MICA
Minerals Intelligence Capacity Analysis

FACT SHEET

Life Cycle Assessment (LCA)

Description of the method of Life Cycle Assessment (LCA).

Scope (conceptual model & main characteristics)

Life Cycle Assessment (LCA) is a comprehensive evaluation of the cradle-to-grave life cycle of a product or a service with regard to its environmental impacts. The environmental assessment of the product or service is based on a complete overview of environmental interventions: emissions of substances and extractions of resources. These emissions and extractions are translated into a limited number of environmental impact categories.

The object of the analysis is the so-called product system: the total of processes which are involved in the production, use and waste disposal of a product or service. In these systems all (technical) processes are included from cradle-to-grave.

LCAs can be made of a specific product system to identify hotspots in the cradle-to-grave chain. Comparative LCAs specify alternative systems to fulfill the same function, to assess the environmental consequences of different options.

The methodology of LCA is standardised by the International Organization for Standardization in ISO 14040/14044 (ISO, 1996 and ISO, 2006). There are also European initiatives to harmonize the performance of LCA in compliance with ISO, like the International Reference Life Cycle Data System (ILCD) (EC, 2016a) and Product Environmental Footprint (PEF)/Organisation Environmental Foorprint (OEF) (EC, 2016b).

Methodological steps have been defined in ISO 14040:

1. Goal and Scope Definition
2. Life Cycle Inventory Analysis (LCI)
3. Life Cycle Impact Assessment (LCIA)
4. Life Cycle Interpretation

In the Goal and Scope Definition, the functional unit is defined and the mode for analysis is selected.

In the Life Cycle Inventory, process information is collected for all processes in the cradle-to-grave chain. For each process, inputs and outputs are specified: extracted resources, inputs of goods and services from other processes, emissions and final waste emitted into the enviornment, and outputs of goods and services to other processes. These processes are linked to form the product system. Allocation choices have to be made to attribute process inputs to outputs, in case a multi-output process is part of the product system. Emissions and extractions are then aggregated to form the Life Cycle Inventory table.

The aggregate emissions and extractions are the input for the Life Cycle Impact Assessment. The translation of emissions and extractions into state or impact indicators is based on characterization models. These models take into account the dispersion, deposition, exposure and (potential) damage Characterisation models thus translate the emission of a certain substance into a contribution to certain environmental impact categories, such as global warming, toxicity or eutrophication. These impact categories are sometimes further modelled into impacts further down chain the cause-effect chain into damages of different safeguard areas, i.e. damage to resources, human health and ecosystem health.

In the Interpretation step, the results are scrutinized and may give rise to a re-visiting of the earlier steps. The interpretation step is also the step to specify uncertainties, do sensitivity analysis, and assess the consequences of certain methodological choices.

Contexts of use, application fields	-> contexts (e.g., environmental, economic, social assessment) -> which types of stakeholder questions are concerned?

LCA is generally used to answer one of the following three questions

1. Where in the product system are the main sustainability impacts?
2. How do the sustainability impacts of alternative product system compare to each other?
3. Do the sustainability impacts of a specific product system comply with external standards?

To answer the first type of questions, a contribution or hotspot analysis is performed. The aim is to guide improvement of the production. For the second type of question, a comparative analysis is used for alternative products. There are stricter guidelines when the results of a comparative analysis are published. Statements that show one product superiority over another can be misleading as the outcomes of an LCA depend on the data availability and assumptions made by the researchers (Guinée 2002). The third question leads to a compliance evaluation to evaluate whether a product complies with externally set standards.

The core application of LCA is product related decision support. It can be used by companies, for hotspot identification in product systems, product development, product comparison, green procurement and market claims. However, LCA is also, next to other tools, important for technology choices, setting technologies into a product related chain perspective. LCA is increasingly used at a strategic level for business development, policy development and also for education. In policies, LCA is the main tool to support ecolabelling. At EU-level, it is used to support product policies by standardizing it into Product Environmental Footprints (PEFs). Another development is the Organisational Environmental Footprint (OEF) that follows the life cycle approach but takes the “product portfolio” of the organization as the functional unit (EC, 2016b). LCA based tools are also used to support policies on bio-energy, both in Europe and in the US. The CO2 calculators used there to determine the potential benefits of various bio-energy supply chains are LCAs with a standardized set of data and methodological choices.

A relevant disctinction in applications is that between attributional LCA (a-LCA) and consequential LCA (c-LCA). While the starting point of a-LCA is the present situation, c-LCA is concerned with change. In a-LCA, therefore, the analysis specifies the contribution of the functional unit to the total existing environmental pressure. In c-LCA, the changes in environmental pressure of the addition of one functional unit are specified (EC, 2010a; EC, 2010b). The difference at the micro-level is subtle, but when larger changes are involved it becomes critical.

The life cycle approach is gaining territory in many different policy applications. A new development in the LCA field is the movement towards Life Cycle Sustainability Analysis (LCSA) (Guinée, 2016). This includes upscaling from the micro-level to the macro-level, it includes expanding the analysis to include economic and social impacts, and it includes developing forward-looking analyses, especially the assessment of emerging technologies. Such new applications also call for new additions to the methodology, new databases and new ways to deal with uncertainties and unknowns.

Type(s) of data or knowledge needed and their possible source(s)	-> which types of data are needed to run the method, from which sources could they come… -> could be qualitative data or quantitative data, and also tacit knowledge, hybrid, etc.

A quantitative LCA-study requires LCI data on technical processes included in the system under study. Mostly such data are collected on a case-by-case basis with the help of the companies involved.

In addition, life cycle impact assessment (LCIA) data are required. These include characterization factors and normalization factors, to aggregate extractions and emissions into a limited set of environmental impact categories.

The collection of data for an LCA is a very elaborate job. However, several (commercial) databases are available that contain descriptions for some general processes. Also for impact assessment several databases exist that contain data for characterization sets and normalization sets. Sometimes the databases come in packages, together with the LCA software tool (see section 'operational tools').

LCI data

In LCI databases process data are often organized around a unit process. A unit process describes the produced goods (economic output), consumed goods (economic input) , emitted substances (environmental output) and consumed resources (environmental input). In existing LCI databases, process data are almost always quantified in relation to some physical economic output (e.g. 1 kg of produced material or 1 MJ of produced electricity). Process data provided by companies are often also organized around unit processes, but given in terms of inputs and outputs per unit of time, e.g. emission of 5 tonnes of CO_2 per year, input of 1000 tonnes of wood per year, etc..

There are many LCI databases available. An overview of available databases and their descriptions are given by openLCA Nexus. https://nexus.openlca.org/

The overview of databases contains commercial databases, like Ecoinvent and GaBi, as also initiatives to build open source databases, like the UNEP/SETAC Database Registry (the registry) and the European ELCD database with the Commission's "European Reference Life Cycle Database" (ELCD) of Life Cycle Inventory (LCI) data sets.

Sometimes the databases are a combination of LCI data and Impact Assessment data. For details is referred to the description given in OpenLCA Nexus.

LCIA data

Life Cycle Impact assessment (LCIA) is the phase in which the set of results of the Inventory Analysis, mainly the inventory table with emissions and extractions, is further processed and interpreted in terms of environmental impacts and societal preferences. To this end, a list of impact categories (environmental problems) is defined, and models for relating environmental interventions to suitable category indicators for these impact categories are selected. The actual modeling results are calculated in the characterization step, and an optional normalization serves to indicate the share of the modeled results in a worldwide or regional total. Finally, the category indicators results can be grouped and weighted to include societal preferences of the various impact categories.

There are many different sets of characterization factors. Some of these characterization factors model effects on the state level, so called midpoint level, resulting in impact scores for global warming, ozone layer depletion, human toxicity etc. (e.g.CML2002). Other sets take into account further modeling of these state indicators into damage indicators for areas like human health, ecosystem health and resources, so called endpoint indicators (e.g. Ecoindicator99, ReCiPe). Finally , there are impact assessment factors that also take into account the valuation of these damages into monetary terms and thus also include a weighting step across the impact categories (e.g NEEDS, EDP).

On a European level there is an initiative from ILCD to develop a recommended set of Impact Assessment data (EC, 2011). The actual ILCD compliant characterization and normalization factors for the recommended set of data is made available in a downloadable spreadsheet (EC, 2016a).

The Life Cycle Impact Assessment (LCIA) guide of the ILCD handbook (EC, 2016b) provides two documents:

- A framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators (EC, 2010a);
- Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment (LCA)(EC, 2010b).

Recent developments in the LCIA field include the development of resource depletion, resource scarcity and criticality indicators. This increases the applicability of LCA for resource management issues.

Model used (if any, geological mathematical, heuristic…)	-> e.g., geological model for mapping -> e.g., mathematical model such as mass balancing, matrix inversion, can be stepwise such as agent -based models, dynamic including time or quasidynamic specifying time series… -> can also be a scenario

Quantifying the product system is based on matrix inversion. The matrix is a product by product matrix with appending environmental extensions: extractions, land use and emissions. It is comparable to the mathematical model of Input Output Analysis (IOA, see separate factsheet) but operates at the micro-level, using a much more detailed matrix of a limited number of products.

For the Life Cycle Impact Assessment, characterization factors are used as multiplyers for the environmental interventions. These characterization factors are based on environmental fate models.

System and/or parameters considered	-> **the system can be described by its boundaries**. These can refer to a geographic location, like a country, or a city, the time period involved, products, materials, processes etc. involved, like flows and stocks of copper, or the cradle-to-grave chain of a cell phone, or the car fleet, or the construction sector, or the whole economy… -> **parameters** could possibly refer to geographic co-ordinates, scale, commodities considered, genesis of ore deposits and others…

The LCA method uses a functional system boundary, determined by the product and including all that is involved in producing, using and managing the waste. Unit processes are linked together in a product system. Unit processes are described in physical units by the consumption and production of materials by technological processes (see figure 1). The relevant processes are combined in a process tree (see figure 2). The processes in a process tree most likely are situated in different countries of the world, and emissions and extractions are occurring in different places and over multiple years. Hence the LCA system is neither time nor location specific. The resolution of processes in the process tree is very high, detailed technological processes, but the scope is limited to one specific function.

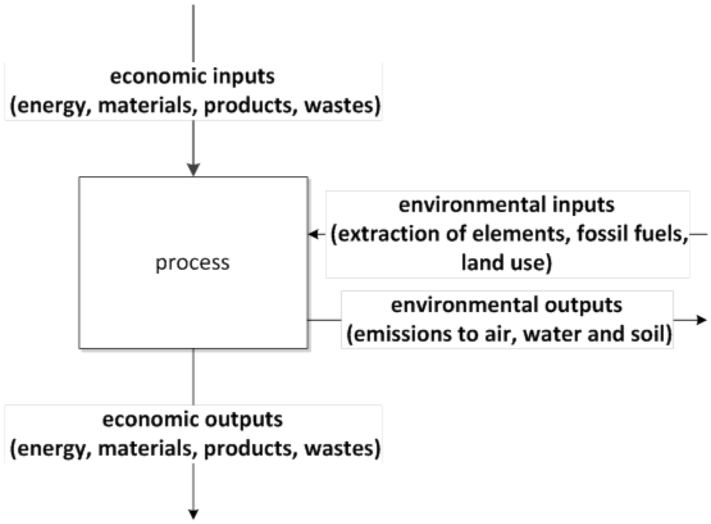

Figure 1 Unit process in LCA

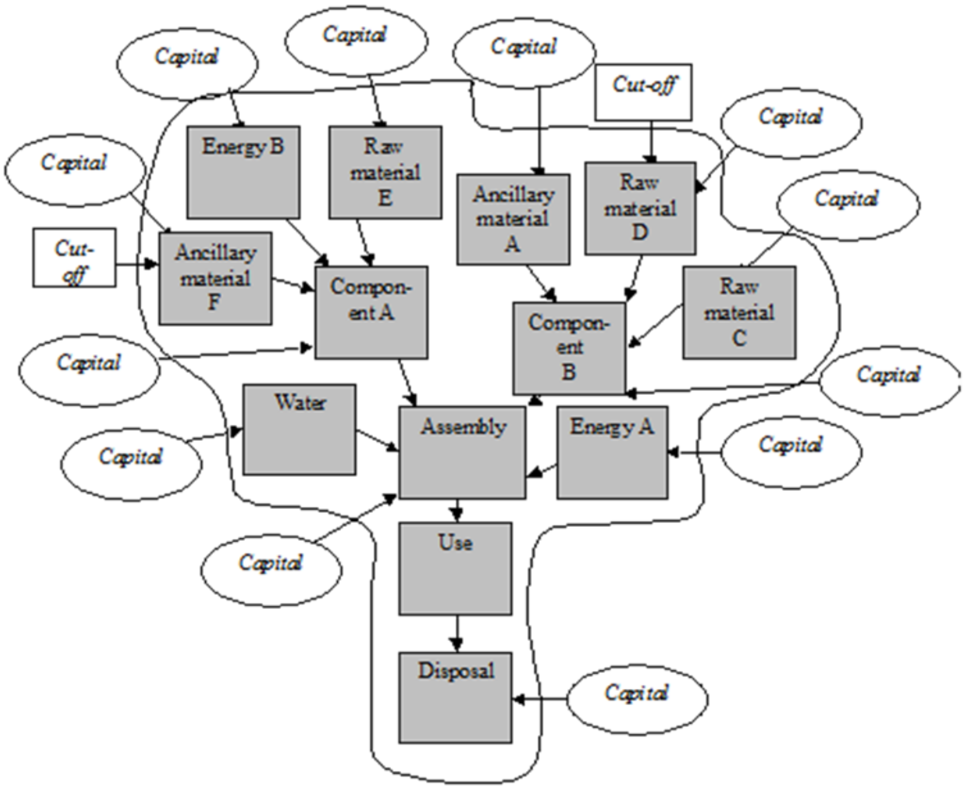

Figure 2 A generalized LCA process tree, with the product system boundary

The object of analysis in LCA thus is the product system, i.e., the total of processes which are related to the provision of a given function. LCA follows a cradle-to-grave approach: all processes connected with the function of a product (or other types of function), from the extraction of resources until the final disposal of waste, are considered.

Time / Space / Resolution /Accuracy / Plausibility…	-> to which spatio-temporal domain it applies, with which resolution and/or accuracy (e.g., near future, EU 28, 1 year, country/regional/local level…) -> for foresight methods can also be plausibility, legitimacy and credibility…

LCAs are highly detailed and product-specific and have a very high resolution in terms of processes, applied technologies and their environmental pressures (Guinée et al., 2002; EC, 2010a&b; EC, 2016).

LCA usually does not specify space, i.e., no distinction is made for where exactly emissions or extractions take place. LCA therefore only concerns "potential" effects and is not suitable to assess "actual" environmental damage, transgression of environmental quality standards, or risks. Attempts are made nowadays to define the LCI data more location or at least country specific, leading to a variety of unit processes to produce the same product. Attempts are also made to define more location specific impact factors. This is especially relevant in the applications around c-LCA and bio-energy, related to land use.

Likewise LCA does not specify when extractions and emissions take place. Most LCA methods and software model processes and reaction mechanisms in a steady state mode of analysis. However, developments take place to model future scenario's depending on specific future conditions (SETAC-Europe working group on scenario development).

The region and time representativeness of processes and their interventions will depend on the scope of the LCA case. Databases exist that describe background processes, like Ecoinvent and ELCD (see section data needs/databases). In these databases the representativeness of the technology in terms of region and year is defined. The databases give a static description of technologies. They seldom contain data describing the change of technologies over time. The databases are irregularly updated.

Indicators / Outputs / Units	-> this refers to what the method is actually meant for. Units are an important part but that is most of the time not sufficient to express the meaning. For example, **the indicators used in LCA express the cradle-to-grave environmental impacts of a product or service**. This can be expressed in kg CO_2-equivalent. But also in €. Or in millipoints. Or in m^2year land use. -> for foresight methods the outputs are products or processes

The main aim of LCA is to provide environmental information, and its main indicators therefore are related to environmental pressures and impacts. LCA is comprehensive with respect to the environmental interventions and environmental issues considered.

In the LCA, results can be specified on various different positions in the cause-effect chain. Many LCA-studies (or more correctly LCI-studies) stop after the inventory phase and do not aggregate the interventions in terms of impact categories. The resolution of interventions in LCA is very high. An inventory table might include thousands of substance-compartment-emissions and extractions. In the environmental impact assessment these interventions are aggregated into a limited number of environmental problems, so called impact categories. In order to facilitate the interpretation these emissions and extractions (pressure indicators) are transformed into state (e.g. concentrations in air) or impact indicators (e.g. % of species affected) and aggregated. For this purpose characterization factors are used based on characterization models that model the cause-effect chain from pressure (emission, extraction) to state or impact. Impact assessment indicators are often defined at "midpoint" level, the contribution to well-known environmental impact categories such as global warming, ozone layer depletion, or toxicity. Equivalency factors are used for that, for example global warming emissions are translated into CO2-equivalents. Some methods, for instance the Eco-indicator 99, model up to the level of “endpoints” describing damage to human and ecosystem health.

An LCA-study may include normalisation and weighting of the different impact category results, which makes it possible to aggregate the LCA result into one figure. A number of different weighting methods are used in LCA-studies based on Distance-to-(political)Target, on monetization of environmental impacts or on panel methods.

There are many different impact assessment methods available, see for example Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment (LCA) (EC, 2010b) and OpenLCA (GreenDelta, 2014). Table 1 gives an overview of ILCD recommended impact categories on midpoint and endpoint level and their units.

LCIA method	**Flow property (= quantity measured by the indicator of the LCIA method, i.e. of the characterisation factor per reference unit of elementary flow)**	**Unit group data set (with reference unit)**
ILCD2011; Climate change; midpoint; GWP100; IPPC2007	Mass CO2-equivalents	Units of mass (kg)
ILCD2011; Climate change; endpoint - human health; DALY; ReCiPe2008	Disability Adjusted Life Years (DALY)	Units of time (a)
ILCD2011; Climate change; endpoint - ecosystems; PDF; ReCiPe2008	Potentially Disappeared Fraction of species (PDF)	Unit of items * time
ILCD2011; Ozone depletion; midpoint; ODP; WMO1999	Mass CFC-11-equivalents	Units of mass (kg)
ILCD2011; Ozone depletion; endpoint - human health; DALY; ReCiPe2008	Disability Adjusted Life Years (DALY)	Units of time (a)
LCD2011; Cancer human health effects; midpoint; CTUh; USEtox	Comparative Toxic Unit for human (CTUh)	Units of items (cases)
ILCD2011; Non-cancer human health effects; midpoint; CTUh; USEtox	Comparative Toxic Unit for human (CTUh)	Units of items (cases)
ILCD2011; Cancer human health effects; endpoint; DALY; USEtox	Disability Adjusted Life Years (DALY)	Units of time (a)

ILCD2011; Non-cancer human health effects; endpoint; DALY; USEtox	Disability Adjusted Life Years (DALY)	Units of time (a)
ILCD2011; Respiratory inorganics; midpoint; PM2.5eq; Rabl and Spadaro 2004	Mass PM2.5-equivalents	Units of mass (kg)
ILCD2011; Respiratory inorganics; endpoint; DALY; Humbert et al 2009	Disability Adjusted Life Years (DALY)	Units of time (a)
ILCD2011; Ionizing radiation; midpoint - human health; ionising radiation potential; Frishknecht et al 2000	Radioactivity Uranium235-equivalents	Units of radioactivity (kBq)
ILCD2011; Ionizing radiation; midpoint - ecosystem; CTUe; Garnier-Laplace et al 2008	Comparative Toxic Unit for ecosystems (CTUe)	Units of volume*time (m3*a)
ILCD2011; Ionizing radiation; endpoint- human health; DALY; Frishknecht et al 2000	Disability Adjusted Life Years (DALY)	Units of time (a)
ILCD2011; Photochemical ozone formation; midpoint - human health; POCP; Van Zelm et al (2008)	Mass C2H4-equivalents	Units of mass (kg)
ILCD2011; Photochemical ozone formation; endpoint - human health; DALY; Van Zelm et al (2008)	Disability Adjusted Life Years (DALY)	Units of time (a)
ILCD2011; Acidification; midpoint; Accumulated Exceedance; Seppala et al 2006, Posch et al 2008;	Mole H+-equivalents	Units of moles
ILCD2011; Acidification; endpoint; PNOF; Van Zelm et al 2007;	Potentially not occurring number of species in terrestrial ecosystems * time	Unit of items * time
ILCD2011; Eutrophication terrestrial; midpoint; Accumulated Exceedance; Seppala et al 2006, Posch et al 2008	Mole N-equivalents	Units of moles
ILCD2011; Eutrophication freshwater; midpoint;P equivalents; ReCiPe;	Mass P-equivalents	Units of mass (kg)
ILCD2011; Eutrophication	Mass N-equivalents	Units of mass (kg)

marine; midpoint;N equivalents; ReCiPe;		
ILCD2011; Eutrophication freshwater; endpoint;PDF; ReCiPe	Potentially Disappeared Fraction of species (PDF)	Unit of items * time
ILCD2011; Ecotoxicity freshwater; midpoint; CTUe; USEtox	Comparative Toxic Unit for ecosystems (CTUe)	Units of volume*time (m3*a)
ILCD2011; Land use; midpoint; SOM;Mila i Canals et al 2007)	Mass C deficit	Units of mass (kg)
ILCD2011; Land use; endpoint; PDF; ReCiPe	Potentially Disappeared Fraction of species (PDF)	Unit of items * time
ILCD2011; Resource depletion - water; midpoint; freshwater scarcity; Swiss Ecoscacity2006	Scarcity adjusted amount of water used	Units of volume
ILCD2011; Resource depletion- mineral, fossils and renewables; midpoint;abiotic resource depletion; Van Oers et al 2002	Mass Sb-equivalents	Units of mass (kg)
ILCD2011; Resource depletion- mineral, fossils and renewables; endpoint;surplus cost; ReCiPe	Marginal increase of costs	Units of currency 2000 ($)

Table 1 ILCD recommended midpoint and endpoint impact categories and their units (EC, 2011)(references to the original methods are given in the ILCD report)

Treatment of uncertainty, verification, validation

-> evaluation of the uncertainty related to this method, how it can be calculated/estimated

The credibility of LCA can be limited by unclear or unspecified methodological choices. Also when well documented, methodological choices related to system boundaries, the functional unit and especially allocation have a large influence on the outcomes. This is unavoidable and required a careful interpretation of results. Because all economic processes and all environmental consequences must be specified, the LCA system is often complex and it has extensive data requirements, which in practical applications often cannot be fully met.

The uncertainty is highly dependent on the question at stake and the used data and models. The uncertainty of an LCA may be expressed in terms of data quality indicators, sensitivity analysis and peer reviews. Uncertainty treatment is presently an important topic in the LCA field, and approaches are being developed to add to any LCA case study.

Main publications / references	-> e.g. , ILCD handbook on LCA, standards (e.g. , ISO) -> can include reference to websites/pages

EC (European Commission), 2010a. ILCD handbook: General guide for life cycle assessment—Detailed guidance. Ispra, Italy: European Commission, Joint Research Centre, Institute for Environment and Sustainability. http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf

EC (European Commission), 2010b. ILCD handbook: General guide for life cycle assessment—provisions and action steps. Ispra, Italy: European Commission, Joint Research Centre, Institute for Environment and Sustainability. http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-PROVISIONS-12March2010-ISBN-a-clean-v1.0-EN.pdf

EC (2010a). *A framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators.* http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-LCIA-Framework-Requirements-ONLINE-March-2010-ISBN-fin-v1.0-EN.pdf

EC (2010b) Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment (LCA). http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-LCIA-Framework-Requirements-ONLINE-March-2010-ISBN-fin-v1.0-EN.pdf

EC (2011) *Recommendations for Life Cycle Impact Assessment in the European context - based on existing environmental impact assessment models and factors.* http://eplca.jrc.ec.europa.eu/uploads/ILCD-Recommendation-of-methods-for-LCIA-def.pdf

EC (2016a). *European Platform on Life Cycle Assessment* http://eplca.jrc.ec.europa.eu/?page_id=140

EC, 2016b. *Website ILCD method.* http://eplca.jrc.ec.europa.eu/?page_id=86#

EC (European Commission), 2016c. Product Environmental Footprint and Organisation Environmental Footprint methods http://ec.europa.eu/environment/eussd/smgp/

GreenDelta, 2014. *LCIA methods Impact assessment methods in Life Cycle Assessment and their impact categories.* http://www.openlca.org/documents/14826/2c5b8391-68d9-49a1-b460-a94f18e7d2df

Guinée, J.B., M. Gorrée, R. Heijungs , G. Huppes, R. Kleijn, A. de Koning, L. van Oers, A. Wegener Sleeswijk, S. Suh, H.A. Udo de Haes, H. de Bruijn, R. van Duin, M.A.J.

Huijbregts, 2002. Handbook on Life Cycle Assessment. Operational Guide to the ISO Standards. Springer, 2002, xii + 692 pp. DOI: https://doi.org/10.1007/0-306-48055-7

ISO International Standard 14040 (1996). Environmental management - Life cycle assessment - Principles and framework. International Organisation for Standardisation (ISO), Geneva. https://www.iso.org/standard/37456.html

ISO International Standard 14044 (2006). Environmental management - life cycle assessment - requirements and guidelines. International Organization for Standardization, Geneva. https://www.iso.org/standard/38498.html

openLCA Nexus. https://nexus.openlca.org/

Wrisberg, N., H.A.Udo de Haes, U.Triebswetter, P.Eder, R. Clift (2002) Analytical Tools for Environmental Design and Management in a Systems Perspective. The Combined Use of Analytical Tools Kluwer Academic Publishers, Dordrecht

Related methods	-> List of comparable methods, their particularities... (or a link to one or several other fact sheet(s))

Hybrid LCA is a combination of LCA and EEIOA (see separate factsheet) and might be used to overcome the drawbacks of both methods. The LCA system has a high resolution but has a limited scope while the EEIOA system has a low resolution but represents the total economy (which makes it possible to take into account background systems and other systems then the functional system of the LCA)(Suh & Nakamura, 2007; Heijungs et al., 2006). To relate micro level changes to effects on the macro level it is necessary to embed the micro system into a macro system. In this sense both methods, LCA and EEIOA, seem to be complementary. In Van Oers et al. (2013b) the possibilities of the use of hybrid LCA EEIO models is further elaborated.

When the LCSA field is further developed, other models will increasingly be used, or a life cycle dimension will be added to other methods and tools.

Some examples of operational tools (CAUTION, this list is not exhaustive)	-> e.g., software... Only give a listing and a reference (publication, website/page...) -> **should be provided only if ALL main actors are properly cited**

Computer programmes are indispensable for the complicated LCA operations. Dozens of such programmes exist in various research groups involved in LCA. Mostly such software tools are designed for specific purposes, such as for use in product design, the comparison of different products, or products in specific economic sectors (energy production, plastics, waste management, building materials). Only a very few are designed as general LCA software to be used by other than their developers.

LCA software tools are an interface to manage LCI and LCIA data. There are many tools available, some of them may also include LCI and/or LCIA databases. Some overviews of LCA-tools:

http://www.buildingecology.com/sustainability/life-cycle-assessment/life-cycle-assessment-software

http://www.linkcycle.com/comparison-of-best-life-cycle-assessment-software/

http://www.openlca.org/

Key relevant contacts	-> list of relevant **types** of organisations that could provide further expertise and help with the methods described above.

The Society for Environmental Toxicology and Chemistry (SETAC) has, since the beginning of the nineties, acted as a platform for scientific discussions, both in North America and in Europe, and recently also in South-east Asia. LCANET, an EU concerted action, acted in 1996-1997 as a platform for discussing research needs. The LCA methodology is currently standardised within the ISO framework (ISO 14040 series). Methodology guides have been published on national levels (e.g., Guinée et al., 2002).

The methodology of LCA is standardized by the International Organization for Standardization in ISO 14040/14044 since 2006.

The Institute for Environment and Sustainability in the European Commission Joint Research Centre (JRC), in co-operation with the Environment DG have developed the ILCD handbook. The ILCD handbook's main goal is to ensure quality and consistency of life cycle data, methods and assessments (EC, 2010). The ILCD handbook consists of a set of documents that are in line with the international standards on LCA (ISO 14040/44).

Glossary of acronyms /abbreviations used	-> Definition