LCA

What is LCA?
LCA is the shortening for Life Cycle Assessment and is a tool to assess the environmental impact of a product (goods or service) throughout its life cycle. The life cycle includes the phases: raw material extraction, processes, transport, production, use and waste management. This perspective is often described from cradle to grave. To this all inflows and outflows during the products life cycle are added, such as material, electricity and emissions. LCA is focusing on the whole product system, which makes it possible to avoid shifting of a potential environmental impact from one part of the system to another.

What result does LCA give?
The result from an LCA is the contribution to impact on the nature, humans and/or the society. Examples on this are the global warming potential, acidification, eutrophication and human health. This can be used to find the aspects in a products life cycle that contributes most to the environmental impact. It can, for example be a life cycle phase, like production, or a component.

When to use LCA?
Results from LCAs can be used to reach improvements, directly (through decision making) or indirectly (through communication and learning). An overview of use areas are:

- Decision making, for example to find strategies to decrease environmental impact from a product, or to choose between products;
- Learning, for example to learn about product systems environmental impact;
- Identifying improvement possibilities;
- Communication, for example LCA-based environmental labeling and environmental product declaration or as a base for new policies.

How is LCA performed?
LCA is performed in the four phases goal and scope definition, inventory analysis, impact assessment, and interpretation.

In the first phase the object and goal of the study is decided (goal and scope). In this step the functional unit, the performance of a product used as a reference unit, is decided. Examples of this are beverage packaging (liters of packaged drink), decoration material (m^2*km) and passenger transportation (person*km). The goal definition includes the reasons for carrying out the study, the intended application, and the audience.

In the second step, the inventory analysis, a system model is built based on the goal and scope of the study and data is collected. In this step emissions and resource use during the life cycle are calculated.

In the third step, environmental impact assessment, emissions and resources are related to different environmental problems. Then, the environmental impacts can be related on the same scale by weighting. The last step involves the interpretation of the results and conclusions from the study can be drawn. LCAs are iterative and it is often needed to go back to previous steps and process them again.

Depending on the time, data access and use area the analysis can be more comprehensive and provide a quantitative results or simplified and give a qualitative or quantitative result. Guidelines on how to perform an LCA can be found in ISO-standards, handbooks and also tools for simplified LCA.

An LCA can be simplified by using already existing and available data, or by excluding a dimension. For this purpose there are several tools developed, for example matrix tools with guidelines for calculation or checklists.

Where can I lean more?
There are several ISO-standards for LCA, such as:

ISO 14040: Principles and framework
ISO 14044: Requirements and guidelines
ISO 14047: Impact assessment - Examples of application
ISO 14048: Data documentation format
ISO 14049: Goal and scope definition and inventory analysis- Examples of application
See www.iso.org

Handbooks in LCA:
Guinée, J.B.; Gorrée, M.; Heijungs, R.; Huppes, G.; Kleijn, R.; Koning, A. de; Oers, L. van; Wegener Sleeswijk, A.; Suh, S.; Udo de Haes, H.A.; Bruijn, H. de; Duin, R. van; Huijbregts, M.A.J. Handbook on life cycle assessment (2002). Operational guide to the ISO standards. I: LCA in perspective. IIa: Guide. IIb: Operational annex. III: Scientific background, ISBN 1-4020-0228-9, (Dordrecht, Kluwer Academic Publishers).

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

Scientific articles:
There are several published scientific articles of LCA and its applications. Databases for finding them are www.scopus.com and www.sciencedirect.com.

Publication list at the Swedish Life Cycle Center web page: http://lifecyclecenter.se/publications/

SLCA

What is SLCA?
SLCA is the shortening for Social Life Cycle Assessment and is an assessment of the social impact, the impact on humans and societies, from a product (goods or service) during its life cycle. The life cycle includes raw material acquisition, production, transport, use and disposal.

What result does SLCA give?
The methodology for SLCA is under development and there is no consensus on a single methodology. Different approaches give different answers. Generally speaking, the result is a qualitative assessment of how humans are affected in the different life cycle phases. From this study the most important social impacts and in what countries the impact occurs can be identified.

When use SLCA?
Since the method is under development, it is preferably used internally by a producing company. The result can be used to find risks and opportunities to contribute to a sustainable development. The results can also be used to guide product development in a company towards a greater use of sustainable materials, or to help identify the greatest risks of negative social impact in the value chain to be able to work in a more sustainable way with their suppliers. Other actors, such as Governments and politicians, could benefit from the results in the policy development. In the future, it can hopefully be used to compare different products, for example, be the basis for a labelling system for social sustainability.

How is SLCA performed?
The first step includes a description of the product life cycle and the significant raw materials and countries are identified. Then stakeholders are identified, such as workers, local communities, the whole of society, consumers and companies involved. The negative and positive impacts on stakeholders throughout the life cycle are then analyzed based on a number of social issues, such as working conditions, access to drinking water and forest, and human rights. The analysis can be performed on a general level, as an initial screening, or specifically in the constructions that are part of the product life cycle.

Where can I lean more?
Benoit C, Mazijin B, ed., 2009. Guidelines for social life cycle assessment of products: Social and socio-economic LCA guidelines complementing environmental LCA and Life Cycle Costing,

contributing to the full assessment of goods and services within the context of sustainable development

Ekener-Petersen E. 2013. Tracking down social impacts of products with social life cycle assessment, TRITA-FMS-PHD; 2013:01, PhD Thesis, KTH Royal Institute of Technology

Fontes J (main author). 2013. Handbook for Product Social Impact Assessment, PRé Sustainability

LCC

LCC is the shortening for Life Cycle Costing and is a technique for assessing a products (goods or service) cost during its life cycle. The term life cycle refers to the economic life cycle of the product. Included phases can be somewhat different depending on the application. One example of life cycle is the phases research, development, procurement, use and disposal. There are several explanations of LCC. These can be summarized as conventional LCC, environmental LCC and societal LCC. Costs included in a conventional LCC are internal. In an environmental LCC external costs that are likely to be internalized are also included. An environmental LCC can be performed as a combination of conventional LCC and a LCA. A social LCC considers all costs for the society and can be likened a Cost Benefit Analysis.

What result does LCC give?
The result from an LCC is the total cost during the products life cycle, and an identification of phases with the highest cost.

When to use LCC?
Examples of use areas are information and marketing from producers, as a base for decision at procurement for the procuring organization, and to identify and plan for significant costs for the user of a product system. LCCs can also be used when stipulating requirements in public procurement.

How is LCC performed?
There are several models for LCC developed for different sectors and use areas. It is common that organizations develop their own method. These are often excel-based, but it can also be specific computer programs. Common to all are that costs during the life cycle are summarized and that the present value of future costs are calculated. The used interest rate is decided from case to case and is often company specific.

Where can I lean more?
The Swedish Environmental Council has developed LCC-models for different products, see se www.msr.se, www.kkv.se

LCC is within the EU-commissions toolbox for green procurement, see: http://ec.europa.eu/environment/gpp/toolkit_en.htm

A book on environmental LCC: Hunkeler D, Lichtenvort K, Rebitzer G (eds) (2008) Environmental life cycle costing. SETAC

There are several published scientific articles of LCC and its applications. Databases for finding them are www.scopus.com and www.sciencedirect.com.

PEF and OEF

What are PEF and OEF?
PEF is the shortening for Product Environmental Footprint and OEF stands for Organisation Environmental Footprint. Both PEF and OEF are developed by the European Commission based on several methods such as Life Cycle Assessment, Ecological Footprint and Water footprint. The life cycle includes the extraction, transportation, processing, use and disposal (or reuse/ recycling). This includes both direct impacts (e.g. impacts on the production site, impacts of transport vehicles

controlled by the company) and indirect impacts (e.g. occurring in the supply chain, at extraction, if these activities are not controlled by the company; occurring in the use stage).

One of the differences between the PEF and OEF methods and other leading methods is the fact that it takes methodological choices in order to promote consistency and comparability of results. For this purpose Product Environmental Footprint Category Rules needs to be developed. These are now being developed in so called pilots, by companies, government agencies, industry associations etc.

What result do PEF and OEF give?
The result is contribution to impact categories. The PEF and OEF method can potentially cover 14 impact categories: climate change; ozone depletion; human toxicity - cancer effects; human toxicity - non-cancer effects; particulate matter/respiratory inorganics; ionizing radiation; photochemical ozone formation; acidification; eutrophication – terrestrial; eutrophication – aquatic; ecotoxicity- freshwater aquatic; land use; resource depletion - water; resource depletion – mineral and fossil fuel.

When to use PEF and OEF?
There are several use areas for PEF and OEF. These can be summarized as:

- In-house improvement of product environmental performance (design for environment);
- Communication (B2B and B2C) of the environmental performance of a product or organization;
- Improvement of production processes along the life cycle.

How are PEF and OEF performed?
PEFs and OEFs are performed in the phases goal definition, scope definition, resource use and emissions profile, environmental footprint impact assessment, and environmental footprint interpretation and reporting. In short this means that the intended application and target audience is decided in the goal definition. Relevant assumptions and boundaries are decided in the scope definition. Then relevant data within the system boundaries are collected and a resource use and emissions profile is built for input and output flows. These are then classified into relevant impact categories. For each category a characterized result is then calculated. In the last phase the result is interpreted and reported.

The PEF and OEF method can potentially cover 14 impact categories (see above). Of these the categories covering relevant environmental issues related to the product supply chain should be covered.

Where can I learn more?
You can follow the development of PEF and OEF at the EU-commissions homepage. Guides for PEF and OEF are available there:
http://ec.europa.eu/environment/eussd/product_footprint.htm
http://ec.europa.eu/environment/eussd/corporate_footprint.htm

CF

What is CF?
CF is the shortening of carbon footprint and it is the measure of the carbon dioxide equivalents of a product (good or service) over its life cycle. The life cycle includes the phases: raw material extraction, processes, transport, production, use and waste management.

There are different explanations of CF, ranging from direct CO_2-emissions to full life cycle greenhouse gas emissions (including both direct and indirect emissions). One comprehensive definition of carbon footprint of a product can be found in the ISO standard ISO 14067. It follows: “the sum of greenhouse gas emissions and removals in a product system, expressed as carbon dioxide equivalents and based on a life cycle assessment using the single impact category of climate change.“

What result does CF give?
The result is the contribution to the global warming potential, expressed as carbon dioxide equivalents.

When to use CF?

According to the ISO TS 14067:2013, the information from a carbon footprint can be used to:

- Providing information to consumers and others for decision‑making purposes during purchasing, use and the products end-of-life phase;
- Enhancing climate change awareness and consumer engagement on environmental issues;
- Supporting an organization's commitment to tackling climate change;
- Supporting implementation of policies on climate change management.

How is CF performed?
When the Carbon Footprint is based on a life cycle assessment (LCA) the procedure is the same as in LCA, except that it only focus on the impact category global warming potential. For more information, see text on LCA.

Where can I lean more?
PAS 2050:2011. Specification for the assessment of the life cycle greenhouse gas emissions of goods and services.

Wiedmann, T. and Minx J.(2008). A definition of Carbon Footprint. In: C.C Pertsova, Ecological Economics Research Trends: Chapter 1, pp.1-11, Nova Science Publishers, Hauppauge NY, USA.
The Carbon Trust. Carbon Footprint Measurement Methodology - Version 1.1 [Internet]. London; 2007. Available from: http://www.carbontrust.co.uk

ISO TS 14067:2013 Greenhouse gases – carbon footprint of products-requirements and guidelines for quantification and communication

There are also published scientific articles of CF. Databases for finding them are www.scopus.com and www.sciencedirect.com.

Glossary:

Life cycle: "Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal." (ISO 14040:2006)

Life-Cycle Approach: "Takes into consideration the spectrum of resource flows and environmental interventions associated with a product from a supply-chain perspective, including all stages from raw material acquisition through processing, distribution, use, and end-of-life processes, and all relevant related environmental impacts (instead of focusing on a single issue)."(Official Journal of the European Union, 4.5.2013

Life-Cycle Assessment (LCA): "Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle." (ISO 14040:2006)

Life-Cycle Impact Assessment (LCIA): "Phase of life cycle assessment that aims at understanding and evaluating the magnitude and significance of the potential environmental impacts for a system throughout the life cycle (ISO 14040:2006)". "The LCIA methods used provide impact characterisation factors for elementary flows to in order to aggregate the impact to obtain a limited number of midpoint and/or damage indicators". (Official Journal of the European Union, 4.5.2013).

Life Cycle Management (LCM): "Managerial practices and organizational arrangements in a company or a product chain that are expressions of life cycle thinking (Baumann and Tillmann, 2004)". "An integrated concept for managing the total life cycle of goods and services towards more sustainable production and consumption." (UNEP 2010).

Life Cycle Thinking (LCT): "A way of thinking that considers cradle-to-grave implications of different activities and products without going into details of an LCA study." (Baumann and Tillmann, 2004)

Life Cycle Thinking (LCT) is about going beyond the traditional focus and production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle." (http://www.michaeldbaker.com/portfolio-items/guidance-on-taking-a-life-cycle-perspective-to-sustainability/)

Life Cycle Thinking is about understanding environmental, social and economic impacts into people's hands at the time they are making decisions. It offers a way of incorporating sustainability in decision making processes and can be used by decision makers in both the public and private sector for the developement of policies and products, as well as for procurement and the provision of services." (http://www.lifecycleinitiative.org/)

Life Cycle Perspective: "The key aim of thinking about products and processes using a life cycle perspective is to avoid burden shifting. This means minimizing impacts at one stage of the life cycle, or in one geographic region, or in a particular impact category, while avoiding unrecognized increased impacts elsewhere. Taking a life cycle perspective requires a policy developer, environmental manager, or product designer to look beyond their own system, knowledge, or in-house operations. The approach to applying a life cycle perspective in order to arrive at a broader perspective is called Life Cycle Assessment (LCA)." (www.epa.gov)

Carbon footprint of a product, CFP, is the sum of greenhouse gas emissions and removals in a product system, expressed as CO2equivalents and based on a life cycle assessment using the single impact category of climate change." (ISO TS 14067:2013)

Ecoefficiency: As defined by the World Business Council for Sustainable Development (WBCSD), "eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity." (http://www.wbcsd.org)

Life cycle inventory data (**LCI-data**) describes the flows from and to nature for a product system. Inventory flows include inputs of water, energy, and raw materials, and releases to air, land, and water.