LCA Compendium – The Complete World of Life Cycle Assessment
Series Editors: Walter Klöpffer · Mary Ann Curran

Mary Ann Curran *Editor*

Goal and Scope Definition in Life Cycle Assessment

Springer

LCA Compendium – The Complete World of Life Cycle Assessment

Aims and Scope

Life cycle assessment (LCA) has become the recognized instrument to assess the ecological burdens and human health impacts connected with the complete life cycle (creation, use, end-of-life) of products, processes, and activities, enabling the assessor to model the entire system from which products are derived or in which processes and activities operate. Due to the steady, world-wide growth of the field of LCA, the wealth of information produced in journals, reports, books, and electronic media has made it difficult for readers to stay abreast of activities and recent developments in the field. This led to the realization of the need for a comprehensive and authoritative publication.

LCA Compendium – The Complete World of Life Cycle Assessment discusses the main drivers in LCA (SETAC, ISO, UNEP/SETAC Life Cycle), the strengths and limitations of LCA, the LCA phases as defined by ISO standards, specific applications of LCA, Life Cycle Management (LCM) and Life Cycle Sustainability Assessment (LCSA). Further volumes, which are closely related to these themes will cover examples of exemplary LCA studies ordered according to the importance of the fields of application. They will also present new insights and new developments and will keep the whole work current. The aim of the series is to provide a well-structured treatise of the field of LCA to give orientation and guidance through detailed descriptions on all steps necessary to conduct an LCA study according to the state of the art.

LCA Compendium – The Complete World of Life Cycle Assessment anticipates publishing volumes on the following themes:

- Background and Future Prospects in Life Cycle Assessment (published in March 2014)
- Goal and Scope Definition in Life Cycle Assessment (published in September 2016)
- Life Cycle Inventory Analysis (LCI)
- Life Cycle Impact Assessment (LCIA) (published in March 2015)
- Interpretation, Critical Review and Reporting in Life Cycle Assessment
- Applications of Life Cycle Assessment
- Special Types of Life Cycle Assessment (published in July 2016)
- Life Cycle Management (LCM) (published in August 2015)
- Life Cycle Sustainability Assessment (LCSA)
- Life Cycle Assessment Worldwide

More information about this series at http://www.springer.com/series/11776

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Preface

When the *LCA Compendium* was conceived and as a follow-up to the introductory volume *Background and Future Prospects in Life Cycle Assessment* (published 2014), the series editors, Walter Klöpffer and Mary Ann Curran, planned an overall structure of individual topics/volumes that could be divided into two main categories:

1. Volumes that basically address the classical four phases of LCA as defined by ISO:
   - Goal and scope definition (published 2016)
   - Inventory analysis
   - Impact assessment (published 2015)
   - Interpretation
2. Volumes that focus on applications of LCA which go beyond the environment as the only dimension and include new developments and approaches:
   - LCA application
   - Special types of LCA (published 2016)
   - Life cycle management (published 2015)
   - Life cycle sustainability assessment

So the volume/book "Goal and Scope Definition in Life Cycle Assessment" is the second in the planned series and addresses one of the four LCA phases defined by ISO.

"Goal and scope" is the "alpha" in an LCA, while "interpretation" is the "omega" (and both phases are closely interrelated). A successful outcome of an LCA is totally dependent on a clear, unambiguous definition of the purpose of the study from the outset. More than a simple introduction to an LCA, goal and scope definition is an integral part of conducting an LCA and relates to any of the other phases. The structure of the LCA methodology has been well established by the international standard 14040 (2006). It clearly asserts the goal and scope definition phase as the first of four interrelated phases:

1. Goal and scope definition – Clearly defining the goal and scope of the study (including selecting a functional unit)
2. Inventory analysis – Compiling an inventory of relevant energy and material inputs and environmental releases (life cycle inventory analysis)
3. Impact assessment – Evaluating the potential environmental impacts associated with identified inputs and releases (life cycle impact assessment)
4. Interpretation – Interpreting the results to help decision makers make a more informed decision (life cycle interpretation)

Due to the iterative nature of LCA, it is important that, in a result and interpretation phase, any of the relevant result aspects mentioned and conclusion aspects drawn must be already stated or mentioned in the goal and scope.

The 2006 ISO standard (14040) states that "the scope should be sufficiently well defined to ensure that the breadth, depth and detail of the study are compatible and sufficient to address the stated goal." It is also critical in directing future data collection efforts (the inventory analysis phase). The importance of properly defining the goal and scope of an LCA study cannot be overstated.

According to ISO 14040, the goal of an LCA states:

- The intended application
- The reasons for carrying out the study
- The intended audience, i.e., to whom the results of the study are intended to be communicated
- Whether the results are intended to be used in comparative assertions intended to be disclosed to the public

The ISO 14044 standard establishes both requirements and recommendations for the choice of impact categories, category indicators, and characterization models to be used in LCIA as part of an LCA study. This selection process must be done at the outset of a study, during the goal and scope definition phase.

The book describes the importance of the goal and scope phase for the entire LCA study. In this first phase of the LCA framework (ISO standardized), the purpose of the assessment is defined, and decisions are made about the details of the industrial system being studied and how the study will be conducted (Chap. 1, Mary Ann Curran).

Selecting impact categories, category indicators, characterization models, and peer review is decided during goal and scope definition. The relevant chapter provides practical guidance and an overview of LCIA methods available in LCA software (Chap. 2, Ralph Rosenbaum).

Although not specified in the ISO standards, attributional LCA and consequential LCA are presented in order to appropriately determine the goal and scope of an assessment (Chaps. 3 and 4, Martin Baitz and Martina Prox, Mary Ann Curran).

The book closes with the tight interconnection between goal and scope definition and the interpretation phase (Chap. 5, Andreas Ciroth).

Example goal and scope documents for attributional and consequential LCAs are provided in the annexes. Annex A describes the goal and scope of an attributional

assessment of alternative drinking water delivery systems as an example of supporting government policy making. Annex B is also an example of attributional LCA but for the manufacture of Christmas trees. Annex C is an example of a consequential LCA in support of government decision making for aluminum production in Greenland.

My sincere thanks to "my" authors for their willingness to share their contributions that illustrate, from the front of science and practice, nature, function, and interrelations of "goal and scope definition."

Rock Hill, SC, USA Mary Ann Curran
13 April 2016

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Chapter 1
Overview of Goal and Scope Definition in Life Cycle Assessment

Mary Ann Curran

Abstract This chapter describes the goal and scope definition phase of Life Cycle Assessment (LCA) including how to properly define the goal of an LCA, which then leads to defining the scope and boundaries of the system to be assessed. The chapter explores goals through various applications of LCA in the public and private sectors. It goes on to explore the connections between requirements for critical review, the approach to conducting impact assessment, and the interpretation phase of LCA.

In the goal and scope definition phase of an ISO-standardized LCA, the purpose of the assessment is established and decisions are made about the details of the product system being studied. The goal and scope are defined at the outset of the study, before any data are collected. The importance of this first phase according to ISO 14040 and 14044 is often underestimated as it is much more than a simple introduction to the LCA process. It is a very important phase of LCA methodology because this is where the exact approach to be followed is determined. However, the goal, as well as the scope, can be modified during the course of the work as data are collected and new information is revealed, e.g., it may be discovered that the proposed co-product allocation scheme does not work, not enough data are available to assemble a full life cycle inventory, etc. Such modifications should be (and in some cases, have to be) described transparently in the data spreadsheets and final report. The rules given by the standards are intentionally loose to allow for a variety of possibilities to be defined in the goal and scope. Items to be defined in the goal and scope definition phase include the functional unit, system boundaries, data granularity reflecting process-specificity or genericness (i.e. foreground or background) data, exclusion of life cycle stages or inputs, and the selection of impact indicators and characterization factors.

Keywords Attributional LCA • Consequential LCA • Critical review • Functional unit • Goal • Government decision making • Home/office delivery water • Interpretation • ISO 14040 • ISO 14044 • ISO/TR 14049 • ISO/TS 14071 • ISO/TS

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14072 • LCA • LCI • LCIA • LCA framework • Life cycle assessment • Life cycle impact assessment • Life cycle inventory analysis • Product manufacturer decision making • Scope

1 Defining the Goal and Scope of a Life Cycle Assessment

LCA is a powerful tool for making holistic comparisons among possible or competing systems, as well as for optimizing an existing system, which is also a form of comparison. A successful outcome is totally dependent on a clear, unambiguous definition of the purpose of the study from the outset. More than a simple introduction to a Life Cycle Assessment (LCA), goal and scope definition is an integral part of conducting an LCA and relates to any of the other phases. The structure of the LCA methodology has been well established by the International Standard 14040 (ISO 2006b). It clearly asserts the goal and scope definition phase as the first of four inter-related phases:

1. Goal and Scope Definition – Clearly defining the goal and scope of the study (including selecting a functional unit);
2. Inventory Analysis – Compiling an inventory of relevant energy and material inputs and environmental releases (Life Cycle Inventory (LCI) analysis);
3. Impact assessment – Evaluating the potential environmental impacts associated with identified inputs and releases (Life Cycle Impact Assessment (LCIA));
4. Interpretation – Interpreting the results to help decision makers make a more informed decision.

Due to the iterative nature of LCA, it is important that, in a result and interpretation phase, any of the relevant result aspects mentioned and conclusion aspects drawn must be already stated or mentioned in the goal and scope.

2 Historical Development Within the ISO Framework

As seen in Fig. 1.1, the LCA framework has evolved over time. In 1990, the Society for Environmental Toxicology and Chemistry (SETAC) held the first in a series of LCA-related Pellston style workshops (see also Fava et al. 2014).[1] Although LCAs

[1] Pellston workshops, named for the location of the first workshop of this type (Pellston, Michigan), aim to advance cutting edge technical and policy issues in environmental science by assembling scientists, engineers, and managers from government, private business, academia, and public interest groups to share current information on a given topic. At the end of the intense 4-5 day workshop, a document is produced that describes this knowledge with recommendations for enhancing the current state of the science.

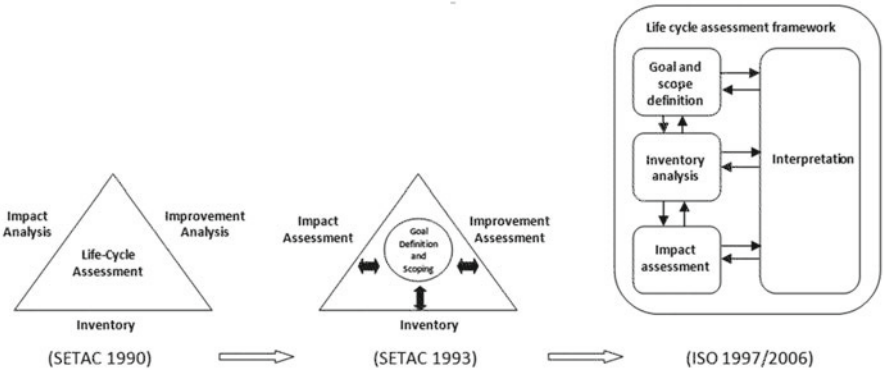

Fig. 1.1 Evolution of the LCA framework (Fig. 1.1 was published in LCA Compendium, volume "Background and Future Prospects in Life Cycle Assessment", p 193 (Curran and Young 2014))

had been performed previously in one form or another, it was during this workshop when the name was coined and the resulting document presented the name of the method (Fava et al. 2014; SETAC 1990). As seen in Fig. 1.1, the original LCA framework consisted only of three components with goal definition obviously missing. This omission was corrected in 1993 in a following SETAC workshop, held in Sesimbra, Portugal (Fava et al. 2014). A new component called 'Goal Definition and Scoping' (GS&D)was inserted in the middle of the SETAC triangle with arrows connecting it to Inventory, Impact Analysis, and Improvement Analysis, to depict the interconnectedness of the phases. By 1996, the triangle was replaced by a flow diagram with 'Goal and Scope Definition' clearly shown as a first step; although the four interrelated phases of LCA are not necessarily conducted in 1, 2, 3, 4 order, GS&D should be addressed as a first step.[2]

3 Envisioning the Goal Statement in Life Cycle Assessment

As already mentioned, but worth repeating, it is crucial for the goal of the study to be clearly defined at the outset. A well-defined goal will in turn help define the scope and boundaries of the study. The 2006 ISO standard states "the scope should be sufficiently well defined to ensure that the breadth, depth and detail of the study are compatible and sufficient to address the stated goal." It is also critical in directing future data collection efforts (the inventory analysis phase). The importance of properly defining the goal and scope of an LCA study cannot be overstated.

Conducting an LCA can help answer a number of important questions of concern to decision makers. Some examples include the following:

[2] This was also when the component 'Improvement Analysis' was renamed 'Interpretation'.

- What is the impact of a product system to particular interested parties and stakeholders?
- Which product or process causes the least environmental impact, overall or in each stage of its life cycle?
- How might changes to the current system affect the environmental impacts across all life cycle stages?
- Which technology or process causes the least amount of acid rain, smog formation, or damage to local trees (or any other impact category of concern)?
- How can the process be changed to reduce a specific environmental impact of concern (e.g., global warming)?

A properly worded question can help lead to the creation of a useful goal statement. As Solomon Ibn Gabirol said, "A wise man's question contains half the answer".[3]

Reasons for conducting an LCA vary widely and range from establishing a baseline of a product's environmental profile for the manufacturer's internal use to developing a product label for external public use. The following sections explore example goals for LCAs conducted in the private and public sectors. In addition to applying LCA to product systems, new guidance for conducting 'organization LCA' is being developed.

3.1 Private Sector

The private sector is incorporating LCA in many applications including various aspects of products throughout design and development: manufacturing; marketing; use and reuse; and disposal and end of life management. Reasons for wanting to commission an LCA include the following:

- Establishing a baseline of overall environmental impact to identify environmental 'hotspots'.
- Identifying possible opportunities for improvement across the product life cycle.
- Comparing alternative manufacturing processes or supply chains to identify potential tradeoffs.
- Determining the environmental preferability between alternative product choices.
- Improving products through continuous improvement set often with concrete reduction targets (e.g., successor product must be X % less impactful than its predecessor while providing comparable performance).

[3] Solomon Ibn Gabirol. (n.d.). BrainyQuote.com. Retrieved April 6, 2016, from BrainyQuote.com. Web site: http://www.brainyquote.com/quotes/quotes/s/solomonibn175130.html

3.2 Public Sector

In general, governments and the public sector lag behind the private sector in terms of embracing LCA as a tool for supporting decision making. However, there are many measures that can be implemented to use LCA results in public policy making. This can occur at multiple levels and lead to an environment that allows life cycle thinking help set the course towards a greener, more environmentally sustainable economy, including:

- Informing government programs and prioritizing their activities.
- Establishing consistent policies across consumers, producers, suppliers, retailers and waste managers.
- Establishing consistent policies and policy goals such as harmonizing regulations, voluntary agreements, taxes and subsidies.
- Introducing policies that appropriately support take-back systems to strengthen resource conserving-based economies.

4 Steps to Properly Defining the Goal/Writing a Clear Goal Statement

Defining the goal and scope entails close communication between the LCA practitioner and the commissioner (i.e. the group paying for the LCA study), at a minimum. The commissioner's role is typically to state the intent of conducting the LCA. That is, they explain why they want the assessment to be conducted. The practitioner's job is then to define and present the appropriate methodological choice. Together, they develop the goal and scope that is most likely to deliver results in line with the 'why' question and provide data and information that are helpful to the commissioner of the study.

It is not unusual for the initial goal statement, by the LCA commissioner, to be rather vague and stated in very general terms, such as "We want to do an LCA on our products/production" or "We want to know the environmental strengths and weaknesses of this product" (Baumann and Tillman 2004). It is necessary to transform such general ideas into a specific purpose in order to adequately guide methodological choices which will result in useful results. This transformation may be done iteratively throughout the course of the study.

According to ISO 14040, the goal of an LCA states:

- The intended application,
- The reasons for carrying out the study,
- The intended audience, i.e. to whom the results of the study are intended to be communicated,
- Whether the results are intended to be used in comparative assertions intended to be disclosed to the public.

Furthermore, the standard states the scope includes the following items:

- The product system to be studied;
- The functions of the product system or, in the case of comparative studies, the systems;
- The functional unit;
- The system boundary;
- Allocation procedures; impact categories selected and methodology of impact assessment, and subsequent interpretation to be used;
- Data requirements;
- Assumptions;
- Limitations;
- Initial data quality requirements;
- Type of critical review, if any;
- Type and format of the report required for the study.

The decisions made here dictate the rest of the LCA procedure. For example, a critical review of the study results may be needed if the intent is to disclose the results to the public in a comparative assertion (i.e. a statement of environmental superiority of one product over a competing product).

5 Determining the Study Scope (Setting the Boundaries)

At its essence, how the study boundaries are drawn defines where the analysis of the specific life cycle begins and where it ends, and identifies the activities included within the technical system. A flow diagram is often used to help guide this process. Figure 1.2 depicts the boundaries of a system for a concrete product.

System boundaries need to be specified in other dimensions in addition to the relationship between the technical system and the natural system. Geographic (spatial) and time (temporal) boundaries must also be defined. Following that, data collected for each process and sub-processes should be representative or adequate for the purpose of the stated time and spatial boundaries.

Spatial boundaries are important because of differing environmental requirements (such as discharge limits) and consumer behaviors in different cities, states and countries. Also, physical realities differ by location, such as fresh water availability. Last but not least, generic or background data should be checked for spatial appropriateness, as supply chains and technologies can vary in different regions.

Time boundaries are important for similar reasons. Since life cycle inventories consist of large amounts of diverse data (that is, they are usually sourced from different databases) it is unlikely that all data will have been collected within the relevant time period. In this case, the practitioner must evaluate if the data are still representative and usable or if new, more recent data are needed.