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Eco-design

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1.1. What are we talking about?

The economic development that accompanied the Industrial Revolution in the 19th century brought about a profound change in product design. From an artisanal approach, combining design and manufacturing and, most of the time, carried out by the same person, we moved to a much more scientific approach, organized around three successive functions: design (design office), implementation of this design (methods office) and manufacturing (factory). For a long time, product design was the preserve of design offices and engineers.

During the 20th century, while many advances were noted in the systematization and in the rationalization of the design process, the environmental dimension remained limited to curative actions (reduction of effluents and polluting emissions). In the 1990s, ecological concerns and the development of life cycle analysis of products allowed the approaches around the design of products to be reconsidered. This life cycle analysis has since been completed by the social life cycle analysis[1] which takes into account social and societal parameters in addition to environmental parameters.

Awareness of the environmental and social impact of products at all stages of their life cycle is leading researchers, politicians and manufacturers to look at alternative product design solutions. The idea of developing products with a lower impact on the environment and society is beginning to gain ground. Initially seen as a mechanistic way of solving the environmental problem, the concept of eco-design

1 https://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/social-lca/

will quickly evolve to integrate the human dimension by combining the method of product development (conception) and the use that is made of it (design). Taking into account the impact of the product on the environment over its entire life cycle (use of resources, waste, etc.) is completed by a reflection on the needs to which the product responds and on the use made of it by humans and its impact on society. The solutions that can be developed by combining these two issues radically challenge the traditional approaches to product design. Eco-design is based on the theory of the circular economy, defined by ADEME (The French Agency for Ecological Transition) as an "economic system of exchange and production which, at all stages of the product life cycle (goods and services), aims to increase the efficiency of resource use and decrease the impact on the environment while allowing the well-being of individuals". The circular economy should globally aim to drastically decrease resource waste in order to decouple resource consumption from GDP growth, while ensuring reduced environmental impacts and increased well-being. It is about doing more and better with less. The AFNOR XP X30-901 standard[2] proposes seven areas of action for the circular economy.

– Sustainable sourcing: involves both sustainable purchasing and sustainable transportation (covered in Chapters 2 and 7);

– eco-design;

– industrial symbiosis (see Chapter 6);

– economy of functionality[3], also called economy of service, is a new business model based on the provision of a good or a product whose price is based on the rental and not the sale;

– responsible consumption;

– extension of the duration of use;

– effective management of end-of-life materials or products (covered in Chapter 6).

The relative youth of the eco-design concept explains the rapid evolution of the principles that govern it, as well as the difficulties that many companies encounter in following this evolution[4]. In this book, we refer to the definition used by the French Ministry of Ecological Transition:

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2 https://normalisation.afnor.org/en/?s=circular+economy

3 https://economiedefonctionnalite.fr/en/in-practice/

4 This diversity and these evolutions can be found in the definitions of eco-design. The eco-design cluster and the European network ENEC have identified 34 different definitions of eco-design in the literature (https://www.eco-conception.fr/static/definition-de-leco-conception.html).

> [...] eco-design consists of integrating environmental protection into the design of goods or services. It aims to reduce the environmental impacts of products throughout their life cycle: extraction of raw materials, production, distribution, use and end of life. It is characterized by a global vision of these environmental impacts: it is a multi-stage (taking into account the various stages of the life cycle) and multi-criteria approach (taking into account material and energy consumption, discharges into the natural environment, effects on the climate and biodiversity).

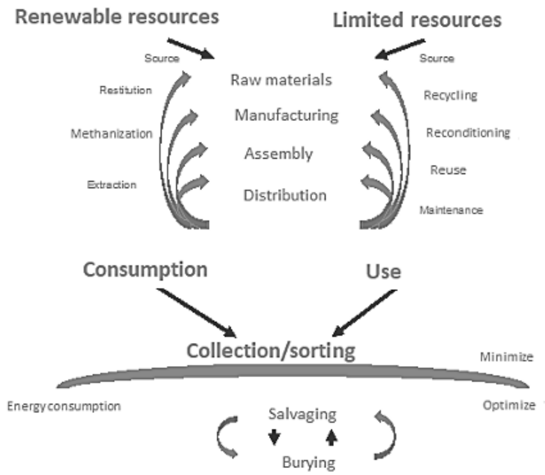

Figure 1.1. *Circular economy diagram adapted from the Ellen MacArthur Foundation. For a color version of this figure, see www.iste.co.uk/jaegler/sustainable.zip*

1.2. Why is this so?

In 2021, the ADEME in its barometer on the "Practices and positioning of French companies", noted an important evolution in the practices of eco-design by French companies[5]. The growth in the number of eco-design projects in companies as well as the anchoring of this approach in their strategic plan demonstrate by this

5 https://www.economiecirculaire.org/articles/h/ademe-barometre-ecoconception-2020-pratiques-et-positionnements-des-entreprises-francaises.html#:~:text=Communiqu%C3%A9%20de%20presse%20ADEME%20%2D%20f%C3%A9vrier%202021&text=It%20r%C3%A9v%C3%A8le%20that%20the%20majority%C3%A9,products%20submitted%20on%20the%20march%C3%A9

generalization, the growing importance of this new practice. What are the reasons for this craze?

1.2.1. *An economic challenge for the company*

The implementation of an eco-design approach in a company often results very quickly in better control of costs, or even in a reduction of the latter. Taking into account the whole life cycle of the product allows us to optimize the costs in each phase, from the acquisition of the raw material to the recycling or the revalorization of the product at the end of life. In an eco-design logic, the choice of raw materials or components can be made with a view to increasing the reliability of manufactured products, that is, by improving their reliability or reducing maintenance interventions. Taking into account – from the beginning – logistic constraints or aspects related to energy consumption is also a factor of savings. Eco-design is one step in a virtuous circle. Thinking about recycling or revalorization of the product from the design stage makes these operations much less restrictive and often less costly for the company.

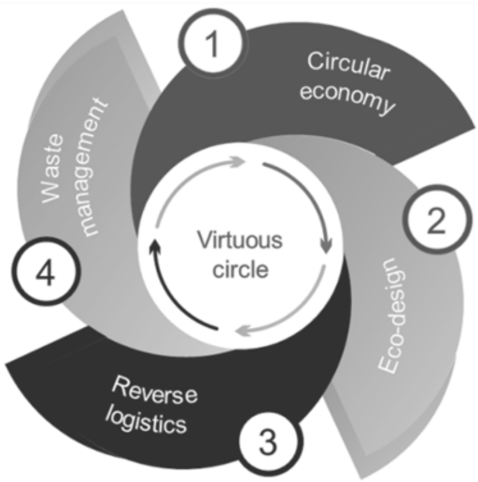

Figure 1.2. *Virtuous circle. For a color version of this figure, see www.iste.co.uk/jaegler/sustainable.zip*

1.2.2. *A commercial issue*

More and more customers are looking for environmentally friendly products. Eco-designed products are a better response to changes in consumer behavior in the face of the climate emergency[6] and consumers are increasingly showing their preference for products manufactured by companies that take environmental issues into account. Subscribing to an eco-design approach is likely to reinforce the attractiveness of the company's products and increase its turnover.

1.2.3. *A challenge for innovation*

In connection with the commercial issue, eco-design can represent a real innovation lever and thus reinforce the competitive position of the company within its current markets while also giving it access to new markets. The very principle of eco-design is based on the permanent search for innovation. Questioning the processes involved in creating and using products imposes the search for new paths and allows us to explore opportunities that have not been exploited until now.

1.2.4. *An image issue*

Awareness of the environmental emergency allows eco-design to benefit from a very positive and valorizing image among the public and among stakeholders. Thus, the company's ability to display its eco-design achievements often gives it a platform in the media and the possibility of multiplying the impact of communication.

1.2.5. *A risk management issue*

By rethinking the product life cycle, eco-design also makes it possible to highlight certain risks that were not previously identified as such. Taking into account regulatory constraints allows the company to be less exposed to the risk of not respecting legal constraints. Economic or operational risks are also better taken into account by considering product life cycles. Society's sensitivity to environmental issues can represent a real trap for companies that do not properly control their communication and image, leading to denigration operations on social networks or boycotting[7]. A major risk is also the scarcity of resources. The three main resources used are water, sand and fossil fuels. Eco-design can limit this risk.

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6 In a study published in 2021 by CITEO, in the face of the environmental emergency, 61% of French people consider it essential to produce better and consume better and 59% of them say they integrate the environmental dimension into their purchasing behavior (https://www.citeo.com/le-mag/infographie-quest-ce-que-la-consommation-responsable-pour-les-francais).

7 Some mobile applications such as Yuka, ZEI or Clearfashion rate the behavior and products of companies according to eco-responsibility criteria.

1.2.6. *A challenge of internal mobilization*

Commitment to an eco-design approach is also a marker of citizenship. The company's commitment to concrete and visible actions in favor of eco-responsibility is likely to promote employee fulfilment, strengthen team cohesion and its ability to attract new talent. Eco-design is by nature experienced internally as an approach that enhances the company's image with its stakeholders and represents an additional motivating factor for employees. In a less apparent way, eco-design, through the inter-functional exchanges it imposes in its processes, is a vector of collaboration between departments, resulting in fewer internal disputes and better fluidity in the company's operations.

By the differentiation it allows and by dynamism and innovation, eco-design can be considered a real lever for value creation for companies.

1.3. Institutional, legal and normative framework

Public authorities' awareness of the need to regulate purchasing practices in order to move towards a more sustainable dimension is recent, but it has given rise over the last 10 years to a significant body of regulations and legislation, standards and labels.

1.3.1. *Institutional framework*

The institutional framework depends on countries. Some examples are presented below. In France, two structures offer help and support to companies wishing to engage in eco-design.

– The *Agence pour la transition écologique* (ADEME)[8], a governmental agency which, among its missions, informs and advises companies on the methods that can be deployed to carry out an eco-design approach.

– *Pôle Eco-conception*[9], created in 2008, is an association that brings together manufacturers. The missions of the association are to support the development of sustainable consumption and production. The association supports companies in their objectives of improving their performance and creating value through life cycle thinking while reducing environmental impacts. Eco-design is obviously at the heart of *Pôle*'*s* approach.

8 https://www.ademe.fr/en/frontpage/

9 https://www.eco-conception.fr/

In the UK, the Ellen MacArthur Foundation is a reference in terms of circular economy. The foundation regroups more than 250 organizations and proposes reports, case studies and a tool to measure the circularity of a product.

In Germany, the Federal Environment Agency[10] developed an eco-design kit and created an eco-design award with a criterion matrix.

In the US, the USAID (U.S. Agency for International Development) has a program called SURE (Scaling Up Renewable Energy) promoting the circular economy. One of their white papers is named “clean energy and the circular economy”.

1.3.2. *Legal framework*

Eco-design is a voluntary approach. As such, there are few direct regulatory constraints to frame it in French legislation. At the European level, there are, however, some directives setting eco-design objectives for member states.

At the French national level, the legislation does not directly mention eco-design but it encourages it by the framework it imposes.

– “Extended Producer Responsibility” (*Responsabilité Elargie du Producteur*, RPE) is a principle that appeared in the legislation in 1975 in Article L. 541-10 of the Environmental Code by imposing on producers the treatment of their waste. In 1992, the scope of this extended producer responsibility included household waste[11] and then extended to many other sectors (electronic equipment, paper, batteries, etc.). In 2020, the AGEC Law (Anti-waste and Circular Economy, *Anti-gaspillage et Economie Circulaire*)[12] marked an important evolution by generalizing the change of model by imposing on companies the treatment of their waste as well as to reduce their production of waste by prevention, thus opening the door to the concept of eco-design.

– The law “Reducing the Environmental Footprint of the Digital Economy in France” (*Réduire l’Empreinte Environnementale du Numérique en France*, or REEN law)[13] published on November 15, 2021, takes a further step towards eco-design in the digital economy sector by requiring players in the sector to commit to eco-design.

10 https://bundespreis-ecodesign.de

11 Decree of April 1, 1992 on household packaging: https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000175185/

12 https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000041553759/

13 https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000044327272

At the European level, four directives concern eco-design:

– Directive 2002/95/EC of January 27, 2003[14] known as ROHS (Restriction of Hazardous Substances) prohibits the use of certain hazardous substances.

– Directive 2002/96/EC of January 27, 2003[15] known as WEEE (Waste Electrical and Electronic Equipment) requires the collection, treatment and recovery of all waste.

– Directive 2005/32/EC of July 6, 2005[16] defines the requirements for eco-design.

– Directive 2018/851/EC amends directive 2008/98/EC on packaging and packaging waste. It classifies packaging into three categories: primary packaging intended for the consumer, secondary packaging grouping products either for the customer or for the point of sale, tertiary packaging designed for handling and transport excluding transport containers.

Outside the European Union, many countries have developed specific legislation around eco-design, such as the UK, where a set of regulations covers the eco-design of energy-intensive products, imposing a number of constraints on manufacturers to access the British market. These regulations, which aim to reduce the environmental impact associated with the manufacture, use and disposal of these energy-intensive products, also concern those that have an impact on energy consumption. They require manufacture and importers to ensure that their products meet these requirements. Many countries, including the United States, China, Japan and Brazil, also have a legal framework adapted to the eco-design and energy consumption of products on the market.

1.3.3. *Normative framework*

Two ISO standards have been built around eco-design:

– ISO 14062: Environmental management – Integrating environmental aspects into product design and development[17]. This standard aims to meet the objectives of sustainable development. It is intended for designers and developers of products, in order to propose a number of principles for integrating environmental concerns into

14 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0019:0023:fr:PDF

15 https://eur-lex.europa.eu/resource.html?uri=cellar:ac89e64f-a4a5-4c13-8d96-1fd1d6bcaa49.0007.02/DOC_1&format=PDF

16 https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000000882019

17 https://www.iso.org/obp/ui/#iso:std:iso:tr:14062:ed-1:v1:en

the design and development process. This standard is available at the French level with the experimental standard AFNOR NF XP X 30-262.

– ISO 14040: Environmental management – Life cycle assessment – Principles and framework[18] specifies the principles and framework for conducting life cycle assessments. It aims to meet Sustainable Development Goal 13.

1.4. Best practices

Eco-designing a product is a process of anticipation that allows us to project ourselves at each stage of its life and use. This reasoning implies a good understanding of the complete life cycle of the product in a logic that is at the same time defective, creative and innovative.

– Is there waste? Redundancy? Inappropriate use of processes that are unnecessary or could be simplified?

– Is it possible to improve the life of the product, its reparability?

– What are the solutions to reduce the amount of energy used in its production and in its use?

– How can the repackaging or refurbishment of the product be facilitated?

– How can its recycling be simplified?

The best practices around eco-design are numerous and most often associated with a sector of activity or a category of products (agri-food products, electronic products, ready-to-wear, services, etc.) (Bordage 2019). The details of the practice of eco-design by sector are not mentioned; however, three best practices are presented in this chapter with the objective of allowing us to initiate and action in favor of eco-design in each industry:

1) implement a product life cycle analysis;

2) implement an eco-design approach;

3) eco-design packaging (see also Chapter 5).

1.4.1. *Best practice 1: Implementing a product life cycle analysis*

All definitions of eco-design refer to the life cycle of the product. The life cycle analysis (LCA) can be a prerequisite to launch a reflection on the eco-design of a product. It can also have a comparative objective. An LCA of a product implies, first

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18 https://www.iso.org/standard/37456.html

of all, identifying and understanding each of the stages and then analyzing the constraints and specificities. These analyses, specific to each product, are a prerequisite to the implementation of an eco-design approach. The ISO 14040 family of standards provides us with a methodological guide to build this best practice[19]. An LCA has three main phases: definition of the framework, identification of input and output flows, and identification of impacts. Each of these phases is completed by an interpretation of the results.

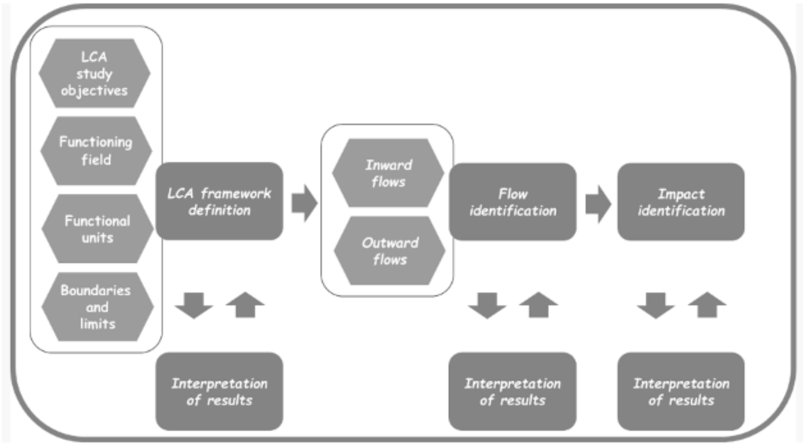

Figure 1.3. *Life cycle assessment. For a color version of this figure, see www.iste.co.uk/jaegler/sustainable.zip*

Step 1 defines the framework of the LCA. This initial phase is intended to set the rules of the analysis (ISO 14041) and to identify the functions that will be studied in the LCA. Definition of the functional field is based on the functional analysis methods[20]. The functional analysis allows us to express the need and then to confront the need with the context of its use in order to define the service functions which will then be transformed into technical functions. A product can have several functions and each of them must be identified. The main function of a lighter is to provide a flame, but this main function can be completed by complementary

19 ADEME presents this best practice on its website dedicated to eco-design (https://www.ademe.fr/expertises/consommer-autrement/passer-a-laction/dossier/lanalyse-cycle-vie/comment-realise-t-acv).

20 Several functional analysis methods can be used, including the APTE® method (http://www.methode-apte.com/) or the SADT method (https://www.techno-science.net/definition/677.html).

functions: grip, capacity of the reservoir, safety (not burning fingers), ease of storage, absence of odor, etc. If we take the example of a city bike, its main function is to allow the cyclist to move. Its complementary functions are being comfortable, easy to maneuver, resistant to bad weather, reasonably priced and able to support accessories.

What are the functional units to be used to evaluate the service rendered by the product? The functional unit corresponds to a unit of measurement. For the example of a lighter, the functional unit can be the number of possible ignitions. For a car, life span in number of kilometers, for a washing machine, life span in number of washing cycles, for a light bulb, life span in number of hours of lighting. What is the reference flow? The reference flow is used to determine the quantity of consumables used by the product to cover the needs of the unit.

Another analysis concerns the boundaries of the system under study. In other words, what are the elements of the system that will be studied? This first step concludes with validation of the approach or possibly redefinition of the scope of the analysis.

Step 2, the life cycle inventory, consists of establishing the balance of the incoming and outgoing flows necessary to manufacture a product or a system. All of the flows will be counted with the functional unit chosen in the previous step. The input flows include raw materials, energy resources and transport used for all stages of the life cycle. The outflows counted include atmospheric or liquid effluents, solid waste and all other discharges and co-products. To perform these calculations, two categories of data are required: activity factors (kilometers driven, tons or cubic meters transported, kWh equivalent consumed, etc.) and emission factors expressed in grams of chemical components emitted into the air or water. This step is particularly delicate because the risks of error are significant. The use of dedicated LCA software reduces this risk[21]. At the end of this second phase, the interpretation of the results obtained may require new data to achieve validation.

Step 3 is the identification of impacts. On the basis of all the flows identified in the second phase and according to the reference flows, the identification of impacts consists of evaluating the potential impacts on human health and on the ecosystem. These analyses can be detailed in each category with, for example for the environmental impact, more detailed analyses of climate change, depletion of mineral and/or fossil resources, air acidification, etc.

21 The eco-design cluster offers on its website a selection of LCA software (https://www.eco-conception.fr/data/sources/users/9/docs/selection_de_logiciels_d’acv.pdf).

1.4.2. *Best practice 2: Implementing an eco-design approach*

To implement an eco-design approach[22], the Brezet wheel (Brezet and Van Hemel 1997) proves to be an efficient and quick tool to implement for steering the team of an eco-design project.

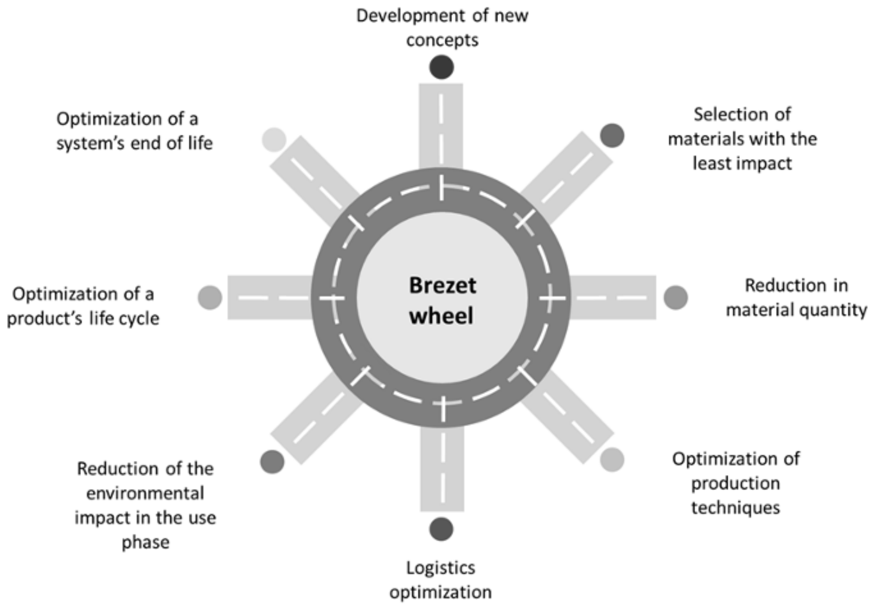

Figure 1.4. *Brezet wheel. For a color version of this figure, see www.iste.co.uk/jaegler/sustainable.zip*

A Brezet wheel is divided into eight steps.

– The development of new concepts focuses on the way the service is delivered such as dematerialization[23], shared use[24], and biomimicry[25] or functional optimization[26].

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22 https://www.eco-conception.fr

23 Such as the digitization of certain services or the design of digital services with low environmental impact.

24 The pooling of certain resources or transport, for example.

25 For example, the "nose" of the Shinkansen (Japanese TGV) is inspired by the aerodynamics of the kingfisher's beak. The shape of some surfboards is copied from the fins of some fish.

– The second step concerns raw materials. It is a question of using less toxic, renewable, recycled, recyclable, less energy-consuming materials, etc.

– The third step aims to reduce the use of raw materials, whether by mass or volume, by designing differently or by rationalizing.

– The fourth step aims at optimizing production techniques. Production activities must be less energy-intensive, create less waste, reduce the use of consumables and select less polluting ones.

– Step five tends to optimize logistics for both packaging and transport (see Chapters 5 and 7).

– Step six aims to reduce the impact during the use of the product (energy, consumables, waste, etc.).

– Step seven aims at optimizing the product's life span through its durability and reliability, ease of its maintenance, and strengthening of the user/product link. However, once these seven steps have been considered, the product may reach the end of its life.

– The last step is to optimize this end of life through upgrades, reuse, recycling, easy disassembly for recycling, biodegradation, for example.

1.4.3. *Best practice 3: Eco-design of packaging*

Packaging products account for 8% of the carbon footprint in the purchase of a consumer product[27] and 5,000 kilotons of household packaging are thrown away each year in France[28]. To address the environmental issues related to packaging, the National Packaging Council[29] has created a methodological guide consisting of 26 questions. Chapter 6 explains in detail how to package in a sustainable and responsible way.

The objectives of a company's approach to eco-designing its packaging are often convergent with those of other eco-designed products: improving recyclability, reducing quantities purchased and costs, and better satisfying consumers. Some objectives are complementary to the previous ones, such as promoting sorting

26 The work around the improvement of certain functions can be focused on the reduction of waste during the use of the product or at the end of its life, the reduction of pollution or the reduction of materials necessary for its manufacture or energy necessary to its operation.

27 CGDD no. 121, April 2012.

28 https://www.planetoscope.com/recyclage-collecte/694-.html

29 https://conseil-emballage.org/en/

among consumers through appropriate marking. Based on an LCA[30], the eco-design unit[31] offers a complete guide to eco-designing packaging[32]. The approach described offers a set of strategies that can be combined to reduce the environmental impact of packaging through eco-design. These strategies cover, in particular, the choice of materials and quantities used (both in thickness and in the shape of the packaging itself), the reduction of the quantities of energy used, the choice of packaging solutions that reduce logistical constraints and take into account new forms of distribution and collection of packaging, solutions to reduce food waste and facilitate sorting, etc. The guide also proposes calculation and analysis methods to optimize packaging choices as well as specific key performance indicators.

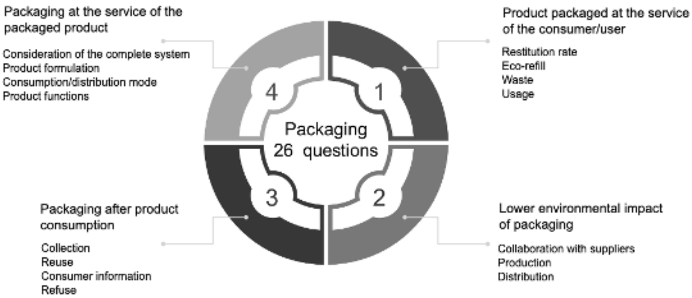

Figure 1.5. *Eco-design of packaging. For a color version of this figure, see www.iste.co.uk/jaegler/sustainable.zip*

1.5. Measuring eco-design performance

In principle, an eco-design approach involves modifying the existing design process in order to reduce its ecological footprint. At first glance, evaluation of the performance of such a process may seem simple. The comparison of the eco-designed solution with the initial situation seems to be sufficient to validate, or not, the sustainable performance of the approach. Beyond this apparent simplicity, two questions must be asked.

1) What is the basis for measuring the comparative performance of the two solutions?

2) Are there impact transfers that may distort the apparent results?

30 See Eco-design – **Best practice 1**.

31 https://www.eco-conception.fr/static/eco-conception-des-emballages.html

32 The packaging eco-design guide can be downloaded from the following link: https://www.eco-conception.fr/library/h/guide-eco-conception-des-emballages.html

Before answering the first question, it is necessary to verify that the two solutions correspond to the same functionalities, that is, meet the same uses with an equivalent service. The performance of an eco-design solution is measured through the impact generated by the solution on its environment. This is mainly the impact on the carbon footprint and the water footprint[33]. More precisely, the impact can be measured in terms of greenhouse gas emissions, air, water or soil pollution, resource depletion, ozone layer depletion, reduction of biodiversity, alteration of habitats or eutrophication of lakes. These impact measures concern both the eco-designed product or service and the site[34] used to obtain the eco-designed product or service. A French initiative is a reparability index, which represents an axis of eco-design. Article 16-I of law no. 2020-105 of February 10, 2020 for the fight against waste and for the circular economy imposes the compulsory display of this index for electrical and electronic products[35]. This index, which corresponds to a scale of 1–10 (from the least repairable to the most repairable), informs consumers of the impact of breakdowns on the life span of the appliances they buy. The calculation of the index is based on five criteria:

– documentation (the score depends on the length of the manufacturer's commitment to make technical documentation of the device available to repairers and consumers);

– the ease of disassembly and access to parts and fasteners score measures the ease of disassembly operations and the specificity of the tools to be used;

– the spare parts availability score is determined by the length of the manufacturer's commitment to make spare parts available and the time it takes to make them available;

– the spare parts price score is the ratio between the price of the parts and the price of the product;

– depending on the product category, it is possible to determine an additional specific score.

An analysis of possible impact transfers necessarily complements the measurement of performance, as it is often the case that the improvements undertaken during an eco-design process have a positive impact on the environmental footprint indicators during one of the stages of the life cycle, but that it generates more negative results

33 Measures of these two footprints are presented in the chapter "improving your performance".

34 It can be an industrial site as well as more widely the right-of-way represented by the construction of new infrastructures.

35 https://www.ecologie.gouv.fr/indice-reparabilite

at another stage of this life cycle. For example, extension of a product's life span may be made possible by the use of a more environmentally toxic material.

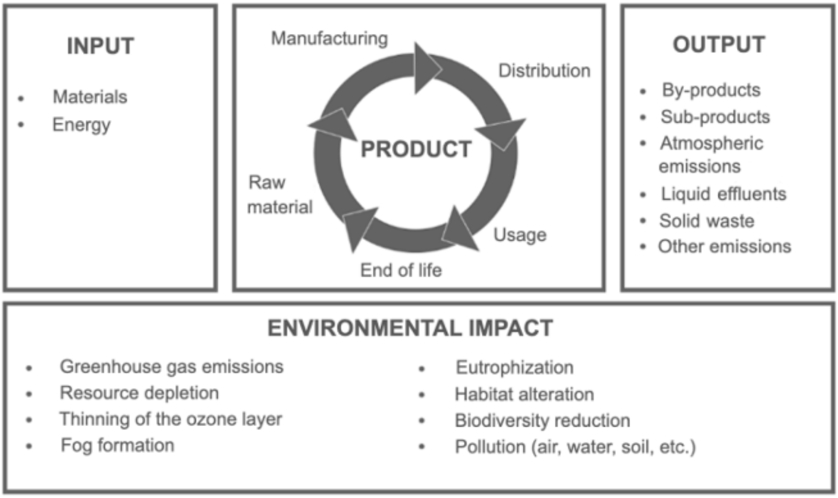

Figure 1.6. *Assessment of the environmental impact of inputs and outputs (source: AFNOR (2005)). For a color version of this figure, see www.iste.co.uk/jaegler/sustainable.zip*

Eco-design concerns both the product itself and the impacts identifiable at all stages of its life cycle. There are many examples of eco-design, such as end-of-life and reverse logistics (see Chapter 6). Larose Trintaudon has reduced the weight of its bottles. This has had an impact on resource consumption, as well as on transport emissions thanks to lighter loads. The textile sector faces many environmental challenges. Levi's has worked for five years to come up with new, more sustainable jeans. It is made of organic or recycled materials and is fully recyclable. The water consumption to produce it has also been drastically reduced. Other sectors are also particularly scrutinized, such as digital technologies. Fairphone has designed cell phones with fair trade materials. Overall, 40% of the plastic used is recycled. The product's lifespan is extended thanks to its reparability index, which ranges from 8.7 to 9.3 out of 10 depending on the product. The battery can be replaced by the user, and the connectors are universal. Finally, any product recovered is fully recycled. Having a smartphone today means using the Internet and consulting websites. We must therefore also take into account the impacts related to these uses.

Box 1.1. *Eco-design*