of literature studied and referred to in the report.

The eleventh chapter, Appendix, are the environmental policies of Volvo and Scania referred to in the text.

2 Life Cycle Thinking and LCA

This chapter is an introduction to the theoretical background to the concepts of Life Cycle Approaches and Life Cycle Assessments.

Life cycle assessment, LCA, is an analytic method to evaluate a product's or service's environmental impact throughout its entire life cycle, the so-called cradle-to-grave perspective (Baumann & Tillman, 2004). Companies can use LCA studies for different purposes and in spread applications throughout the organisation, for example in design, in strategic planning, for developing performance indicators and in policymaking. This chapter is an introduction to the concept of life cycle thinking, life cycle approaches and particularly Life Cycle Assessment, LCA.

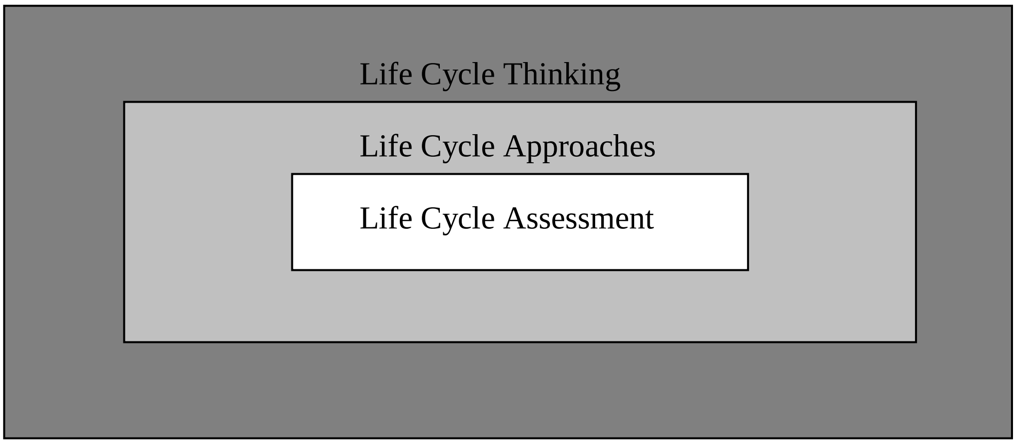

Figure 3. Levels of life cycle perspectives (Frankl & Rubik, 2000).

Figure 3 shows the level of detail when evaluating products in companies. The general Life Cycle Thinking is the idea of always considering the impacts from the product's whole life cycle. The most detailed perspective is performing an LCA study where the detailed data is generated into an estimation of the environmental impact.

The life cycle perspectives when analysing, evaluating and improving an organisation or a specific product, prevents problem shifting that can occur when focusing on a division or level in an organisation or one phase of the products' life cycle. The most common way of using life cycle perspectives is through Life Cycle Thinking, LCT. Considerations are made on a very general and qualitative level (Frankl & Rubik, 2000). However more specific approaches to incorporate life cycle perspectives are available.

2.1 The Life Cycle Approaches

Since the start of the discussion on environmental issues, there has been a need for ways to evaluate organisations and products from environmental aspects. The concept of life cycle thinking and life cycle approaches is a response to these challenges, and the participants of the UN World Summit on Sustainable Development in 2002 stated:

"We must develop consumption and production policies to improve the products and services, while reducing the environmental and health impacts, using, where appropriate, science based approaches, such as life cycle analysis" (UN, 2002)

The idea of life cycle approaches is based on the holistic image of a product and its impacts. When analysing the product you should not only consider its production phase (cradle-to-gate perspective), for relevant estimations you should consider the whole life cycle (cradle-to-grave):

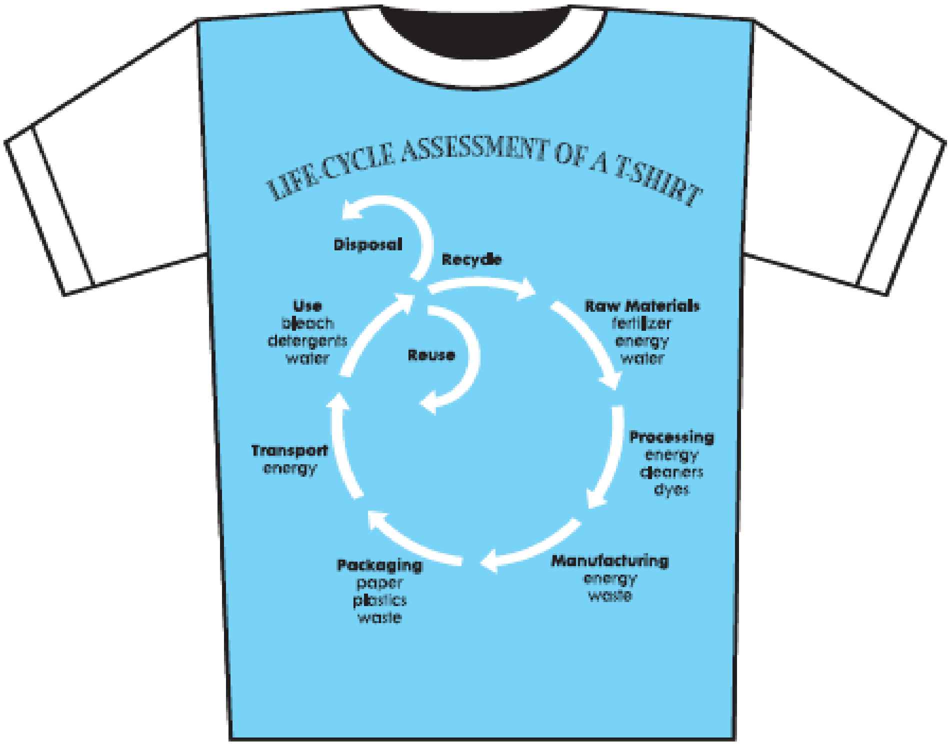

Figure 4. The life cycle of a T-shirt (UNEP, 2004).

Figure 4 shows an example of a life cycle of a t-shirt including six general stages of a products' life cycle and the resource exchange with the environment that is a dynamic process that continues throughout the whole life cycle.

2.1.1 General benefits of Life Cycle Approaches

The most important general benefits of life cycle approaches are: avoiding problem shifts and optimising environmental improvements. It could also be applicable when comparing products (UNEP, 2005).

Problem shifts occurs when companies recognize a problem on a products specific life cycle stage. While solving the problem on that stage it can, fully or partially, shift and occur during another stage. This means that gains in one stage can be balanced out or even exceeded by losses on other stages. Analysing all the life cycle stages and how they influence each other can prevent problem shifting.

By evaluating the costs of improvements and assessing the result of the improvement, you can identify in what life cycle stage the most cost-effective efforts can be made. For instance, small adjustments in the planning or design process often are cheaper than investing in end-of-pipe solutions.

Using life cycle approach can be a very efficient way when communication between different stakeholders is necessary for making improvements. Market forces are important drivers for economic reasons. Using in eco-labelling, of certain kind, is one response with a life cycle approach to the markets' increasing demand for sustainable products. Environmental Product Declaration, EPD, is another concept in the eco-labelling family that is under development (read more on EPD in chapter 3.4.1.). EPD is based on LCA.

2.2 Life Cycle Assessment

As introduced earlier Life Cycle Assessment, LCA, is a method for analysing and evaluating the environmental impacts from a product. This is a further presentation of LCA.

2.2.1 LCA – Background information

Life Cycle Assessment can be used as a tool for evaluating the environmental impact from products and services. It considers the whole life cycle, from raw material extraction to usage and waste management. One definition is:

"LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by

- Compiling an inventory of relevant inputs and outputs of a system;
- Evaluating the potential environmental impacts associated with those inputs and outputs
- Interpreting the results of the inventory and impacts phases in relation to the objectives of the study

LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. cradle-to-grave) from raw material acquisition through production, use and disposal. The general categories of environment impacts that needs consideration include resource use, human health, and ecological consequences" (International Organization for Standardisation, 1997).

2.2.2 General History

Industry actors have been using LCA for more than a decade. The LCA tool is a result from the environmental debate that started in the 1960's. In 1969 the Coca-Cola Company LCA was used to support a decision on beverage packaging (Hunt & Franklin, 1996). The first LCA reports almost exclusively dealt with packaging. Companies wanted to compare different packaging methods from energy; raw material and most importantly waste management perspectives, to simplify decision-making. Due to the energy crisis, which emerged in 1973 the energy perspective where given a more central role. The crisis had a big part of the spreading of the concept to public parties. After the crisis the debate on LCA faded a bit, and once again it became something for private companies. The advocates for LCA found it useful for strategic planning of their activities as well as for planning and designing new products. The low public interest in LCA and in environmental issues in general lasted until the mid 80's. A series of environmental disasters brought these issues back on the agenda. Due to the volume of solid wastes, waste management issues brought packaging aspects of LCA to focus of interest. Later on the concept started to be used within marketing divisions in industries spreading the life cycle thinking to customers and contributing to the spreading of the areas of application (Hunt & Franklin, 1996).

Studying the historical development of the use of LCA, some differences can be noticed. The purpose for conducting LCA has shifted from packaging, through energy until today's widespread application areas. It seems that companies still are unsure as how to use LCA. Therefore it would be reasonable to assume that the trend in LCA use will continue to shift.

2.2.3 Methodology development

The potential for LCA as an important environmental evaluation tool was recognized early on. The number of companies using it grew rapidly and many companies had their own environmental databases (Hunt & Franklin, 1996). But, until the beginning of the 90's the methodology for carrying out an LCA was rather diversified and the accountability were often questioned. The criticism had its grounds in contradicting results for the same type of products (Baumann & Tillman, 2004). Some meant that the sponsors of the studies could influence the outcome of the study and use the results to favor their product or products. The process of developing a uniform methodology became unavoidable if the concept were to survive. The first conferences were set up to create general guidelines for LCA methodology and as a result of the initial discussions and workshops led by the Society for Environmental Toxicology and Chemistry, SETAC, the first *Code of Practice* was published in 1993. The standardization process of the LCA started after the publication and as a result the International Organization for Standardization published the first standard in 1997 (ISO 14040:1997). The standardization made the concept more accessible and the LCA studies more comparable. By 2006 the first standard was updated to include principles and framework for life cycle assessment including, goal and cope definition, inventory analysis, impact assessment and interpretation. The ISO 14040:2006 covers LCA and LCI work but does not describe the techniques in detail nor does it define methodologies for different phases of LCA or LCI (International Organization for Standardization, 2006).

2.2.4 LCA – Step by step

To be able to continuously interpret and understand the LCA study there are a few central parts that need to interact. These are *Goal and scope definition, Inventory analysis, Impact assessment* and *Interpretation.*

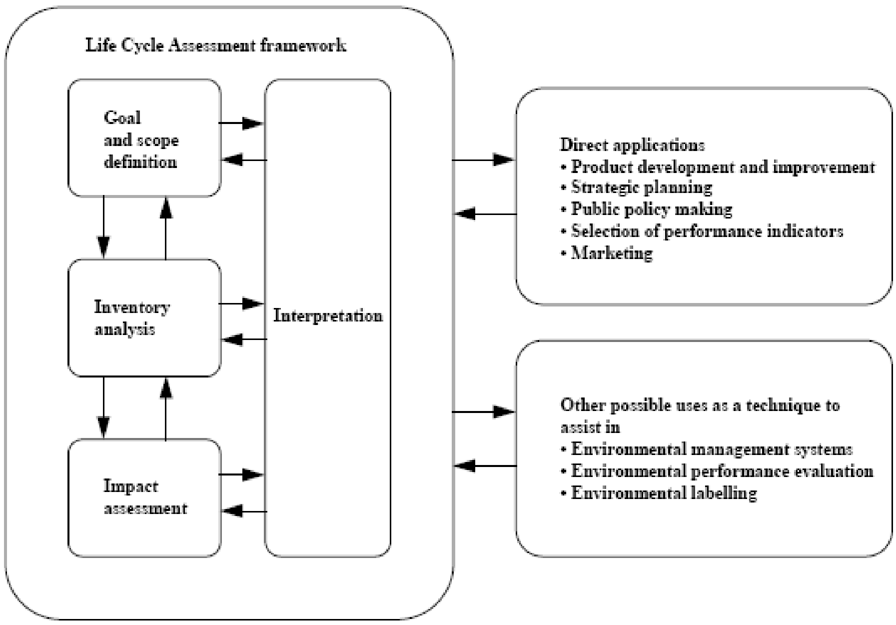

Figure 5. The LCA framework according to ISO 14040:1997.

Figure 5 show a schematic framework on how the LCA can be approached. It implies that a LCA study dynamic, and initial assumptions can be altered along the process.

Goal and scope definition is the most important part of the LCA study. It is the process of determination why the study should be carried out, what the intentions are. It affects the results of the study and some parts may not be defined immediately due to unclear conditions. They may be altered later in the LCA process after the Inventory analysis. But, to clarify and to make a comprehensive image of the study, there is a need to recognize and define a few dimensions (Baumann & Tillman, 2004):

The first step of the Goal and scope definition is to determine what the purpose of the study is, and to set a goal for the study.

The second step is to define the scope and modeling requirements for the study by deciding on e.g. functional unit, impact categories, system boundaries, time horizon, and data quality requirements and by making relevant limitations.

The third step is to decide procedural aspects of the study. Reporting is also essential in the LCA study process and how to do this should be decided before moving on from the Goal and scope definition.

During the Inventory analysis part of the study the data is collected and processed. It is the most expensive and time-consuming part of the LCA study. The Inventory analysis can be divided into (Baumann & Tillman, 2004):

Data collection for the product. The data should give information about inputs of raw materials and energy, and all physical inputs. Data for emissions to air, water and land and other environmental aspects should also be included. To model the system and its material or energy use you often draw a flow chart. The detail of the flow chart depends of complexity of the system and the data.

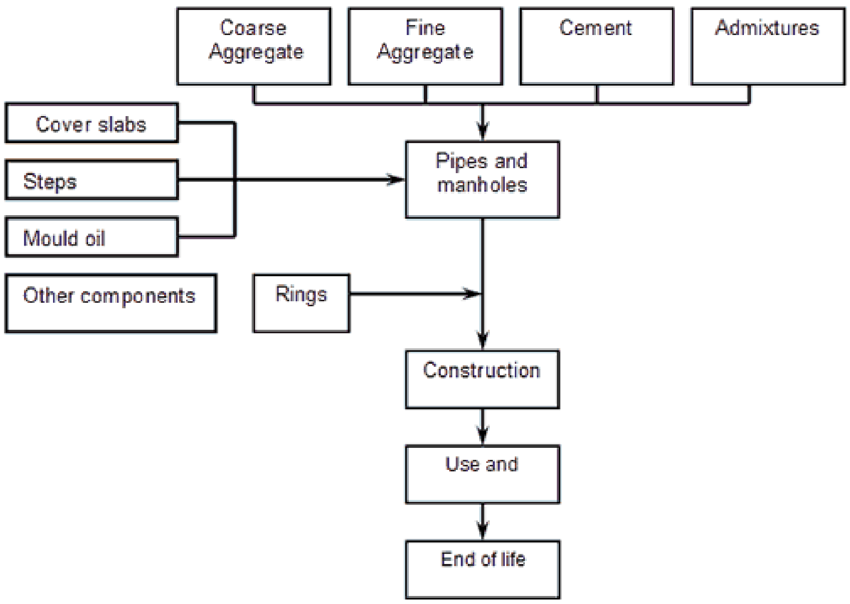

Figure 6. An example of a simple flow chart to help Data collection (CPSA, 2001).

Figure 6 shows how the life cycle stages, inputs and outputs were treated in a study of sewer systems in the UK (CPSA, 2001). All flows within the technical system defined are represented with a box and flow arrow. The data collection defines each flow.

Calculation procedures or processing of the data collected is always necessary. Normalization of all the data to become uniform and calculation of the flows in the system, in the terms of the determined functional unit is important. After calculating the internal flows of the system, the external flows (i.e. flows crossing the system boundaries) must be calculated. When both the internal and external flows have been identified, the resources used by the entire system can be calculated. Finally, documentation is very important. It supports the calculations and the assumptions made or the allocation issues dealt with. Allocation is how impacts should distributed on different processes or products and difficult to handle, especially in complex production systems with many products and also when it comes to recycling processes.

The Impact assessment is the third part of the LCA study. The goal is to use the results from the Inventory analysis to describe the environmental impacts, to transform the numbers into something easier to relate to. The process can be divided into these four parts (Baumann & Tillman, 2004):

Category definition aims to further clarify what types of impacts that are caused by the product or service. It connects to the decisions in the *Goal and scope definition.* The impacts should be categorized into the general type of effects it has on land use, global warming, acidification, work environment and so on.

Classification. The aim of the classification is to assign input and output data to the impact categories. Because some outputs contribute to more than one impact they may occur more than once, there is a risk of double counting.

Characterization is mainly a step to assign the relative contribution to the selected impact categories. The potential contribution must be estimated. Some kind of equivalency factors for some of the impact categories is often used.

Valuation/Weighting is the final step of the Impact assessment. The characterization results in quantitative results for each impact category. These results have to be valued/weighted against each other to give a fair outcome of study. There are different methods to value/weight: authorized targets, authoritative panels, proxies or technology abatement.

Interpretation of the results from the Inventory analysis or Impact assessment, or both, can be a very complex process. The inventory often contains too wide array of parameters and you have to select the relevant results to draw conclusions and make recommendations from. The interpretation interacts with all the other parts of the LCA study and requires that the inventory as well as the assessment part fulfils the requirements set in the Goal and scope definition. ISO14043 identifies the following main issues (International Organization for Standardisation, 1997):

Identification of significant environmental issues is made by identifying the key results. By selecting results from earlier stages of the study, from e.g. data from the *Inventory* or results from *Impact assessment*. It should also present other relevant information: methodological choices, valuation method used and the role and responsibility of different parties involved in the study.

Evaluation of the study includes a qualitative check of the data and processes. By making an analysis or discussing on the consequences of leaving out information when making necessary limitations, the extent of the study is put in context and its relevance can be appreciated by the reader. There should also be a data sensitivity analysis conducted, that analyses how changes in the input data would affect the outcome of the study. The Evaluation is also supposed to include statements on the study's general completeness and consistency.

Conclusions and recommendations are the final part of the Interpretation part of the LCA study and should, except from traditional conclusions and recommendations, include results from a critical review of the study.

2.2.5 Screening and simplified LCAs

Data collection is the most time consuming part of the LCA. However, the resource demand of the study can be decreased by carrying out a screening or simplified LCA. This is useful for companies that have limited resources but still want to use LCA, if they have many product produced in the same production facilities or when data availability for a certain life cycle stage is limited (Baumann & Tillman, 2004).

Conducting screening LCAs means that a certain key issue is and studied more thoroughly throughout the LCA or the focus of the study is on the most important life cycle stage.

A simplified LCA (or streamlined LCA) is carried out by excluding some aspects of the full LCA. By neglecting some life cycle stages, some inputs or outputs, or impact categories the LCA procedure is made less time consuming and expensive. When conducting simplified LCA, however, it is important to investigate the possible aspects to exclude and to make a sensitivity analysis to investigate the accuracy of the LCA.

The point of making these LCA can be economic or time aspects. Sometimes you need results in the start of a design process, where the degree of freedom is large and changes are less costly. However, conducting full LCA is very time consuming and conducting screening or simplified LCAs are a way to generate results quickly. Even though results from these kinds of studies are less accurate, thus reliable, they can give important indications. And, the initial screening or streamlined LCA can be completed with less missing data (Baumann & Tillman, 2004).

2.3 Individual use of LCA

Using LCA companies can study their products from their own perspective, and evaluate the products from their own priorities. Even if external comparability of LCA studies can be questioned, using their own guidelines the company can eliminate this problem for internal use. Resource demand can also be controlled which is beneficial for companies that does not have an extensive commitment to nor knowledge of LCA.

3 LCA Applications

This chapter is a presentation of the most common business applications for LCA. The presentation includes five general application areas: Strategy definition, Research and Development, R&D, and design, Production and procurement, Marketing and Information, Training and Education.

How companies use LCA varies. Depending on the reason for undertaking LCA activity, the driving forces and stakeholders involved the results is used for different purposes. The driving force can vary from e.g. legislation, market forces, competition or individual initiatives. As described earlier some of the traditional use of LCA has been waste management or energy consumption issues.

Frankl & Rubik (2000) show that the most important specific LCA applications for industry today in general are: bottleneck identification, external communication, change-oriented decision-making, research and design, comparing products to other manufacturers' products, procurement specifications, internal information and training, anticipating and negotiating legislation and marketing. Thus, the most areas of application would be included in the product development chain. Also strategic planning, green marketing and studying production processes are considered important use of LCAs. The study also shows that these areas are believed to be the most important applications in a foreseeable future (Frankl & Rubik, 2000)

For categorizing the different LCA applications in the studied companies a framework defined by Frankl and Rubik (2000) is applied to this study. The framework has divided LCA application into five categories and put them in a product development context.

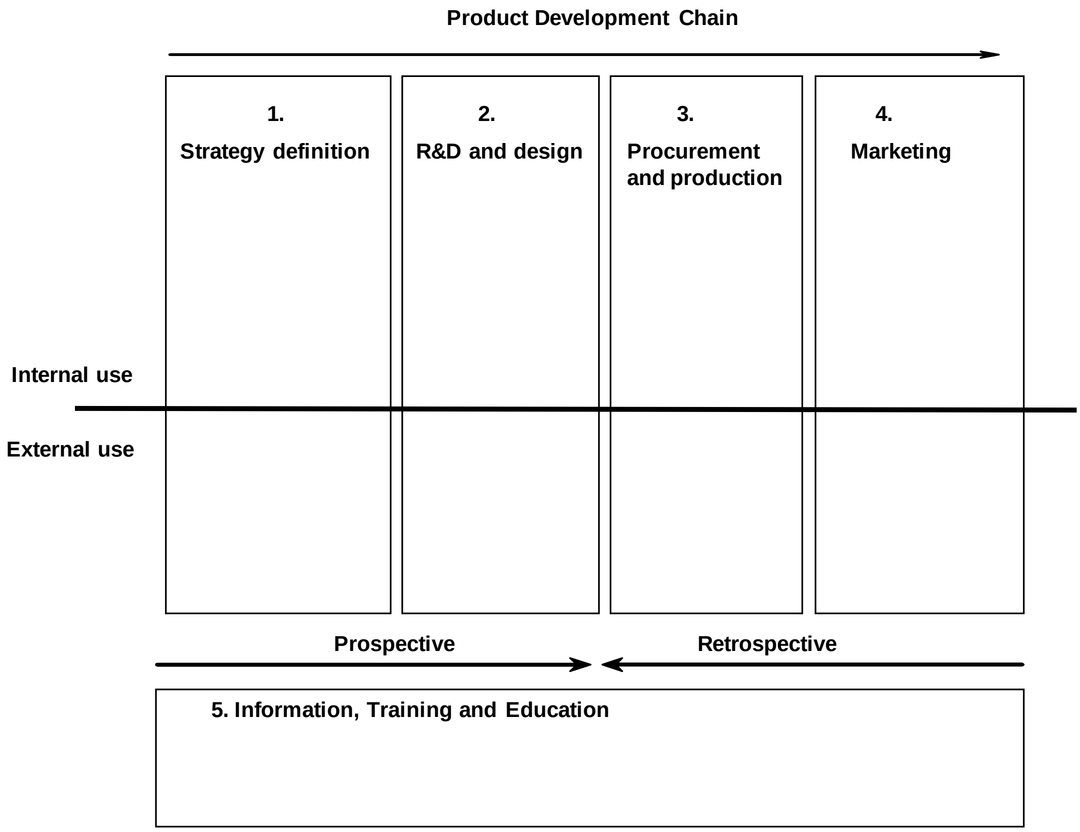

Figure 7. Product development chain (Frankl & Rubik, 2000)

Figure 7 shows a product development chain that reaches from box 1 'Strategy Definition' to box 4 'Marketing'. Box 5 'Information, Training and Education' indicate the continuous exchange of LCA-based knowledge throughout the development chain. Time perspectives of the LCA-based information are also shown in the figure. It should be noted that the figure shows only the product development chain under the companies' control, and is not the same as the products' life cycle. The model also implies that LCA can be used both retrospectively and prospectively.

3.1 Strategy definition

Including LCA and environmental consideration is becoming increasingly important for companies decision making (Confederation of Swedish Enterprise, 2001). To create a sustainable business you need to have sound environmental awareness. This means that considerations of environmental impacts is being made on strategy and policy levels in companies and not separated from other decision making in the companies (Bergström, 2006).

LCA information can create understanding of the environmental impacts that a product causes. Managers and other decision-makers, though, often lack education on environmental issues and how to model environment and ecology. In long term strategies life cycle perspectives are important for both production and product consideration (Frankl & Rubik, 2000). In this regard it would be suitable to use LCA.

3.2 R&D and Design

R&D and design purposes are generally considered the most important business application for LCA (Frankl & Rubik, 2000).

The design phase is a process of parallel activities, where environmental considerations have to be integrated with all the other aspects of products. On a competitive market the decision making for all these activities has to be made under some extent of time pressure, since first mover advantages is becoming increasingly important for competitive reasons. Strategies for incorporating environmental aspects to design is often referred to as eco-design, Design for Environment (DfE) or green product development. These strategies do not have a historical link to LCA, but LCA is becoming an increasingly important part of eco-design. The goal of eco-design is, through environmental, considerations to minimize direct and indirect environmental impacts whenever possible (Baumann & Tillman, 2004).

The design phase defines the products' properties. By incorporating LCA studies in decision-making regarding the early stages of the design phase allows minimizing of future impacts from the analysed product. Since the products' properties is decided in the design and construction phase decisions in this phase will inevitably result in future environmental impact. Thus, improvements in design and construction would result in continuously improved environmental performance from a life cycle perspective, as shown in Figure 8.

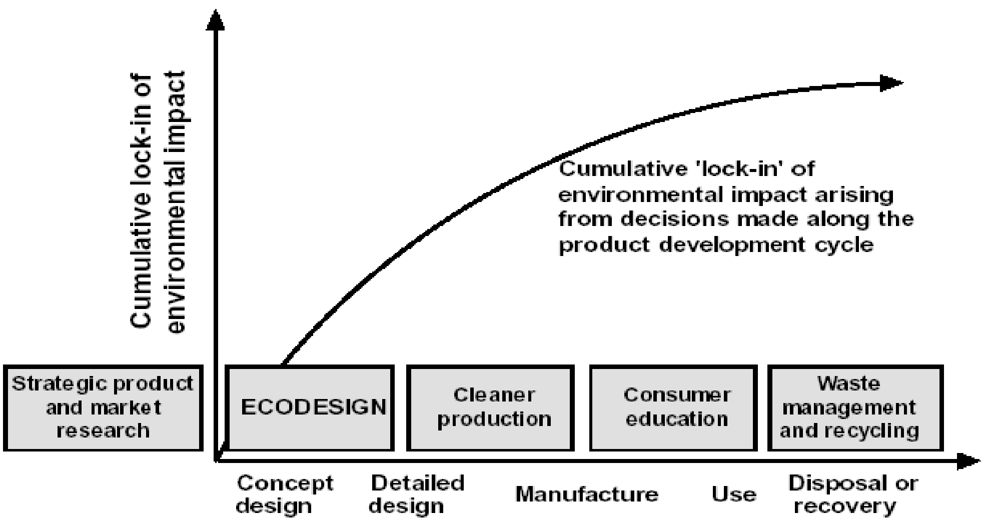

Figure 8. Environmental impact lock-in from decision-making on design (Lee & Park, 2005).

Figure 8 shows the environmental impact “lock-in”, from decisions made in the design phase of the product development. The time axis represents the products life cycle from a business perspective. This implies that through early environmental considerations performance can be optimised (Lee & Park, 2005).

A popular concept for integrating environmental aspects in design is Ecodesign or the similar Design for Environment, DfE. A close on the design phase reveals four main stages: planning, conceptual design, embodiment design and detail design. This is general order in the designing phase. One can regard the cumulative “lock-in” effect as a potential for environmental improvement, and as the figure shows the greatest potential, from a life cycle perspective, lies within the earliest stages of the design phase.

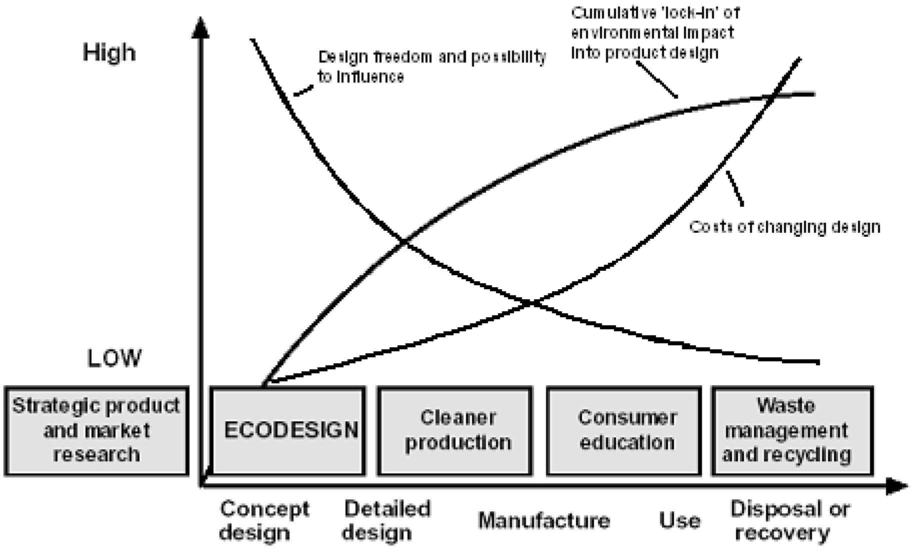

Figure 9. Change effect from eco-designs.

Figure 9 shows that there also are economic benefits of incorporating the environmental considerations early in the products’ design processes. The figure indicates that early changes in design from e.g. environmental decision making are cheaper to realise when the degree of freedom in the design process is large. As the design process develops changes are becoming more expensive.

Eco-design, or similar concepts, can use LCA. The eco-design process inevitably contains some kind of environmental assessment were LCA could be used (Lee & Park, 2005). However, it is not said that other evaluation tools are not to be used.

3.3 Procurement and production

The production process follows the design phase in the product development chain. Using LCA to study the potential improvement in the production system is not as traditional use of LCA as e.g. marketing or product design purposes. The application of LCA depends on the production system. A common use of LCA for all production systems, however, is identification of 'hot-spots'. The studies should include all down-stream activities before the use phase in the products' life cycle and are used to recognize the production processes that cause the greatest environmental impact, including raw material extraction, components and transports. The production processes in the studied companies are mostly pure assembly processes, thus influence of the total emission levels or energy use is not that great. However, a common factor for all assembling industries is their complex supply chains. Supply chain analysis is important for evaluating the products total impacts.

3.3.1 Supply chains

The truck industry uses the traditional supply chains that reaches from raw material via manufacturing, distribution and ends at the customers. However, laws and directives on producer responsibility has influenced the development of an extended green supply chain, were collection and re-use, remanufacture and/or recycling follows the customer's use phase. The extended green supply chains includes the whole life cycle of the product in a similar way that a LCA study do, making LCA highly applicable when analysing the supply chains. LCA can be used to e.g. (Baumann & Tillman, 2004):

- identify were efforts are most needed, assess different logistical alternatives,
- to shift focus from process optimisation to supply chain optimisation
- to support eco-design and strategic decision making by introducing eco-design partnerships with suppliers and/or environmentally sound construction materials.

LCA together with other analytic tools can be used to increase eco-efficiency in the supply chain. The communication of information between suppliers and customers is important for the usefulness of an LCA approach. Software tools and databases for sharing environmental information within the supply chain is a way to increase transparency and facilitate communication for the network of involved actors (Baumann & Tillman, 2004).

3.3.2 Procurement

Procurement is the process of purchasing materials, components and products. Thus, the purchasing department are in position to influence the companies' environmental improvement by making environmentally sound procurement decisions, so called green procurement. Traditional procurement considers mostly economic, quality and compatibility. Environmental quality is a new relatively new aspect in supplier selection, but LCA studies can simplify this decision making process by offering detailed or aggregated environmental information. The lack of standard procedures for conducting LCA in procurement limits the applicability in practice. However, the increased interest in environmental performance from customers has influenced many suppliers to develop so called environmental product declarations, EPD, that contains information on environmental aspects (Baumann & Tillman, 2004).

3.4 Marketing

Marketing purposes is an important application of LCA results. Green marketing is marketing by communicating environmental benefits to a recipient, either businesses or private consumers. The studied companies mostly use business-to-business communication. Business-to-business communication is characterized by the higher level of detail in product information. This is due to the higher competence and interest from business customers. Environmental information may, subsequently, contain more detailed technical figures (Confederation of Swedish Enterprise, 2002).

There are some different ways companies can communicate environmental information. Environmental product declarations, EPDs, were developed mainly for business-to-business communication. EPDs, in short, are the communication of LCA results. Eco-labelling and self-declared environmental claims are other examples of environmental communication.

3.4.1 Environmental Product Declarations

As mentioned earlier EPD is a way of communicating environmental information business-to-business. The goal of EPDs in general is to create the basis for a fair comparison for products and services from an environmental performance perspective. The EPD is a communication tool that collects LCA results and additional environmental information from the whole supply chain. Through registration and verification from an independent third party verifier is supposed to offer a credible image of the products' environmental impact. The main advantages of using certified EPDs are, according to the Swedish Environmental Management Council (2007 :

Objectiveness through the use of internationally accepted standards for LCA methodology (ISO 14040:2006). Support a unified way of conducting LCA studies within the company.

Non-selectiveness and neutral because there are no preset environmental performance levels that has to be met.

Comparability after collecting and calculating data in an internationally harmonized way.

Credibility because of review, approval and follow-up by an independent third party verifier.

Accuracy since the data has to be updated continuously based on company documentation routines.

The whole EPD labelling process is regulated in the ISO 14025 standard that regulates environmental declarations type 3 (The Swedish Environmental Management Council, 2007).

3.5 Information, training and education

Another important application of LCA result is the learning process in companies. The LCA reveals the potential areas of improvements. It gives an overall view of the direct and indirect environmental impact caused by the company's activities and educating different groups of competences based on these results can create acceptance and more effective improvements. LCA is generally highly appreciated in engineering, and in technical divisions in companies (Frankl & Rubik, 2000).

If the company has developed EPDs for external communication to markets, the information can also be used internally for product-related environmental improvements. It can support an effective use of an EMS, be used as input for Eco-design and simplify information exchange for purchasing and procurement (The Swedish Environmental Management Council, 2007).

LCA can also be useful for building confidence between other stakeholders to the company. It can be used for communication of environmental performance of the products to NGOs and for educating consumers, thus creating conditions for a greener market (Frankl & Rubik, 2000).

4 Aspects of successful LCA implementation

This chapter will present four aspects of what can make LCA successfully implemented in a company or organisation. The presentation will account for theories on: Driving forces, LCA integration with EMS, Institutional theory and barriers to LCA implementation.

There are many different conditions to be met for making LCA a natural part of decision making and business activities overall. Many pieces influences the companies' implementation of LCA: there have to be an interest and commitment to LCA in the company, it has to generate valuable results and the use of LCA should be compatible with the companies' environmental management systems, if they have one. This chapter will describe the presence of possible driving forces in companies, the level of implementation (institutionalism) and how LCA can be integrated with EMS.

Assuming that the company has the economic potential and technical knowledge to conduct LCA, there are some conditions that have to be fulfilled for a company to adopt LCA as a part of their organisation. But most of all, the company has to be concerned about the environment, thus willing to improve their environmental impact.

Environmental management systems, EMS, have proved to be used by almost all companies that use LCA (Frankl & Rubik, 2000). The focus of the EMS is the organisation and LCA focuses on products, they are not compatible in this context. However, if they can coexist together they can increase the effectiveness of both LCA and EMS work.

Different stakeholders influence the companies' decisions, and actions like using LCA. Traditionally market and politics are two stakeholders perceived as very important. Other stakeholders to be mentioned are stockholders, NGOs, media and employees. However, Frankl & Rubik saw that stakeholder pressure is perceived in similar fashion in both LCA companies and non-LCA using companies hence are not decisive for LCA use per se (Frankl & Rubik, 2000). However, some of these stakeholders can be derived into some of the driving forces for companies to adopt LCA, thus important in that context.

To explain companies' LCA adoption, two different important aspects has been taken into consideration in this report: what driving forces the company recognises and how well they can complement their EMS with LCA. These aspects can then create understanding for the level of implementation, from the theory on institutionalism.

4.1 Driving forces

The initial driving forces for starting LCA work in companies vary. In 2000, Frankl & Rubik established that the driving forces for LCA work considered most important in Swedish industry are:

- Product-related environmental problems
- Cost avoidance due to future liabilities
- Initiatives by Research and Development, R&D

Other drivers of secondary nature are, in selection:

- Cost-saving opportunities
- Emerging green markets
- Meeting eco-label criteria
- Decision of the management

Environmental legislation and competitors' use have proven not to be important driving forces for LCA for Swedish industry (Frankl & Rubik, 2000). The Confederation of Swedish Enterprise feels that legislation on e.g. carbon dioxide would be too complex and that traditional regulation is not useful (Confederation of Swedish Enterprise, 2002). They would support some market-based instruments to support product development to lower environmental impact from products. Frankl & Rubik also finds that legislative driving forces are considered more important in e.g. Germany (Frankl & Rubik, 2000).

Another difference is the perception of the emerging green market. In Germany this is generally considered more important than in Sweden (Frankl & Rubik, 2000; Baumann, 1998).

When it comes to market forces there is currently some shortcomings in the current demand for green products, and demand is central for any development of products. However, there are ways of influence demand. It is important to communicate environmental performance in credible, accessible ways to the intended target group; in the case of truck industry it is a question of business-to-business communication. In business-to-business market, customers more often, than in other cases demand that producers supplies more sophisticated environmental information, e.g. through EPD (Baumann & Tillman, 2004). There is also increased demand that suppliers and contractors are included in the development towards a lowered impact from a life cycle perspective. However, often greened products are more expensive in purchasing. This seems to be a limiting factor, even though the life cycle cost is lower. Regardless, customer demand for green products maybe one of the most important driving forces for environmental work and lowering environmental impacts from products (Confederation of Swedish Enterprise, 2002).

In customer communication of environmental information different types of eco-labelling can be used. In business-to-business communication one of the most useful are ISO type 3 declarations, Environmental Product Declarations (EPDs). An EPD is based on LCA and all information is verified by an impartial verifier, thus adding credibility to the information communicated. The concept of EPD is presented more carefully in chapter 3.4.1.

Cost avoidance due to future liabilities is basically a consequence of take-back systems. Today, Swedish producers' liability legislation includes packaging, tyres, newsprint, cars, and lead batteries for cars. Today truck industry is not affected but prospective LCA studies can lower risk of future liabilities. Analysing components and the materials used in products can make e.g. effective waste management or detailed dismantling information easier to put into practice.

Cost saving due to identification of potential improvement areas in the product life cycle is a classic application, and a historical driving force to LCA (Hunt & Franklin, 1996). These potential improvements can be analysed prospectively with LCA. For instance, changes in production processes can be compared to the current settings.

Studies by Baumann (1998) show that individual initiatives by R&D engineers or other employees can be one of the most important driving forces for adopting LCA. It is important that the LCA entrepreneur is able to convince managers and co-workers to commit to LCA. If the company does not have a strong believe and strong internal driving forces to adopt LCA, chances are that the LCA experience will be short-lived. The importance of the initiators will be described further below, in chapter 4.3 on Level of implementation – institutionalisation.

4.2 Integration with EMS

Using well documented frameworks are important for creating confidence from stakeholders. Even if commitment to environmental improvements is often perceived as good, it has to be done in a structured way. By implementing international standards companies can be confident in their methods to help create environmental improvements (Finkbeiner, Wiedemann, & Saur, 1998). The international standard referred to in this report is the ISO 14001 and ISO 14040-43. This chapter will clarify how the procedural tool (the EMS) and the analytic tool (LCA) can complement each other to achieve an effective environmental work.

There are two different ways of integrating LCA and EMS, either EMS is integrated into LCA or LCA is integrated into EMS. Implementation of EMS is often preceding the use of LCA in companies that have different groups of products. It has also been shown that LCA studies are more likely to take place in companies that uses an EMS, and have well organised environmental work (Baumann, 1998).

An effective individual company combination of using LCA and EMS simultaneously can increase effectiveness and efficiency of environmental management efforts.

In a company that already uses an EMS, LCA can be an effective complementary tool in many regards:

- LCA can identify products with substantial environmental impact
- LCA can be effective in prioritising EMS objectives
- LCA considerers the use phase of products
- LCA can assist in investment decisions
- LCA can assist in Design for Environment, DfE
- LCA can assist in supplier audits and choice of materials

What the actual benefits from using LCA and EMS are depends on the company and its situation. However, generally a company that uses an EMS and wants to start using LCA should begin with their most important product. The combination of LCA in an EMS enables individual solutions to problems enlightened and is cost efficient (Finkbeiner, Wiedemann, & Saur, 1998).

The other way around, an EMS can be applied after the company has started using LCA, LCA can be helpful in implementing an EMS. The EMS would then serve as a beneficial complement to LCA in several ways:

- EMS can help in realising recommendations based on the LCA results
- EMS can expand the optimisation scope to the entire organisation, rather than on the specific product or products
- EMS can assist in involving decision-makers
- EMS involve more employees than the LCA specialists and can be helpful in promoting a corporate identity
- EMS focus on continual improvement

The last condition for successful implementation of LCA into EMS, or vice versa, is a knowledge factor. Finkbeiner, Wiedemann & Saur end their reasoning on the the dynamic relation between LCA and EMS by a last conclusion: It is very important that companies' managers and consultants have very strong background of both tools (Finkbeiner, Wiedemann, & Saur, 1998).

4.3 Level of implementation – institutionalisation theory

When adopting LCA, or any new techniques, in a company it is evident that the process of making it a natural part of the organisation has to go through a few stages. The most recognised institutionalisation theory divides this process into four stages: innovation, habitualisation, objectification and sedimentation (Tolbert & Zucker, 1996).

When a company decides to adopt a new innovation, e.g. a method or a tool like LCA, the first stage is habitualisation. The decision on using LCA can be motivated by many drivers, described earlier, either external or internal. Common for all drivers are that they have to create a notion that there is a benefit from using LCA, that it can improve environmental performance in ways that current environmental tools cannot. Introduction of LCA can either be done top-down or bottom-up, depending on the internal political arrangement. A decision to take on LCA by management is a typical top-down approach. Individual commitment from employees or a group of employees to adoption of LCA is a bottom-up approach. Regardless of introduction, in the habitualisation stage the concept of LCA is generally not very acknowledged. It is almost exclusively the decision makers or the initiators that are versed in LCA (Baumann & Tillman, 2004).

The objectification stage is probably the most crucial for the LCA implementation. After conducting the first LCA studies, it is important to develop some consensus regarding how to use LCA. For a wider implementation it is important to create understanding of the tool throughout the involved organisation, and not only the people that already has recognised the concept. Two mechanisms for creating wider understanding have been recognised: having a true 'LCA-champion' that can promote LCA successfully and monitoring business in the same sector. This contradicting the notion of the driving forces described earlier, thus this mechanism can be described as less influential in the case of LCA. If the LCA initiator is very persuasive and communicative, he might be able to show how LCA could benefit in problem solving in the organisation. The initiator, or entrepreneur, has to have a strategy to make the managers and decision makers realise that LCA has got many applications, not only for evaluating the most important products. He, or she, must also create interest around LCA, by communicating surprising results or successful LCA implementation in other companies (Baumann, 1998).

Companies that are in the objectification stage have taken focus off the technical, economic and internal politics. They also tend to stride towards focusing on the possible internal applications rather than concentrating on other companies' use of LCA. An organisation, or structure, around LCA should also have started to evolve but may still be temporary.

The final stage of institutionalisation is sedimentation. When a company has come this far, there is no longer a need to promote or show evidence of the benefits from using LCA. The company has a formal structure of their LCA work and the initiator no longer has to push for development around the concept within the company. Regardless of the extent of the LCA studies the company has taken LCA for granted and routines on when to conduct LCA have been developed. It takes major commitment for the company to reach the sedimentation stage and both economical and physical resources, thus making abandoning LCA at this stage unlikely (Baumann, 1998; Baumann & Tillman, 2004; Tolbert & Zucker, 1996).

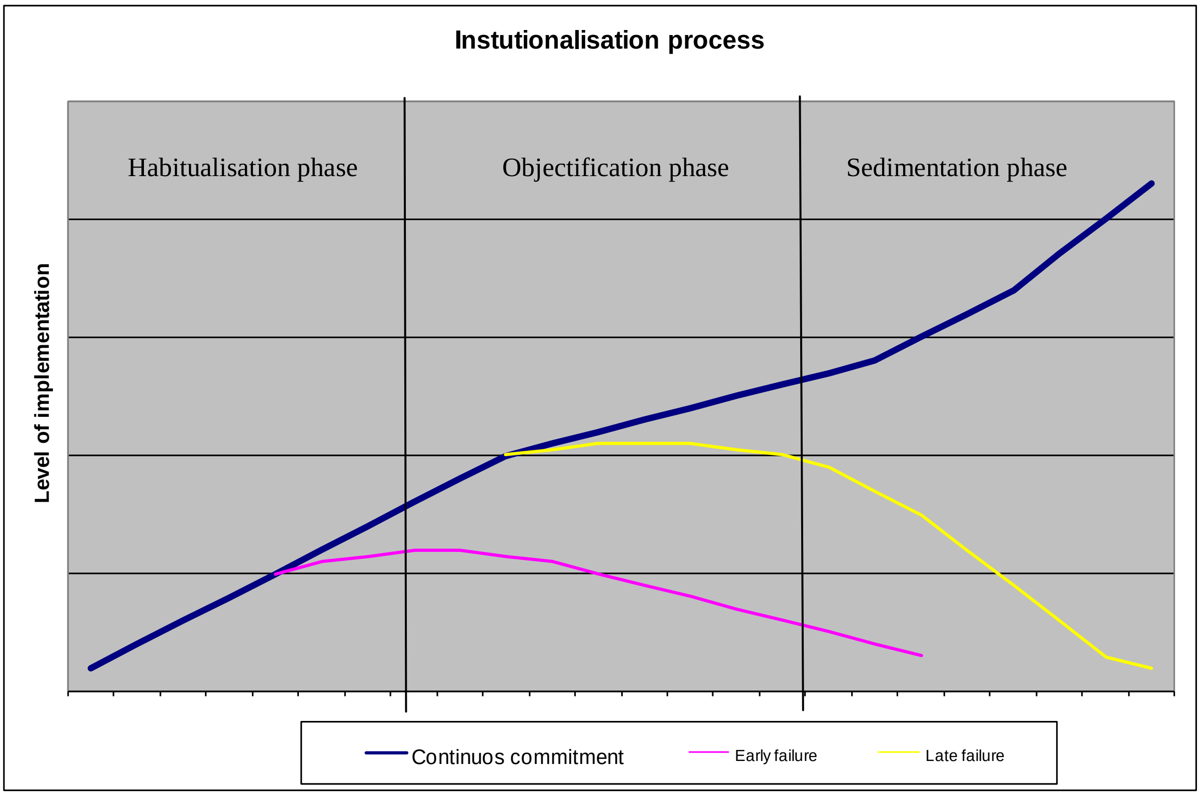

Figure 10. The Institutionalisation process (inspired by Frankl & Rubik (2000)).

Figure 10 shows the dynamic process of adopting new innovations in companies, in this case LCA. The fading lines describe how the level of implementation decreases when companies somehow decides not to commit further to LCA. This decision can be taken during the whole institutionalisation process, but is visualised in the graph either in the habitualisation phase or in the objectification. Theoretically a decision to fade out LCA use can be made in the sedimentation phase as well, but can be considered unlikely.

To sum up Baumann and Tillman (2004) concluded that there are some crucial factors for a successful implementation of LCA:

- how well unexpected LCA results are communicated and dealt with
- how well continuous LCA studies can offer learning of the products depending on size of the company and products diversity

- whether the driving force for initiating LCA implementation is external or internal. External driving forces tend to make companies abandon LCA, because of the lack of knowledge within the company.

They also stress that LCA implementation is individual, and the same pattern of implementation cannot be applied to all companies. This is another example why the LCA initiator plays a great part of the process.

4.4 Barriers to LCA implementation

Even though LCA is useful for analysing products' and services' environmental impact there are some general barriers to using this tool. LCAs are often criticized for being too complicated and technical. This affects communication and applicability for use by different competences within a company. Depending on level of detailed of course, but nonetheless LCAs are resource demanding, thus often making it unavailable for small enterprises and governments in developing countries. Building databases from a number of LCA are even more costly. The most significant barriers from company perspectives are (UNEP, 1999):

- Absence of perceived needs,
- Lack of LCA expertise and know how,
- Lack of resources and
- Lack of appropriate data and methodologies.

The relative significance of these barriers differs for companies and governments (UNEP, 1999). The involvement of assumption and subjective valuation creates great demand for transparency in the LCA study. Problems can also occur during the data collection phase, and most commonly problems on data availability and quality (Baumann & Tillman, 2004)

It should also be pointed out that LCAs only studies the environmental aspects and implications of the products. Other important aspects, economic and social are not included in the LCA. Therefore, LCA is often not enough to alone support decision making in companies.

4.5 Comments on the literature study

Studying some theoretical views on the concepts linked to the questions has brought light onto what to look for in studying the companies. It has also supplied sufficient information to be able to continue studying the questions posed relating to the problem.

The literature studied is not covering the all the aspects of LCA work but it is a reflection of the information available publically and the research made on these subjects.

5 European Truck industry

This chapter is a presentation of the two of the largest, by Western Europe market share, truck manufacturers. The companies are DaimlerChrysler and, DAF. It is a presentation of the companies in general, and especially their use of LCA and LCA-related information. The chapter start with a short description of a few trends in the truck industry.

During the latest decades there has been some substantial improvements made on some environmental issues. In the transport sector, and in truck industry, improvements on emission levels of environmentally hazardous compounds have been substantial.

5.1 Sector development

The degree of fulfilment on governmental goal on emissions of sulphur dioxides, nitrogen oxides and hydrocarbons are high. These are compounds linked directly to goals on air quality and even if urban areas have occasional problems the prognosis are positive. However, the goals on climate change and subsequently the emission of carbon dioxides have not showed the same positive development. This is probably related to the fact that there has been no regulation on carbon dioxide emission.

The carbon dioxide emissions are, are as well as other emissions, linked to the vehicle mileage, the proportion of different fuels and emission per driven kilometre. But when strict regulation on sulphur dioxides, nitrogen oxides and hydrocarbons has lowered these emissions, carbon dioxide emission has been neglected.

The continuous increase of vehicle mileage demands an increase of either sustainable fuel consumption or fuel efficiency, possibly a combination of both. Otherwise the emission of carbon dioxide would continue to increase.

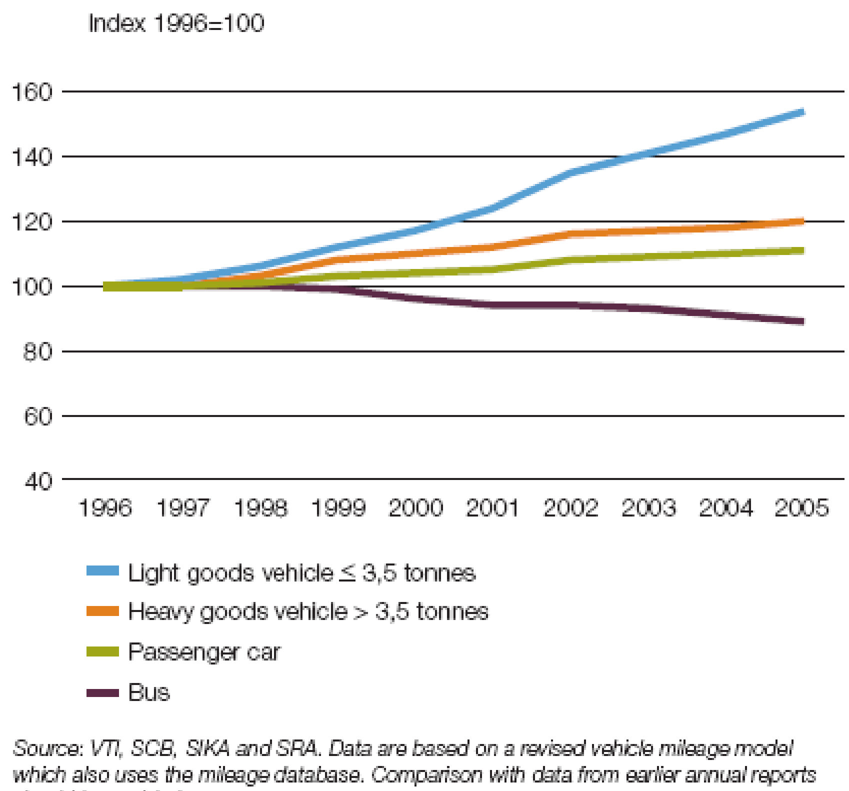

Figure 11. Development of vehicle mileage in Sweden 1996-2005 (Vägverket, 2005).

Figure 11 shows the increase of vehicle mileage by vehicle type. There are increases in all types of vehicles, except for buses. And this trend is striking for the whole world.

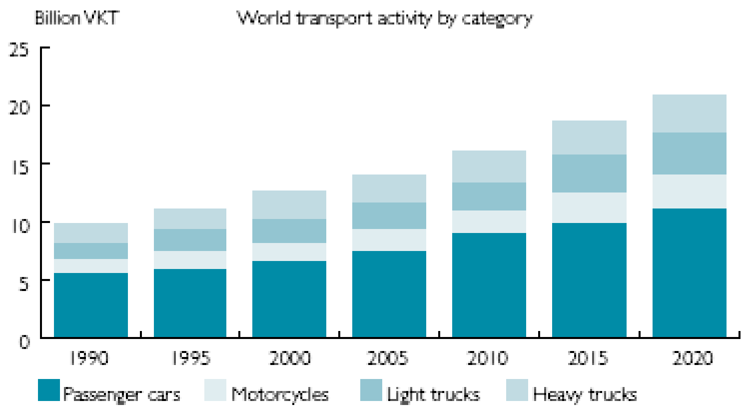

Figure 12. World transport activity development (OECD, 2001).

The trend towards increased use of trucks, as Figure 111 and Figure 12 shows, supports the notion of truck industries' importance on environmental impacts. The increase of transport activity has influenced the number of trucks sold. In 2006 there was an increase of 15.5% in the sales of heavy trucks (ACEA, 2007).This should benefit the manufacturers and influence further investments.

The truck manufacturers have accepted the challenge of fuel efficiency and according to European Automobile Manufacturer Association, ACEA, the modern trucks consumes about two thirds of the fuel used in the corresponding model from the late 1960's (ACEA, 2007), as shown in Figure 133. And they also feel that the development of new techniques will improve fuel economy even more. Investments in research are essential for developing new techniques and truck manufacturers' stands for a large part of total investment from the automobile industry.

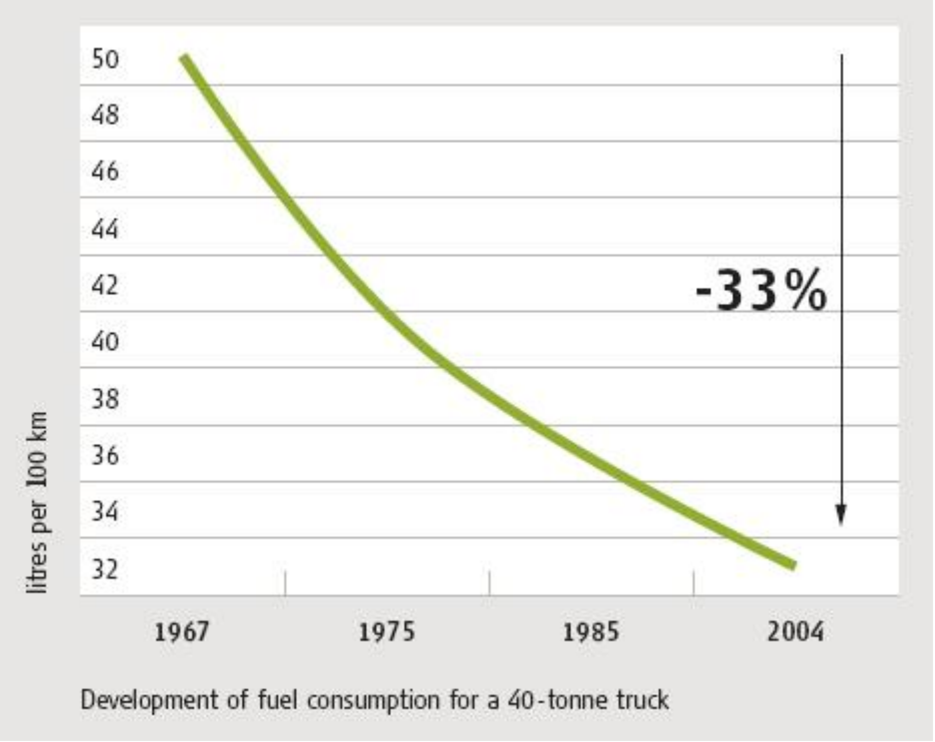

Figure 13. Fuel economy in trucks 1967-2004. (ACEA, 2004)

What role LCA plays in lowering of fuel consumption, described in Figure 13 as general improvement from a 40-tonne truck, and for all environmental impacts remains unclear. LCA results from companies are not often communicated directly.

This report has studied four of the largest truck manufacturers in Europe: DaimlerChrysler, Volvo, DAF and Scania. The focus has been on the two Swedish, or at least Swedish founded companies. DaimlerChrysler and DAF have been studied for comparison to other European companies. It should be pointed out that the material from the studied differs; studying Volvo and Scania Annual and Environmental reports and homepage information has been completed with qualitative interviews and email correspondence and internal documents. In the case of DaimlerChrysler and DAF no interview has taken place, and only material accessible to the public has been studied.

The following part of this chapter present the results from the study of the European companies DaimlerChrysler and DAF. The presentation includes some general information to give a fair image of the influence on the sector as a whole, information on the companies' environmental commitment, if they have implemented EMS and the central information on their LCA use.

5.2 Daimler Chrysler Group and Mercedes-Benz

DaimlerChrysler is a German American fusion between Daimler-Benz and Chrysler, formed in 1998. The truck group is the world's leading truck manufacturer with at total of 529,499 commercial vehicles sold worldwide in 2005. The truck group includes a number of brands for different market exposition:

- North America – Sterling Trucks, Freightliner and Western Star Trucks.
- Asia: Mitsubishi Fuso.
- Western Europe: Mercedes-Benz.

The DaimlerChrysler Truck group had the single greatest share of the Western European market for medium duty trucks and heavy duty trucks. In 2006 the retail sales was 84,639 gaining a market share of 22% (DaimlerChrysler, 2007).

The DaimlerChrysler group has implemented the Environmental Management Systems ISO 14001 or EMAS at about 96 % of the production facilities worldwide. In USA all suppliers has to be certified according to ISO 14001, and requirements of environmental compatibility is mandatory for suppliers worldwide.

The DaimlerChrysler group has adopted very proactive environmental guidelines in their environmental policy. The first statement in their environmental strategy (DaimlerChrysler, 2006):

'Protecting the environment is the primary objective of the DaimlerChrysler Group'

is an example of a big ambition. Further statements in their guidelines indicate that they aim at being world leading when it comes to environmental performance, regarding both products and manufacturing. The main environmental efforts that DaimlerChrysler focus on in their production activities is decreasing the use of solvents, carbon dioxide emissions and resource efficiency to avoid waste material. Product development are focused on lowering carbon dioxide emissions and consumption of fossil fuels

The Daimler Chrysler group have Design for Environment, DfE, experts working with environmentally responsible development of their cars and commercial vehicles. They recognize that there are differences towards development of commercial vehicles and passenger cars in that professional customer are more focused on economic factors (DaimlerChrysler, 2006). Within product development they recognise the link between economic and ecologic benefits when it comes to fuel consumption and lightweight design, and they focus these areas in their DfE. The attitude in the DfE at

DaimlerChrysler agrees with the theories on how the degree of freedom, and the influencing options, in the early design stages can yield the best improvements described earlier in chapter 3.2 (DaimlerChrysler, 2006).

The DfE team brings together experts from five sectors: Life Cycle Assessments; Dismantling and Recycling Planning; Materials and Process Engineering; Design; and Production. They work with a goal to make quantifiable improvements of the DaimlerChrysler vehicles.

5.2.1 Application of LCA

DaimlerChrysler, or members of the DaimlerChrysler group, has been using LCA for almost ten years, and have gathered extensive experience from conducting over 100 LCAs on parts and several complete car LCAs.

The cross-divisional DfE team of experts in the DaimlerChrysler group is responsible for developing LCAs for the passenger car and commercial vehicle group Mercedes-Benz. They follow every step of the vehicle development process and have a formal LCA organisation in every project. Their primary task is to evaluate new components and vehicle concepts. The following areas of LCA application have been recognised:

Daimler Chrysler is clearly dedicated to DfE. They have adopted a strategy to use DfE in almost all product development projects and to include environmental aspects, and decision making, in the general decision making regarding each project. One LCA project report is ended with the conclusion:

"Vehicles are complex products that interact with the environment in very complex ways. Therefore, simple solutions, e.g. a focus on fuel economy or light weighting, recycling or single material strategies only, are bound to fail. It is a prime task of DfE and LCA to take this fact into account and come up with more intelligent solutions." (Finkbeiner & et.al., 2006)

DfE representatives are included in the project management and LCA studies are a natural part of the DfE division's activities. Because LCA has strong formal position in Daimler Chrysler's DfE activities, the LCA relation to strategy definition can be classified as strong.

DfE is included in all R&D and design projects, and the DfE division conducts its own LCA research. Thus, LCA's relation to R&D and design is very strong in Daimler Chrysler. Their use of LCA during the last ten years included creating comprehensive LCA databases. The LCA on individual parts and its results are mostly used for decision making on technological and material concepts. Full vehicle LCAs are also conducted at the product development milestones, based on the previous studies the new LCA is calibrated throughout the process. Achievements from using

LCA are, among others, increased use of renewable and recyclable materials and improved recycling properties. Another important result from their LCA studies of complete vehicles is the mapping of all life cycle stages and the conclusion that they are all relevant, from different impact categories (Finkbeiner, 2001; Finkbeiner & et.al., 2006).

The DaimlerChrysler group are starting to develop environmental certificates for their vehicles. The certificates are based on comparing LCAs of previous vehicles in the same vehicle category or the predecessor model (Finkbeiner & et.al., 2006). However, they have not yet certified any commercial vehicles. Thus, the link between LCA and marketing in DaimlerChrysler in the context of trucks is yet weak.

DfE is used for internal purposes for learning of the products, how to make the most of LCA and the integration of LCA into product development. In the research on LCA the DfE division recognized the need for prospective LCA. The reason for this is, as mentioned earlier, that the degree of freedom is greater in the early stage of the design process. Thus, the early stages of design decide the environmental performance of the products. DaimlerChrysler has recognised that the uses of LCA results have higher quality if studies are repeated continuously. Research at DaimlerChrysler show that when having conducting an extensive LCA for a product or product family as a reference the following LCAs will be less time consuming and even more accurate.

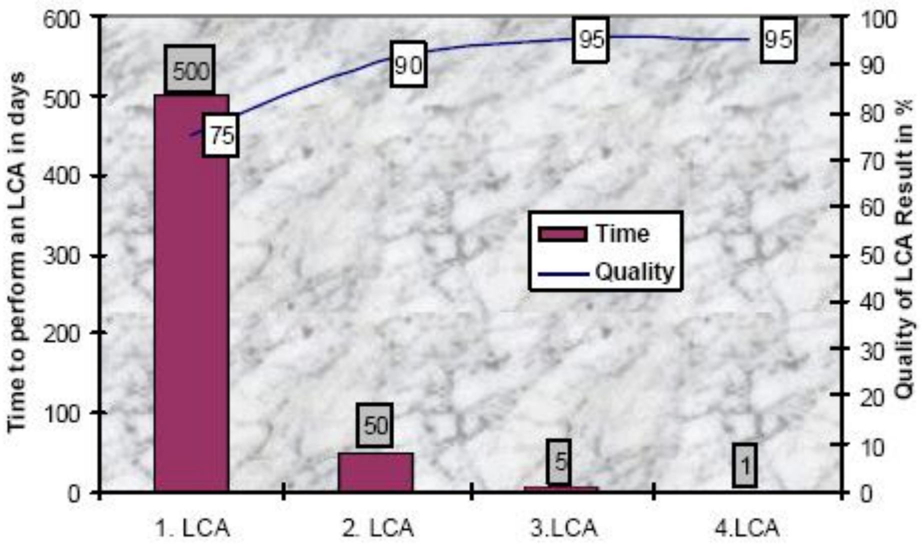

Figure 14. Learning Curve from repeated LCAs in DaimlerChrysler. (Finkbeiner et al., 2001)

Figure 14 show how quality of the LCA results increase by the number of LCAs performed. The first LCA processes many data, thus is very time consuming. The second LCA can re-use information making it less time consuming. During the second LCA old data can be updated while collecting new information, making the second

LCA more accurate. As new LCA are conducted less new data needs to be collected reducing time use and increasing quality.

Based on the notion about the quality of LCA studies and the degree of freedom in the design process, using multiple LCA studies on the same product, or product family, in the design process can improve the final results. For instance: the first LCA may point out some problem areas of the new product. The following LCA can now be used to monitor and control improvements. The end result may subsequently be substantial improvements to the reference product. Results from the environmental evaluation are used to publish environmental performance information available for employees and the public. The intention is to create beneficial behaviour from communicating environmental awareness (Finkbeiner, 2001).

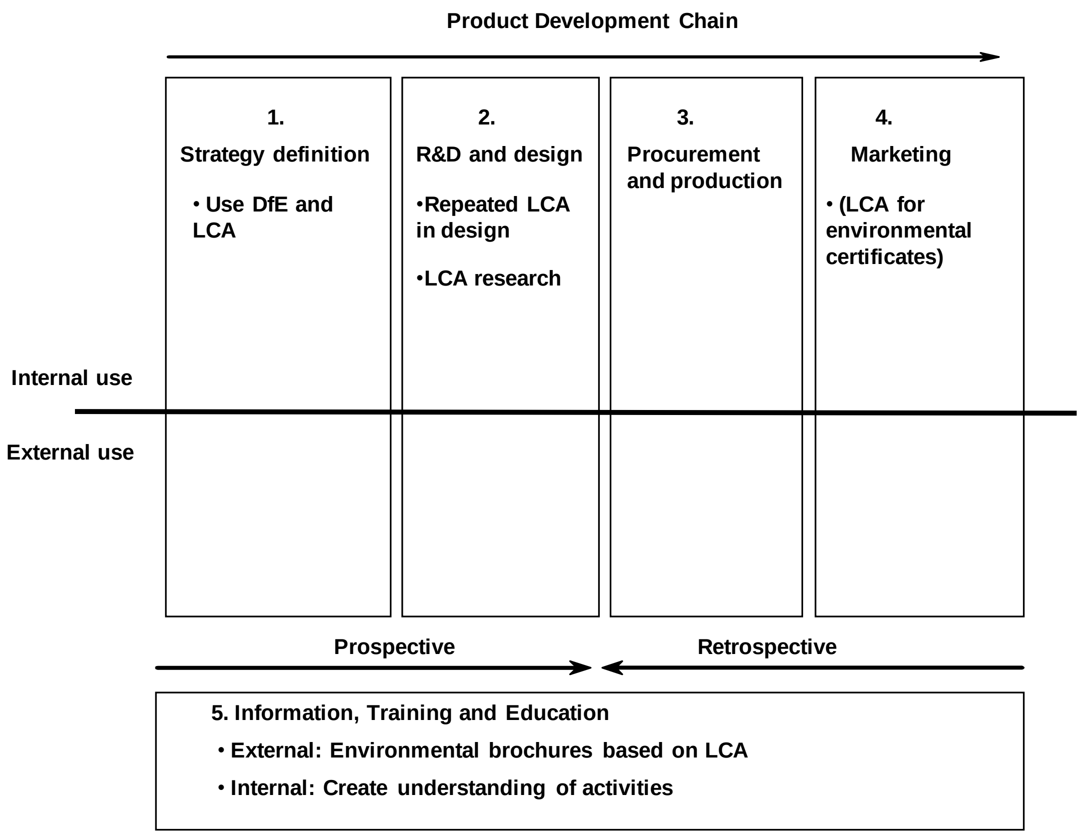

Figure 15. LCA application in DaimlerChryler Truck group.

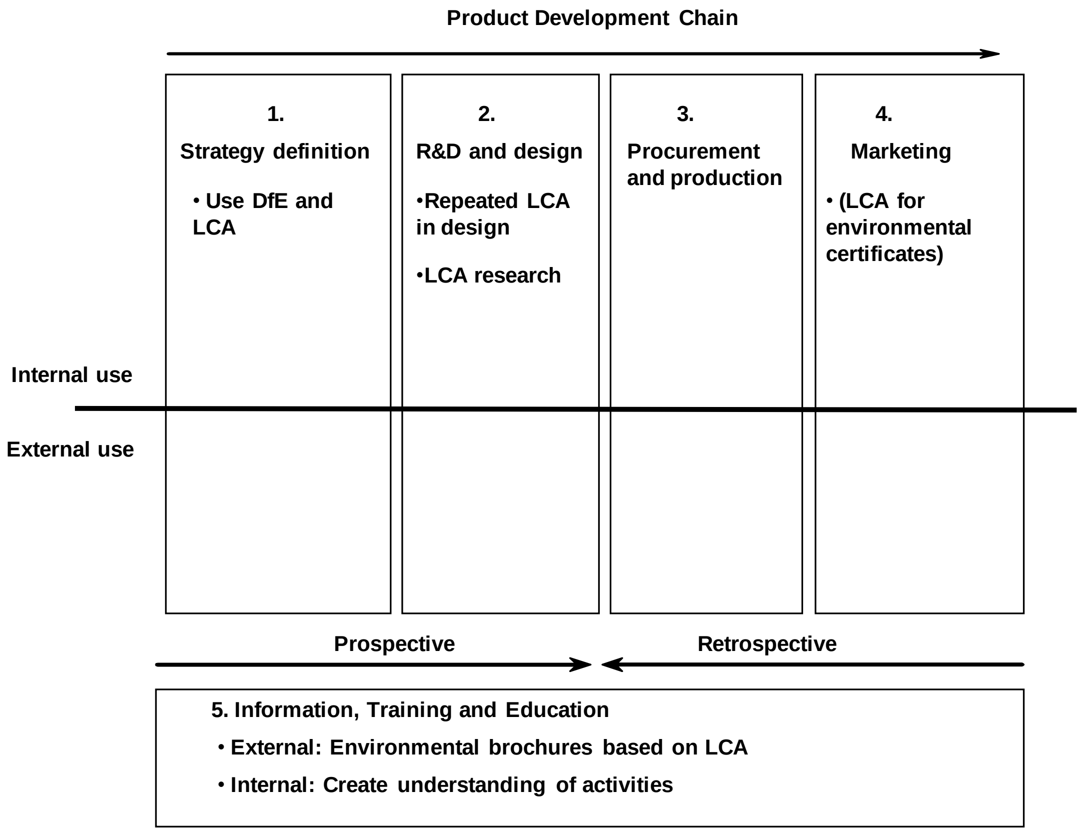

Figure 15 shows the general LCA application within the DaimlerChrysler Truck group in the Frankl & Rubik framework described in chapter 3. All LCA studies are performed by the cross-divisional DfE team.

In the material studied and in the contact with Dr. Matthias Finkbeiner at DaimlerChrysler there has been no indication of any problems from integrating the use of LCA and their EMS.

5.2.2 Level of implementation

Based on the above appreciation of DaimlerChrysler's use of LCA I would argue that DaimlerChrysler is a company in an advanced sedimentation phase in their institutionalisation process. The wide spread use of LCA in four of the application areas, the LCA research in the DfE team and the formal organisation of their LCA work in projects are three facts that support this notion. DaimlerChrysler does not seem to be absolutely depending on one, or a few, advocates to drive their LCA work forward. There is, however, still room for wider LCA implementation. Developing new way of using LCA in their organisation can be put within the scope of their LCA research.

5.3 DAF

Another important actor in the truck industry sector is the German DAF, a member of the American PACCAR group originally called Pacific Car and Foundry Company (PACCAR Inc., 2007). The PACCAR have different brands active on several markets around the world:

North America: Peterbilt and Kentworth

Europe: DAF

In 2006 DAF gained a Western Europe market share of 14,5%, with retail sales of 55,900. The main markets are North America and Europe, but they are also represented on smaller markets like Australia and Mexico (PACCAR Inc., 2006).

The company seems to have adopted a very extensive environmental policy, and they have established action plans on all stages of their product’s life cycle stages. DAF’s environmental commitment include the implementation of EMS, a separate recycling policy, Ecodesign team for product development and design, actively lowering the environmental impacts from their manufacturing facilities, considering environmental aspects in purchasing and uses environmental improvements in marketing. And they have established more specific goals for each area (DAF, 2007). These commitments are not purely based on a specific Life Cycle approach or LCA studies but are individual efforts on different life cycle stages to generate improvements from the DAF activities as a whole.

5.3.1 Application of LCA

DAF has realised an environmental policy principle that communicates life cycle consideration on environmental impacts from their products:

‘The complete life cycle of the product is taken into account in our activities, from initial development through to disposal.’ (DAF, 2006)

LCA is used for purposes within the company and for external communication.

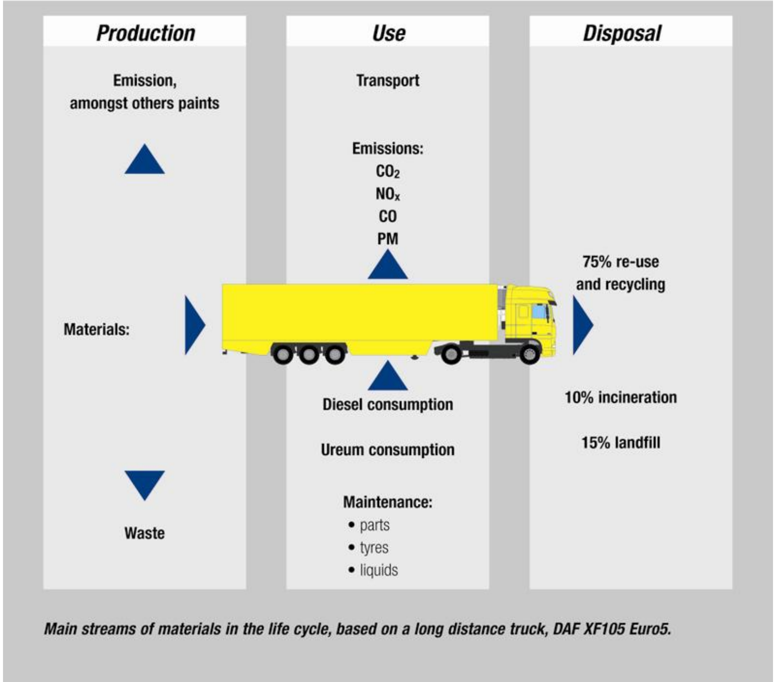

Figure 16. Material flow during the DAF XF105's life cycle. (DAF, 2007)

Figure 16 shows the simplified LCA scheme used within DAF. According to Wilma Margry at DAF Environment the scheme is used for training of engineers, and for communication of environmental information to the public (Margry, Wilma; DAF Environment, 2007).

LCA studies are conducted by the DAF Ecodesign team that aims to combine economic and ecology to strive towards their goals of efficiency. DAF has also implemented an internal Ecodesign tool for their constructors to have quantitative environmental data available during their design process. The constructor can use the tool for conducting life cycle assessments of the product or for continuous evaluation of the environmental benefits from weight reducing measures. The tool is used for comparing new products to older ones or for information on improvements on original designs (DAF, 2006). Recently issued LCA studies are:

- 2004 LCA study into Retreatment Systems and ureum use (DAF, 2004)
- 2005: LCA of After Treatment Systems and ureum use (DAF, 2005)

While the 2004 study was conducted successfully the 2005 study, however, was later cancelled for unknown reasons (DAF, 2006).

DAF have also made LCA of a complete truck, and are going to update data in 2007 (DAF, 2006). The result of this study show that impacts, indeed, is concentrated to the use phase of the trucks. Based on this notion they have chosen to focus their product development on emissions and fuel efficiency (Margry, Wilma; DAF Environment, 2007).

In strategy definition DAF has made use of LCA to establish the distribution of environmental impacts to the different life cycle stages. The results showed that the use phase has the biggest impact. From this, DAF has focused on use phase-related issues like fuel efficiency and emissions.

In R&D and design DAF uses Ecodesign, and in their Ecodesign process engineers can perform LCA studies. They do not perform that many stand alone LCAs, but in 2006 they started implementing LCA of full vehicles (DAF, 2006). Depending on how well this project turns out the future extent of the relation of LCA to R&D and design can be classified. However, because of their historical commitment to LCA there still is an evident link.

In DAF they have Ecodesign training for engineers. Even though it is hard to say anything about the focus on LCA specifically in the Ecodesign training, they seem to be committed to communicating life cycle thinking to their engineers. Hence there is a relation LCA to Information, Training and Education is obvious.

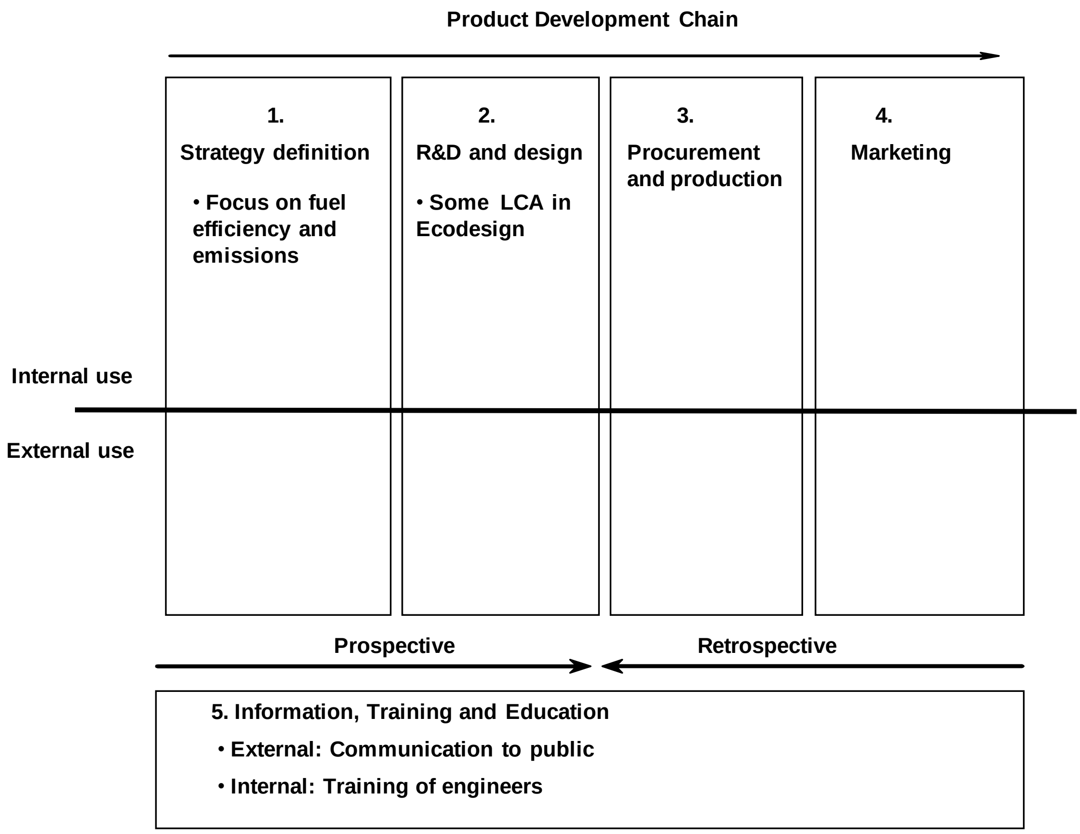

Figure 17. DAF LCA application.

DAF has, as established above, three main application areas for LCA: Strategy definition, R&D and design and Information, Training and education. Figure 17 shows these applications in the LCA application framework.

It has been difficult to appreciate how well LCA and EMS cooperates in DAF, but there has been no indication of any conflicts.

5.3.2 Level of implementation

The wide use of Ecodesign its link to LCA indicates that LCA is a natural part of the DAF organisation. However the number of studies actually conducted indicates some uncertainty towards the benefits of using LCA, thus placing DAF in the objectification phase.

Even though having committed to Ecodesign the somewhat unclear image of DAF’s LCA implementation is related to the use of LCA in their Ecodesign process, how often LCA is actually used. It could prove that DAF has come further than given credit for.

6 Swedish truck industry

This chapter is a presentation of the Swedish truck manufacturers Volvo and Scania. General facts on the companies and their environmental efforts are presented along with a mapping of the LCA use.

This chapter studies the companies’ environmental work in general and their LCA work in particular. The information is gathered from information published on their websites and from on-site interview with persons versed in environmental and LCA-related activities in Scania and Volvo respectively.

Firstly, the companies are presented with some general facts and figures. Secondly, the goal is to reflect the companies’ environmental commitment by describing their environmental image communicated in the companies’ annual and environmental reports, on homepages and by the company representatives interviewed in the field study.

Thirdly, information on LCA application within the companies is presented. LCA application is interpreted and put in the context of the LCA application framework used in this report, described more thoroughly in chapter 3.

6.1 Scania

The Swedish truck manufacturer Scania was founded 1891. From its original activity, producing train carriages, it has developed to a major player on the international truck market. The original production in Södertälje has grown and the production now takes place on 12 different locations in Europe and South America. The company has operations in over 100 countries and the number of employees exceeds 28,000. The Scania Company has been an independent organisation since 1996 and the separation of SAAB and Scania.

Scania’s most important markets are Western Europe (58% of deliveries), the fastest growing market Central and Eastern Europe (15%), Asia, Africa and Oceania (14%) and Latin America (13%).

The current share on the Western European market is 12,9 %, based on vehicle registrations. The total worldwide sales exceeded 59,000 vehicles in 2006 (Scania AB, 2006).

6.1.1 Environmental image presentation

Scania’s environmental work is organised in the Executive Board and coordinated in a network of managers and coordinators, with environmental responsibility for their business area. The environmental coordinators have a supportive and advisory role and managers are responsible for local targets and follow-up. To structure their efforts Scania has implemented the ISO 14001 standards to all its production facilities. Also, important divisions like Group management, procurement, development resources and market units are certified (Scania AB, 2007).

The Scania commitment to environmental issues from life cycle perspectives is communicated in their environmental policy, see Appendix. To realise their environmental policy and management they have established more concrete environmental objectives. Scania recognises its impacts and contribution to climate issues. They try to link their efforts to their activities in the industry and transport sector. To decrease Scania's contribution they have established carbon dioxide emission related goals for all Scania activities:

- Improve fuel efficiency in their products
- Encourage their customers to use their products in a fuel-efficient way
- Improve energy consumption in production processes
- Continue research and development relating to the use of alternative fuels
- Encourage research and use of non-fossil replacement fuels

The environmental strategy in the Scania organisation is to lower impacts from their products' entire life cycle. This includes their products and its production. Their environmental work focuses on economising resources and energy as well as meeting demands from customers on low fuel consumption and low emission levels (Scania, 2007). Another external stakeholder recognised is authorities, and they are devoted to have a dynamic dialogue when it comes to establishing emission level and legislation that comprises Scania's activities. They are also following the development on different European directives e.g. IPP-directives or manufacturers' liability legislation for truck industry, but are not actively contributing and have adopted a wait-and-see attitude towards this type of directives (Henstedt, Wästljung, & Johansson, 2006).

Scania has adopted a life cycle perspective on all their environmental improvement efforts. The life cycle perspectives that Scania has adopted is presented graphically in Figure 18 below:

Figure 18. The Scania definition of their products' life cycle (Scania, 2007).

Figure 18. The Scania definition of their products' life cycle (Scania, 2007). shows the different stages of Scania products' life cycle. Scania has developed individual measures within each stage to promote the active environmental image adopted on policy and management level.

In the research and development stage they focus on low fuel consumption and exhaust emissions, avoiding and phasing out hazardous substances, thus creating conditions for effective end-of-life treatment (Scania, 2007).

In the procurement stage Scania actively monitor their suppliers' use of ISO 14001. They stress that it is important for suppliers to share Scania's view on the environmental and that they meet Scania's requirements irrespective of where the supplier is located. In their production processes efforts are focused on minimising emissions and residual products, not only by effective use of end-of-pipe solutions but by continuous improvement of their production processes. Scania investments in their production is not carried out simply for environmental reasons, however environmental aspects often is one of the motivation factors. All investments are made from the strategic investment strategy, and have to be motivated from efficiency per krona spent (Scania AB, 2007).

Scania also has also developed an educational program to help customers to use their products in an efficient way, with maintenance programs and driver education.

One area that Scania has focused their environmental efforts on is the end-of-life stage. Even though Scania is not currently comprised by manufacturers' liability legislation they have developed detailed dismantling information for all their products. This is a response to their commitment to ensure environmentally suitable handling of the vehicle and its different components after the product's working life. To minimise the negative impacts from this stage, and the whole life cycle, Scania feels that it is important that the right preconditions is created in the planning and development stages of the product's.

6.1.2 LCA application

In spite of the recognized a life cycle perspective on environmental management in policies and objectives; Scania uses LCA to a very limited extent (Henstedt, Wästljung, & Johansson, 2006).

Even though a few stand alone LCA have been conducted historically they have not established any routines nor system, e.g. internal databases or guidelines, for communicating environmental information or simplifying the LCA process. On the rare occasions of conducting LCA studies, the studies have been carried out as isolated project by external competence (Henstedt, Wästljung, & Johansson, 2006). Examples of studies are: comparing different filter solutions, material alternatives in lightweight doors and on LCA on different wheelhouse components.

Scania have doubt about the applications of a wider LCA usage. They feel that comparability, costs and questionable perceived benefits from using LCA are obvious obstacles. They are convinced that balanced estimations on environmental impacts in product development can be equally effective as the results from detailed LCA studies. They have not adopted any formal routines for making these estimations; they rely on internal communication between the involved competences. They have taken a decision not to commit to LCA and at this point they see no reason for further implementation of LCA in their organisation (Henstedt, Wästljung, & Johansson, 2006). However, Urban Wästljung does not close the LCA door entirely, but he thinks that it would take some heavy persuasion to make Scania reconsider their decision.

Scania has also developed an EPD for trucks with the DC 12 14 engine. However, it remains unclear what this EPD is based on. No LCAs has been conducted for the EPD (Henstedt, Wästljung, & Johansson, 2006).

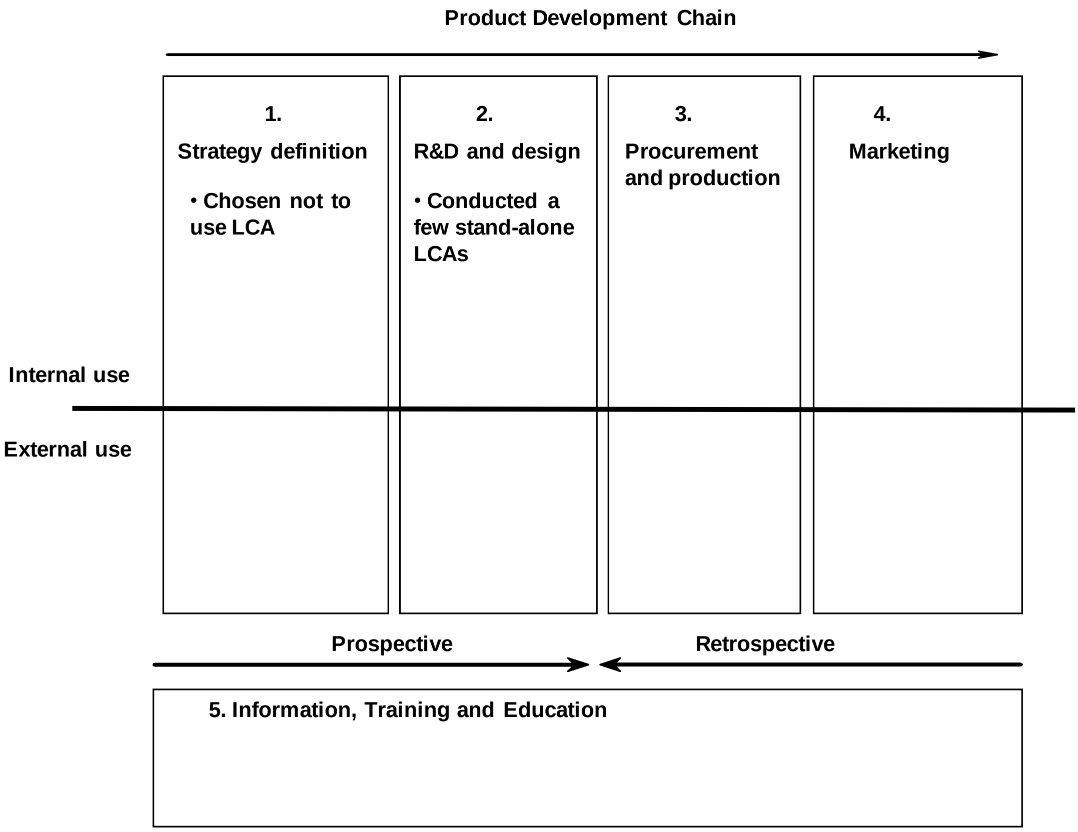

Figure 19. Scania's use of LCA.

Figure 19 show Scania's limited use of LCA. Scania have made a few efforts to use LCA in their product development. Studies have been carried out for specific decision making processes in R&D and design. Examples of studies are: fuel filter contra filter, material alternatives in lightweight doors and on different wheelhouse components. The LCA studies were carried out by either external consultants or graduate theses; hence Scania has not built up any internal competence on LCA.

6.1.3 Driving forces

The driving forces for starting LCA work in Scania were mostly external. People in the organisation became curious when they saw that competitors around them started using LCA. They decided to consult external consultants and issue thesis project for students, but the results were not satisfying.

6.1.4 Level of implementation

The strongly limited use of LCA marks Scania as a company in the early objectification phase of the institutionalisation process. Even though they are familiar with the concept of LCA the level of implementation is very low and they have not showed any signs towards further progress.

6.2 Volvo Trucks

The first Volvo trucks were produced in 1928. The initial production from the island Hisingen, Gothenburg, Sweden has grown and the Volvo group has become an important global actor for manufacturing heavy-duty trucks, buses and construction equipment and diesel engines. Production and development currently takes place in Sweden, Belgium, Brazil and the USA and assembly and factory facilities on 16 different locations. The number of employees in Volvo trucks alone exceeds 21,000 and the company operates on 185 markets worldwide (Volvo AB, 2006).

The Volvo group purchased Renault trucks and MACK trucks in 2001. MACK is an American manufacturer for heavy commercial vehicles focusing the North American markets. Renault trucks have its origin in the automobile manufacturer Renault. The Renault trucks company develops and produces a wide selection of commercial vehicles, from lightweight distribution vehicles to heavy duty trucks.

Volvo Truck's most important market areas are Western Europe, North America and Eastern Europe where deliveries of vehicles were 37%, 35, 2% and 9, 7% respectively. Other areas of great importance are South America (7, 5%) and Asia (7, 1%), other markets constitutes about 3, 5% of deliveries made in 2006 (Volvo AB, 2006).

Volvo Trucks has a strong position on the Western Europe market with a share of 14, 2 % and 39,100 delivered vehicles. Renault has a market share of about 10, 6% in the heavy duty truck segment (Volvo AB, 2006).

6.2.1 Environmental image presentation

Volvo adopted their first environmental policy in 1970, and made environment care one of their core values in 1990, along with safety and quality. The current environmental policy, adopted in 2004, states the views of their environmental programmes. Their environmental improvement programmes are characterized by a *holistic view*, *continuous improvement, technical development* and *resource efficiency*, see Appendix. It also includes a more specific view of each of these aspects of the environmental policy.

The policy includes statements for the *holistic view* with life cycle perspectives, pollution preventions, and suppliers, dealers and all businesses units within the Volvo group to adopt the policy.

Statements on *continual improvements* focus on involving all personnel and formulating, reporting and monitoring on predefined goals. Technical development statements focuses on e.g. development of transport solutions with low environmental impact and reducing fuel consumption, exhaust emissions, noise and climate change. They also want to promote the development on harmonized legal requirements and to phase out use of environmentally harmful materials. Waste management and energy and material efficiency are mentioned in statements on resource efficiency.

Volvo uses a number of different tools to improve environmental performance of their products: black and grey lists of hazardous chemicals, design guidelines and LCA.

From the environmental objectives established improvement efforts are made on:

- Products**:** energy efficiency (fuel consumption), exhaust emissions, after-treatment and material efficiency.
- Production**:** carbon dioxide neutral production plants (Initially Volvo Tuve and in second phase: Umeå and Ghent, Belgium),

When it comes to improving energy efficiency the research on combustion technology in diesel engines is the dominating field of interest for Volvo. They mention the recent development on fuel consumption while pointing out that there is still room for further improvement (Volvo AB, 2007).

Volvo has established that the waste majority of the environmental impacts from their products come from the use phase. Diesel engines are important from this context and focus in product development is on fuel efficiency and emissions.

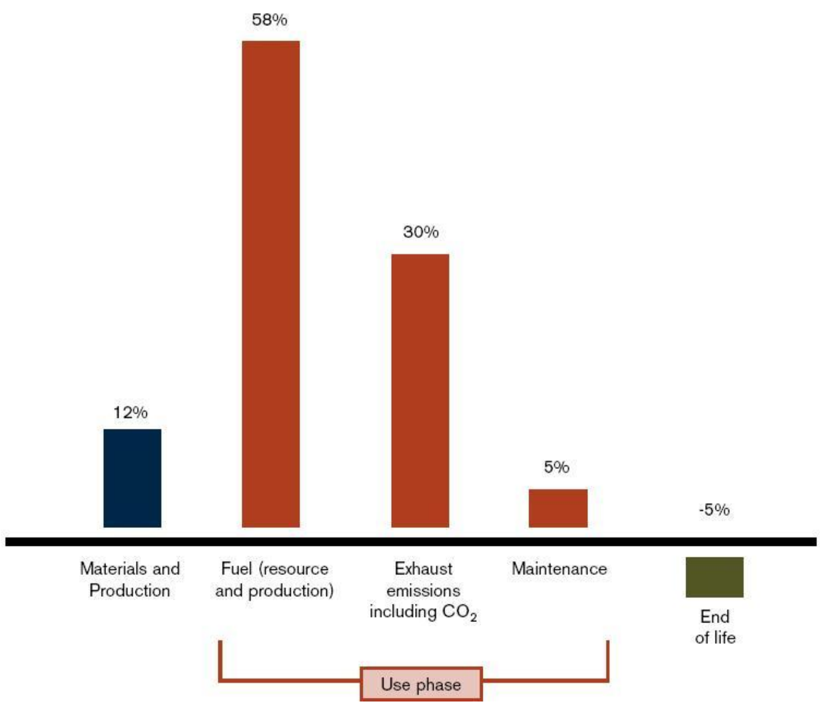

Figure 20. Volvo Trucks Environmental Impact Assessment (Volvo AB, 2001).

Figure 20 shows a Volvo Truck environmental impact assessment and the distribution of impacts throughout the simplified life cycle. The data from 2001 is still representative and indicates that approximately 89% (considering the whole lifecycle) of the impacts can be related to the use phase of Volvo's trucks (Volvo AB, 2004).

6.2.2 LCA application

Volvo has frequently been performing LCA studies since the mid 90's. The LCA practitioners are LCA-experts in the Volvo Technology company, VTEC. The VTEC is a business area within the Volvo group that performs LCA studies for the whole Volvo Group and Volvo Car Corporation.

The first LCA group were established within the Volvo Environment & Chemistry department in 1996. The LCA specialist today works at Volvo Technology Company, VTEC. They use a method, developed at the Competence Centre for Environmental Assessment of Products and Material Systems, CPM, called Environmental Priority Strategies for making LCAs. All results are documented according to the Sustainable Product Information Network for the Environment, SPINE, format also developed at CPM. The results are gathered in a LCA database. Thus, the exchange with CPM has been very beneficial for Volvo (CPM, 2006).

During the last decade LCAs has been issued by companies in the Volvo group and performed by the LCA experts at Volvo Technology, see Figure 21:

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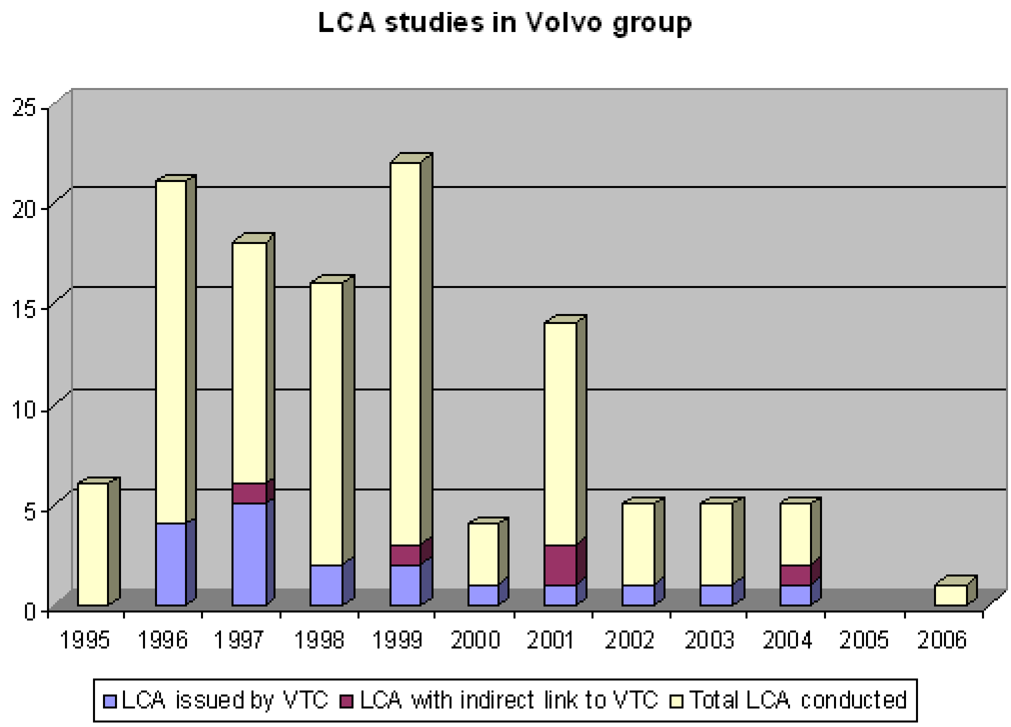

Figure 21. LCA studies conducted at Volvo Technology (Gunnarsson & Bern, 2004; Gunnarsson, Email, 2007).

Figure 211 shows a chart over the performed stand alone LCA studies over time by Volvo Technology and how many issued by the Volvo Truck Company. The black part of the bars indicates that the study has been issued by other companies within the Volvo group on components used in trucks. In the late 90's there were a peak, a direct result of a decision to develop EPDs for all business areas major products. The goal was to communicate environmental information on the best selling products, and the first EPDs was published in 2001 (Volvo AB, 2001). The intensity of studies has decreased. Volvo explains this as being a direct result of the EPD being completed. Much of the future LCA work will be related to updating the EPD (Mårtensson & Gunnarsson, 2007).

LCA has been used for two purposes in strategy definition. Firstly, they have made an EIA, see Figure 20, based on LCA to support the focus on R&D and design towards increasing fuel efficiency and lowering emissions. Secondly, based on LCA Volvo has decided to promote the alternative fuel DME. Volvo has made a comparison of a few future fuel alternatives from a life cycle perspective using LCA, resulting in a pro-DME position (Volvo AB, 2004).

In R&D and design LCA from stand alone studies are coordinated in a LCA database. The LCA database contains information on environmental performance on materials and components; the database is available for engineers via their intranet. Regarding the LCA studies in the design process they recognise difficulty in using LCA because they are time consuming and retrospective. Thus, making integration of LCA results in design phase with large degree of freedom hard (Mårtensson & Gunnarsson, 2007). The number of LCA studies conducted witness of a historically strong, but somewhat fading position in R&D and design.

Regarding Marketing Volvo has, as mentioned earlier, decided to create EPDs for all major products. The EPD is a way to communicate environmental information to customers and is based on the LCA database. The EPD is available for the customers as well as for the public via an interactive calculation tool on the Volvo homepage (Volvo AB, 2007). Volvo's efforts to develop EPD suggest that LCA has a role in marketing.

The LCA database and the results are also considered very important in the internal learning process about their products (Mårtensson & Gunnarsson, 2007). By communicating environmental information of materials, components and whole vehicles internally, engineers can understand how to improve the holistic performance of the product by focusing on the most important problem areas. External communication and transparency of environmental information published on homepages are also important to Volvo as well as communicating LCA results to support their pro-DME position. Thus, LCA has a relation to Information, Training and Education in Volvo.

Figure 22 shows the current use of LCA in Volvo Trucks put in the theoretical framework:

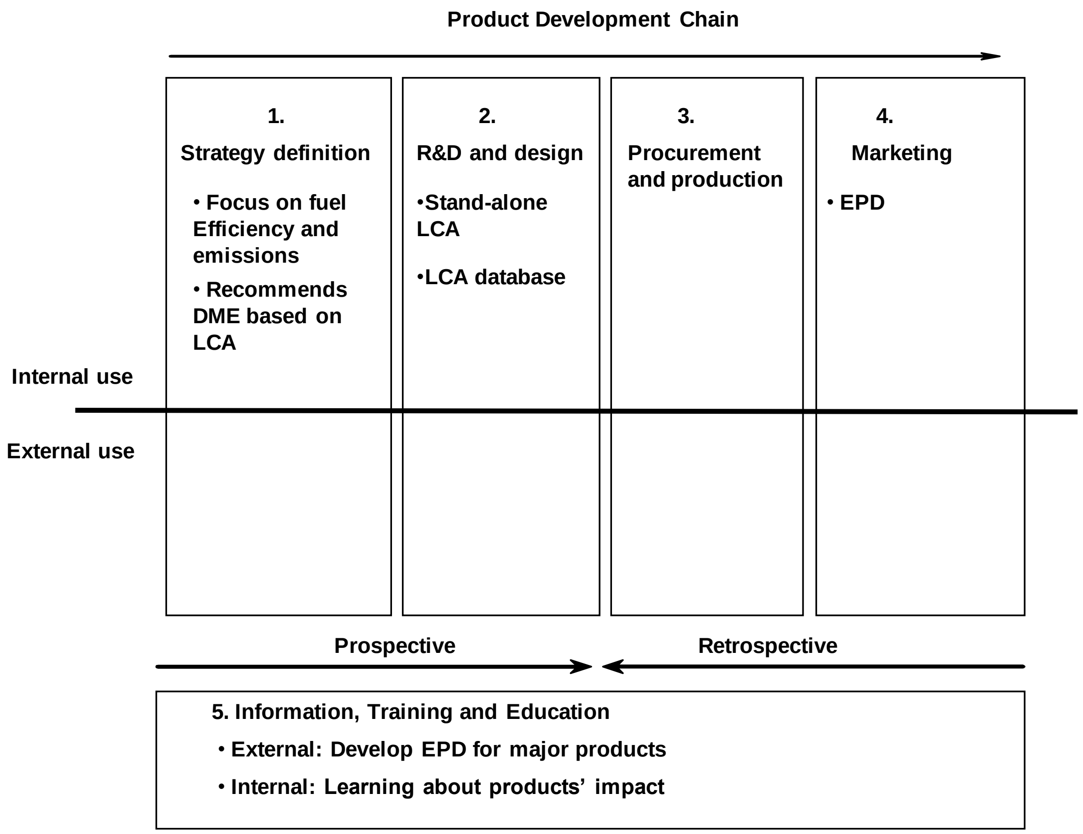

Figure 22. LCA application in Volvo Trucks.

Figure 22 shows how Volvo makes use of LCA in four applications. Volvo uses LCA for Strategy Definition, R&D and design, Marketing and Information, Training and Education purposes.

Even though the trend, shown in Figure 21, is revealing that the most LCA intensive period may have passed Volvo recognises important future application of LCA in evaluating new technical innovations and updating old LCA studies (Mårtensson & Gunnarsson, 2007).

In studying Volvo no indication of integration problems between their EMS and LCA work was identified.

6.2.3 Driving Forces

One of the most important driving forces for starting work on LCA in work, were engineers in Volvo Cars that wanted to show the importance of lowering weight to reduce fuel consumption. They used LCA studies to motivate such efforts. Some of these persons have later on continued to do research on LCA and weighting aspects (Mårtensson & Gunnarsson, 2007).

A recent driving force has been the insecurity in the future alternative fuels. For motivating their standpoint and in the communication with governments it has been beneficial to show evaluation of different alternatives using LCA. However, governments have not been active in demanding LCA nor other environmental tools for evaluating products (Willkrans, Volvo, 2007).

Future driving forces recognised in Volvo are customer's demand. Customers are becoming increasingly interested in environmental information (Mårtensson & Gunnarsson, 2007). Volvo has acknowledged this by providing extensive environmental information, both through their web-based EPD system, where customers can make their own calculations from their unique situations and in the annual environmental reports.

6.2.4 Level of implementation

Volvo is a company that has reached an early sedimentation stage, with a high level of implementation. They are very experienced with the concept and have routines and a formal organisation around their LCA work. However, Volvo seem a bit unsure how take their LCA work further.

7 Comparison & analysis

The first part of the analysis will present and discuss the result from the studied companies. First a summary of the results from each LCA application area will be made. Second, the companies will be fitted into the institutionalisation process. Finally, the driving forces in Scania and Volvo will be analysed. No further attention will be paid to integration issues between EMS and LCA, because there was no indication that it is a deciding factor in the companies' LCA work.

This chapter will sum up the study of the companies, and the aspects chosen for this project. Firstly, LCA application in the companies has been studied from interviews (in the case of Volvo and Scania) and internal documents (Volvo), homepage information, public documents and email correspondence. Secondly, I have appreciated the level of implementation of LCA in each company. This appreciation is my personal view of the LCA status in the companies and is not an absolute company position. Thirdly, I have studied the driving forces for LCA work in Volvo and Scania and in the analysis I comment on their influence and importance for their current use of LCA.

7.1 The application of LCA

Firstly, I have made a short summary of the companies' use of LCA. Secondly, Using the Frankl & Rubik framework I have been able to map the companies' use of LCA systematically, and in chapter 7.1.5 I have aggregated the results of each company into an indication of the LCA use in an industry perspective.

The companies use LCA for various applications to their organisations. A short recap of the results follows:

DaimlerChrysler has recognised LCA as very useful environmental improvement tool. They use LCA for three out of five application areas, strategy definition, R&D and design and information, training and education. They have also shown interest in using LCA information in marketing via developing environmental certificates (so far only for passenger cars). The LCA studies are performed as a part of their commitment on DfE, subsequently performed by the LCA experts within the DfE team. The level of expertise is very high in DaimlerChrysler and they are conducting LCA research. The LCA research has generated valuable information on how to use the tool effectively and has a seemingly strong position in the company.

Even if the sector study shows that DAF currently uses LCA in three applications it should be pointed out that these results are based on their use of their Ecodesign tool. The tool can be used to perform LCA, however how often this is actually done remains unclear. Thus, the link to LCA is rather vague.

However, using LCA results DAF has recognised that their product development should focus on fuel efficiency and emissions. The use of LCA in R&D and design is limited to one study finalised within the scope of the data collection. Even if DAF uses an Ecodesign team and an Ecodesign there seems to be an uncertainty towards the role of LCA. The LCA use for the third application area; information, training and education; is also somewhat unclear but is not neglected in the overall impression of the company.

The similarities and differences between the companies can easily be displayed in the LCA application framework. This also gives an image of the diversity of the application areas recognised in the companies:

Scania have taken a rather defensive position towards LCA. Influenced by external driving forces (competitors use) they started to conduct LCA studies for R&D and design purposes. Since they had limited in-house knowledge of LCA they hired consultants or issued thesis projects for conducting LCA. The results were not satisfying and the concept was almost completely abandoned as they decided not to further implement LCA to their organisation. However, LCA may still be performed in Scania in very rare individual efforts. There are still neither any routines nor coordination for the work with LCA.

Volvo has used LCA frequently since establishing a formal organisation for conducting studies in the Volvo Technology division. However, the intensity of conducting studies has decreased during the recent years. Volvo explains this as being a direct implication of their LCA database that is close to 'complete' and that traditional LCA work is coming towards an end. Also, the decrease in the number stand alone LCA studies may also be related to the finalising of the EPD.

7.1.1 Diversity in LCA use

Summing up the industry's use of LCA, the results from in this study would be:

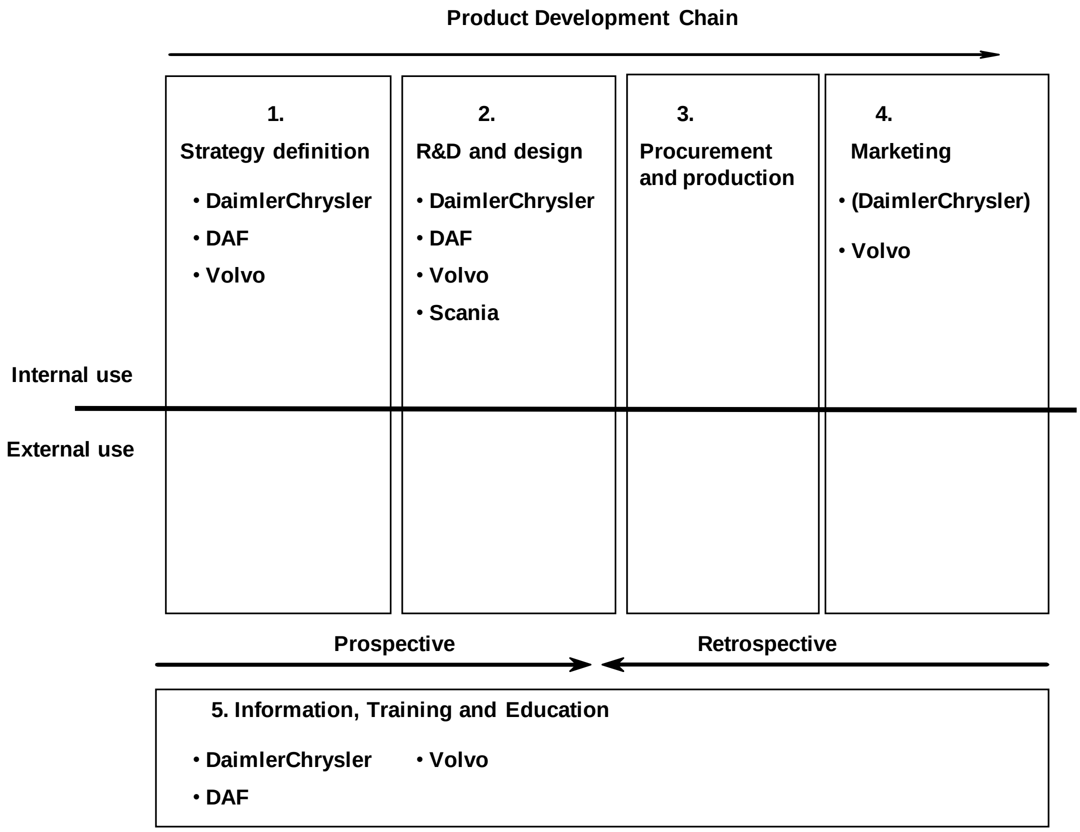

Figure 23. LCA application in the studied companies.

Figure 26 show the distribution of LCA application in the studied companies. Notable is that all studied companies uses, or have used, LCA for R&D and design purposes, however the extent and purpose of the use varies.

Three companies use LCA in strategy definition to some extent and the same three companies also uses LCA for other internal purposes in information, training and education. There are some differences between the tree companies. Volvo and DAF use LCA to motivate strategies towards lowering fuel consumption and emissions. DaimlerChrysler uses LCA for a more detailed description of their products' environmental impacts, not only focusing on the use phase.

In R&D and design it's hard to recognise differences between the companies, since not enough full LCA reports have been reviewed. Scania's very limited use of LCA of course implies a weak commitment to this application. Also DAF does not conduct that many stand alone LCA studies but uses their Ecodesign. Volvo and DaimlerChrysler have stronger commitment to this application and LCA studies are conducted on a regular basis, stand alone studies on components as well as on full vehicles. All companies in this box seem to try to incorporate environmental aspects in their product development but have somewhat different approaches.

Volvo and DaimlerChrysler are the only companies that seem to have recognised any benefits of using LCA for direct or indirect marketing purposes. The EPDs based on LCA in Volvo has come a bit further than the environmental certificates in DaimlerChrysler (only passenger cars so far). Thus, Volvo has a stronger position in this application.

No companies in this study use LCA for neither procurement nor production purposes.

It is also hard to appreciate the LCA application in Information, Training and Education. How the company communicates LCA based information internally is difficult to get a read from an external viewpoint. A good initiative is the DAF Ecodesign training for their engineers.

The diversity in the truck industry's application of LCA is evident. This is a very interesting result and will be discussed further. Another interesting result is that three companies are using LCA in several different parts of their organisation, and one company has chosen not to.

7.2 Level of implementation analysis

Studying the companies from an external viewpoint an appreciation of the companies' level of implementation and position in the institutionalisation process has been made:

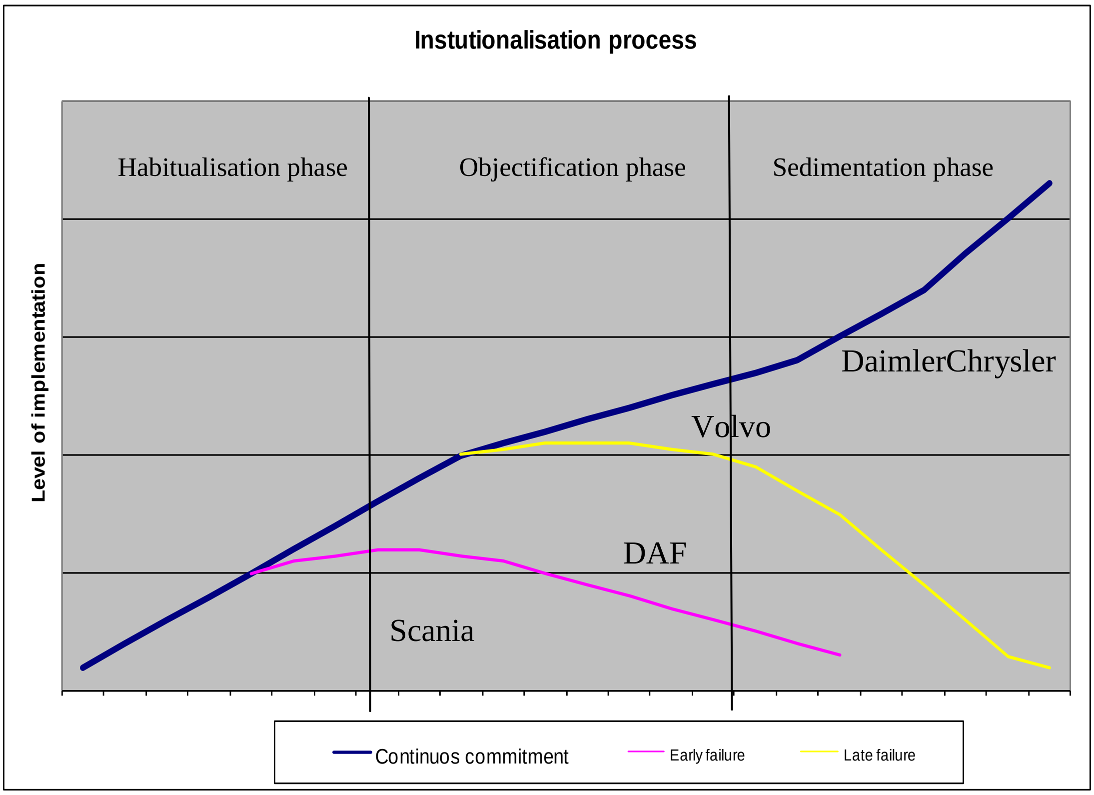

Figure 27. The distribution of the companies' position in the institutionalisation process.

The distribution of the companies is displayed above, in Figure 27. The figure shows that some the companies have reached the same institutionalisation phase but still have different level of implementation. The black line describes the level of implementation in a company that continues to commit to LCA, and that does not abandon the concept easily. The light and dotted line describes the situation in a company that has overcome the initial difficulties, but comes to a point where they see no further use of LCA and fades out related activities, because of lack of interest or due to a formal decision. The grey and dotted line describes a company that 'tries' to use LCA. They are not especially familiar on how to apply LCA to their organisation; they have no in-house competence to perform studies or to promote sufficient benefits from using LCA and abandon the concept without any greater losses.

Based on the studies of the companies and the results presented I think that:

DaimlerChrysler have reached the highest level of implementation as well having the most advanced institutionalisation. This is based on the rigorous LCA research and application in the organisation, and their formal organisation of LCA work in the DfE division.

DAF has reached the objectification phase, but has a low level of implementation. It might appear strange considering their formal commitment to Ecodesign, but I recognise an uncertainty to their attitude towards LCA. This is based on their number of LCA studies issued and that information on their LCA use was somewhat diffuse. However, they are familiar with the concept of LCA and I think they show an ambition to use LCA in some way.

Volvo is the company that is hardest to place in this context. Figure 21 shows a fading commitment to conducting stand alone LCA studies. However, their commitment to EPD is strong, and they have the most sophisticated EPD. The relatively high level of implementation is due to the fact that they have conducted quite a few LCA studies over the years, compared to e.g. DAF, and have LCA databases and routines for their LCA work. Their place in the crossing between the objectification and sedimentation phase is based on the recognised doubt on how to make use of further LCA and how to proceed with their commitment.

The company with the lowest level of implementation and the least advanced in institutionalisation process is Scania. They are a company that follows a typical ‘early failure’ development. They did not have enough beneficial first time experiences from LCA, and lacked people that could convince decision makers of any advantages to further commit to LCA.

There is also diversity when it comes to institutionalisation. Figure 27 shows that there are differences not only in how far they have come in the institutionalisation process but also in the level of implementation.

7.3 EMS & LCA

During the study of the companies no indication of integration problems between LCA and EMS has been mentioned, nor do they speak of any benefits from having both LCA and EMS work in the organisation simultaneously. This can maybe be explained, to a great extent, by the focus of the tools. The EMS focus on the actual facilities’ and organisation’s performance, and often has established goals. The companies’ use of LCA is focused towards products and product development. This means that the focal points differs too much to be of any help to and at the same time does not interfere with each other.

8 Explaining the differences

The analysis of the result shows on differences between the studied companies, both in LCA application and in level of implementation. The differences between the companies depend on many factors. In this study the focus has been put on the driving forces for conducting LCA. For starting as well as for continuous commitment to LCA work. For practical reasons only the Swedish truck manufacturers Scania and Volvo could be analysed further.

8.1 Scania’s driving forces

As shown earlier in the study Scania has made a very limited use of LCA in their organisation.

In Scania the internal driving force in their early LCA work, were not strong enough. They were curious about the LCA concept, but maybe not enough versed up in how the tool should be applied and how to interpret the results. The lack of knowledge led to that the LCA work was outsourced, and it seem that this were devastating for their continuous commitment. They did not see enough useful results nor did they have made large investments in organising their LCA work. The external consultants failed in showing how LCA can yield other results than the final numbers, and LCA was abandoned before a thorough evaluation of the concept was done. They saw no point in further LCA implementation. However, LCA has come a long way since then and so has Scania. Methodology and application areas are in constant development, and people change. The Scania representatives left the door; if not fully open at least ajar. LCA may still have a future in Scania.

8.2 Volvo’s driving forces

Volvo had a more beneficial first time experience from using LCA. The initial practitioners had a goal with the studies and probably the results were clear (lower weight reduces fuel consumption?). The LCA promoters had to be successful in convincing internal decision makers of the benefits of LCA and how to use these results. Obviously, they were successful.

In the case of Volvo there were strong internal driving forces in the beginning of their LCA work. However, now they seem to have reached a fork in the road whether to take the ‘full leap’ into the world of LCA or to look to other alternatives. They seem to have taken an attitude towards a continued LCA commitment, but still they seem to have doubts on how this commitment is going to be realised. Their commitment to EPD may not be enough to reach wider implementation in the future. The goal can also be to optimise their current LCA work. It is unlikely to think Volvo will abandon the LCA concept. The investments are too big, the learning from LCA is too important and the tradition is too strong.

8.3 Different views on LCA

The results clearly show a great diversity in LCA application in the truck industry. The diversity in how the companies' use LCA in their organisation can, to a great extent, be explained by in what context LCA studies are performed. In DaimlerChrysler and DAF they are used as a part of a design strategy (Design for Environment and Ecodesign respectively). These design strategies are used in all projects within the companies and even if the relation between their strategies and LCA seem to be stronger in DaimlerChrysler have come a long way to making environmental consideration a natural part of decision making in the most common LCA application areas (Strategy definition, R&D and design and Information, Training and Education). However, neither DaimlerChrysler nor DAF use LCA for any wider marketing or procurement purposes. To further develop and to make the most of their LCA work, this could be the way to go.

Both having reached an advanced stage of institutionalisation when it comes to LCA, there are some differences between DaimlerChrysler and Volvo. Still finding DaimlerChrysler as the company that has come furthest in implementing LCA to their organisation Volvo is the company that uses LCA in the widest spectra of application areas. DaimlerChrysler uses LCA mainly in a design context. One evident aspect in which Volvo differs from DaimlerChrysler is that they do not use a design tool for conducting their LCA work. They decide on a case-to-case basis when to issue stand alone or full vehicle LCA studies. Volvo is unique when it comes to organising their results and communicating them externally through e.g. a web based EPD calculation tool. The EPDs could prove to be an increasingly valuable asset in marketing their products, based on a common notion that customers will demand environmental information to wider extent. The commitment to EPDs, I think, is very decisive for further implementation of the LCA concept at Volvo. Volvo is also, seemingly, the only company that has used LCA in the ever present debate on future fuel alternatives, to actively support the company pro-DME position

DAF has presented a somewhat diffuse image of their work with LCA. On one hand they have committed to using Ecodesign that traditionally involves LCA. On the other hand the reported number of LCA studies actually conducted at the company implies a somewhat unclear commitment to LCA in the Ecodesign process. DAF, I think, needs to get their priorities straight. Using their Ecodesign process it would be beneficial to commit to one environmental assessment method, to get the most from it. Whether it is LCA or not is hard to say.

When it comes to LCA application Scania stands out. It is the only company in the study that presently does not make use of LCA. The company have made trial studies but did not see any benefits from further LCA efforts. Their strategy to focus on emissions and fuel efficiency is not supported by LCA results, but is as they say 'obvious' when it comes to lowering environmental impact.

Comparing Volvo and Scania there seem to be evident links between strong internal driving forces, successful first time experiences and continuous commitment to LCA. This is in line with the theory on institutionalism described in chapter 4.3. Volvo, having a strong internal driving force has shown more patience in the institutionalisation process, and has reached a higher level of implementation.

8.4 The future of LCA in the truck industry

Predicting the future is always very difficult. It is not made easier by the diverse view and application of LCA that this study shows. However I think that considering that three of the most important actors currently use LCA it is likely to believe that the concept will live on, in some form. Even if traditional LCA work may fade eventually, developing new ways of using LCA is a great challenge for the companies. In this matter I think that the truck manufacturers can turn to other businesses for inspiration and guidance. There are sector that has been using LCA for a longer time than the truck industry and maybe their experience can be helpful in the creative process of finding new application areas for LCA. This study has shown upon at least two areas that need further exploration, Marketing and Procurement and production. As there seem to be some curiosity on how to use LCA for Marketing I think this were the future LCA work is headed.

9 Conclusions

From studying the companies included and the results in the report the following conclusions can be made:

- There is a great diversity in how LCA can be applied within the European truck industry.
- LCA is frequently used to motivate and promote different Strategy definitions.
- LCA in R&D and design is still the most important area of application.
- LCA has not been found to have any use in Procurement and production.
- LCA in Marketing seems to be an emerging area of application.
- LCA for internal and external Information, Training and Education is very important. The companies seem to appreciate the learning process of the products you can have from interpreting LCA results.
- Companies can find themselves in the same institutionalisation phase, but still the level of implementation can vary
- The differences seem to have strong relation to the presence of strong internal driving forces.
- Integration with EMS is not perceived as a barrier to further implementation of LCA. No companies have indicated any problems in having both an active EMS and LCA work.
- The difference on widely the LCA is implemented in the company, can also be explained by their view of LCA. DaimlerChrysler and DAF uses LCA in their design tools, Volvo on the other hand can see wider application of LCA.

The first conclusions are rather obvious observations from the analysis of the results of each application area in the Frankl & Rubik framework used consequently throughout the study. These are well motivated in chapter 7.1.

Looking at Figure 27 on the institutional process and level of implementation I have motivated each company's position. The conclusion that companies can be put in the same institutionalisation phase but have different level of implementation, I think is well motivated by the companies' intensity of their LCA work.

The conclusion on the driving forces concur that the theory on institutionalism seems to be applicable to the reality in this case of LCA implementation. Studying Volvo and Scania it was an evident difference in the presence of internal driving forces that supported LCA commitment, and this can largely explain the companies' current LCA position.

The conclusion on EMS and LCA is motivated by that integration with EMS has not been seen as a barrier for the companies' use of LCA.

The final conclusion is based on the main application of LCA. In DaimlerChrysler and DAF LCA is concentrated to the design tools (DfE and Ecodesign respectively). In Volvo LCA is used for multiple applications and they see benefits from using LCA in other applications than in just product design. To say anything on what is more beneficial is difficult, but in DaimlerChrysler and DAF there is at least a potential for a wider application in for instance marketing.

10 Personal thoughts and recommendations

The report is finished by my personal thought on the subject studied and the result found. I will also make some recommendations for how the companies could proceed, given that they would like to further implement LCA to their organisation.

I think that LCA could have a bright future in the European truck industry. Maybe it is not the most effective design tool for creating environmentally improved products, because it seems to me that LCA could be a very effective support environmental decision making. Because using LCA in a uniform, by using ISO 14040 or such standards, way the result could be made comparable and credible. Presenting LCA result in a comprehensive way could be very useful, not only in the internal communication between LCA experts and engineers or managers but also in external communication to support strategies and customer information.

I also support further research on LCA applications on new areas of application, on the semi-developed areas as well as the traditional areas. Company research I would focus on their own use of LCA, evaluate the benefits from having LCA work and what can be done differently if not satisfied. For instance in procurement, demands on standard compatible environmental data on the suppliers could be a way to simplify and optimise the LCA work. If suppliers knew exactly what data the companies demanded it probably would not be considered a problem. Suppliers that could give data in uniform and useful formats could be promoted before others.

Another area where LCA could be implemented further is in marketing. Volvo is the only company that actively use LCA based EPDs for external communication. DaimlerChrysler has touched upon a similar concept when environmentally certifying some of their passenger cars. DaimlerChrysler could easily do something in this area. Another possibility is collaboration between DaimlerChrysler and Volvo in agreeing upon developing either EPDs or the same environmental certificates. If two of Europe’s biggest truck manufacturers developing the same kind of environmental information it would enlighten and influence other manufacturers as well. DaimlerChrysler and Volvo could benefit from this, as they already have developed systems for conducting LCA. In the long run, but as a first step towards more environmentally aware consumer behaviour, standardised environmental information (EPDs or environmental certificates) could be requirement for public procurement. Lobbying this would benefit DaimlerChrysler and Volvo.

For DAF, that already has established a relation to LCA (or at least Ecodesign) the next step could be looking into how they can use their LCA results in marketing purposes.

Scania should re-evaluate their decision not to use LCA. They claim that there is no proof that they can benefit from LCA. My opinion is that if three of the most important competitors are using LCA, there probably is something to gain. However, just starting to use LCA can again fail. I think they have to make broader evaluation on how to use LCA, and its results. It is important that Scania, and other companies, makes organisation specific implementation plan for LCA, and that they focus on what can possibly be gained other than the results as such. The other companies, again and again, indicate that maybe the most important lesson LCA teaches is not the actual numbers but the lessons thought on the way to the final results.

In this master thesis project there were (as always?) some complications. The intentions were a bit more careful study of the six most important truck manufacturers. However, lack of data from IVECO and MAN made a fair judgement of their LCA application impossible.

To make the study more exact, more detailed data would be needed. Access to all internal document regarding LCA and LCA-related information would add accuracy both in mapping LCA application and assessing how far they have come in the institutionalisation process. One should also acknowledge that there are many complex aspects to successful LCA implementation and that the conditions described in this study only are the most important that I have encountered.

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12 Appendix

The appendices are the environmental policies from Scania and Volvo referred to in the report.

12.1 Scania Environmental Policy

Scania continuously improves the environmental performance of its products, processes and services.

Business demands and other requirements form the basis for improvement, where fulfillment of legislation is fundamental.

Scania's environmental work is proactive, based on a life-cycle perspective and the principle of precaution.

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12.2 Volvo Environmental Policy

Environmental Care is a Volvo Core Value. The Volvo Group is to be ranked as a leader in terms of Environmental Care among the world's top producers of transport related products, equipment and systems. The environmental programmes shall be characterized by holistic view, continual improvement, technical development and resource efficiency. The Volvo Group will by these means gain competitive advantage and contribute to sustainable development.

Holistic view

In our efforts to reduce environmental impact from our products, operations and services we shall:

• take account of the complete life cycle;

• take a leading position regarding environmental care, wherever in the world we operate, with applicable legislation and other regulations as a minimum standard;

• make pollution prevention a prerequisite for all operations;

• encourage suppliers, dealers and other business partners within our sphere of influence to adopt the principles in this policy.

Continual Improvement

Our environmental activities shall be integrated in all operations and be improved continually by:

• formulating, communicating and monitoring clearly-defined goals;

• involving our employees.

Technical development

We shall strive to exceed demands and expectations from our customers and society by:

• active and future-oriented research and development efforts;

• developing transport solutions with low environmental impact;

• promoting development of harmonized legal requirements;

• continually reducing our products' fuel consumption, exhaust emissions, noise and impact on climate change;

• reducing the use of environmentally harmful materials.

Resource efficiency

Taking account of the complete life cycle, our products and industrial operations shall be such that:

• the consumption of energy and raw materials is minimized;

• the production of waste and residual products is minimized, and waste management is facilitated.

The environmental programmes and their results shall be communicated in an open and factual manner. Business areas and business units are responsible for implementing action programmes based on this Policy.

March 24th, 2004

Leif Johansson

President of AB Volvo and CEO

Supersedes policy dated September 16th, 1997 960-04-030

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