

Chapter 4

LCA Applications

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Abstract The chapter gives examples of applications of LCA by the central societal actors in government, industry and citizens, and discusses major motivations and challenges for the use of LCA to support science-based decision-making from their respective perspectives. We highlight applications of LCA in policy formulation, implementation and evaluation, present different purposes of LCA application in industry at both product and corporate levels, and discuss challenges for LCA applications in small- and medium-sized enterprises. Our synthesis demonstrates the importance of LCA as a tool to quantify environmental impacts of products and systems and support decisions around production and consumption and highlights factors that prevent its even more widespread application.

Learning Objectives

After studying this chapter the reader should be able to:

- Explain the main motivations for use of LCA by governments, industry, and citizens and their main types of LCA applications.
- Demonstrate an understanding of the challenges and opportunities in the different types of LCA applications.

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4.1 Background

Recent decades have witnessed numerous applications of LCA to support decisions in an environmental sustainability context (see Chap. 3). Much efforts have been made to facilitate the application of LCA and life cycle thinking in society ranging from the regulatory and governmental level, through industry and production to the level of citizens and consumers. The dissemination of LCA has been aided by a number of initiatives for supporting and harmonizing the application of the tool. In 1997 the first version of the ISO 14040 standard (later updated as ISO 2006a) was published in an attempt to harmonize the framework and principles of LCA and to increase transparency and comparability of LCA studies. In 2001, The United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) joined forces in the launch of a global Partnership to strengthen the dissemination and use of LCA worldwide, known as the Life Cycle Initiative (LCI). The purpose of the initiative was to “enable users around the world to put life cycle thinking into effective practice”. Another initiative supporting a more widespread application of LCA was The European Commission’s project, The European Platform of Life Cycle Assessment, launched in 2005. Its objective was to “promote life cycle thinking in business and in policy making” in the European Union by focusing on underlying data and methodological needs. The homepages of these initiatives provide a wide palette of information, tools and support (<http://www.lifecycleinitiative.org>; <http://eplca.jrc.ec.europa.eu/>).

In parallel, many initiatives have been launched at the national level to facilitate and support the application of LCA, often under the auspices of governmental institutions such as environmental protection agencies (see Chap. 3), inspiring numerous private and public LCA consultancies to emerge in assistance to companies or institutions without the in-house LCA expertise. Recent widespread LCA-related services are an elaboration of Environmental Product Declarations (EPDs) or performance of Greenhouse Gasaccounting. Moreover, universities, research institutions and private companies often enter into close collaboration on LCA methodology development and application of LCA via, e.g. commercial projects or industrial PhDs.

Here, we present examples of applications and discuss major motivations and challenges for the use of LCA to support decision-making from the perspectives of decision-makers within governments, industry and citizens. More details are given in Part III of the book with chapters dedicated to different stakeholders and multiple examples of the use of LCA within different technology domains. Chapter 18 gives a more detailed introduction to the use of LCA and life cycle thinking in policy-making in different parts of the world, and Chap. 19 discusses the globalization of the use of LCA. Life cycle management (LCM) within business and industry is the topic of Chap. 22, while Chap. 24 introduces the use of LCA in the development and management of environmental labels and declarations.

4.2 Government Perspective

Application of LCA and life cycle based approaches can support policy formulation, policy implementation and regulation imposed by policies, and can be used to perform evaluation of policies. As part of the pan-European project CALCAS (Coordination Action for innovation in Life Cycle Analysis for Sustainability), reviews were conducted in mid-2000s to identify LCA applications to support different stages of the policy cycle, i.e. their formulation, implementation and evaluation (CALCAS 2008). Table 4.1 presents an overview of such applications. Since then, the pressing need to move towards more sustainable societies has made LCA increasingly recognized in high policy-level, and its role in the policy cycle has been formalized in some countries or regions. For example, in Europe, the European Commission has listed LCA as one of the reference models for the impact assessment of policies in the European Union (EU) within its “better regulation guidelines” document published in 2015 (European Commission 2015). This holds a potential to increase the use of LCA in retrospective assessments of existing policy frameworks (i.e. evaluations or fitness checks) and prospective assessments of future possible policy options (policy development).

Table 4.1 Examples of LCA applications at different stages of the policy cycle

Topic	Initiation year and/or geographical scope
<i>LCA as a knowledge tool in policy formulation</i>	
Environmental technologies action plan (ETAP)	2004; EU
Integrated product policy (IPP)	2003; EU
Directive on the eco-design of energy using products (EuP)	2005; EU
Strategy for the sustainable use of natural resources	2005
Sustainable production and consumption action plan (SCP)	2007; EU
Biofuels	Germany
Application of pesticides	Costa Rica
<i>Supporting the implementation of information based instruments: LCA & policy implementation</i>	
Eco-labelling	Various countries
Environmental product declarations (EPD)	Various countries
Strategic environmental assessment directive	2004
Public procurement	EU, Japan
Construction products directive	1989; EU
Ordinance on the avoidance and recovery of packaging wastes	Germany
Waste management	France, Mexico, Japan
<i>LCA as a tool for policy evaluation</i>	
Thematic strategy on prevention and recycling of waste & Waste framework directive	2005; EU
Waste oil directive	2000; EU

Based on CALCAS (2008)

4.2.1 Policy Formulation

As an example of LCA used for policy formulation, the European Commission has promoted Integrated Product Policy (IPP) to minimize environmental impacts of products by considering all stages of their life cycle, from the cradle to grave (Mudgal 2008). The IPP comprises various instruments and tools, ranging from soft instruments that act through influencing the market (like environmental labelling or green taxation), through subsidies to industries (e.g. financial support to pioneers), to hard regulation such as the Eco-design Directive for Energy-related Products (ErP), which establishes a regulatory framework for eco-design of products that use energy and products that allow for generation, transfer and measurement of energy (Directive 2009/125/EC). This directive is an example of how life cycle thinking has guided policymaking within the EU, where the focus has shifted from manufacturing processes, to a focus on the use of products and their disposal (Wenzel et al. 1997; Azapagic and Perdan 2000). Many other examples of the use of LCA in policy formulation are given in Chap. 18.

A major challenge to the application of LCA in these contexts is the communication of environmental performance of products. It is often done using different approaches to life cycle inventory modelling and life cycle impact assessment, which may lead to inconsistent and sometimes misleading results. To facilitate the communication of reliable and reproducible information about the environmental performance of products and organizations, the European Commission has elaborated LCA-based methods for product environmental footprint (PEF), and organization environmental footprint (OEF) (Finkbeiner 2014; Galatola and Pant 2014) (see also Chap. 24).

4.2.2 Policy Implementation and Evaluation

Governments may use LCA as decision support to advise the introduction of novel technologies in the market (e.g. the use of biofuels, or introduction of electric cars) or the selection of waste management systems (e.g. EU Waste Framework Directive 2008/98/EC imposing “to handle waste in a way that does not have a negative impact on the environment or human health” and requiring the need for life cycle thinking in waste management) (European Parliament and Council 2008; Meylan et al. 2014). In Denmark, LCA was used in the 1990s to guide the development of the current Danish collection system for beverage containers (glass and plastic bottles and aluminium cans) and it has been used for assessment of recycling strategies for various waste fractions. The country has also operated with panels of key actors along the product life cycle who were consulted in the development of product-oriented policy initiatives. In Switzerland, findings from an LCA study were used to justify compensation rates to municipalities according to how waste glass packaging is collected and what disposal option is chosen by the municipality

(Meylan et al. 2014). In Sweden LCA was used to assess environmental impacts of introducing waste incineration tax, considered to “encourage waste reduction and increase materials recycling and biological treatment” (Björklund and Finnveden 2007). While the proposed design of such a tax would result in increased recycling, the LCA found that this would lead to only small environmental improvements. Thus, it was proposed that the design of the tax should include the fossil carbon content of the waste. Such examples can also be found outside Europe. In the United States, the California Oil Recycling Enhancement Act was initiated in 2009 to support management of used oil and support selection of least-polluting options (refining and reuse, distillation or combustion with energy recovery) by the state (Reed 2012). This act “requires that the Department of Resources Recycling and Recovery coordinate, with input from representatives of all used oil stakeholders, a comprehensive life cycle assessment of California’s used lubricating and industrial oil management process” (CalRecycle 2012).

4.3 Industry Perspective

The application of LCA in enterprises can be classified into five main purposes: (i) decision support in product and process development; (ii) marketing purposes (e.g. Eco-labelling); (iii) development and selection of indicators used in monitoring of environmental performance of products or plants; (iv) selection of suppliers or subcontractors; and (v) strategic planning (Huang and Hunkeler 1995; Bültmann 1997; Hanssen 1999; Baumann 2000; Heiskanen 2000; Frankl and Rubik 2000; Ekvall 2012). We note that LCA applications within industry may well serve more than one purpose, and often the same LCA can be used for different purposes within a company (e.g. product development is often combined with marketing efforts). Furthermore, as experience with using LCA grows in an enterprise, one application can trigger another (e.g. insights gained from an LCA into product environmental performance can lead to decisions about selection of suppliers or setting strategies). We also note that although LCA has traditionally been developed as a tool to be used at product level, and is still used as such, there is an increasing interest in using LCA at the corporate level to reflect the performance of the company or individual plants in a life cycle perspective. This is particularly relevant for (but not limited to) large enterprises and for applications related to monitoring of environmental performance and strategic planning.

4.3.1 Applications at Product Level

At product level, LCA is often used during product development and for identifying environmental hotspots of a product or process either within the organization or in its supply chain. For instance, a survey showed that the German industry in the

1990s mainly used LCA internally, to identify hotspots in products and systems, followed by product and process optimization (Bültmann 1997; Frankl and Rubik 2000). Another survey showed that large Danish companies, represented by 39 companies considered to cover 90–100% of Danish enterprises having practical experience with LCA in the 1990s, indicated that LCA had revealed new environmental aspects of their products that they had not anticipated. In 79% of the cases, this led to setting new priorities for environmental efforts, including changes in products and processes, like saving or substituting materials (Broberg and Christensen 1999).

In parallel to application in product and process development, LCA is often used for marketing purposes at different levels. As public concerns about the state of the environment have become increasingly pronounced and consumers more environmentally conscious, enterprises have also placed a larger focus on quantifying their environmental performance, using LCA and communicating this to the public as a way to brand their enterprise as green. Here, the major company expectations to the use of LCA are to get a competitive advantage and increase the company image or reputation (Broberg and Christensen 1999). Ecolabels or environmental product declarations (Chap. 24) can signal good environmental performance and be used to make a given product more appealing for environmentally conscious consumers.

4.3.2 Applications at Corporate Level

The use of LCA to document and monitor environmental performance at the corporate level is today often limited to a few selected impact categories, typically footprint indicators (see Sect. 10.4) like carbon footprint and blue water footprint. This situation may change in the future together with the development of guidelines for organization environmental footprint (OEF) (Dubois and Humbert 2015). At the corporate level, industry can also use LCA for setting strategic objectives. For example, Unilever set a target of halving their environmental impact by 2030, considering the life cycle of their products (Unilever 2015). Similarly, companies may want to carry out LCA to better understand their environmental performance in an effort to implement environmental management system (EMS) (Lewandowska et al. 2013, 2014). EMS is “a tool to implement a structured program of continual improvement in environmental performance” and “a tool to manage and communicate an enterprise’s environmental performance to internal and outside parties” (Lombardo 2012). EMS standards nowadays often require a life cycle perspective in order to avoid greenwashing by companies outsourcing parts of their production to suppliers. There is thus often a relationship between the implementation of EMS and the implementation of LCA within companies. For example, among Spanish automotive supplier companies who have received the EMS ISO 14001 certification and have a certified eco-management and audit scheme (EMAS), the use of LCA is a common practice (Gonzalez et al. 2008). Organizations who have implemented a

certified EMS impose higher demands on their suppliers to adopt environmentally friendly practices (Gonzalez et al. 2008). The contributions made by LCA to EMS range from the identification of overall environmental aspects and identification of the activities in the life cycle that have the largest environmental burdens, to a comparison of alternative manufacturing routes (Stewart et al. 1999). A major challenge in this context seems to be putting the results into practice, mainly due to lack of power or information of stakeholders along the product supply chain (Nakano and Hirao 2011).

4.3.3 *Challenges of Small- and Medium-Sized Enterprises*

Small- and medium-sized enterprises (SME) can use LCA for the same reasons as large companies. Yet, small- (10–49 employees) and medium-sized (50–249 employees) enterprises generally lag behind large companies in the implementation of LCA (Johnson and Schaltegger 2015). The major reasons are thought to be the cost of an LCA, the need for changes in workplace routines, perceived complexity of the LCA methodology and shortage of qualified personnel to carry out an LCA (Kurczewski 2013). A study of 10 SMEs revealed that a downside of LCA is that it becomes too comprehensive and too complex to be easily understood, leaving an impression in some companies of LCA as a ‘black box’ (Zackrisson et al. 2008). A closer collaboration with an experienced LCA practitioner and an expert was found to resolve this problem in some of the cases (Zackrisson et al. 2008). Similarly, based on a comprehensive literature review, Johnson and Schaltegger (2015) reported that major barriers for implementation of sustainability management tools (including LCA) by SMEs were (i) lack of awareness of sustainability issues; (ii) absence of perceived benefits; (iii) lack of knowledge and expertise on sustainability issues; (iv) lack of human and financial resources; (v) insufficient external drivers and incentives; (vi) unsuitability of formal management tools to fit the often informal and flexible SME structure; and (vii) complexity of tools.

While the use of LCAs by SMEs was considered marginal (as of 2012), it is however reported to become more and more common (Baumann et al. 2012; Schischke et al. 2012; Kurczewski 2013). This may be due to the increased legislative focus on environmental performance, and the potential market benefits from having an environmentally friendly profile, not least through a market pull from large companies that are often important costumers. This is reflected by a survey of 146 European SMEs which revealed that most SMEs have limited knowledge of LCA, and have little internal knowledge of environmental assessments and their communication (Pamminger 2011). The main drivers for SMEs to start using environmental assessment tools have been the customer demand or the pressure from legislation (Pamminger 2011; Schischke et al. 2012). However, industries focusing on emerging renewable resource technologies, such as bio-based plastic, had more knowledge and were, in fact, keen on using LCA for communicating the environmental performance and benefits of their technology compared to

conventional technologies (Pamminger 2011). The authors' experience with LCA application by SMEs in Western Europe shows that SMEs are eager to contribute to an LCA (e.g. through provision of data) when a dedicated and sufficient budget is available, e.g. through the involvement in a larger research project. Experience also shows that SMEs typically find interest in identifying impact reduction opportunities, particularly those stemming from activities in the life cycle on which they themselves exert some influence. Similar findings were reported in European countries where the tradition of using LCA has historically not been that strong (Kurczewski 2013; Witeczak et al. 2014).

4.4 Citizen Perspective

LCA results can also serve as decision support for individuals, be it in their capacity of citizens or consumers. In many cases, these decisions relate to the private consumption of goods and services. Consumers are knowingly or unknowingly exposed to LCA results, or conclusions drawn from LCA results, through ecolabels (see Chap. 24) or other consumer information from producers (e.g. printed on packaging) and media reporting academic findings, and they hold some power through their influence in the market of consumer products. Consumer decisions that may be supported by an LCA can range from choosing the product with the lowest environmental impact amongst a group of similar products (e.g. the more environmentally friendly vacuum cleaner), over choosing the most environmentally sound way of fulfilling a function (e.g. washing dishes by hand or in a dishwasher) to most effectively reducing the total personal environmental impact (e.g. reduce meat consumption, hot showers or car driving).

Besides decisions related to private consumption, citizens may also indirectly be affected by LCA results when following political discussions on large infrastructure-related decisions where LCA provides the underlying decision support. For example, municipalities often use LCA to support decisions on waste management infrastructure (European Commission 2008). If a political decision is made about increasing recycling and reducing landfilling or incineration, this will affect citizens, as they will have to sort their waste into recyclable fractions rather than throw all their waste into the same bin. Chapter 35 deals with the use of LCA in waste management.

4.5 Concluding Remarks

LCA is an important and useful tool to map environmental impacts and support policy development and concrete decisions, and for a company it can support the development of a positive image. There are, however, factors that hamper its more widespread application. This chapter has mainly addressed LCA applications in

developed countries because this is where LCA has been applied the most and the needed data has been most available. However, large differences exist in the application of LCA between developed and developing countries in terms of both frequency and incentives. These differences and the challenges that they pose for a global dissemination of LCA and life cycle thinking are discussed in Chap. 19 on globalization and mainstreaming of LCA. The next chapter takes a closer look at the relationship between LCA and sustainable development.

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