# Life cycle assessment: past, present and future

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*The keynote lecture of Jeroen Guinée is based on [1]*

## 1. INTRODUCTION

The study of environmental impacts of consumer products has a history that dates back to the 1960s and 1970s. Especially in a comparative context ("Is product A better than product B?"), it has spawned long and sometimes fierce debates. This is understandable, as alternative products typically have a number of distinguishing features and they constitute the core of our economy.

It has been recognized that, for many of these products, a large share of the environmental impacts is not in the use of the product, but in its production, transportation or disposal. Gradually, the importance of addressing the life cycle of a product, or of several alternative products, thus became an issue in the 1980s and 1990s. Out of this emerged the idea of life cycle assessment (LCA). In this presentation, the history of LCA will be presented briefly distinguishing two periods (1970-1990 and 1990-2000), the developments of the last decade up to where we are now will be summarized and an outlook to the future will be sketched.

## 2. HISTORY OF LCA

### 2.1 1970-1990: decades of conception

The first studies that are now recognized as (partial) LCAs date from the late 1960s and early 1970s. The scope of these studies was initially limited to energy analyses but was later broadened to encompass resource requirements, emission loadings and generated waste. LCA studies in this period mainly focused on packaging alternatives. After a period of diminishing public interest in LCA and a number of unpublished studies, there has been rapidly growing interest in the subject from the early 1980s on. It's also in this period that a first impact assessment method was introduced, dividing airborne and waterborne emissions by semi-political standards for those emissions and aggregating them, respectively, into so-called "critical volumes" of air and "critical volumes" of water.

The period 1970-1990 comprised the decades of conception of LCA with widely diverging approaches, terminologies and results. There was a clear lack of international scientific discussion and exchange platforms for LCA. During the 1970s and the 1980s LCAs were

performed using different methods and without a common theoretical framework. LCA was repeatedly applied by firms to substantiate market claims. The obtained results differed greatly, even when the objects of the study were the same, which prevented LCA from becoming a more generally accepted and applied analytical tool.

### 2.2 1990-2000: decade of standardization

The 1990s saw a remarkable growth of scientific and coordination activities world-wide, which is reflected in the number of (SETAC; Society of Environmental Toxicology and Chemistry) workshops and other forums that have been organized in this decade and in the number LCA guides and handbooks produced. Next to SETAC, the International Organization for Standardization (ISO) has been involved in LCA since 1994. Whereas SETAC working groups focused at development and harmonization of methods, ISO adopted the formal task of standardization of methods and procedures. Also the first scientific journal papers started to appear in the Journal of Cleaner Production, in Resources, Conservation and Recycling, in the International Journal of LCA, in Environmental Science & Technology, in the Journal of Industrial Ecology and in other journals.

During this period, LCA also became part of policy documents and legislation. Furthermore, several well-known life cycle impact assessment methods, still used today, evolved from methods developed in this period, such as the CML 1992 environmental theme approach, endpoint or damage approaches but also the nowadays broadly accepted multi-media approach for assessing potentially human and ecotoxic emissions. Although this decade is mainly one of convergence, it is also the stage of scientific scrutiny, research into the foundations of LCA, and exploring the connections with existing disciplines. For instance, we observe sprouting ideas on consequential LCA and related allocation methods. These and other sophistications mark the transition to the present decade of LCA, which is a decade of elaboration but also of divergence in methods again.

## 3. THE PRESENT OF LCA: DECADE OF ELABORATION

The first decade of the 21st century has shown an ever increasing attention to LCA. In 2002, the United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) launched an International Life Cycle Partnership, known as the Life Cycle Initiative. The Life Cycle Initiative's main aim was formulated as putting life cycle thinking into practice and improving the supporting tools through better data and indicators. Life cycle thinking also continued to grow in importance in European Policy.

The European Platform on Life Cycle Assessment was established in 2005, mandated to promote the availability, exchange, and use of quality-assured life cycle data, methods and studies for reliable decision support in (EU) public policy and in business. In the USA, the U.S. Environmental Protection Agency started promoting the use of LCA and simultaneously environmental policy gets increasingly life-cycle based all over the world. For example, several life cycle-based carbon footprint standards have been, or are being, established.

The period 2000-2010 can be characterized as the decade of elaboration. While the demand on LCA increases, the current period is characterized by a *divergence* in methods again. As ISO never aimed to standardize LCA methods in detail and as there is no common agreement on how to interpret some of the ISO requirements, diverging approaches have been developed with respect to system boundaries and allocation methods, dynamic LCA, spatially

differentiated LCA, etc. On top of this, life cycle costing (LCC) and social life cycle assessment (SLCA) approaches have been proposed and/or developed.

## 4. THE FUTURE OF LCA: LIFE CYCLE SUSTAINABILITY ANALYSIS

Many of these recent developments in LCA were initiated to broaden and deepen traditional environmental LCA to a more comprehensive Life Cycle Sustainability Analysis (LCSA). Recently, a framework for LCSA was suggested linking life cycle sustainability questions to knowledge needed for addressing them. The framework *broadens* the scope of current LCA from mainly environmental impacts only to covering all three dimensions of sustainability (people, planet and prosperity). It also *broadens* the scope from predominantly product-related questions (product level) to questions related to sector (sector level) or even economy-wide levels (economy level). In addition, it *deepens* current LCA to also include other than just technological relations, e.g. physical relations (including limitations in available resources and land), economic and behavioral relations, etc.

The term framework is used as, unlike LCA, LCSA is a trans-disciplinary integration framework of models rather than a model in itself. Structuring, selecting and making the plethora of models practically available in relation to different types of life cycle sustainability questions is then the main challenge. Although this is fully compatible with ISO's clause "there is no single method for conducting LCA", it is a significant deviation from LCA practice up till now.

Up till now there is only little experience will LCSA, particularly with the deepening part, but it is getting more and more attention which is reflected by an increasing number of scientific papers, sections in scientific journals, a UNEP-SETAC working group and a subject section on LCSA within the International Society for Industrial Ecology (ISIE).

## REFERENCES

[1] Guinée, J. B., R. Heijungs, G. Huppes, A. Zamagni, P. Masoni, R. Buonamici, T. Ekvall and T. Rydberg (2011). Life cycle assessment: past, present and future. *Environ. Sci. Technol.* **45** (1) (2011) 90–96.