Chapter 23
Ecodesign Implementation and LCA

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Abstract Ecodesign is a proactive product development approach that integrates environmental considerations into the early stages of the product development process so to improve the environmental performance of products. In this chapter, the ecodesign concept will be discussed, in terms of its implementation into manufacturing companies. Existing methods and tools for ecodesign implementation will be described, focusing on a multifaceted approach to environmental improvement through product development. Additionally, the use of LCA in an ecodesign implementation context will be further described in terms of the challenges and opportunities, together with the discussion of a selection of simplified LCA tools. Finally, a seven-step approach for ecodesign implementation which has been applied by several companies will be described.

Learning Objectives
After studying this chapter, the reader should be able to:

- Define ecodesign and understand its importance in the context of sustainability.
- Understand the extensive variety of ecodesign methods and tools.
- Understand the main challenges of Life Cycle Assessment (LCA) implementation in the context of ecodesign.
- Understand how to communicate LCA results within an ecodesign activity.
- Explain simplified LCA approaches for implementation into ecodesign programmes.
- Understand how to measure progress and set goals for ecodesign implementation.
- Carry out a seven-step approach for ecodesign implementation into companies.

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23.1 Introduction to Ecodesign

There are many reasons for the environmental problems we experience in the world. Massive population growth and an increase in relative wealth (and thus growing consumerism) on a global level are two significant contributors to the strain on our fragile ecosystem. Manufactured products are essential for the wealth of society and for our desired quality of life. However, our growing consumption of products lies directly or indirectly at the root of a great deal of the pollution and depletion of resources that the consumerist society causes (Commission of European Communities 2001). Environmental impacts are caused by every product in some way or another, from the extraction of raw materials, through their production and use, to the management and final disposal of waste (Baumann et al. 2002).

Regardless of the nature, size and time of occurrence of environmental impacts for a product, the vast majority of environmental impacts are actually decided already in the very early phases of product development. In fact it is estimated that approximately 80% of a product's environmental performance[1] is fixed during the early phases of the product development process (McAloone and Bey 2011). It is during product development that materials, technologies and the product's lifetime are decided. The product developer has thus a great influence on the product's life cycle and therefore also on the later occurring environmental impacts and on the environmental performance of the products. For this reason, it is important that the product developer integrates environmental considerations carefully and systematically into the product development activity (McAloone and Bey 2011). This integration of environmental considerations into product development is called *ecodesign*.

Ecodesign is a proactive approach to environmental management during product development, with the aim of integrating environmental considerations into the product development process. The goal is to minimise environmental impacts throughout the product's life cycle, without compromising other essential criteria such as performance, functionality, aesthetics, quality and cost (Johansson 2002; van Weenen 1995). Ecodesign requires a balanced view of the whole product life cycle, focusing attention on the reduction of the major environmental impacts of the product, throughout its lifetime.

Ecodesign calls on the knowledge and competencies of many disciplines in the product development process, as considerations about materials, processes, logistics, recyclability—and many more—are likely to arise as potential contributors to an improved environmental profile of the product design in hand (Brones and Carvalho 2015). The involvement of many functions and professions in this process gives rise to multiple viewpoints and increases the likelihood for optimal solutions (McAloone and Bey 2011).

[1]The environmental performance of a product can be determined by the sum of all the environmental impacts it causes during its lifetime (Nielsen and Wenzel 2002).

Taking a systematic approach to understanding where and why a product has environmental impacts in its lifetime can lead to competitive advantages for the company. It has been demonstrated, for instance, that environmental thinking in product development leads to efficient products, which are both economically viable to produce, cheaper to operate and maintain, and more robust during their lifetimes (de Caluwe 2004; Eagan and Finster 2001).

Designing products with improved environmental performance is a necessary action for industries to ensure both competitive and environmental advantages (Bey et al. 2013). The systematic incorporation of environmental considerations during the product development process (i.e. ecodesign implementation) is not an easy task, especially in the early stages, which are characterised by greater degrees of design freedom, but also limited information about the product and its pending manufacturing processes.

Over the past couple of decades, several approaches and methodologies have been developed to support manufacturing companies to integrate ecodesign into their product development processes (Baumann et al. 2002; Pigosso et al. 2014). For ecodesign to be successful, activity at three main levels of the company is required:

- *Strategic* (*or managerial*), to set the goals and expectations throughout the whole organisation;
- *Tactical,* to schedule and prioritise the good intentions of management; and
- *Operational,* to deploy ecodesign methods and tools directly, within product development projects.

Strategic approaches are related to the integration of ecodesign into the strategic decision-making and business processes. Some examples of activities carried out in the context of a strategic ecodesign implementation include: definition of environmental targets for the product portfolio; deployment of responsibilities across different hierarchical levels; development of a communication strategy to customers and stakeholders; development of strategic competences in the organisation; etc. In other words, strategic-level ecodesign implementation creates the foundation, the goals and the resources in the organisation for the ecodesign process to be a success (Pigosso et al. 2013a, b).

At the *tactical* level of the company, the task is to ensure that the goals, strategies, and visions of the strategic management group are prioritised and organised in a way that they can be integrated into the product development process. This activity is very important, as without it, no decisions can be made to ensure a systematic approach to ecodesign. It is at this level that: (1) candidate ecodesign projects are chosen, (2) methods and tools are prioritised and integrated into the product development process and (3) the product development process is generally updated to include environmental considerations. It is also here that ecodesign implementation roadmaps are made and deployed (Pigosso et al. 2013a, b).

The actual development of products with improved environmental performance takes place during the so-called *operational* ecodesign implementation, which starts in the early phases of the product development process, where the greatest improvement opportunities lie. Identifying the desired environmental performance of products, the environmental hotspots (environmental aspects and life cycle stages that have the highest environmental impact), developing alternative product concepts based on ecodesign guidelines, selecting concepts to be further developed based on their environmental performance, etc., are some examples of activities carried out in the operational implementation of ecodesign.

The ambition for ecodesign implementation is often correlated to the main internal and external drivers of the company for ecodesign implementation. Usually, companies that are applying ecodesign due to a legislative compliance driver (e.g. compliance with European directives) have a lower ambition when compared to companies that are implementing ecodesign due to an internal strategic driver (e.g. to a sustainability strategy or organisational values). Companies that are implementing ecodesign due to customer requirements, for example, usually begin the ecodesign implementation with a limited ambition, which is subsequently expanded as the companies learn the other business benefits linked to ecodesign implementation.

23.2 Ecodesign Methods and Tools

Since the establishment of ecodesign as a product development practice and as a research object for scientists, several ecodesign methods and tools have been developed—both by academics and in industry. Currently, more than 150 ecodesign methods and tools exist (Pigosso et al. 2014), and the number continues to grow.

The methods and tools that exist have various goals and focuses, such as "evaluate environmental impacts", "reveal potential trade-offs" (Byggeth and Hochschorner 2006) and "facilitate the choice between different aspects" (Baumann et al. 2002; Byggeth and Hochschorner 2006). In this section, we provide an overview of a selection of existing ecodesign methods and tools.

Ecodesign methods and tools are defined as any systematic means for the management and implementation of ecodesign at an operational level. Ecodesign methods and tools are usually applied in the early phases of the product development process (Fig. 23.1), where the largest improvement opportunities lie.

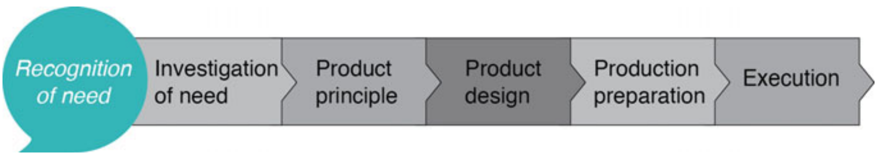

Fig. 23.1 One way to depict the product development process (Andreasen and Hein 1987)

As mentioned earlier, a large amount of the environmental impacts of a product's life cycle are determined in the early phases of its development (McAloone and Bey 2011).

According to their main purpose, the ecodesign methods and tools can be classified into three main groups (Pigosso et al. 2011a, b):

- Prescriptive: Present generic guidelines (from a pre-established set of best practices to minimise the environmental impacts);
- Comparative: Compare the performance of different products, concepts or design alternatives for a given product;
- Analytical: Identify improvement potentials by means of an assessment of the most relevant environmental aspects.

A few examples of ecodesign methods and tools, classified according to the product development phase (Fig. 23.1) and type of tool (prescriptive, comparative and analytical), are presented in Table 23.1.

Most of the existing ecodesign methods and tools are focused on the early stages of product development, mainly in the "product principle" and "product design" phases. Furthermore, there is a tendency to the use of analytical tools rather than to comparative and prescriptive ones.

The ecodesign methods and tools presented in Table 23.1 are further described in Table 23.2, with an indication of references, where more information can be obtained.

23.3 LCA and Ecodesign

In this section we explore in some more depth, how LCA can be used in an ecodesign context, to support the development of products with improved environmental performance.

Table 23.1 Examples of ecodesign methods and tools (all are cited in Tables 23.2 and 23.3)

	Analytical	Comparative	Prescriptive
Recognition of need	Eco-QFD STRETCH (Strategic environmental challenge)		
Investigation of need	Eco-roadmap	EcoBenchmarking	
Product principle	Eco-function matrix	LiDs wheel	Ten golden rules
Product design	LCA Environmental effect analysis (EEA)	DfE matrix MECO matrix	EcoDesign pilot
Production preparation	–	–	–
Execution	EcoValue	Eco communication matrix	

Table 23.2 Description of presented ecodesign methods and tools

Method/tool	Description
Eco-QFD (quality function deployment) (Ernzer et al. 2005)	Supports the transfer of market insights to the product's requirements list. In this method, the environmental demands are acquired from an expert team instead of directly from the customer. It allows the product developer to focus on the internal (product properties) and not the external environmental parameters (e.g. generating energy, waste treatment)
STRETCH (strategic environmental challenge) (Cramer and Stevels 1997; Stevels 2007)	Focuses on assessing improvements in the most promising environmental opportunities throughout the product life cycle. Considers product business units and market strategies, in addition to potential changes in environmental pressure exerted by external stakeholders. It consists of five steps: (1) Identify the major forces that influence business strategy, (2) Develop scenarios that the company can adopt based on core strengths and develop a list of potential marketing strategies for the product. (3) Specify opportunities for environmental improvements for each scenario. (4) Select the environmental challenges that will lead to substantial improvements in the environmental performance of products. (5) Address the selected environmental challenges
Eco-roadmap (Donnelly et al. 2006a, b)	Concise graphical tool that captures short- and long-term environmental drivers (legislation [enacted and future] and customer requirements) in one document. The eco-roadmap contains the actual product-relevant legislation and customer requirements in the scope of sustainable and environmentally compliant product design. The eco-roadmap also highlights draft legislation, emerging customer requirements, and industry trends for future sustainable and environmentally compliant product features
EcoBenchmarking (Boks and Diehl 2005; Boks and Stevels 2003; Wever et al. 2005, 2007)	Supports organisations to understand and develop a critical attitude towards their own products, to create awareness about environmental issues in and outside a company, and thus to find environmental improvement options for their products that are feasible for implementation. The method is based on 10 steps with specific goals and questions to be answered and can be adjusted in two ways (light vs. extended; information vs. physical) depending on the context and needs
Eco-function matrix (Lagerstedt et al. 2003)	A communication platform for functional priorities and environmental impacts is established by combining the Environmental Profile and Functional Profile of the product. The functional profile describes and evaluates properties, areas and activities that are associated with the functionality of the product and its commercial viability. The Environmental Profile identifies the characteristics of the products that are correlated with the generation of environmental impacts. It can be applied at different stages of product development, according to the degree of specification and detailing of Environmental and Functional Profile

(continued)

Table 23.2 (continued)

Method/tool	Description
EcoStrategy wheel (Knight and Jenkins 2009)	Contains eight strategies (function optimisation, reducing the impact on the use stage, reducing the use of materials, choosing the right materials, optimisation of lifetime, production optimisation, optimisation of treatment of end of life, improved distribution) to environmentally improve products and is based on knowledge of the team members. Strategies are used as a checklist and are sources of inspiration to support meetings using brainstorming techniques
Ten golden rules (Luttropp and Lagerstedt 2006)	Consists of a summary of several guidelines and manuals used by companies from various sectors, with recommendations of environmental strategies. It can be used to improve the environmental performance of the concept of a product or to compare various alternative concepts. In order to be used by a particular company, it must first be transformed and customised according to the characteristics of the company and its developed products
Life cycle assessment (LCA) (Bhander et al. 2003)	Quantifies environmental impacts of the whole life cycle of goods and services. It involves all successive stages of a product system, ranging from extraction of raw materials and energy required in manufacturing, use and distribution until the final disposition of the product, which may include recycling of materials and components, and other ways of post-consumption treatments
Environmental effect analysis (EEA) (Lindahl 1999, 2000)	Qualitative dialogue process with a starting point in the use of available experiences and environmental requirements from stakeholders. The tool was developed to assist product development teams in quick and effective assessment of environmental issues, clarifying their goals and objectives, and toward fulfilling them in real product development efforts. The basic principle is to list all activities considered to have significant environmental influence, and for each activity judge the quantity and seriousness of each aspect, as well as to suggest ways for making improvements that will reduce the impacts of the proposed product
DfE (design for environment) matrix (Eagan and Finster 2001)	The matrix raises questions about the environmental impacts of a product through 100 issues that allocate a wide range of environmental and design issues and provides a semi-quantitative analysis of the product design alternatives. The totals for each life cycle stage (pre-manufacturing, manufacturing, packaging and distribution, use and maintenance, end-of-life) and environmental impacts indicate improvement areas in terms of the environmental attributes of a product throughout its life cycle. The total score of the matrix is a relative measure of environmental product attributes and complements the economic parameters of customer value and manufacturability that should also be evaluated

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Table 23.2 (continued)

Method/tool	Description
MECO matrix (Hochschorner and Finnveden 2003; Wenzel et al. 1997)	Estimates the environmental impact of each life cycle stage (raw material, manufacturing, use, disposal and transport) and is performed by estimating the amount of material (M), energy (E), chemical (C) and other materials (O) used in the product life cycle. All input and output flows must be considered for a category in relation to a time base according to the functional unit of product and the stage of the life cycle chosen
EcoDesign pilot (Wimmer et al. 2005)	Once the environmental strategies are selected for the improvement of an existing product, different design rules and guidelines guide the designer during the design process. To improve the environmental performance, each product requires specific measures depending on its environmental impact at different stages of its life cycle (extraction of raw materials, manufacturing, transportation, use and disposal). A good set of measures of the design rules and guidelines can be found in the EcoDesign PILOT software
EcoValue (Gheorghe and Ishii 2007; Jones et al. 2001; Kengo et al. 2001; Pascual and Stevels 2005, 2006)	Ecovalue is defined as the ratio between a monetary amount (price) and the environmental load over the life cycle of the product/service concerned. Ecovalue acknowledges market diversity, where consumers value different attributes in products. For this purpose, the criteria used to set priorities rely on market composition, consumption power, and a product's environmental load. Units used include retail price in monetary units and a product's environmental load, expressed in millipoints (mPt)
Eco communication matrix (Stevels 2001)	Supports the development of the marketing and communication strategies. Most of the data necessary for completing the matrix are derived from the earlier phases of the project (benchmarking, ecodesign matrix, etc.). Comparisons can be made between products of different generations and/or of competing products. The rows of the matrix correspond to energy consumption, materials, packaging and transportation, substances, durability/recyclability, manufacturing and life cycle perspective. The columns of the matrix correspond to the company internal benefits, benefit to clients/customers and benefits to stakeholders and society. Each of these benefits are divided into tangible, intangible and emotion perception

LCA is one of the most well-known methods that can support ecodesign implementation (Brezet et al. 1999; Cappelli and Delogu 2006; Hunkeler and Vanakari 2000; Munoz et al. 2006). It provides a quantification of environmental aspects and impacts across the product life cycle and supports the between concepts and design options. LCA involves all successive stages of a product life cycle, ranging from extraction of raw materials through the environmental impacts of manufacturing, distribution and use of the product, all the way until its final disposal, which may include subsequent activities such as recycling of materials and components, plus other ways of treating post-consumption (Azapagic and Clift 1999).

LCA has gained broad acceptance in industry as a trustworthy method to quantify the environmental aspects and potential impacts of the life cycle of products. The LCA methodological framework is defined by ISO 14040 and 14044 standards (ISO 2006a, b), which describe the minimum requirements for its correct use and performance. The holistic systems perspective, which is applied in LCA, enables the company to disclose the 'problem shifting' which occurs when solutions to environmental problems at one place in a product's life cycle create new problems elsewhere in the life cycle (Jeswiet and Hauschild 2005).

23.3.1 LCA Challenges

It is important to understand the challenges and limitations of LCA in the context of ecodesign, in order to be able to use the two approaches to product environmental improvement. Many authors have written about the challenges of LCA within ecodesign (Alting et al. 2007; Keoleian et al. 1994; Portney 1993), which can be expressed in five main areas, as described in the following.

The first challenge relates to the dilemma of opportunity (and cost) versus knowledge (and numbers). In the early phases of the product development process, the cost of making a design decision is very low and the window of opportunity to affect ecodesign improvements and integrate environmentally enhancing features into the product is the largest (Bhander et al. 2003; Keoleian et al. 1994). However, by nature of this early phase of the project, it is here where we know the absolute least about our product, thus rendering it very difficult to quantify the contents of related processes for the manufacture of a product that has not yet even been fully conceptualised (Bhamra et al. 1999; Tchertchian et al. 2013). The later in the product development process one waits, the more quantitative the data one has to model in an LCA, yet the smaller the window of opportunity to affect any changes—and the higher the cost of doing so. A number of tools and guidelines exist, to bridge this opportunity-knowledge gap, but it remains a limitation. One obvious action is to perform an LCA on a previous product or a competitor's product, as there is almost always some product on the market with similar functionality and ingredients to the product we are designing.

Challenge number two relates to the required knowledge and competencies of the product developer (Portney 1993). LCA is in itself a detailed and highly specialised approach, belonging to a strong scientific knowledge domain (Ny et al. 2006). Ecodesign, within the context of product development, is usually dominated by well-trained, highly skilled and well-practiced designers and engineers, with competencies in the systematic design and development of products and systems (Diehl 2005; Hesselbach and Herrmann 2003). In other words, LCA is a highly analytical (natural science dominated) activity and ecodesign is a highly synthesis-oriented (technical, engineering) activity. LCA has two important places in a manufacturing company: (i) the environmental, health & safety (EH&S) function of the organisation, where reporting and high-level (maybe product family) assessments are carried out; and (ii) in the product development department, where the knowledge of products, processes, ecosystems and use scenarios provide important guidance for ecodesign. The challenge is always, how to ensure the right level of LCA knowledge in the mind of the product developer and/or how to compensate for the lack of LCA knowledge through a combination of bridging tools (Poudelet et al. 2012; Tchertchian et al. 2013), plus the pairing of LCA specialists with product development specialists. The solution to this challenge lies in strategic management recognition, paired with a tactical management prioritisation.

The third challenge with LCA in the ecodesign activity relates to completely new products, where we cannot rely on previous product releases or competitors' products, to create some form of benchmark for the ecodesign effort in especially the early phases of product development (Trappey et al. 2011). Completely new products are more of a marginal case, when compared to incrementally innovated products, but there are still examples that need environmental attention (e.g., electronic products, many clean-tech products, nano-based products, etc.). In such product development cases, LCA tends to play a lagging, rather than a leading role (Poudelet et al. 2012).

Challenge number four relates mostly to the misconception of the scope and merits of LCA. LCA is an analysis method—a very well developed and accepted one at that. Challenges arise when the company expects great product development and ecodesign advances, based alone on the results of an LCA (Brezet et al. 1999; Russo et al. 2014). It is not possible to "analyse oneself to a better product", i.e. to improve a product solely based on an analysis of its environmental performance, and therefore LCA should not be deployed as the only method to ecodesign improvement for a project. Instead, one should pair the analysis activity with the task of synthesis (product development), as the methods and tools exist in abundance, to support the good ecodesign process afterwards.

The fifth and final noteworthy challenge that LCA as a scientific field faces lies in the claims from "competing approaches". A popular claim within the current Cradle to Cradle (C2C) approach is that LCA belongs to the realm of eco-efficiency, which is a reductionist and limiting agenda, whereas C2C belongs to an agenda of positivism, growth and innovation (Hauschild 2015; McDonough and Braungart 2010; Rossi et al. 2006; see Chap. 25). Whilst the mental model created by this claim is compelling and easy to understand, it is not necessarily entirely useful. Ecodesign, LCA, C2C and a number of other approaches to enhancing environmental performance of products, can easily be used interchangeably and must respect each other's basic philosophies and scientific bases, if they really are to be deployed with successful environmental improvement to follow (Bakker et al. 2010; Bjørn and Hauschild 2011; Reay et al. 2011).

23.3.2 *Using and Communicating LCA for Ecodesign in the Organisation*

Referring again to the two key areas of a company in which LCA plays a role, namely the EH&S department and the product development department, it may be that the company has LCA information, data and results available, but the question is, how to access these data and what to use them for (Miettinen and Hämäläinen 1997). If a full LCA has been carried out, the final *improvement assessment* phase ought to point to areas of ecodesign priority for a particular product. However, it may be that only the inventory analysis and impact assessments have been carried out, which will pose difficulties for the ecodesign activity within the company, to directly use the data (Poudelet et al. 2012). The age and the scope of existing LCA studies in the company will also dictate their usefulness for the ecodesign process, but nevertheless, key focus areas should be possible to derive from the LCA activity (Chang et al. 2014).

Importantly also, the existence of LCA studies inside the company indicates that some previous attention has been given to the environmental improvement of products and processes in the organisation. Tracing the people, the projects and the types of data gathered and analysed will give a good idea of the intentions of the company with respect to ecodesign improvements and give good starting points for future activities. Especially understanding the goals and scope for existing LCA studies in the company is important, as it will uncover some details regarding the existing (or maybe earlier) environmental strategy of the company.

Identifying existing LCA results is one important task, and communicating these across the organisation is another. Understanding how to interpret and communicate LCA results is very important, in order to ensure that both management and product development professionals understand how to make further improvements based on the results calculated (Tingström and Karlsson 2006). There are a number of ways in which an LCA can be reported, and for the sake of ecodesign, it is important to choose a presentation of LCA studies in a way that supports the product development task. In other words, a presentation of environmental impact categories (global warming potential, air pollution, solid waste, etc.) is probably less useful for a product developer than presenting a more detailed model of the actual product or system (down to component level), showing comparative analyses, maybe with aggregated calculations (person equivalents, eco-points, energy, etc.). It may also be sufficient to carry out a faster but less detailed screening LCA to support the ecodesign task, as opposed to a much more trustworthy but also relatively time-consuming full product LCA (Simon et al. 2000).

23.3.3 Simplified Approaches Aimed At Integrating LCA Into Ecodesign

The practical use of environmental LCA methods and software tools in industry has revealed the need for simplification for product development projects. Hence, streamlined life cycle assessment methods have been derived from experience with the complex full methods (Jeswiet and Hauschild 2005).

Simplified LCA, also known as Streamlined LCA, has emerged over the years, as an efficient way to evaluate the environmental attributes of a product, process, or service life cycle. The aim of simplifying LCA is to provide essentially the same type of results as a detailed LCA, i.e. covering the whole life cycle, but in a superficial way (e.g. using qualitative and/or quantitative generic data), followed by a simplified assessment, thus reducing significantly the expenses and time expended.

Simplified LCA should still include all relevant aspects, but good explanations (e.g. company guidelines, materials negative lists or materials black lists, preferred mode of transportation) can to some extent replace resource-demanding data collection and treatment. The assessment should focus on the most important environmental aspects and/or potential environmental impacts and/or stages of the life cycle and/or phases of the LCA and give a thorough assessment of the reliability of the results (Zackrisson et al. 2008).

Full-scale LCA is traditionally quantitative. However, it is recognised that where quantification is not possible (for reasons of time, cost or data availability, for example), qualitative aspects can—and should—be taken into account (Heijungs et al. 2010). Simplified-LCA (S-LCA) is not meant to be a rigorous quantitative determination, but rather a tool for identifying environmental "hot spots" and highlighting key opportunities for effecting environmental improvements.

It is not complicated to apply quantitative and detailed LCAs to simple products, such as packaging, since they consist of few components or types of material, where information on most of the commonly used materials is available (and, if necessary, it is quick and easy to collect). For more complicated products, such as, e.g. televisions, a complete LCA may prove to be very resource-demanding and at the same time somewhat imprecise, due to the number of possible processes, materials, suppliers, etc., being very high and varied. Furthermore, the database on "not so common" materials is limited so for these cases, S-LCAs are more helpful, especially in the early stages of product development. In the case of improvements in already existing product systems, the use of (full) LCA may become easier, once data from a reference system can be used (with a well-known life cycle).

Streamlined approaches and other ecodesign methods and tools, such as design checklists and matrices, are essential to support ecodesign implementation in the early design phases. The practical use of these tools in product development depends on the nature and complexity of the product system (e.g. new vs. established), the product development cycle (time-to-market constraints), availability of technical and financial resources, and the design approach (integrated vs. serial).

These factors influence the role and scope of LCA in an ecodesign process. Effective communication and evaluation of environmental information and the integration of this information with cost, performance, cultural and legal criteria will also be critical to the success of design initiatives based on the life cycle framework.

Some examples of simplified LCA methods and tools are presented in Table 23.3. These methods and tools present a life cycle perspective and provide an analysis or comparison of the environmental impacts associated to a product, using or providing qualitative or semi-quantitative data. In order to avoid repetition, the simplified LCA methods and tools presented in Table 23.2 [STRETCH (Strategic Environmental Challenge), and MECO matrix)] are not replicated in Table 23.3.

Table 23.3 Simplified LCA methods/tools (Pigosso et al. 2011a, b)

Ecodesign method/tool	Summary	Criteria for assessment	Approach
Design abacus (Bhamra and Lofthouse 2007)	Used to rate a product on social, economic and environmental areas, in both the analysis and planning of a design. It helps you identify design goals, compare many design variables and compare different product designs across the product life cycle	Defined by the user (example: energy, material, usability, cost, life span, end of life)	Qualitative
Eco-compass technique (Sun et al. 2003)	Used to evaluate the environmental impact of an existing product. Combining the cost and benefit, a product's life locus tree can be built up and the environmental impact of a product is assessed on the performance of process and life stages of a product using these eight indices	Mass intensity, energy intensity, health and environmental potential risk, revalorisation, resource conversation, and service extension	Semi-quantitative
ECODESIGN checklist method (ECM) (Wimmer 1999)	Points out purposefully redesign tasks in order to increase the environmental performance of a product. Based on a holistic view of the product in three analysis levels (part-, function-,	Usability of product (customer's needs oriented), low energy consuming	Semi-quantitative

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Table 23.3 (continued)

Ecodesign method/tool	Summary	Criteria for assessment	Approach
	and product level) the method shows clearly, where the weak points of a product are and how to realize reuse, recycling of parts, where to integrate, omit or create functions and where to reduce consumption or increase efficiency, usability of the whole product	product (use stage), low resource consumption and avoiding waste (manufacturing stage),durable product, reuse of product-parts, recycling of product-materials	
Ecodesign web (Bhamra and Lofthouse 2007)	Provides a quick way of helping designers to identify which areas of the product should be focused on to improve its environmental performance. It works by comparing seven design areas with each other to identify a "better than"/"worse than" output	Materials selection, materials usage, distribution, product use, optimal life, end of life	Qualitative
Environmental design strategy matrix (EDSM) (Lagerstedt et al. 2003)	Identifies some design strategies based on characteristics of products at the different life cycle stages	Life cycle length, energy consumption, resource consumption, material requirement, configuration and disposal route	Qualitative
Green design advisor (GDA) (Ferrendier et al. 2002)	Provides a direction of improvement, as well as the design features with the highest improvement potential and shows the weak points, as well as good design features. Additional design guidelines exist; however, there are no automatically generated design alternatives	Number of materials, mass, recycled content, recyclability, toxicity, energy use, time for disassembly, disposal cost	Semi-quantitative
Green design tool (Kassahun et al. 1995)	Based on analysing "top level greenness attributes" of a product, providing to the designer an overview of the environmental status of product design. It can be applied using the basic concept of the product	Reusability, label, internal joints, material variety, material identification, recycled content, chemical usage, additives, surface	Semi-quantitative

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Table 23.3 (continued)

Ecodesign method/tool	Summary	Criteria for assessment	Approach
		finishes, external joints and hazards level of material	
MET matrix (Byggeth and Hochschorner 2006b)	Aims to find the most important environmental problems during the life cycle of a product, which can be used to define different strategies for improvement. The environmental problems should be classified into the categories	Material cycle, energy use, toxic emissions	Qualitative or quantitative
The environmentally responsible product assessment matrix (ERPA) (Hochschorner and Finnveden 2003)	The central feature of ERPA assessment is a 5 × 5 matrix. One dimension is the life cycle stages and the other is environmental concerns. The method can be used to evaluate products, processes, facilities, services or infrastructure. Each element of the matrix is assigned a rating from 0 (highest impact) to 4 (lowest impact), according to a checklist. The rating is based on the seriousness but also on whether possibilities of reducing impacts have been utilized or not	Materials choice, energy use, solid residues, liquid residues and gaseous residues	Semi-quantitative

23.4 Creating Goals and Measuring Progress with Ecodesign

Whether it be LCA-driven/supported or not, any ecodesign process is best supported if a set of measurable goals and performance indicators are established for the activity. These are a fundamental element of any successful ecodesign activity, as they can provide an early warning to prevent environmental damage (Issa et al. 2013).

The use of environmental performance indicators (EPIs) to monitor product performance is often identified as one of the successful factors for effective ecodesign implementation, as such indicators can help to pinpoint improvement opportunities and prevent environmental damage through the product under development (Fiksel et al. 1998; Herva et al. 2011).

Most methods and tools to measure the environmental performance of products, such as Life Cycle Assessment (LCA), still present high complexity and large data requirements to the ecodesign activity (Hur et al. 2005), providing results that can be classified as *lagging EPIs*. Lagging EPIs measure the product's impacts on the environment, as a final result of a process.

In contrast to lagging EPIs, *leading EPIs* aim to produce simpler measures of environmental aspects that can inspire effective actions towards improving products' environmental performance. Environmental aspects are defined as elements of the organisation's activities, products or services that interact with the environment. In this context, the use of leading product-related EPIs can be seen as a simpler and faster quantitative approach to ensure performance measurement and improvement during the product development process (Bovea and Perez-Belis 2012).

Databases of leading product-related EPIs exist, in some cases including accompanying guides, with the aim of supporting companies to select the most relevant EPIs, based on the developed products and their strategies (see e.g. Issa et al. 2015).

23.5 Carrying Out Ecodesign, Step by Step

Many approaches and processes are advocated and published, proposing a process of ecodesign (Bhamra et al. 1999; Brones and Carvalho 2015; Herva et al. 2012; Kengpol and Boonkanit 2011; Luttropp and Lagerstedt 2006; Pigosso et al. 2013a, b; Poole et al. 1999; Rio et al. 2013), and in at least a large company setting, the absolute most important route to success is to integrate ecodesign decisions and considerations into the established product development process for the company (Pigosso et al. 2013a, b). However, a generic process of decision-making and ecodesign implementation can be derived from the various ways and processes suggested.

One such approach has been published by the Technical University of Denmark (DTU), as the result of a sponsored campaign by the Danish Environmental Protection Agency and the Confederation of Danish Industry. The approach, named *Environmental Improvement through Product Development: A Guide* (McAloone and Bey 2011), describes seven generic steps towards ecodesign implementation, and is created based on a detailed analysis of other existing approaches, plus a number of trial implementations in industry. The following gives a summary of this approach, which steps the user through an analytical point of departure, through a creative-synthesis ecodesign approach, before considering how to implement the proposed ecodesign changes in the organisation on a more permanent basis. Examples of the application of each one of the proposed steps can be found in the guide.

23.5.1 Environmental Improvement Through Product Development: A Seven-Step Approach

The following seven steps guide the user through a solution-oriented process, towards environmental improvement. The seven generic steps are meant to provide a simple and inspiring way of approaching ecodesign, by isolating the task from the ordinary product development tasks in the company, the idea being to gain focus in the product development team, about the "ideal ecodesign approach" in a workshop setting. The approach attempts to create space for innovation by focusing solely on environmental issues. At the end of the approach, it is the intention that the practitioner considers how to integrate the seven steps into their own organisation's product development process.

The approach is constructed with a focus on:

- Gaining an *overview* of a current product's environmental problems;
- Providing *insight* into important details concerning the product's environmental impacts, its use and its users;
- Creating *solutions and concepts* that lead to environmental improvements; and
- Creating *foresighted proposals* for the creation of an environmental strategy for product development.

The approach is designed as a chain of exercises that ought to be completed from start to finish, in the order that the steps are presented. The approach charts an eco-redesign process, so as to ensure that there is an established benchmark product beforehand; it therefore requires that a product is chosen in advance as the object for environmental improvement. The product can be either an already marketed product, which will serve as a reference product, or a product that is currently under development. The first case is the simplest, as it is easier to identify data about the product's life cycle.

The first six steps of the seven-step approach isolate the environmental task and focus on identifying environmental problems. Subsequently improvement proposals are created. Step 7 provides a framework for an action plan and the basis for systematic integration of the proposed environmental improvements into the product development process. See Fig. 23.2.

Step 1: Describe the use context

As the very first exercise, it is important to reach a common understanding of the product and its value contribution under use. This provides a common starting point for discussions about the environmental product improvement possibilities for the product, for use later in the process, when the creation of product alternatives is in focus. It is important that the alternatives created meet the same requirements for the customer. Redundant product attributes should be considered as waste, both from an environmental and a customer perspective. Step 1 is intended to reach a

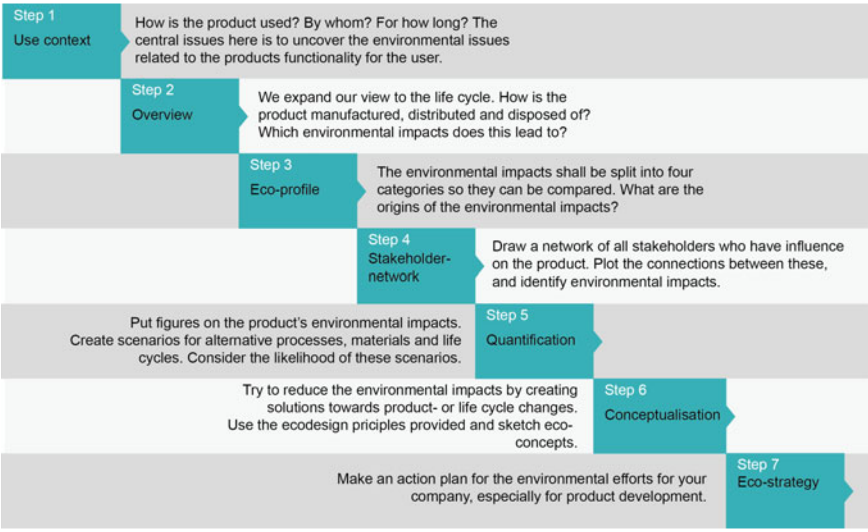

Fig. 23.2 Seven-step approach to ecodesign, as described by McAloone and Bey (2011)

description of the product's functionality to the user. This description provides the benchmark for all subsequent decisions and can also be used when, for example, alternative concepts shall be compared.

The description of the use context is achieved by answering the following questions:

- "*What should the product be used for*?" which leads to a description of the basic task that the product must carry out for the user.
- "*What does the product do*?" which allows for a description of the product's functionality, including the technological principle and the features that the product must possess in order to deliver the service to the user.
  - "... *For whom*?" leads to a description of the main user or user group.
  - "... *How long*?" and "... *how often*?" lead to a definition of the time frames in which the product must operate.
  - "... *Where in the world*?" leads to a definition of the geographical area in which the product must operate.

The responses to the above questions lead to a clear description of the product in the form of the *value contribution that the product delivers to the user*, or in other words, the product's *functional unit*.

Step 2: Create an overview of the environmental impacts

In this step, the aim is to create an overview of the product's life cycle and all significant environmental impacts that may occur throughout the life cycle of the product. A product life cycle typically consists of five main stages:

- *Materials* covers materials extraction and manufacturing (e.g. the manufacture of plastic granules from crude oil) and semi-finished products (e.g. steel profiles from iron ore), etc.
- *Manufacture* includes the purchase of components, plus the manufacturing and assembly processes, both at suppliers and in in-house production facilities.
- *Transport* covers the entire logistics chain, from suppliers to the end-user and beyond, including distribution activities by ships, trains, planes, trucks, vans and cars.
- *Use* includes the actual usage and possible ancillary products that are necessary for the product to perform its function (e.g. paper filters for a coffee maker). The use stage also includes installation and possible maintenance activities.
- *Disposal* includes reuse/recycling, incineration and landfill. The actual distribution of these disposal options depends on many factors, including regulatory requirements where the product is disposed of, who disposes of the product (an individual or a company), etc. It is obviously difficult to predict how the product will be disposed of, as this stage is typically far in the future.

Depending on preference, one may choose to integrate the transport life cycle stage into all of the other product life stages, as transport is in itself the "glue" between each life cycle stage. However, many choose to specify and gather all transport activities into one stage for itself, so as to (i) remember to pay attention to transport's environmental impacts and (ii) highlight the transport activity's contribution to the overall environmental footprint of the product.

Figure 23.3 shows a picture of how one could organise the overview of environmental impacts by means of adding sticky notes to a schematic of the product life cycle. The advantage of this approach is that it is a simple way of granting access to all team members in the product development team, to come with their own proposals of environmental impacts.

Step 3: Create your environmental profile and find root causes

Having created an overview of the product's main life cycle stages and environmental impacts in Step 2, the idea of Step 3 is to begin to categorise the identified environmental impacts according to their type. Subsequently the possible causes for the environmental impacts' emergence should be noted, before beginning to gather data on the environmental impacts that can be quantified.

The idea with this step is to create a more nuanced picture of the physical relationships that underpin each environmental focus area, than was created in Step

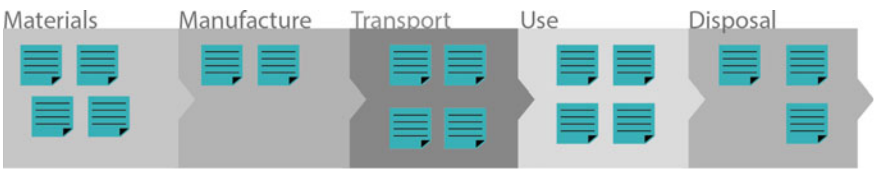

Fig. 23.3 Identifying environmental impacts throughout the product's life cycle

2. A number of focus areas can then be prioritised, based on the team's consideration of the need for action.

The already identified environmental impacts will now be organised into one of four categories: *M*aterials, *E*nergy, *C*hemicals or *O*ther (Field et al. 1993; Wenzel et al. 1997; Hochschorner and Finnveden 2003):

- *Materials:* This includes resource and disposal aspects of each life cycle stage, i.e. whether a material is based on a scarce resource, whether it can be easily recycled, or whether it must be landfilled, etc. Remember also to consider whether ancillary materials are used, particularly in the use stage, e.g. paper filters for coffee makers.
- *Energy:* This includes energy sources and energy aspects in the product life cycle stages. There can, for example, be large differences in energy consumption for material processing, depending on whether one takes new or recycled raw materials into consideration. Remember also to consider component suppliers. The transport and use-related energy consumption is also recorded under this category.
- *Chemicals*: This includes chemical consumption and chemical-related emissions of each life cycle stage, such as toxic chemicals used in manufacture.
- *Other:* In this category all other aspects are noted, that one has chosen to consider. For example, health and safety in own (or suppliers') manufacturing plants, aspects related to Corporate Social Responsibility (CSR), or general economic concerns.

This categorisation of the environmental impacts is created in a so-called *MECO matrix* (Fig. 23.4).

The reason for first carrying out Step 2 before this categorisation in Step 3, is that the MECO matrix can be limiting for the product developer, who feels compelled to fill in the matrix in a systematic manner, from the top left to the bottom right. By inserting a Step 2 and simply identifying the environmental impacts at a more abstract life cycle stage level, the environmental impacts are in focus, rather than

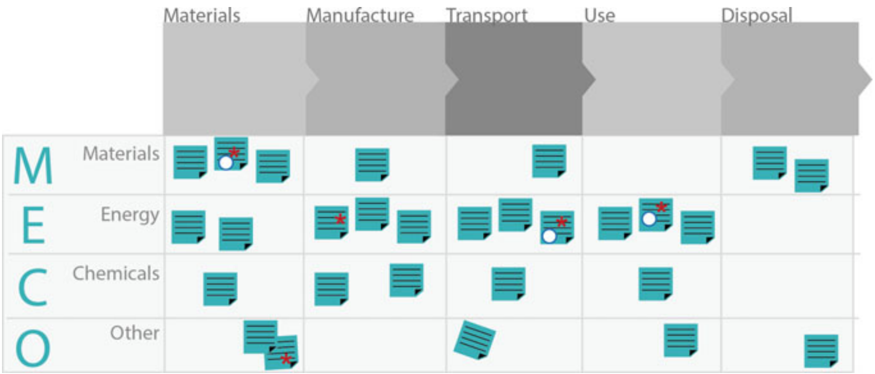

Fig. 23.4 MECO-matrix and product life résumé with environmental impacts categorised

their MECO categories. Having carried out Step 2, the sticky notes created can be simply moved down from the life cycle arrows to the respective MECO categories. One will then see that it is fine to have empty MECO cells, which may not actually have environmental impacts for the particular product under consideration.

Step 4: Sketch the stakeholder-network

Classic environmental efforts in companies take their point of departure in a product or a technology, directing special attention towards the improvement of the product's life cycle performance. This approach (which is represented in Steps 1–3) is a useful way of identifying environmental focus areas for the product itself, if one assumes that the product is used in a specific way, and in a specific context.

A weakness of taking the product-technology approach in isolation, however, is that it is built on a large series of assumptions, about the use, the user, the product development activity, the supply chain and many other stakeholders connected directly or indirectly to the product.

Step 4 of this approach therefore proposes that the product development team identifies the various stakeholders who are connected to a particular set of activities, within which the product plays a role. It is these stakeholders who experience "value" and "goodness" from the product. Environmental impacts often occur in the exchanges between stakeholders, e.g. in negotiations along the supply chain and/or as a result of lack of overview of the roles and responsibilities in the product's so-called *stakeholder-network*.

A stakeholder-network consists of several types of stakeholders, for example the manufacturing company, a component supplier, an external designer, a freight forwarder, the authorities, customers, users, a disposal company and so on.

Sketches of the stakeholder-network give an insight into which stakeholders are affected by certain environmental impacts. To clarify the relationships between stakeholders and the impacts that occur, one can outline *information exchanges*, *material flows* and the resulting *environmental impacts*.

Step 5: Quantify the environmental impacts

Many decisions about the product's environmental profile can be taken on the basis of experience, dialogue and scenario-building. At some stage, however, some of the judgments and choices in product development must be based on hard numbers and quantitative assessments.

Step 5 in the seven-step approach is therefore focused on the quantification activity, of the environmental impacts, with the help of a quantitative life cycle assessment technique. The figures created in this exercise are used to carry out an internal comparison of product alternatives and visualisation of the orders of magnitude between the impacts of the product across their life cycle stages and alternative life cycles. A detailed overview of LCA tools and a discussion of the different types of LCA (full LCA, simplified LCA) have been given earlier in this chapter. It is here where the LCA tools fit well into the ecodesign process, in order to provide overview and priority for ecodesign improvement action.

As previously mentioned and exemplified, there are many possible methods and tools to choose from, when quantifying the environmental impacts of a product at this stage of the ecodesign process. Ultimately, the choice of method will depend on:

- Who will apply the method: a product developer, an industrial designer or an environmental specialist;
- How much one knows about the product at the time of the use of the method;
- Whether one wishes to use a fully tailored computer tool, or whether a spreadsheet or pocket calculator would suffice.

Common for all methods is that one must define the important environmental impacts in the product's life cycle, and model these within the framework of the chosen method. Some methods include data on materials and processes, which ease the quantification task, especially if the method is software-based. Figure 23.5 shows an example of the outcome of the quantification task.

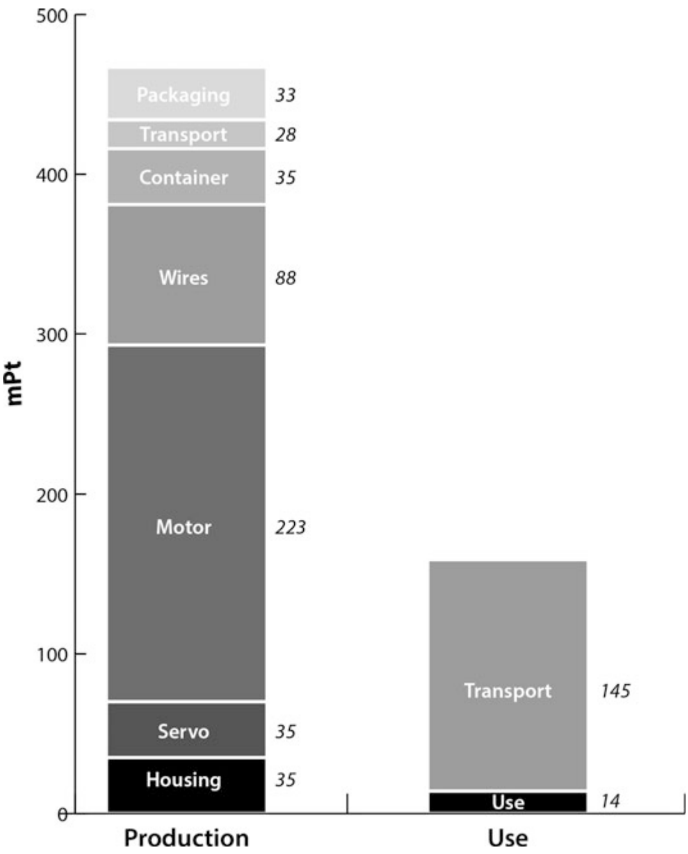

Fig. 23.5 Example of screening LCA exercise, to highlight key environmental focus areas during ecodesign

Step 6: Create environmental concepts

Step 6 of the ecodesign process described here is concerned with creating environmentally superior alternatives to those identified in Step 5, through the process of conceptualisation. This step is probably the closest to the normal product development and conceptualisation activity of all the seven steps described here. There are various tools available to aid this task:

- Approaches which are generic for any conceptualisation process, such as *brainstorming, brainwriting, sketching,* etc.
- The company may have *checklists* and *negative lists* (of materials, processes, chemicals), which prompt environmental thinking.
- Creation of *future scenarios* (e.g. "Outline the world's least energy-consuming house, which can be realised in the year 2020") in order to make a leap forward and perhaps find radical environmental concepts to back-cast from.
- The deployment of relevant *environmental principles* that can inspire and guide the environmental conceptualisation process.

There are hundreds of environmental principles to choose from when carrying out ecodesign (Pigosso et al. 2014; Vezzoli and Manzini 2008). For the sake of providing a generic list of exemplar principles, the seven-step ecodesign guide proposes ten environmental principles. The principles are meant as a way of viewing the "ideal" ecodesigned solution that the product developer could be expected to produce, if there were no other constraints in the product development process. The idea with these ten principles is to push the solution space for ecodesign to a large and creative space. It is clear that not all ten principles will ever be possible to fulfil for any one design; for this reason the concepts that may arise from following any one of the principles could be called "ideal concepts". The subsequent task for the ecodesigner would be to reconcile the ideal concepts arising from following each of the ten principles in turn, into a set of consolidated ecodesign concepts that consider as many as possible of the ten principles. The ten environmental principles are as follows:

- Reduce the *material intensity* of the product or service
  "By reducing the amount of material in the product, fewer material resources are required for manufacturing, the product requires less transport work, and there is less material to belandfilled or recycled. Attempt also to reduce the indirect material requirements, which are related to, e.g. the extraction of raw materials".
- Reduce the *energy intensity* of the product or service
  "As energy supply today is not based on 100% renewable sources, and as fuels are often fossil, the consumption of energy typically leads to environmental loads that can be reduced by changing the design".
- Reduce the *dispersion of harmful substances* through the product
  "Substances which in themselves are harmful, but which are used to achieve certain product characteristics—e.g. brominated flame retardants—can seep

from the product out into nature and into the food chain, for instance by evaporation".

- Increase the amount of *recycled and recyclable materials* in the product
  "It is a good idea to improve the possibility of recycling, for example by producing the product with few materials and by making them easily separable. At the same time, it is essential to apply increasing amounts of recycled materials in the product, since this will increase market demand for these materials".
- Optimise the product's *durability*
  "Unless the product has a very high environmental impact in the use stage, it is a good idea to make products that last for a long time, as this makes the production of new products for the same purpose unnecessary. At the same time, it is not useful to invest too much in the durability of products which are known to have a short use stage due to, for example, rapid technology obsolescence".
- Incorporate *environmental features* into the product
  "Make sure that the product is designed to reduce environmental loads, for instance by using standby functions, low-energy features or duplex features on printers".
- *Signal the product's environmental features* through the physical design
  "Make the product's environmental features visible to the user by, for example, placing the standby button on the front of the product or by setting the duplex mode as default in the printer driver settings".
- Maximise the use of *sustainable resources and supply chains*
  "Is there a link between recyclability of the product and use of recycled materials in the production? Do we know the origins of the materials and resources we use (with respect to both environmental and ethical standards)? Have we considered alternative materials on the merits of their environmental performance?"
- Optimise the product's *performance*
  "It is environmentally advantageous to combine several complementary functions in one product and to focus on the effectiveness of the product as a whole. The customer will evaluate the product's value, based on both its usability and its ability to efficiently meet a specific demand/desire. High perception of utility often leads to efficient use and increased durability of the product".
- *Design the life cycle first* and then the product
  "By thinking through all stages of the life cycle, one can achieve a very good understanding of the environmentally relevant properties the product must have, and these are then taken into account in the development process. Products which are developed on the basis of thorough knowledge of users' activities and needs have a better chance of achieving optimised life cycles and environmental profiles".

A simple example of the use of the above ten environmental principles would be when trying to produce an ecodesigned office chair. Following the first environmental principle (*reduce material intensity*), the ecodesigner may arrive at an ideal product concept, where the chair had very few materials, and maybe even the same materials throughout. By following a subsequent environmental principle, (e.g. *optimise the product's durability*), the ecodesigner may arrive at an ideal concept, where the chair's dimensions and materials choices were much more voluminous and hardwaring than for the first principle. The task of product development in general is dependent on creating sub-concepts that some way or other come into conflict with each other, in their ideal states, before applying compromises and design decisions, to end up at a final solution. The same idea is intended here for the environmental principles, where the creation of the final solution should be a product of the best possible consolidated solution to the principles posed. The office chair, in this example, would probably combine light-weight materials and smart structural designs, together with an easy maintenance (easy-wipe, sturdy, high scratch resistant) material choices, for as much of the chair's components as possible.

Step 7: Develop an environmental strategy

Steps 1–6 above describe an approach that isolates a product development team in an intensive ecodesign workshop-type activity. For environmental efforts, ideas and requirements to become rooted in the organisation, a strategy and prioritisation of efforts is required. Step 7 therefore prompts the product developer to reflect on the achievements gained in this activity, in order to consider which of the possible improvement proposals are worthy not just of the product currently being ecodesigned, but of being integrated generally into the company's product development process.

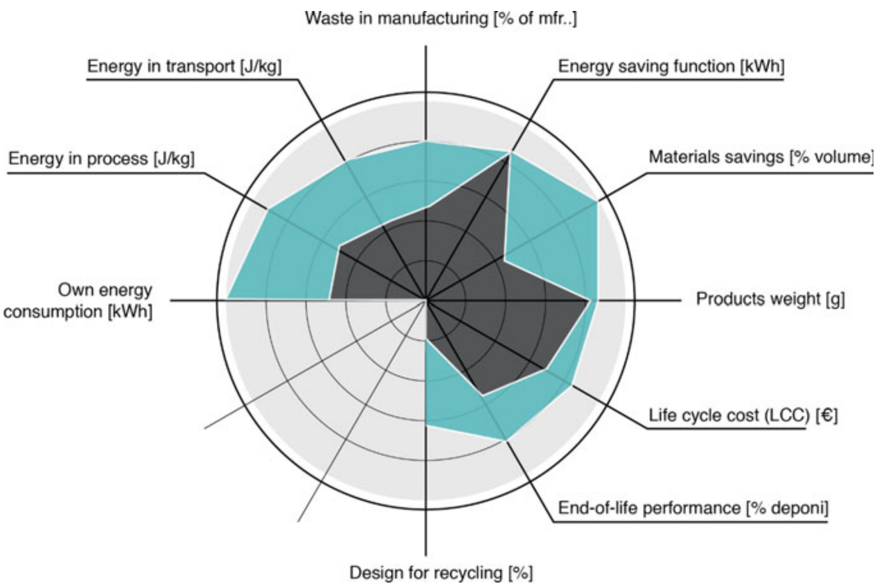

Fig. 23.6 First attempt at ecodesign strategy

The last task in this approach is therefore to decide on an environmental strategy, by using the product that has been the case of consideration for the first six steps in the approach, to attempt a generalisation of the environmental product development effort for the whole company. In the first instance this will have to be sketched out; later on it can be refined and made concrete, so that it can become a part of the company's strategic foundation and action plan.

Figure 23.6 shows an example of an initial sketch of an ecodesign strategy for a company. The next task is to begin to put real numbers and improvement goals onto the strategy wheel, in order to create a set of concrete ecodesign improvement goals for the company for an agreed period. The grey area represents the current profile, and the green area represents the targets for the future.

23.6 Final Remarks

This chapter has focused on the process of ecodesign in a company context. It has paid particular attention to the role that LCA plays in the ecodesign activity, and where the interplay between LCA and ecodesign can be optimised, to create efficient and effective improvements to products, processes and systems. It can be seen that a careful and systematic approach to integrated analysis (LCA) and synthesis (ecodesign) is optimal in order to achieve environmentally enhanced solutions through the ecodesign activity.

The chapter has discussed just a few examples of methods and tools, but has demonstrated through categorisation, that there are ways to support the product developer to choose the most suitable methods and tools according to the type of product, stage of the product development process and ambition of the product development team. Although, we have only scratched the surface of the many methods and tools that exist, there are several categorisations and collections of tools to be studied in literature (Pigosso et al. 2011a, 2014; Bovea and Pérez-Belis 2012).

Finally, a generic ecodesign process has been described. This process was chosen for this chapter due to its simplicity, to its balancing of analysis and synthesis, and because it has been tested in industry. It is important to remember, however, that it is seldom in an established manufacturing company that one would have the luxury of being able to carry out such a dedicated ecodesign activity for every single product development project. This would probably not be the most efficient way of prioritising efforts in the company. Instead, the task of the strategic and tactical practitioners in any company ought to focus on the *integration* of ecodesign considerations into the company's existing product development process (Pigosso et al. 2013a, b). When environmental enhancements are expected on the same level as cost saving achievements, quality enhancing design efforts and manufacturability considerations, we can be sure that ecodesign is truly integrated into the organisation's way of thinking about product development, business creation, and general purpose.

This chapter has had its primary focus on the *activity* of ecodesign, and not so much on the *purpose*. From one company to the next, the purpose/ambition for carrying out ecodesign may differ, whether it be to achieve a certain ecolabel, to adhere to a given legislation, to out-compete a competitor, or to achieve the ambitious goal of circular economy. Regardless of the purpose, the activity at the level of ecodesign remains the same. For simplicity—and to be loyal to the field, this chapter has stuck to the *discrete product* as the object of ecodesign. In recent years, the ecodesign activity has broadened, from single products, through the ecodesign of more complex systems (Cluzel et al. 2012), through services or combined product/service-systems (Lindahl et al. 2014), and to ecodesign of communities and societies. For all of these newer ecodesign focus areas, the basic principles remain the same, namely focus on life cycle; attention to a healthy balance of analysis and synthesis; choice of most suitable methods and tools; and application of common product development good practice, in order to achieve promising results. The good news is that the vast majority of methods, tools and guidelines for ecodesign now exist. The large and exciting task remains in mastering how to deploy an ecodesign process that results in environmentally excellent improvements, which are also great successes on the marketplace!

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