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Use of life cycle assessment (LCA) in global companies

Jussi Nygren and Riina Antikainen

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PREFACE

Increasing public awareness of environmental issues has forced industry and business to develop more ecological products and to inform stakeholders about how their activities produce emissions and consume natural resources. Several environmental assessment methods have been developed to measure these impacts, life cycle assessment (LCA) being the most elaborated and well known. Even though being a standardised method, there still are knowledge gaps and confusion related to many areas of LCA, such as setting the system boundaries, interpretation and comparison of the results, and the uncertainties related to studies.

Life Cycle Assessment Framework and Tools for Finnish Companies (FINLCA) -project started in 2009. The project identifies problems and obstacles in the use of life cycle methods, especially from the corporate perspective, and develops knowledge and know-how on LCA and related methods. A network of research institutes and companies was established to create a national roadmap on how life cycle methods can be promoted in Finnish industries. The project aims at developing life cycle approaches and a framework to assist, which are the most feasible methods and best practices. The aim is also to improve the environmental competitiveness of the Finnish companies. The research project constitutes of a theoretical part and several case studies. Theoretical part focuses in the recent development in life cycle methods. Case studies and information from companies are utilized to support the theoretical findings.

Finnish Environment Institute (SYKE) is the coordinator of the FINLCA project, other partners being VTT Technical Research Centre of Finland, Åbo Akademi University, University of Oulu and School of Science and Technology, Aalto University. The project has been financed by Tekes, and Finnish Forest Industries (= Metsäteollisuus ry), the Finnish Plastics Recycling Ltd (= Suomen Uusiomuovi Oy), Scandinavian Development Association, Outotec Oyj, Metals Industry (= Metallinjalostajat ry), Neste Oil Oyj, the Federation of Finnish Technology Industries (= Teknologiateollisuus ry) and Tikkurila Oyj.

The aim of this FINLCA report is to give a global perspective on the current use of LCA and related methods. The findings and results are used to support the creation of the framework.

The authors gratefully acknowledge the financiers of the project and all the comments given to improve the report.

November 2010, the authors

TERMINOLOGY

DfE	Design for Environment
EDP	Environmental product declarations
GRI	Global reporting initiative
EMAS	Eco-management and audit scheme
LCA	Life cycle assessment
LCC	Life cycle costs
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
NGO	Non governmental organization
MFA	Material flow analysis
SFA	Substance flow analysis

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1 Introduction

1.1

Brief introduction to life cycle approaches and LCA

Increasing public awareness of environmental issues has forced industry and business to develop more ecological products and to inform stakeholders on how their activities produce emissions and consume natural resources. Several environmental assessment methods have been developed to measure these impacts.

In order to assess all the environmental impacts of a product or service, the whole production life cycle from cradle to grave must be assessed. This concept is called life cycle thinking. Life cycle approaches are methods for estimating the impacts of material and energy flows along the production chain. The results of these assessments can be used for internal purposes of process development and external purposes of stakeholder communication. Ideally, they identify the main impacts and help in finding solutions to minimize environmental effects. (Rebitzer et al. 2004)

Some life cycle approaches focus on resource efficiency and material flows (material flow analysis, MFA; substance flow analysis, SFA), others on energy flows (thermodynamic methods). Economic aspects are incorporated in tools, such as life cycle costing, economic input-output analysis and cost-benefit analysis. In principle, these approaches convert environmental and other impacts into money, so that an integrated economic-environmental analysis of the production process is possible (Finnveden & Moberg 2005). Some approaches are designed to assess only one impact. For instance carbon footprint is a popular way of indicating climate change impacts and water footprint estimates the consumption of water resources.

Life cycle assessment (LCA) is the most defined and developed life cycle approach. It is an extensive method designed for accounting all relevant environmental impacts of products and services. It includes the entire product life cycle: material sourcing, production, use and end-of-life. The standards ISO 14040 and 14044 describe the principles and framework and the requirements and guidelines of LCA. LCA starts with goal and scope definition. It provides a description of the product system and formulates the questions to be answered. The scope is defined by system boundaries, which outline the parts of production included in the analysis and the impact categories considered. The next step is life cycle inventory (LCI), in which inputs and outputs for a product are compiled and quantified within the system boundaries. Life cycle impact assessment (LCIA) aims at understanding and evaluating the magnitude and significance of potential environmental impacts for a product system throughout the life cycle of the product,

The results of LCI and LCIA are interpreted in relation to the goal and scope of the study. LCA is a learning process and usually the steps are revisited and modified during the process. The results can be used to identify in which stages the environmental impacts are produced and what are the most important impacts of the product

in question. Results are also used for environmental reporting and would ideally enable a consumer to compare products of the same kind.

Simplifications of the full LCA are also popular. These streamlined LCAs look at processes with a narrower scope or use qualitative models and average data, to find out the primary impacts. Sometimes only the LCI phase of LCA is conducted, without impact assessment or interpretation. These simplified learning instruments require fewer resources than a full LCA while still providing valuable insight.

In this report, when we use term LCA (LCI and LCIA) we refer to life cycle assessment following the principles of ISO 14040 and 14044. Life cycle approaches and life cycle methods are used to refer to all above mentioned methodologies.

1.2

Aims of the report

The focus of the report is to give a global perspective on the current use of Life Cycle Assessment and its expanded or streamlined versions. This is done by reviewing public communications of selected multinational companies and literature on the practice of LCA.

A bulk of research on LCA focuses on methodology improvement, while less is known about how business is adopting life cycle approaches and using them in their strategies (Frankl & Rubik 2000). Therefore one aim of this report is to define the rationales behind the use of LCA in companies and the factors inhibiting wider adoption. The internal and external applications of LCA results in the selected companies are utilized to give insight into why companies have started to use LCA.

The impact weighting in LCA is difficult for global organizations, because a wide range of values have to be considered (Schmidt & Sullivan 2002). Therefore, the comparison of different environmental impact categories is also of special interest.

LCA is not precisely defined for all possible applications and there is a lot of room for interpretation and customization within the method. Some companies have developed their own unique ways of conducting LCA in order to overcome methodological difficulties and expand usability. Examples of these novel approaches are presented in more detail.

Research on this theme is challenging because reliable information on internal practices is often not available to the public. However, transparency in environmental management is increasing and especially forerunners in environmental matters communicate their methods in detail.

2 Materials and methods

2.1

Company survey

A survey was conducted on public information provided by 20 multinational companies from different sectors (Fig. 1; Appendix 1). In support of this survey literature was reviewed to find out more about LCA use and the connection of motives and obstacles to application.

The companies were selected to represent a wide range of sectors. The main criteria for selection were the quality and content of the public material they provided. Frequent environmental reports are common among multinational companies, but only some provide detailed information on how environmental impacts are assessed. None of the common corporate reporting certificates (GRI, EMAS, CERES) demand this type of methodological information. The companies were selected on the basis that they provided public and relatively detailed information on their life cycle management. This condition led to selecting a set of companies that are forerunners in the field, since pioneering companies tend to be more open about their practices. Because of this bias and the fact that all the source material is voluntarily provided by profit pursuing companies this survey does not attempt to make statistically valid assumptions on the use of life cycle approaches in general.

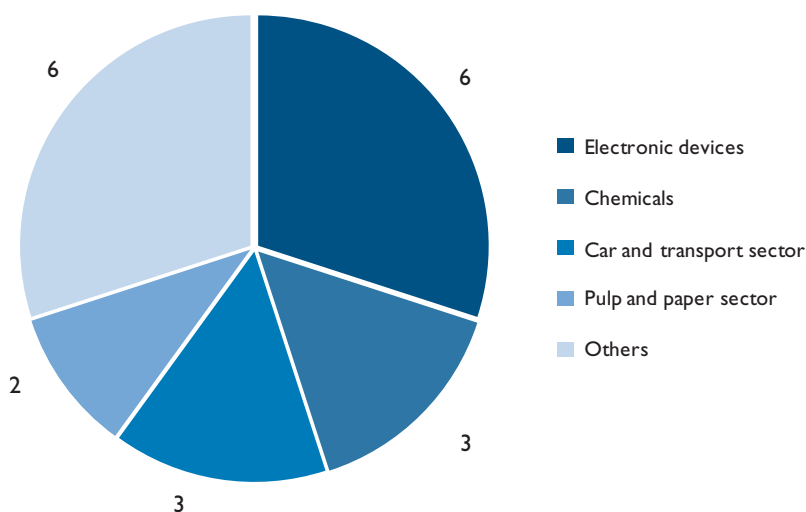


Fig. 1. Coarse categorisation of sectors the companies surveyed.

Available sustainability disclosures, environmental reports, environmental product declarations (EPDs), LCA case studies and research articles of the companies were analyzed qualitatively. The material was screened to find out what type of LCA was applied and how were the results used. The assessed products and assessment tools (specific methods, software, databases) were recorded and tabulated. The weighting of environmental impact categories was also recorded.

2.2

Literature review

In addition to the corporate communications a review of literature was made about adoption and application LCA into business. A few practitioner questionnaire or interview studies dealing with LCA and life cycle approaches have been conducted in Europe (Frankl & Rubik 2000, Jörnbrink & Melin 2008) and North America (Cooper & Fava 2006). Some articles were also reviewed on environmental communication and the use of LCA in communications (Molina-Murillo & Smith 2009, Jose & Shang-Mei 2007). Many companies have been involved in scientific discussion on LCA methods. These articles were used to find more detailed information on methods. Results reported in literature were compared to the findings of the company survey and to support the final conclusions.

3 Results

3.1

Life cycle assessment adoption motives

Companies of different size usually vary in their possibilities to act in fields that are not their direct core business areas. Often larger companies have better possibilities to actively aim for long-term development of business, not just for short-term profits. The increasing use of LCA (Frankl & Rubik 2000) and environmental reporting (Jose & Shang-Mei 2007) are manifestations of this. The companies see several benefits in assessing products' life cycles and their environmental impacts, mostly in the long-term (Frankl & Rubik 2000).

The motives for applying life cycle approaches can be divided into process-oriented, image-oriented and compliance-oriented ones.

The process-oriented drivers are usually the most important ones. According to practitioner survey studies (Frankl & Rubik 2000, Cooper & Fava 2006, Jörnbrink & Melin 2008) the standout reasons for life cycle approach adoption are process efficiency and cost-saving opportunities in energy and material. The benefits come from comparing process, material and infrastructure alternatives. The identification of bottlenecks in the processes is beneficial both from economic and environmental points of view. In this sense LCA is a structured way of achieving efficiency, something that companies have always aimed for regardless of environmental concerns.

Process-oriented motives are followed closely by image and market-oriented ones. Stockholder pressure and the on-going environmental discussions force companies to actively participate in stakeholder dialogue. Having internally produced data on environmental impacts can be useful in responding to stakeholder feed-back and reporting to existing stockholders and clients. Besides communicating with existing business partners, companies also see possibilities of new market openings ('green market'). These image-oriented motives demand external communication of LCA results. The gained information from LCAs can be used in reports and EPDs or certify products with eco-labels. There have been some problems in utilizing the complex LCA results in marketing and often a lot of simplification is needed for efficient communication.

Compliance with regulations is often not a driver for use of LCA, because there is no legislation demanding LCA. Companies may choose to use LCA to provide data for environmental permits (with an example from packaging in Germany), but no existing law specifically requires LCA for this purpose. Nevertheless companies are looking forward on compliance issues. One driver for use of LCA in companies is reported to be compliance with possible future regulations and even the possibility of influencing development of legislation. Large companies can also demand suppliers to comply with environmental standards that may require life cycle approaches. (Hagelaar & Vorst 2002) In this way, LCA can be a useful tool for supplier chain management.

3.2

Factors limiting and promoting adoption

Life Cycle Assessment is not yet a routine procedure in most companies. Companies conduct studies only for some existing or new products (Frankl & Rubik 2000). Several factors can limit the adoption of LCA in business organizations. The most reported barriers for further application are the complexity of the method and the demand for high quality data. Monetary and human resource demand can be too high in comparison to expected results. The results may also be too complex and disputable for effective use in decision-making. Additionally, in some sectors there is no demand from the consumers. Even though the lack of downstream interest can make LCA inefficient in external applications, studies can still benefit internal development and research purposes.

Organizational factors are also important. Top-level commitment and involvement of the whole organization are important in the process of LCA becoming a routine tool. Often a single initiator is important in promoting awareness within the organization. (Frankl & Rubik 2000)

Collaboration with other companies, universities and research institutions can be of assistance in overcoming methodological problems and obstacles of data gathering. The participation in an LCA initiative or project can provide additional support. The positive visibility associated can also be an incentive for participation. Industry interest groups, national environmental institutes and non-governmental organizations (NGOs) are common forums for LCA development and promotion. (UNEP & SETAC 2008, Five Winds & Pollution Probe 2004, Ravemark 2003))

3.3

Company survey results

3.3.1

Level of LCA use

The concept of product life cycle was well adopted in the 20 companies that were reviewed. All of them have been conducting some form of LCA at varying intensities. At least for external purposes most companies were using only one or a few extensive LCAs as examples. Most of the companies did not disclose information on how many LCAs had been conducted, but the overall trend is that LCA use is increasing, especially in companies, which customized and streamlined methods were developed. The assessed products are tabulated in Appendix 2.

3.3.2

LCA and company communication

To answer stakeholder demands companies disclose information of their environmental management in annual reports, EDPs and case studies. Many multinational companies have an environmental research and development team that produces information for these reports. All of the annual reports raise the concept of life cycle and assessing impacts, but often do not include any detailed information, besides company wide results of material and energy flows. Of the sources used, EDPs and case studies proved to be the most relevant communications, where specific information on methods and tools could be found. This complies with the finding of a corporate communications study that detailed LCA is more effective in professional forums,

but for consumer communication simpler messages are needed. (Molina-Murillo & Smith 2009) The source materials can be found in Appendices, Table 3.

In their publications some companies wanted to highlight their products environmental superiority in comparison to other alternatives in the market. Other companies focused on how the product had evolved through time, comparing environmental impacts of different versions of the same product. In some cases LCA revealed that most of the environmental burden comes from the use stage (e.g. detergents, home appliances). Such information can be used point out the environmental responsibility of the consumer.

3.3.3

Reliance on existing resources

Most companies rely heavily on existing LCA software, LCI databases and impact assessment methods. In one survey, 69% of LCA practitioners were reported to use specifically designed software in assessing products (Cooper & Fava 2006). This company survey verifies the wide use of existing software (SimaPro, Gabi, Ecoinvent, Ecolab, ENECO, BEES, Impact 2002+), impact assessment tools (Eco Indicator, CML, TRACI) and specific databases (Appendix 2). Often the tools are used in a customized manner or tools are developed for specific needs.

In addition to utilizing existing tools and resources, many companies are involved in research in the field. It is evident that global companies have been shaping their environmental management practices towards a more active role. Some have developed their own software, which is often based on spreadsheet programs or existing LCA software. Internal LCA research teams were found to be common and often communicating with other LCA developers. Common contexts for co-operation were sector wide LCA initiatives, research institutions and universities. This seems to help in developing methods and gathering data required in LCI.

All companies surveyed mentioned the ISO 14040 series as a guideline for LCA, but customization to better suit the needs of the company was common. In chapter 3.5, three novel ways of conducting LCA are presented as examples of active development of methodology.

3.3.4

Applications of results

The results of LCA were applied in both internal and external ways. Internal process development and Design for Environment (DfE) were commonly reported. Many companies stated that LCA draws attention to the areas in which improvement is needed, makes comparison of different alternatives easier, and allows tracking changes between product generations.

The most reported external use was the creation of EPDs or eco-labels. A few companies released the entire LCA report or a case study of LCA. The companies with larger scale products, such as wind power plants (Vestas) and trains (Bombardier Transportation) were most clearly using the LCA to assure existing and potential clients, but also to communicate with local authorities.

3.3.5

Use of other life cycle approaches

Streamlined LCA approaches were common, even more common than full LCAs. But when using the relatively constricted data sources of this survey, the line between full and streamlined LCA is difficult to draw. However, streamlined methods seem

to be most efficient learning instruments that serve the needs of both internal process development and communication.

In company communications, carbon footprint and MFA were popular assessment methods. Roughly half of the companies were using carbon footprint in connection with LCA. Carbon footprint is a popular assessment method especially for marketing purposes, since the results are relatively easy to understand. In the environmental reports, MFA was often used to draw flow charts on how different materials move through the company. MFA was also used to track how the set environmental goals were met.

The economic aspect lacking in LCA was compensated in a few cases by integrating LCA with LCC. This was considered to serve more strategic applications.

3.4

Environmental impact categories in LCIA

Even though LCA includes a wide variety of environmental impact categories to be assessed, often only a part of them are selected to be analyzed in the companies' and others studies as well. Among the group of surveyed companies, 16 were considered to provide information detailed enough to assess what impact categories they took into account (Table 2). Some uncertainties remain, since the data sources were diverse and the categories overlapping. Four companies were excluded from this analysis, because no clear information on impact categories was found.

Table 2. Environmental impact categories taken into account by companies surveyed.

	Energy consumption	Climate change	Acidification	Eutrophication	Material depletion	Photochemical ozone formation	Ozone depletion	Waste problem	Eco-toxicity	Human toxicity	Water reserve impacts	Land use	Biodiversity
BASF													
Bombadier Transportation													
Continental													
Daimler													
Electrolux													
GE													
GlaxoSmithKline													
Interface													
KONE													
Nestle Waters													
Procter & Gamble													
Siemens													
Unilever													
Vattenfall													
Vestas													
Xerox													

Companies using LCA have very similar lists of environmental impact categories they take into account, regardless of assessed product. This might be due to the guidelines of the ISO 14040 standard series and the use of software with standard sets of impact categories. Energy consumption and climate change impacts were assessed

by all surveyed companies. They also were the most often referred impacts in general communication as well.

Acidification, eutrophication, photochemical ozone creation, ozone depletion and toxicity seemed to be frequently included in impact assessment. Clearly the most ignored aspects were land-use and biodiversity.

Two Japanese electronics companies, Hitachi and Fujitsu, were referring to LCA but closer examination showed that they were conducting only studies of carbon emissions and energy consumption. According to ISO 14040, the goal and scope definition includes selection of impact categories, and thus such a narrow approach can also be an LCA.

Many companies were using software tools for weighting the impacts. This can be an objectivity problem, since there is no general consensus on, which impacts are more important than others (Schmidt & Sullivan 2002). Overall environmental impact scores are easy to understand, but are often misleading. The interpretation of results was mostly attributional and did not relate the impacts to the scale of the environmental deterioration.

3.5

Novel approaches to LCA

3.5.1

Socially and economically expanded LCA: BASF

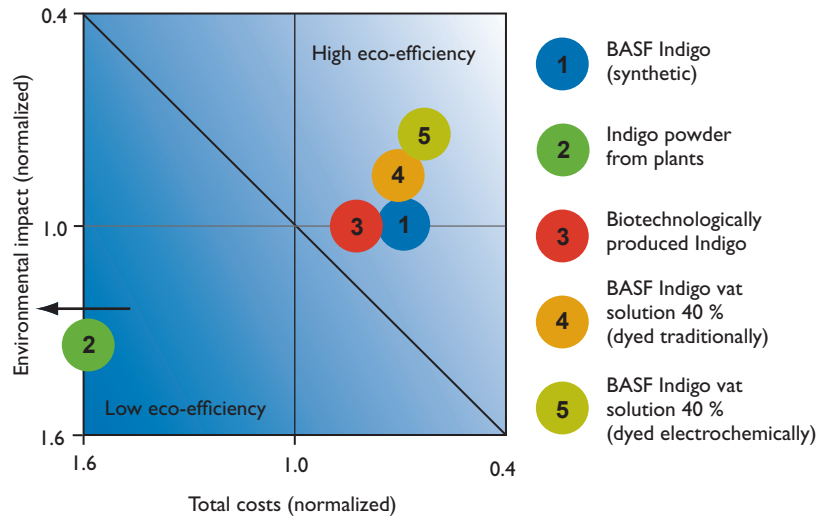
Sustainability is determined by the environmental, economic and social impacts. Traditional LCA only looks at environmental aspects so decisions cannot be based solely on its results. In order to comprehensively assess the sustainability of products, the costs and social impacts have to be integrated into analysis. In this way, the applicability of the analyses directly as a decision-making tool is higher. The results can be aggregated in simplistic graphs (e.g. Fig. 2), which can make discussion with stakeholders easier and deliver a broader view of the whole life cycle.

BASF has developed Eco-Efficiency Analysis for comparing, how products differ in environmental impacts and economic costs (Saling et al. 2002). Environmental impacts are grouped into six categories. They include the consumption of raw materials, energy consumption, emissions to air, water and soil (including waste), toxicity potential of substances produced and employed, the risk potential and land-use. These results are combined with life cycle costs. The results make it easier to identify economic-environmental win-win situations in processes and they are more readily usable for strategic purposes than the ones from environmental LCA.

The SEEBALANCE™ method goes even further that the Eco-Efficiency Analysis by adding a third dimension and integrating social aspects into the analysis (Kölsch et al. 2008). Impacts on five stakeholder groups, employees, future generations, local community, international community and consumers, are considered in the assessment. At least 23 indicators are described for impacts on these stakeholders, ranging from employee safety to the amount of imports from developing countries. The task of quantifying all aspects of production is immense and maybe impossible, considering all the uncertainties, but it can ease value discussions in relation to production and help to identify key areas of improvement.

SEEBALANCE™ method is not in wide scale use, but the Eco-Efficiency Analysis has been completed for over 400 products. The results have been applied in process development, communication and marketing. The strength of these expanded assessments is their ability to simplify complex issues in a transparent way. BASF has also developed illustrative ways of communicating the assessment results (Fig 2).

2a.



2b.

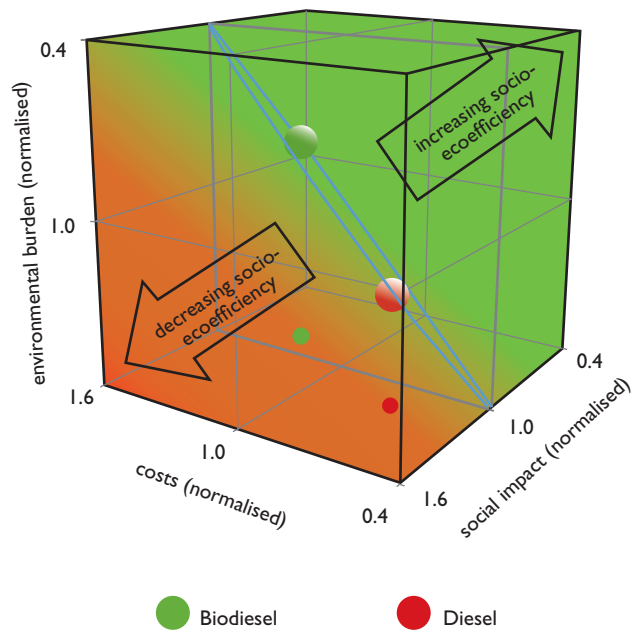
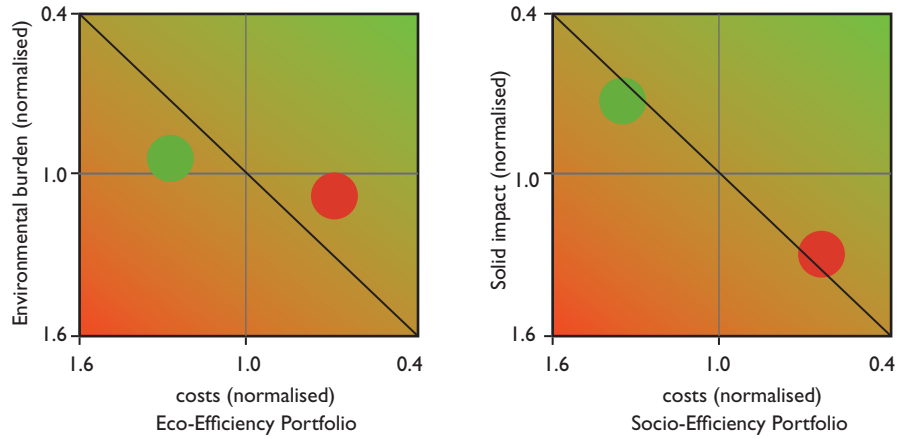


Figure 2a. Eco-Efficiency Analysis results can be downscaled to a two dimensional graph where the x-axis indicates costs and the y-axis overall environmental impact. 2b. SEEBALANCE-results are presented as a “SEECube”, where the compared products in a three-dimensional (costs, overall environmental impact, overall social impact) space. (Based on Kölsch et al 2008).

Assessing impacts on biodiversity: Vattenfall

Biodiversity has rarely been quantified in the context of companies' LCAs. Many companies compensate these effects from their actions by giving donations to projects and charities promoting biodiversity. One example of life cycle based method for assessing biodiversity impacts was found from the electricity company Vattenfall. Its researchers have been developing a method for assessing these effects quantitatively in proportion to a functional unit. Changes in land use are used as indicators for potential changes in biodiversity. The data can be gathered for instance from maps, aerial photographs, national biotope surveys and site visits. Potential biodiversity changes are easier to quantify than for instance actual changes in species richness, and therefore this method is considered applicable for companies.

Environmental indicators such as rare species and landscape features (vegetation variables, presence of natural monuments etc.) are used to divide the area under assessment into four biotope categories: technotope, general biotope, rare biotope and critical biotope. The method includes definition of system boundaries, mapping of biotopes, categorization of biotopes based on site-specific indicators, and evaluation of change in biotope status and extent of area per biotope.

The area changes caused by production processes are related to functional unit, which in the case of Vattenfall was kWh. The results are delivered in the form $\pm m^2/kWh$ for each class or in the form of a graph (Fig. 3).

The reliability of the results depends on how comprehensive the available data on local biotopes is. In Scandinavia there are relatively good background inventories on species richness of certain biotopes. National surveys of critical biotopes and rare species were important sources of reliable information. The method requires some expertise in ecology to make the right conclusions in categorization and interpretation.

The Biotope Method has also been applied to uranium mining in Namibia. There, the level of data on the "before" scenario was lower than in Scandinavia and some simplifications had to be made. This weakened the quality and reliability of the results. The application of this method used previously only in Scandinavia was however considered to be feasible. (Burke et al. 2008)

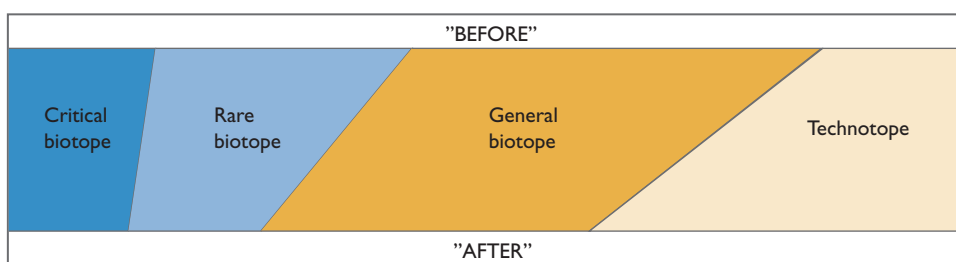


Figure 3. The Biotope method describes landscape changes that affect biodiversity. When, for example, a power station occupies land, technotope area increases at the expense of other, sometimes critical and rare, biotopes. (Based on Kyläkorpi et al. 2005)

Fast Life Cycle Assessment of Synthetic Chemistry: GlaxoSmithKline

Compilation the data for LCA is the most time-consuming phase and this phase is often a limiting factor for wider LCA application. Especially in companies with a large portfolio of products, there is a need to develop fast methods of conducting LCA. Having access to a relevant and reliable database can speed up LCA significantly. Many public databases, industry databases and databases bundled with software are available for professionals. In the last decade many international public databases have been released such as SPINE@CPM, Ecoinvent and European Reference Life Cycle Database (ILCD). But especially in the chemical industry, there is often a lack of appropriate data for conducting an LCA, due to the complexity of processes and plurality of source materials (Finnveden et al. 2009).

The pharmaceutical company GlaxoSmithKline (GSK) has answered this problem by developing FLASC™ (Fast Life Cycle Assessment of Synthetic Chemistry), a web based tool, which includes a comprehensive database and streamlined analysis methods for comparing process and material choices (Curzons et al. 2007).

As the background research for the FLASC-tool, cradle to gate LCI data for approximately 140 substances were gathered. An environmental impact profile for each substance was created, based on eight impact categories. Each substance was grouped on the basis of their environmental impact profile and the structure of the molecule. Statistical analysis was used to identify similarities in these impact profiles and to create a logical and simple grouping of the materials. 14 groups (e.g. aliphatic, alkenes, mono-substituted aromatics etc.) were defined and average data calculated for each group. This group specific data can be used for new materials or materials for which LCI data does not exist. Ready to use average data for all materials and processes saves time and makes the threshold for assessment of novel materials lower.

A web based tool gives a score for overall environmental burden as well as a breakdown of the impact categories. Development of the process is aided by a summary of the steps having the largest life cycle mass and energy use, the efficiency of reactions and data on solvent acceptability (Curzons et al. 2007). The method also includes a list of screening questions intended to help chemists reduce the impacts of the synthetic route. These questions include for example: Can a material be substituted with a better impact profile? Can materials be reused?

Procter & Gamble, also a chemical producer, describes similar efforts to create a customized database for especially for laundry detergents. An existing database (Si-maPro 4.0) was used as a starting point to create a rapid analysis tool for comparing the impacts of different stages of the life cycle (Saouter & van Hoof 2001). It seems that especially in the chemical industry, existing databases are mostly insufficient for conducting reliable and efficient LCA of all products. The research teams are often overloaded with work and a fast LCA-tool can help to solve this problem (Curzons et al. 2007).

4 Conclusions

The field of LCA and life cycle approaches is under constant development. It is seen as a tool with great potential, even increasing in the future. The possibility of combining comprehensive assessment with simple method is an ideal presented by many of the companies. This implies that development efforts should focus on availability of quality data and reliable streamlined approaches to achieve wider adoption of life cycle approaches. Availability of data is already enhanced by public databases provided by different institutions. To improve data availability, co-operation between companies has proven to be helpful.

LCA appears to be the tool of choice for process development and enhanced efficiency is the main motivator for adopting the method. LCA can be a very useful tool for communicating complex phenomena and producing credible and comprehensive information for product declarations and other corporate communications.

The evidence from this survey confirms the finding that companies rely on existing LCA resources such as software and databases in conducting LCA. This is also in line with the generally known problem of the time demand of LCA. By using pre-developed tools the companies can get results fast. It is however debatable whether the generic software and data are sensitive enough for unique features of certain products and processes.

The use of the ISO 14040 standards as a guideline is also very common. This enhances the comparability of assessments and gained results.

The companies reviewed in this survey were forerunners in life cycle thinking. Therefore actual level of LCA use in the scale of industry and business in general remains uncertain. Life cycle thinking seems to be relatively widely applied, but application of LCA is still seen as a more or less a pioneering in enterprises. Some companies have taken an especially active role in developing the method with a clear goal of making LCA a routine tool for product improvement. Other companies are experimenting with it as one option for environmental assessment and mostly using it for communicational purposes instead of supporting product design.

In this survey only relatively large companies operating on a global scale were reviewed. It is clear that these companies have large research and development budgets, so investments can be made on a longer time scale. Although large companies have a possibility to look further and invest in LCA, SMEs still have a long way to go.

An interesting direction of development found is the attempt to expand the LCA to include economic aspects and, as in the case of BASF, also social considerations. Finding a holistic approach to environmental issues would give the necessary perspective and integrate it into decision-making, instead of being a separate part of as it often is. However, in this type approach there are problems related to quantifying very complex phenomena. The results are always debatable, but if the method is transparent it can still be an effective tool in finding compromise.

One reported obstacle for LCA use is the requirement of interpretation in relation to impact assessment. This survey attempted to find trends in the categories used in LCIA. It seems that the use of generic software and ISO standards has led to companies using a general set of impact categories, regardless of how relevant they are for the assessed product. Often the amount of resources used to find data is not in proportion to the scale of the impact. Land use and biodiversity are the least addressed impacts, mainly due to the fact that there is still no consensus on how these issues should be assessed and what are reliable methods. Vattenfall combined land cover and biodiversity assessment in their Biotope method. Integrated with LCA this method is a promising attempt to include these impacts that have mostly not been addressed in a corporate context.

No breakthrough findings were made in this report, but it provides background information and support for further investigations done in the context of the FinLCA project. The next step to get more reliable and detailed results is to conduct a wide scale questionnaire survey of professionals and compare the results to the findings of this report and the findings of previous questionnaire surveys found in literature.

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Appendix I. Company survey sources.

	Publications and URLs
BASF	Kölsch et al. 2008, Saling et al. 2002, Landsiedel & Saling 2002, Five Winds & Pollution Probe 2004, BASF Report 2009 (http://www.basf.com/group/corporate/en/function/conversions:/publish/content/about-basf/facts-reports/reports/2009/BASF_Report_2009.pdf)
Bombardier Transportation	Bombardier Transportation Sustainability report 2008 (http://www.google.fi/url?sa=t&source=web&cd=1&ved=0CBQJfAA&url=http%3A%2F%2Fwww.bombardier.com%2Ffiles%2Fen%2Fsupporting_docs%2FBT_SustainabilityReport_EN.pdf&ei=cR4jLz9MMeWO0ilwIEF&usg=AFQjCNHfmp4phqj99QXN8-kBL8kQAdA0-w), Program Rules Environmental Product Declarations (EPD) - Rail Vehicles (http://www.bombardier.com/files/en/supporting_docs/EPD_Product_Category_Rules_Locomotives_en.pdf) Five Winds & Pollution Probe 2004
Canfor	Five Winds & Pollution Probe 2004, LCA of a newspaper
Continental	Life cycle assessment of a car tire (http://www.conti-online.com/generator/www/com/en/continental/csr/themes/ecology/download/oekobilanz_en.pdf)
Daimler	Finkbeiner et al. 2006, Daimler Facts on Sustainability 2010 (http://sustainability.daimler.com/daimler/annual/2010/nb/English/pdf/DAI_2010_sustainability-online_en.pdf)
Electrolux	Electrolux Sustainability Matters 2008 (http://www.electrolux.com/Files/Sustainability/PDFs/2009_PDF/Elux_ENG_Sustainability08_20090810_Low.pdf), EPD of a refrigerator (http://www.leonardo-energy.org/webfm_send/612)
Fujitsu	Fujitsu for Environment (http://www.fujitsu.com/downloads/ECO/rep2009/fujitsu2009report43-69-e.pdf) Introduction LCA, article (http://www.fujitsu-ten.co.jp/english/company/researchdev/gihou/en_pdf/32/32note2.pdf),
GE	GE website (http://www.ge.com/citizenship/performance_areas/environment_health_safety_cycle.jsp)
GlaxoSmithKline	Corporate Responsibility Report 2009, Curzons et al. 2007, Presentation: GSK Experiences in LifeCycle Inventory and Assessment, Jiménez-González & Constable (http://acs.confex.com/recording/acs/green09/pdf/free/4db77adf5df9ff0d3caf5cafe28f496/paper69806_5.pdf)
Hitachi	Hitachi Environmental Sustainability Report (http://www.hitachi.com/environment/activities/download/pdf/env2009e_044-045.pdf), Environmental Efficiency based on Factor X (http://www.hitachi.com/environment/library/pdf/factorx_en.pdf)
Huhtamaki	Huhtamaki Sustainability Report 2008 (http://www.huhtamaki.com/Websites.nsf/index/4B6A7B05375D4C1BC22575C4004C3482/\$FILE/sustainability%20report%202008_en.pdf),
Interface	Interface Global website (http://www.interfaceglobal.com/Sustainability/Sustainability-in-Action/Life-Cycle-Assessment.aspx), EPD of carpet tile (http://www.interfaceglobal.com/getdoc/a33f2138-6778-4852-9681-75e413ec6f48/InterfaceFLOR-EPD.aspx)
KONE	EPD of Minispace elevator (http://www.kone.com/countries/nl_NL/Documents/brochures/liften/algemeen/brochure_minispace_epd.pdf), KONE Corporate Responsibility Report 2008 (http://www.kone.com/corporate/en/company/Documents/KONE_Corporate%20responsibility%20report%202008_bm.pdf)
Nestle Waters	Nestle Waters Corporate Citizenship Report 2008 (http://www.nestle-watersna.com/pdf/Nestle_Corporate_Citizenship_Report_Final.pdf), Comparative LCA study of bottled water (http://beveragecafootprint.com/), Nestle Waters
Procter & Gamble	Comparative Life Cycle Assessment of Ariel detergents (http://server-it.imrworldwide.com/cgi-bin/b?cg=0&ci=science-in-the-box&tu=http://www.scienceinthebox.com/en_UK/pdf/Ariel%20Actif%20a%20Froid%20LCA%20report%20Nov%202006.pdf), Saouter & van Hoof 2001, Procter & Gamble website (http://www.scienceinthebox.com)
Siemens	Siemens Sustainability Report 2008 (http://www.siemens.com/responsibility/report/08/pool/en/sustainability_report_2008.pdf), Life cycle assessment of LED lamps (http://www.osram-os.com/osram_os/EN/About_Us/We_shape_the_future_of_light/Our_obligation/LED_life-cycle_assessment/OSRAM_LED_LCA_Summary_November_2009.pdf)
Unilever	LCA results of fabric liquids (http://www.unilever.com/images/capsules_tcm3-4586_tcm13-40198.pdf), Use of LCA by Unilever- Benefits and consequences, presentation (http://www.lcafood.dk/upload/OverheadPhilMcKeown.ppt), Shonfield: Applying life cycle thinking in Unilever, presentation (http://www.greenchemistrynetwork.org/pdf/PeterShonfield2004.pdf)
Vattenfall	Biotope Method (http://www.vattenfall.com/www/vf_com/vf_com/Gemeinsame_Inhalte/DOCUMENT/360168vatt/386246envi/2005-TheBiotopeMethod.pdf) EPD of Electricity from Vattenfall's Wind Farms (http://www.environdec.com/reg/epd183full.pdf) Nuclear power EDP (http://www.environdec.com/reg/021/dokument/EPDforsmark2007.pdf)
Vestas	Vestas Annual Report 2009 (http://mags.datagraf.dk/vestasws/2/), Life Cycle Assessment of a Wind Turbine (http://www.vestas.com/Admin/Public/Download.aspx?file=Files%2Ffiler%2FEN%2FEPD+Brochures%2FBrochure_210x280mm_EP_V80-2.0MW_offshore.pdf)
Xerox	Xerox Environmental Health and Safety Report 2009 (http://www.xerox.com/corporate-citizenship-2009/Environment_Health_Safety_Report_2009.pdf), Life Cycle Assessment of a Solid Ink Multifunction Printer Compared with a Color Laser Multifunction Printer (http://www.office.xerox.com/latest/Q92WP-05UA.PDF)

Appendix 2. Company survey results.

	Country	Assessed products	Life cycle approaches reported	Software and specific tools reported	Databases reported
BASF	Germany	Hundreds of chemicals	Integrated LCA and LCC, Social LCA	Internally developed tools: Eco-Efficiency Analysis, SEEBALANCE	Internal database
Bombardier Transportation	Canada	Trains, metro system	LCA, LCC	Spredsheet tool for LCI, Gabi 4, EcoLab, ENECO	ENVIRA, Bombardier Certification & Environmental materials database (CE-MAT), Gabi database
Canfor	Canada	Lumber, pulp and paper products, newspaper	LCA	Thena Environmental Impact Estimator, BEES, CML, Eco Indicator	No information found
Continental	Germany	Several tires and car accessories	LCA	Gabi 3.0	Internal sources, Gabi database, supplier sources
Daimler	Germany	Cars	LCA, integrated LCA and DfR (Design for Recycling)-model, carbon footprint	LCA-DfR-tool based on Gabi 4.0	Internal databases, Gabi 4.0 database
Electrolux	Sweden	Household electronic devices	LCA, carbon footprint	No information found	No information found
Fujitsu	Japan	Electronic devices	Carbon footprint (referred to as LCA), MFA	Internally developed software	Internal database system
GE	US	Not specified (energy production, water purification, appliances etc.)	LCA, streamlined LCA, environmental risk assessment	Internal software	No information found
GlaxoSmithKline	UK	Hundreds of pharmaceutical products	LCA, streamlined LCA	EcoLab, EcoDesign Toolkit, Solvent Selection Guide, Green Metrics, FLASC (Fast Life Cycle Assessment of Synthetic Chemistry)	Internally gathered database
Hitachi	Japan	Electronic devices	Streamlined "System Integration" LCA (SI-LCA), carbon footprint	No information found	No information found
Huhtamaki	Finland	Packages	LCA, carbon footprint	Eco Indicator 99	No information found
Interface	US	Carpets	LCA	Gabi 4.0, TRACI, CML	GABI 4.0 database, Plastics Europe database
KONE	Finland	Elevators	LCA, carbon footprint	Eco Indicator 99	Internal data, "LCA databases"
Nestle Waters	US	Bottled water	LCA, MFA	TRACI, IMPACT 2002+, CML	Ecoinvent, several internal and external sources
Procter & Gamble	US	Detergents	LCA, environmental risk assessment, socio-economic impact analysis	TEAM, SimaPro, CML 92	SimaPro database, TEAM database
Siemens	Japan	LED lamps	LCA, carbon footprint, streamlined LCA, cumulative energy demand	CML, Gabi	Gabi, EcoInvent

	Country	Assessed products	Life cycle approaches reported	Software and specific tools reported	Databases reported
Unilever	US	Several food and hygiene products	LCA, strealined LCA, checklists	Internal tools	No information found
Vattenfall	Sweden	Electricity (nuclear, wind, hydro, coal)	LCA, environmental risk assessment, environmental impact assessment	Biotope method	ECLIPSE, EcoInvent
Vestas	Denmark	Five windturbine models	LCA , EIA (Environmental Impact Assessment)	SimaPro, Eco Indicator 99, Gabi	Internal sources, EcoInvent database
Xerox	US	Printer	Streamlined LCA	SimaPro 7	SimaPro database

DOCUMENTATION PAGE

<i>Publisher</i>	Finnish Environment Institute			<i>Date</i> November 2010
<i>Author(s)</i>	Jussi Nygren and Riina Antikainen			
<i>Title of publication</i>	Use of life cycle assessment (LCA) in global companies			
<i>Publication series and number</i>	Reports of the Finnish Environment Institute 16/2010			
<i>Theme of publication</i>				
<i>Parts of publication/ other project publications</i>	The publication is available only on the internet: www.environment.fi/publications			
<i>Abstract</i>	<p>Increasing public awareness on environmental issues lead industry and business to develop more ecological products and to inform stakeholders on how their activities produce emissions and consume natural resources. Several environmental assessment methods, such as life cycle assessment (LCA), streamlined LCA, carbon footprint, water footprint, material and substance flow analysis (MFA, SFA), and thermodynamic methods have been actively developed to measure the environmental performance of products, services and companies. However, relatively little is known on how companies actually use these methods. This survey was conducted as a part of the so called FINLCA-project (Life Cycle Assessment Framework and Tools for Finnish Companies). The survey aims at giving a global perspective on the current use of Life Cycle Assessment and its expanded or streamlined versions. This is done by reviewing public communications of selected multinational companies and literature on the practice of LCA. Research on this theme is challenging because reliable information on internal practices is often not available to the public. However, transparency in environmental management is increasing and especially forerunners in environmental matters communicate their methods in detail. As a result, LCA and life cycle approaches are seen as a tool with great potential, even increasing in the future. The possibility of combining comprehensive assessment with simple method is an ideal presented by many of the companies. This implies that development efforts should focus on availability of quality data and reliable streamlined approaches to achieve wider adoption of life cycle approaches. Companies often rely on existing LCA resources such as software and databases in conducting LCA. On the other hand, pioneering companies are also active in development of the general LCA methodology and also their own applications. The companies reviewed in this survey were forerunners in life cycle thinking. Therefore actual level of LCA use in the scale of industry and business in general remains uncertain. Life cycle thinking seems to be relatively widely applied, but application of LCA is still seen as a more or less a pioneering in enterprises. More research is needed on how different types of companies use LCA and other life cycle approaches and what are their needs concerning data sources, education on the use of the methods and method development.</p>			
<i>Keywords</i>	Life cycle assessment, environmental impacts, multinational corporations, application			
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KUVAILEHTI

Julkaisija	Suomen ympäristökeskus			Julkaisu-aika Marraskuu 2010
Tekijä(t)	Jussi Nygren ja Riina Antikainen			
Julkaisun nimi	Use of life cycle assessment (LCA) in global companies (Elinkaariarvioinnin (LCA) käyttö kansainvälisissä yrityksissä)			
Julkaisusarjan nimi ja numero	Reports of the Finnish Environment Institute 16/2010			
Julkaisun teema				
Julkaisun osat/ muut saman projektin tuottamat julkaisut	Julkaisu on saatavana vain internetissä: www.environment.fi/publications			
Tiivistelmä	<p>Kasvava kiinnostus ympäristöasioita kohtaan on johtanut siihen, että teollisuus ja yritykset kehittävät lisääntyvässä määrin ympäristömyötäisiä tuotteita ja kertovat sidosryhmilleen entistä enemmän tuotteidensa ympäristövaikutuksista ja luonnonvarojen kulutuksesta. Useita arviointimenetelmiä, kuten elinkaariarviointi (LCA), yksinkertaistettu (streamlined) elinkaariarviointi, hiilijalanjälki, vesijalanjälki, materiaali- ja ainevirta-analyysi (MFA, SFA), sekä termodynaamisia menetelmiä on kehitetty mittaamaan tuotteiden, palveluiden ja yritysten ympäristövaikutuksia. Kuitenkin siitä, kuinka yritykset todellisuudessa käyttävät näitä arviointimenetelmiä, on vasta melko vähän tietoa saatavilla. Tämä selvitys tehtiin osana FINLCA-hanketta (Elinkaarimetodiikkojen foorumi yritysten päätöksenteon tueksi). Selvityksen tavoitteena oli antaa globaali näkökulma elinkaariarviointiin ja sitä lähellä olevien menetelmien käyttöön. Selvityksen pääaineistona oli valittujen monikansallisten yritysten julkisia raportteja ja kirjallisuutta elinkaariarvioinnin käytöstä. Tutkimusaihe koettiin haastavaksi, koska usein tietoa yritysten sisäisistä käytännöistä ei anneta julkisuuteen. Toisaalta läpinäkyvyys ja avoimuus ympäristöasioiden hallinnasta ovat lisääntymässä, ja erityisesti edelläkävijäyritykset kertovat yksityiskohtaisesti käyttämistään menetelmistä. Tämän seurauksena LCA ja muut elinkaariarvioinnin menetelmät voidaan nähdä työvälineinä, joiden hyödyntämiselle on suuri ja lisääntyvä tarve ja mahdollisuus tulevaisuudessa. Monet tarkastelluista yrityksistä tavoittelevat ja toivovat sitä, että laaja ja kattava arviointi voitaisiin tehdä yksinkertaisen menetelmän avulla. Näin ollen menetelmäkehityksen tulisi keskittyä luotettavan ja laadukkaan lähtötiedon sekä yksinkertaistettujen menetelmien yhdistämiseen, jotta elinkaariarvioinnin käyttöönotto ja hyödyntäminen yrityksissä lisääntyisi. Usein yritykset nojaavat olemassa oleviin ohjelmistoihin ja tietokantoihin laatiessaan omia elinkaariarvioinnin menetelmiään. Edelläkävijäyritykset ovat toisaalta usein myös itse aktiivisia kehittämään elinkaariarvioinnin menetelmiä yleisesti ja myös omiin sovelluksiinsa. Tässä selvityksessä tarkastellut yritykset ovat elinkaariarvioinnin edelläkävijöitä. Tämän vuoksi LCA:n ja muiden elinkaariarvioinnin menetelmien todellinen käyttölaajuus yrityksissä jäi tämän työn puitteissa edelleen selvittämättä. Yleisesti ottaen elinkaariarvioinnin hyödyntäminen vaikuttaa olevan melko laajaa, mutta itse LCA-menetelmää käyttävät lähinnä edelläkävijäyritykset. Lisätutkimusta tarvitaan siitä, miten erityyppiset yritykset käyttävät LCA:ta ja muita elinkaariarvioinnin menetelmiä, ja mitkä ovat erityyppisten yritysten tieto- ja koulutustarpeet sekä tarpeet liittyen menetelmäkehitykseen.</p>			
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PRESENTATIONSBLAD

Utgivare	Finlands miljöcentral			Datum November 2010
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Publikationens titel	Use of life cycle assessment (LCA) in global companies (Användningen av livscykelanalys (LCA) i internationella företag)			
Publikationsserie och nummer	Reports of the Finnish Environment Institute 16/2010			
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Publikationens delar/ andra publikationer inom samma projekt	Publikationen finns tillgänglig endast på internet: www.environment.fi/publications			
Sammandrag	<p>Det ökade intresset för miljöfrågor har lett till att industrin och företagen i allt större grad utvecklar miljövänliga produkter och informerar allt oftare sina intressegrupper om sina produkters miljökonsekvenser och förbrukning av naturresurser. Flera uppskattningsmetoder, till exempel livscykelanalys (LCA), förenklad (streamlined) livscykelanalys, koldioxidavtryck, vattenavtryck, material- och substansflödesanalys (MFA, SFA) samt termodynamiska metoder har utvecklats för att mäta produkters, tjänsters och företags miljökonsekvenser. Det finns dock rätt lite information om hur företag i verkligheten använder dessa uppskattningsmetoder. Den föreliggande utredningen gjordes som en del av FINLCA-projektet (Forum för livscykelmetoder som stöd för beslutsfattandet inom företagen). Utredningens mål var att ge en global synvinkel på användningen av livscykelanalys och närliggande metoder. Det centrala materialet i utredningen är offentliga rapporter från utvalda multinationella företag och litteratur om användningen av livscykelmetoder. Undersökningsområdet upplevdes som utmanande eftersom företag sällan ger offentlighet åt sin interna praxis. Å andra sidan håller transparensen och offentligheten i handläggningen av miljöärenden på att öka och i synnerhet företag som är föregångare informerar i detalj om de metoder de använt. Som en följd kan LCA och andra livscykelmetoder ses som redskap som det finns ett stort och ökande behov av och en potential att utnyttjas i framtiden. Många av de studerade företagen har som mål och önskar att en omfattande och täckande uppskattning kan göras med en enkel metod. Sålunda borde metodutvecklingen koncentrera sig på att kombinera pålitlig och högklassig utgångsinformation samt förenklade metoder så att livscykelmetoderna tas i bruk och utnyttjas i allt högre grad i företagen. Ofta stöder sig företagen på existerande program och databaser när de utarbetar sina egna livscykelanalyser. Föregångarna är å andra sidan ofta aktiva i att själv utveckla livscykelmetoder i allmänhet och även för sina egna tillämpningar. Företagen som studerats för denna utredning är föregångare i livscykelmetoderna. Därför blev det fortfarande i detta sammanhang outrett i hur stor utsträckning livscykelmetoder faktiskt används i företagen. Allmänt taget tycks utnyttjandet av livscykelmetoderna vara rätt utbredd, men själva LCA-metoden används närmast av föregångarföretag. Hur olika typer av företag använder LCA och andra livscykelmetoder och vilka informations- och utbildningsbehov företag av olika typ har samt deras behov i anslutning till metodutveckling kräver fortsatt forskning.</p>			
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