“Eco-tool-seeker”: A new and unique business guide for choosing ecodesign tools

Patrick Rousseaux a,⁎, Cécile Gremy-Gros b, Marie Bonnin b, Catherine Henrivel-Ricordel c, Pierrick Bernard d, Léa Floury a, Gwenaelle Staigre f, Philippe Vincent b

a Université de Poitiers, Institut Pr’prime, CNRS UPR 3346, BRIAF, 11 rue Archimède, 79000, Niort, France
b Université d’Angers, Laboratoire Angevin de Recherche en Ingénierie des Systèmes (EA 7315), 62, Avenue Notre Dame du Lac, 49000, Angers, France
c École des Métiers de l’Environnement, Campus de Ker Lann, 35170, Bruz, France
d Eco Engineering, 104 avenue Général Leclerc, 6100, Alençon, France
f Chambre de Commerce et d’Industrie Bretagne, Enterprise Europe Network, Direction Innovation, 19 avenue Charles Tillon, 35000, Rennes, France
e Chambre de Commerce et d’Industrie Pays de la Loire, Enterprise Europe Network, Direction Innovation, 16 quai Ernest Renaud, 44100, Nantes, France
b ADEME, Direction régionale des pays de la Loire, 5, Boulevard Vincent Gâche, BP 90302, 44203, Nantes Cedex 2, France

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Environmental sustainability has emerged as a key issue amongst governments, policymakers, researchers, companies and the general public. In Europe, governments are trying to encourage companies to integrate ecodesign into their processes. A great variety of ecodesign tools exists but the actual implementation level of such tools remains limited or not successfully integrated throughout the different company processes. Having identified the main barriers to ecodesign implementation, this article provides a literature review of the existing tools that can be used in various company departments. From this review, 629 tools were found and characterized. Taxonomy was established to classify these tools into 22 categories of ecodesign tools and 5 departments in companies. These tools are classified as normative or non-normative which can be generic or sectorial as well as “environmental” or “improvement”. A guide (or information system) has been then developed to help companies to choose ecodesign tools for three targets: production, management or communication. The proposed guide can also be useful for researchers, teachers, and trainers. In order to facilitate these choices, a free computerized version of this guide, called “Eco-tool-seeker”, has been developed.

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1. Introduction

Environmental protection as defined today, was first formalized at the international level in 1902 with a convention signed in Paris by nine countries aiming to protect “birds useful for agriculture” (IEA, 1902). Another convention, the International Conference for the Protection of Fauna and Flora, was adopted in 1933 in London, to protect species threatened with extinction and to recognize protected areas such as national parks. However it was not before the 1972 Stockholm Conference that the current legal framework for environmental protection was first drawn up (UN, 1972). Since then, an international conference on the subject has been held every ten years or so.

Such recognition from international institutions is concomitant with the increasing attention paid by civil and scientific societies (IPCC, 2007, 2013, 2014): global warming, depleting of resources, pollution of all sorts, climatic and technological catastrophes as well as their collateral economic and public health consequences have slowly made non-governmental organizations, associations, political representatives and the general public more and more aware of the necessity to protect and preserve the environment. In addition, numerous scientific reports, among the most recent (Adua et al., 2015; Speirs et al., 2015; Awasthi et al., 2016; Cai et al., 2016; Malik et al., 2016; Sun et al., 2015; Wang et al., 2016; Xie et al., 2016), have made it clear that human activities, if they have not created, have at least quickened and aggravated environmental problems and therefore political, legal and jurisdictional measures should be taken — both at global and local scale — in order to reduce, stop and perhaps compensate the violations to the environment made by mankind.

⁎ Corresponding author.
E-mail address: patrick.rousseaux@univ-poitiers.fr (P. Rousseaux).
The recent growing mobilization of politicians and public opinions into public debates, demonstrations and events has shown a real and pioneering will to protect the environment in almost every layer of Western society. Nevertheless, that positive involvement seems to be difficult to convert into concrete solutions within the industrial sector with little time and resources to allocate to environmental approaches (Van Hemel and Cramer, 2002). Thereupon it is becoming crucial to provide ways and techniques to allow every company to develop new behaviors which are more respectful and less destructive of the environment.

One solution is called ecodesign or design for environment, which has been evolving since the 1990s in Europe (Roy, 1994; Van Hemel and Brezet, 1997). Indeed, the idea of thinking about a product and its whole life cycle from design to destruction, focusing on reducing its impacts on the environment, is well accepted and even recognized and prescribed by European regulations (European Communities, 2001).

Today, the literature on ecodesign is relatively abundant but focuses on the scientific concepts and technical tools (Rossi et al., 2016). According to Brones et al. (2014), there is very little research on the applicability and practical implementation of these tools within companies, while the purpose of research in ecodesign is precisely to apply them in companies. For examples: Brones et al. (2014) proposed to include environmental aspects in project management procedures in order to develop ecodesign in companies; Andrae et al. (2016) presented and applied a practical method based on PDCA (Plan—Do—Check—Act) and different Ecometrics to eco-design electronic devices. PDCA, also known as the Deming wheel, is an iterative four-step management method used in quality department for the control and continual improvement of processes and products.

More than being an intellectual approach, ecodesign should be a state of mind or a reflection of its profitability for business. Ideally, the environment should be integrated into the daily routines of companies, and even then, it would still be necessary to ensure ecodesign tool accessibility so that companies would be able to make their own EDT. The main purpose of this manuscript is to provide a guide to help companies to choose the most appropriate EDT according to their needs. This guide does not only apply to industrial and engineering designers, but also to company stakeholders, regardless of company type; so that it can help integrate ecodesign as an operating principle in the functions (or departments) of a company. Its successful adoption requires easy access to different types of EDT.

2. Background

As proposed by Bansal and Roth (2000), three arguments should motivate companies to think of environmental initiatives:

1. **Legitimization**, or the wish to improve the suitability of a company's actions within an established set of regulations, standards, and values: Regarding product specifications and waste management, additional regulations have been introduced at the European level. Such legislative measures notably include:
   - Directive 2005/64/EC on the type-approval of motor-vehicles with regards to their reusability, recyclability and recoverability (2005);
   - REACH Regulation for the safe use of chemical substances (2006);
   - Restriction of the Use of Certain Hazardous Substances Directive (2002 and revised 2012) regarding the ban of hazardous substances in electrical and electronic equipment;

Different pro-environmental political measures have also been introduced at European and international levels, including:
   - Extended Producer Responsibility concept introduced by Lindqvist and Lidgren (1990) and adopted by the OECD (2001);
   - Integrated Product Policy (2001);
   - Integrated Pollution Prevention Control (2008);
   - Primary Energy Factor (2012).

2. **Competitiveness**, or the wish to improve the potential for profitability: Systematic consideration and integration of environmental aspects during product development can be considered essential in order to achieve overall environmental performance which could be improved by an approach known as ecodesign. Economic profits that may be earned when improving the environmental performance of products and processes can be considered as an additional lever (beyond regulation, market competition and consumer demand) for companies moving towards sustainable practices and development (Baumann et al., 2002; Bey et al., 2013).

3. **Moral responsibility**, or the wish, as a functional entity within macro-economic, social and natural environments, to meet social obligations: According to Boks (2006) and Brones et al. (2014), it can be acknowledged that there is a rising pressure on companies to act in a more responsible and sustainable way regarding their products and production processes, to assess

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1. The European Commission published its Green Paper which outlined the rationale for developing product-related environmental policies; the Commission finally adopted its long-awaited communication on IPP opting for a more voluntary approach to greener products. IPP seeks to minimize environmental degradation caused by products throughout their whole life cycle.
2. The European Commission applies an integrated environmental approach to the regulation of industrial and agricultural activities with a high pollution potential.
3. Directive 2012/27/EU on energy efficiency establishes a default coefficient of 2.5 which may be applied by Member States when transforming electricity savings into primary energy savings.
their overall impact on the environment and to provide more environmentally friendly goods and services.

A great number of “EDT” has been developed with the aim of fulfilling these wishes. The concepts of ecodesign were internationally installed in 2003 with the publication of ISO/TR 14062 (AFNOR Ed., 2003). It states that the ecodesign aims to “integrate environmental aspects into product design and development products”.

Subsequently, in 2009, Directive 2009/125/EC specifies requirements ecodesign and sets ecodesign as “the integration of environmental aspects into product design to improve product environmental performance throughout its life cycle” (European Parliament, 2009). In 2002, more than 150 tools were identified by Baumann et al. (2002) and thirteen years later, with the same tool definition, Pigoso et al. (2015) listed 350 of them. Despite the many existing EDT, their use in companies is still limited as originally highlighted by Baumann et al. (2002). Except for some large multinational companies (particularly in the fields of electrical and electronic goods, packaging and motor vehicles) ecodesign plays a small role in our economy, particularly considering SMEs, which make up the vast majority of businesses (within the EU, they represent 90% of all businesses) (European Commission, 2016). It is also often and widely quoted that SMEs probably contribute up to 70% of all industrial pollution (Groundwork, 1995).

In 2010, a survey of 373 companies commissioned by the ADEME, investigated the level of integration of ecodesign in French companies (Appendix A). Its conclusions show that most companies were not feeling concerned about ecodesign, either because they had no interest in it (22%) or because they did not design their products themselves (16%).

At least twenty-five reasons exist for the low implementation and integration of EDT (De Araujo, 2001; Hillary, 2004; Lindahl, 2005, 2006; Lofthouse, 2006; Le Pochat et al., 2007; Seidel et al., 2008; Bovea and Pérez-Belis, 2012; Bey et al., 2013; Vallet et al., 2013; Zhang et al., 2013; Poulikidou et al., 2014). Rossi et al. (2016) classified these reasons into 5 categories: 1-Lack of resources (time, economic, staff) for companies, 2-Great qualitative and quantitative variety of EDT, 3-Lack of multi-objective analysis in ecodesign, 4-Lack of ecodesign interest visibility for the markets and the customers, 5-Faulty environmental legislation. Experience shows that the main reasons are (at least in France), the great number of available tools associated with a lack of procedures for supporting the assessment and selection of tools, low knowledge about them, lack of specialized or trained staff, company size (SMEs have limited financial and staff resources) and low cooperation and/or communication between company departments.

However, as stated in a communication of the European Commission (2011), resource scarcity, critical raw materials and a circular economy are key issues and ecodesign is seen as a promising instrument in European policies. As for the worldwide level, two international phenomena could soon allow ecodesign to have a wider and deeper perspective: world overpopulation and climate change.

Considering the upcoming increase in world population (+30% by 2050 to reach 9 billion people) (PRB, 2016), the pressures on the environment will rise, especially on resources increasingly coveted and used, such as raw materials (fuels, minerals, and metals), food, soil, water, and biomass. However, as stated in the Millennium ecosystem assessment (2005), natural resources are essential to the economy and highly contribute to quality of life.

It is therefore necessary to secure now, the reduction of raw material consumption thanks to ecodesign.

In the 21st session of the Conference of the Parties in Paris (COP 21, 2015), governments agreed to keep the increase of global average temperature well below 2 °C above pre-industrial levels and to pursue efforts to limit it to 1.5 °C. EDT will be part of the solution by providing ways to reduce inter alia emissions of greenhouse gases.

In France in 2011, the General Directorate for Competitiveness, Industry & Services and the Environmental Association, “Orée”, created five interregional networks of expertise in ecodesign throughout the French territory. The objectives were to:

- Federate existing stakeholder ecodesign networks;
- Harmonize skills and EDT;
- Develop and disseminate ecodesign initiatives and practices at a national level.

The entities mobilized in the regional networks are, amongst others, the ADEME (national and regional agencies), Chambers of Commerce and Industry, Associations, Regional Councils, Clusters, Companies, Associations of companies, Consultancies, Universities, Engineering schools and Research Laboratories. One of those interregional networks, called “RENO”, set up a working group in 2014 with the aim of producing an easy to use ecodesign tool guide easily usable for companies. Relying on the different skills and experience of its members, the working group has developed “Eco-tool-seeker”. In order to help companies overcome some of the barriers they face and to pursue ecodesign challenges (Dekoninck et al., 2016), this study aims mainly to present the construction, the use and the analysis of “Eco-tool-seeker”, a business guide for selecting EDT.

3. Materials and methods

To give structure to the guide, two theoretical frameworks and one method were used or developed: terminology (§3.1.1), EDT taxonomy (§3.1.2), and literature review of EDT (§3.2).

3.1. Theoretical frameworks

3.1.1. Terminology

3.1.1.1. Definition of company. The term company (or enterprise) is here considered in its broadest definition: “A company is an institutional unit in its capacity as a producer of goods and services. A company may be a corporation, a quasi-corporation, a non-profit institution, or an unincorporated enterprise. A company is an economic actor with autonomy in respect of financial and investment decision-making, as well as authority and responsibility for allocating resources for the production of goods and services” (OECD, 1993).

For the success of an ecodesign project, different departments of a company need to be represented into the team project (Cluzel et al., 2016). The departments will need different type of tools to participate into ecodesign project. The considered departments into this study are:

- Purchasing,
- R&D and Product development,
- QSE, Management and SD,
- Production and Manufacturing,
- Legal, Sales, Marketing, and Communication.

3.1.1.2. Definition of ecodesign. There are many definitions of ecodesign most having evolved over time and through feedback. This study refers to the most general definition which is as follows: “A systematic integration of environmental aspects in the design and development of products (goods, services, and systems) with the
aim of reducing the negative environmental impacts throughout their life cycle to render equivalent or better service. This approach from the upstream design process aims to find the best balance between requirements, environmental, social, technical and economic in design, and product development” (AFNOR Ed., 2013).

Ecodesign was initially considered applicable only to physical products (AFNOR Ed., 2003), while, more recently, its scope has been expanded to include services and systems (AFNOR Ed., 2013). In many cases, ecodesign is confined to the product development process, where it earns great results, but is unfortunately not used enough to run the rest of company development causing missed opportunities. To increase the environmental performance of business, ecodesign and its results should be integrated into operations of enterprises (Producing goods, Management, and Communication) and subsequently disseminated to the relevant functions or departments within companies. Those business operations, in turn, are embedded in product life cycle and everything must be assessed in accordance with the three dimensions (Economic, Environmental, and Social) of SD.

3.1.1.3. Definition of ecodesign tool. To our knowledge, the term “ecodesign tool” is not defined in any standard or regulation. In the literature, ecodesign tool is defined case by case, in the context of a publication. For example, in Baumann et al. (2002), ecodesign tool stands for “any systematic means clustering for dealing with environmental issues during the product development process”.

Considering the foregoing definition of ecodesign, an ecodesign tool is considered here as any systematic means aiming to integrate the environment into the design of a system (product, services, industrial site). The results of this integration should be contemplated considering the incorporation of ecodesign bias in the various functions or departments of companies. These tools may include laws, standards, scientific methods, computer based tools, communication guidelines, and so on. They are adapted to operational research, decision theory, environmentally and management sciences, communication expertise, and other applications. To avoid the transfers of pollution, it is admitted to take into account the life cycle concept and to consider all environmental impacts and, in some cases, several complementary EDT will have to be used.

This new definition of ecodesign tool opens up for tools that usually are outside the realm of designers but could nevertheless facilitate the integration of ecodesign in companies.

3.1.2. Taxonomy of EDT

3.1.2.1. Proposal for a taxonomy. Some authors have proposed a classification of tools. For example, Janin (2000) determined two main categories: environmental assessment categories (comprising quantitative ones and qualitative ones) and improvement categories, while Charter and Tischner (2001) proposed four categories: analysis (assessment), prioritization of improvement, aid for creativity, and aid for decision-making. Baumann et al. (2002) classified eco-tools in six categories: frameworks, checklists and guidelines, rating and ranking tools, “environmental” tools, software and expert systems and organizing tools, whereas Knight and Jenkins (2009) chose only three categories: guidelines, checklists and “environmental” tools. In a more recent work, Hernandez-Pardo et al. (2011) proposed a use-oriented classification of eco-tools. This classification was created according to three properties: complexity, type, and main function. Finally, Brones and de Carvalho (2015) proposed a conceptual framework which connects three systemic levels (macro, meso, and micro). These classifications are hardly linkable to the various functions of a company. All these classifications are generally intended for engineers and designers to help them in their search for ecodesign solutions.

Taking into account the above definitions and trying to be more comprehensive and complete, the article proposes here different categories of tools at different levels shown in Fig. 1.
At the first level are regulatory and non-regulatory tools. Regulatory tools can be mandatory or voluntary, whereas non-regulatory tools can be normative or non-normative. This defines a second level. While mandatory and voluntary are explicit enough adjectives; the boundary between normative and non-normative needs to be clarified: normative tools include texts of standards (for instance, if a company wants a certification or applicable rules, it will use normative tools to reach its wish or strategy); non-normative tools encompass all other type of texts or methods that can be needed for developing ecodesign.

Normative and non-normative tools can be generic or sectorial; this is the third level. Generic tools are applicable to all sectors, to any type of company, regardless of its size, nature, field of activity or location. Although they apply to all sectors of activity, they do not always provide a response directly applicable to a specific company. Sectorial tools are tools focused on special sector applications and provide more operational responses.

For the fourth level, generic and sectorial tools are classified between “environmental” and “improvement”. “Environmental” tools provide environmental analysis and/or result in an evaluation process in order for the impacts to be determined and in some cases quantified, while others provide weighting and prioritization of the identified impacts in order for the user to screen the most important issues that need to be considered. The fifth level, analyzes only “environmental” tools which are qualitative or quantitative tools.

Finally the sixth level examines “environmental” and “improvement” tools to determine if they are computerized or non-computerized. Computerized tools or computer based tools (software and expert systems) are similar to the methods and tools that have been presented regarding their principles and objectives but they handle enormous amounts of environmental information and are also quicker to use than non-computerized tools.

At this stage, it is important to note the possible issues concerning the classification of the tools. The difficulty here is born of the discrepancies in semantics observed between enterprise functions (or departments), tool fields and business sectors, without mentioning cultural differences. For example, legal and technical units would not reference the same tools inside the “normative” category. That is why “normative” has been used in accordance with AFNOR Ed. (2007) in order to include all references quoted in the article and not only standards. Choices and compromises had to be made while respecting a classification sometimes already chosen by a tool’s creator while trying to stay clear and relevant for as many situations as possible.

Obviously, this classification doesn’t consider what can be called “families of tools” which are linked to the very nature of the tools and are often claimed by the tools’ authors (each family regroups any type of tools in their title and/or description). These families are: ecodesign manuals, guidelines, frameworks, checklists, monitoring, exclusion lists, complete LCA (i.e. following ISO 14044), SLCA, single-criterion approaches, matrix methods, software and expert systems.

In this guide, families are used as filters to sort the results as well as types of standards (international, European, national), business sectors (automotive, chemical, food products, etc) and company functions/departments (Purchasing, R&D and Product development, QSE, Management and SD, Production and Manufacturing, Legal, Sales, Marketing, and Communication).

It has been observed that a tool might be a combination of more than one type of tool, or can regroup tools from different families, sectors and/or services.

3.1.2.2. Using the categories of tools in businesses operations. Previously stated, the aim of this article is to guide them in their research using an entry point they can easily identify: business operations (or activity areas) within their company. Thus, when using the guide, they first choose between three operations: Producing goods (Products & processes), Environmental management, and Environmental communication.

3.1.2.2.1. Producing goods. Two types of tools are found for that operation: “environmental” tools and “improvement” tools. Even if they have been characterized earlier, it is appropriate to study them more from a “products and processes” perspective (INP Grenoble, 2012; Poulikidou, 2012).

A variety of “Environmental” tools exist; they can be qualitative, quantitative or both, easy or more complex to implement, etc. Consequently, the optimal implementation stage may also vary depending on the complexity and data requirements of the tool used. It has been observed that the tools listed under these types may also vary a lot in terms of data and time requirements, type of input and output data, etc. Moreover, many of them consist only of an evaluation process in order for the impacts to be defined and in some cases quantified, while others provide weighting and prioritization of the identified impacts in order for the user to screen the most important issues that need to be considered.

The main “environmental” tools are:

- Complete LCA: This “gold standard”, following an internationally accepted LCA methodology, is indisputable from a theoretical point of view. It is most effectively used for existing products and processes and for policy related questions. However, it seems difficult to use for SMEs, as it requires much time and expertise. It is an expert’s tool above everything else, and its use concerns essentially research issues (academic research, R&D).
- SLCA: For most of the time based on the use of generic databases, SLCA proposes results expressed as an eco-indicator. Very simple assessments can be used to identify areas of focus in innovation and to suggest directions to explore. It considerably reduces the time necessary to acquire data for assessment. On the other hand, understanding the eco-indicator requires a solid knowledge base and interpreting it is the preserve of environmental specialists.
- Single-criterion approaches: These tools differ from others by the fact that they consider only one environmental impact, for example, climate change. This single-criterion approach is not in line with the principle of SD which generally considers all environmental impacts given the state of scientific knowledge.
- Matrix methods: These tools may be quantitative or semi-qualitative. The outlook of these simplified assessment tools is to limit the data collection by the user. Data are generally limited to physical dimensions such as the mass of the materials constituting the product or energy consumption. Each cell in the matrix is filled in using a series of questions designed to be answered with a simple yes or no, and scored on a scale from good to bad. The outcome of a matrix method can also be a quantitative indicator that is, however, estimated based on qualitative data or users’ assumptions. The completed matrix is used to focus attention on areas for improvement. The benefit of these matrices lies in their ease of use. However, they must be handled by an expert on environmental issues.

“Improvement” tools combine the general principles of ecodesign and the basic rules for completing a product development
project while integrating an environmental dimension. Albeit simple to use, these tools have to be handled by people having the minimum environmental knowledge required, and above all must be supported by a system to choose the correct EDT. Several families can be found amongst “improvement” tools such as Ecodesign manuals, guidelines, frameworks: Such “improvement” tools are usually prescriptive and consist of generic strategies and recommendations of aspects that need to be considered in order to minimize the impact of products on the environment. Despite being very useful at the early stages of product planning, such tools do not identify and evaluate the real problems associated with a product and cannot suggest product specific solutions.

Checklists, monitoring and exclusion lists are tools providing guidance to engineers and designers by highlighting parameters and strategies to consider, avoid, not miss, etc. They can be quite easy to understand, however the actual implementation process can be more complicated since they may require detailed and systematic data gathering as well as continuous updates and increased integration into the overall product design process. Checklists can be very similar to guidelines and are usually qualitative or semi-quantitative. The complexity level of such lists can vary from being short and generic to long and detailed. These checklists can be quite long, with many aspects to consider: product performance (e.g. energy consumption), product parts (e.g. disassembly time), the function of the product, etc. Rating and ranking tools are generally relatively simple and quantitative. Proponents for this type of tools find that checklists are not sufficient for engineers and managers to communicate effectively, and they emphasize that “environmental” tools are needed.

3.1.2.2.2. Environmental management. This operation uses tools called “Environmental Management Systems”. The US Environmental Protection Agency defines such tools as: “a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency” (EPA, 2016). They are part of a larger management system and incorporate interrelated or interacting elements that companies use to implement their environmental policy, achieve their environmental objectives, meet their environmental compliance obligations, address their environmental aspects and risks, and to manage their environmental threats and opportunities. These environmental management systems are both “environmental” and “improvement” tools. For example, according to ISO 14001, the main goals of an environmental management system are the identification of significant impaired environmental aspects and a proposal of actions to remedy them. The peculiarity of “environmental” tools in these management systems is the inclusion of the local environmental context in impacts assessment. From a scientific and methodological point of view, nothing prevents use of the same “environmental” and “improvement” tools in Producing and Management operations except that the Producing tools take into account all the life cycle while the Management tools only apply to a single stage of a life cycle. It should be noted that the latest version of ISO 14001 (2015) – the international standard on Environmental management systems – recommends considering the notion of life cycle in environmental management which may contribute to the adoption of an eco-design strategy by companies.

3.1.2.2.3. Environmental communication. This latter operation uses tools that exploit the results of “environmental” and “improvement” tools. These tools have two purposes: internal and external communications. According to IACACT (2016):

- Internal communication uses tools with “pragmatic purposes because it helps companies to accomplish their goals; for example educating, alerting, persuading and collaborating”;
- External communication uses tools with “constitutive means because it helps to shape people’s understandings about environmental issues; for example values, attitudes, and ideologies to take into account in order to face environmental issues and problems”.

Overall, these tools are reference systems and are usually too general to be used in SMEs, because they are not practical enough (Hillary, 2004; Seidel et al., 2008). As previously stated, many categorizations of EDT exist. Those are complementary, often supplemental and form a complex matrix difficult to understand and to use especially for companies and SMEs.

The originality of this guide is to create an easy way to navigate those categorizations to rapidly find the tools needed without missing the benefits of one or more classification.

3.2. Literature review of EDT

The literature search was organized so that the field of ecodesign was covered from the perspective of three targets: production, environmental management, and environmental communication. As each target works more or less with its own literature and databases, the data collection was organized accordingly.

The literature search was conducted in three steps:

1. Screening of databases, journals, conference proceedings, books, doctoral dissertations, official texts, web sites, etc., to find references of EDT. The searched terms used during the investigation process were: Design for the environment, Ecodesign, Environmental assessment, Environmental communication, Environmental design, Environmentally friendly product design, Environmental management, Environmental product development, Environmental Green product design, Life cycle assessment, Life cycle design, and Sustainable product design. Fourteen databases were mainly used (Siegenthaler et al., 2005; Pons, 2008; Bellini and Janin, 2011; Lehtinen et al., 2011; Schiesser, 2011; INP Grenoble, 2012; Poulkidou, 2012; Lindahl and Ekermann, 2013; Tonneller and Bertoluci, 2013; European Commission, 2015; AFNOR, 2008, 2017a, 2017b; Pigosso et al., 2015). The existence of the tools provided by the literature and websites has been checked but this research does not assess nor judge the quality of the tools.

2. Classification of the tools referenced by a simplified taxonomy. The first taxonomy (Fig. 1) aims to be comprehensive, full and detailed but may be too sophisticated for businesses. However, it rationalizes said classification and comes up with a second more understandable classification which is easily exploitable by companies. This new additional classification is based on four main categories of tools: NGT, NST, NNST, and NNST. This simplified taxonomy will allow evolving more easily in the EDT box of the guide. In NGT and NST categories, it is important to note that feedback from companies shows that a standardized tool is more credible and a sectorial one is easier to understand. For these categories, due to technical means, research has been limited to international standards and draft standards (ISO) as well as American, English, French and German national standards. However, this limitation shouldn’t undermine the completeness of the review. Indeed, all standards named NF EN XX or NF EN ISO XX in this article are European standards not only available in French but also in all European languages.
including English. Some ISO standards have been published in the European standards collection, sometimes in their integrity and sometimes partially. Therefore, the portion of national standards only available in non-English language represents about a quarter of all normative tools quoted. The guide would have stayed relevant without them but they remain in its international version since their content and the keywords they propose can be interesting to the research of corresponding local tools. In the category NNST, EU regulations, “improvement” and “environmental” tools as defined above are found. In the category NNST, tools are classified only according to the type of sector.

3. Encoding of the selected tools is as follows: “Tool number”, “Tool name”, if it exists, or “Statutory or normative reference”, “Year of creation or update for a computer tool”, if it is known. “Bibliographic reference” and/or, if available, the “Website address” with the name of the authors or the body.

4. Results

After studying the founded tools (§4.1), developing a protocol to choose EDT (§4.2), “Eco-tool-seeker” has been designed and drawn to finally be methodologically validated (§4.3).

4.1. Typological and sectorial analysis of the founded tools

According to the typology of Grant and Booth (2009), the literary review presented here can be considered as:

- “Mapping review/systematic map” since it categorizes existing literature on a particular topic, EDT. It is a valuable tool offering policymakers, practitioners and researchers an explicit and transparent medium to identify narrower policy and practice-relevant review questions, even if it does not usually include a quality assessment process;
- “State-of-the-art review” because it may provide new perspectives on an issue or highlight an area in need of further research;
- “Systematic review” because it seeks to draw together all known knowledge on a topic area, i.e. EDT.

This literature review provides a compilation of 629 (six hundred twenty-nine) EDT (Appendix B). Considering all the tools identified in the review, the following typological distributions are observed:

- Product/Process Ecodesign: 78% (“environmental” tools: 64% and “improvement” tools: 36%);
- Managerial Ecodesign: 12.5%;
- Ecodesign Communication: 9.5%.

Throughout ecodesign’s history, a large majority of the tools identified have been linked to “Product/Process Ecodesign” most of which are “environmental” tools. Managerial Ecodesign and Ecodesign communications suffer from a lack of tools, which needs to be rectified.

Globally, the numbers of generic and sectorial tools are equivalent and a little less than two-thirds of all these tools are non-normative (Table 1).

In order to ensure the relevance of the guide from a sectorial point of view, the list of economic sectors covered in this study has been cross-checked with the assumed complete list of the United Nations (ISIC, 2008). Moreover, following the remark in §2 stressing that COP 21 should help ecodesign development, the contribution to climate change by these sectors also has been looked into and compared using available tools in the sectors (Table 2).

Considering the list of the United Nations, all sectors producing

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Table 1
Categorization of tools in “Eco-tool-seeker”.

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<thead>
<tr>
<th>Category</th>
<th>Normative tools</th>
<th>Non-normative tools</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic tools</td>
<td>82</td>
<td>220</td>
<td>48.0%</td>
</tr>
<tr>
<td>Sectorial tools</td>
<td>148</td>
<td>179</td>
<td>52.0%</td>
</tr>
<tr>
<td>%</td>
<td>36.6%</td>
<td>63.4%</td>
<td>100%</td>
</tr>
</tbody>
</table>

---

Table 2
Distribution of “Eco-tool-seeker” tools in the list of United Nations economic sectors and contribution of these sectors to climate change.

<table>
<thead>
<tr>
<th>Economic activities sections of the United Nations</th>
<th>Tools number in guide (%; Rank)</th>
<th>Main contribution to the climate changea %; Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Agriculture, forestry and fishing</td>
<td>3 (0.92%; 10)</td>
<td>22.6%; 2</td>
</tr>
<tr>
<td>B: Mining and quarrying</td>
<td>1 (0.31%; 11)</td>
<td>—</td>
</tr>
<tr>
<td>C: Manufacturing</td>
<td>191 (58.37%; 1)</td>
<td>16.3%; 3</td>
</tr>
<tr>
<td>D: Electricity, gas, steam and air conditioning supply</td>
<td>15 (4.58%; 4)</td>
<td>32.6%; 1</td>
</tr>
<tr>
<td>E: Water supply; sewerage, waste management and remediation activities</td>
<td>9 (2.76%; 7)</td>
<td>3.4%; 5</td>
</tr>
<tr>
<td>F: Construction</td>
<td>46 (14.07%; 2)</td>
<td>—</td>
</tr>
<tr>
<td>G: Wholesale and retail trade; repair of motor vehicles and motorcycles</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>H: Transportation and storage</td>
<td>22 (6.73%; 3)</td>
<td>14%; 4</td>
</tr>
<tr>
<td>I: Accommodation and food service activities</td>
<td>1 (0.31%; 11)</td>
<td>—</td>
</tr>
<tr>
<td>J: Information and communication</td>
<td>15 (4.58%; 5)</td>
<td>—</td>
</tr>
<tr>
<td>K: Financial and insurance activities</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>L: Real estate activities</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>M: Professional, scientific and technical activities</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>N: Administrative and support service activities</td>
<td>1 (0.31%; 11)</td>
<td>—</td>
</tr>
<tr>
<td>O: Public administration and defense; compulsory social security</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>P: Education</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Q: Human health and social work activities</td>
<td>4 (1.22%; 8)</td>
<td>—</td>
</tr>
<tr>
<td>R: Arts, entertainment and recreation</td>
<td>13 (3.98%; 7)</td>
<td>—</td>
</tr>
<tr>
<td>S: Other service activities</td>
<td>1 (0.31%; 11)</td>
<td>—</td>
</tr>
<tr>
<td>T: Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>U: Activities of extraterritorial organizations and bodies</td>
<td>5 (1.53%; 8)</td>
<td>—</td>
</tr>
</tbody>
</table>

---

material goods or energy, are endowed with at least one tool, and a strong heterogeneousness is observed. A major part of the tools covered (58.4%) concern the manufacturing sector, followed by “construction” with 14.1%, “transportation” with 6.7%, “Electricity, gas, steam and air conditioning supply” and “information & communication” with 4.6%. Let us note the surprising “Arts, entertainment and recreation”, sector with 4%, which is explainable by a relatively important number of American standards relative to this sector. There is also a strong heterogeneousness regarding industry branches. The best endowed sub-sectors are: “Electrical/electronic equipment” with 37% of the tools, “Packaging” with 10%, “Mechanical” with 8.5%, and “Automotive” with 6.3.

It is also apparent from Table 2 that the four main sectors contributing the most to climate change are primary energy (section D), Agriculture (section A), Manufacturing (section C), and Transportation (section H). Given recent political decisions (3), it is no longer enough to worry about releases of greenhouse gas emissions downstream. “Ecodesign era” solutions such as using electric motors in place of gas motors must be found upstream. Given the number and the nature of sectorial ecodesign tools available, it seems sensible to develop some tools primarily for “Agriculture” and “Electricity, gas, steam and air conditioning”.

4.2. Protocol to choose EDT

In existing literature reviews and guides, selection criteria are technical, methodological and scientific (Handfield et al., 2001; Lindahl, 2005; Loffthouse, 2006) and generally, linked to the quality of the tool: usability, suitability, effectiveness, relevance, usefulness, clarity, scientific strength, function, performance in relation to the objective sought and facilitated use (Le Pochat et al., 2007). Furthermore Lindahl and Ekermann (2013) presented a structure for how various ecodesign methods and tools can be categorized. Selection criteria and structure are not always easily understood by everybody because they are technical and scientific and intended for industrial designers and engineering designers.

To facilitate the selection and make it feasible for all companies, this protocol is based on a more managerial approach. Two criteria are retained:

- The company functions (Purchasing, R&D and Product development, QSE management and SD, Production and Manufacturing, Legal, Sales, Marketing, and Communication); all business functions have been considered, except functions of Chief Executive Officer, Human resources and Finance, which directly or indirectly manage all other functions. According to BusinessDictionary (2016), “Product development” is included in “R&D”.
- The business operation (or ecodesign target), i.e. Production or Environmental management or Environmental communication. Within production, tools are separated into two main categories: “environmental” tools (where to act?) or “improvement” tools (how to act?) (3.1). As the guide will be used by company employees working within different functions inside the company, each identified tool must be associated with the corresponding service(s).

Given the broad definition of EDT proposed (3.1) and the integration of different businesses functions and operations, the number of potential users is very wide as shown in the following Table 3.

Given the RENO objectives (2), the main intended users are companies and in particular for SMEs with poor and/or insufficient awareness of environmental issues.

Based on the literature, the above mentioned criteria and tool types, ecodesign tool categories can be defined, called “Ei”. The choice of “Ei” was made by following a collaborative spreadsheet shown in Fig. 2. For example, if an engineer, designing a new process, wants to know where to act, thanks to a qualitative, preferably normative, tool, our tree will lead him towards tools classified in the category E01 (Fig. 2).

Each tool was classified in one or more “Ei” and to one or more department(s) (Purchasing, R&D and Product development, QSE management and SD, Production, Legal, Sales, Marketing and Communication). The composition of Ei then depends on the function (or department) studied. For NST and NNST, tools are also classified by sector. This composition was made based on the knowledge, skills, and experiences shared amongst the authors of this study. This knowledge includes environmental sciences, law, communication, and management. These skills are research, teaching and training, engineering, ecodesign, standardization, regulation, consulting and business. The experience is based on our relationships with companies within our respective professional bodies i.e. universities and engineering schools, consulting firms, chambers of commerce and industry, and ADEME. Each member of the group made an educated proposal for composition of “Ei” and a consensus was found through debate. Admittedly, this multidisciplinary and empirical expertise includes some degree of subjectivity and the proposed classification could possibly be revised based on feedback from users (offering feedback, especially on missing or misplaced tools, is one of the functionalities of the online version, see link below).

The composition of these “Ei” is presented in Appendix C. For each business function studied (1- Purchasing, 2- R&D and Product development, 3- “Quality, Safety and Environment management and Sustainable development”, 4-“Production and Manufacturing” and 5- “Legal, Sales, Marketing and Communication”) and for each “Ei”, this table lists the corresponding tools, referenced in our list in the appendix B. A tool may be found in several “Ei” but, in the list, a tool belongs to a single category. For instance, if you are looking for a tool that will help you in the design

<table>
<thead>
<tr>
<th>Quality of potential users</th>
<th>Professional functions of potential users</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Scientist: Environmental Sciences &amp; Engineering Sciences</td>
<td>• Academic: Teaching &amp; Research</td>
</tr>
<tr>
<td>• No-scientist: Law, Communication &amp; Management</td>
<td>• Corporate: R&amp;D and Product development, QSE management and SD, Production and manufacturing</td>
</tr>
<tr>
<td></td>
<td>• Consultancy</td>
</tr>
<tr>
<td></td>
<td>• Academic: Teaching &amp; Research</td>
</tr>
<tr>
<td></td>
<td>• Corporate: Purchasing, QSE management and SD, Legal, Sales, Marketing and Communication</td>
</tr>
<tr>
<td></td>
<td>• Consultancy</td>
</tr>
</tbody>
</table>

Table 3
Potential users of protocol to choose EDT.
of a process, and if you want to know how to act according to a NNST that is computerized, the tree in Fig. 2 will lead you to category E16. Then, if you want to work more specifically on Production and Manufacturing, as you can see in Appendix C, only one tool has been referred: tool No. 357, i.e. in the appendix B, "eToolLCD. Available on http://etoolglobal.com/". Then, inside of each “Ei”, the selection of the most appropriate tool depends, on many parameters, such as the product itself (components and processes involved), user preferences, experience and intended evaluation level as well as other parameters related to scientific and technical knowledge, availability of data, information, and resources.

4.3. Design, development and validation of guide

This guide has been designed as an “Information system”. According to Reix et al. (2011), an “information system” is an “organized set of resources (EDT) allowing to acquire, to handle, to store information (references of EDT) into and between organizations (corporate functions)”. This information system consists of interconnected modules, which are acquisition and restitution means, processing and storing information dedicated to processing EDT. Concretely, these modules are theoretical frameworks, methods, database, and software (Fig. 3).

Modules 1, 2 and 3 respectively were described in §3.1.1, §3.1.2, §3.2. Module 4, the literature review (§3.3), provides a compilation of 629 (six hundred twenty-nine) EDT, which are listed in the module 5 (appendix B). These tools may vary significantly in terms of type, objectives, complexity of the application process, data, time requirements and more. Omissions may exist; this list is by no means exhaustive. Module 6 was established according to the previous chapter, §4.2. To facilitate the use of this guide module 7 has been developed using Google Forms. This computer application is called “Eco-tool-seeker”, this “ready to use” tool is a user-friendly way to present the results of the guide. The method used to aid selection of EDT is based on the decision tree of Fig. 2. Thus, the application “Eco-tool-seeker” offers a quick questionnaire and a user-friendly interface. A free version is available in English and in French on the Internet: https://docs.google.com/forms/d/
To validate technically “Eco-tool-seeker”, it is necessary to verify that it meets the criteria of an information system. According to Reix et al. (2011), an information system should have four functionalities that perform a number of processes as shown in Table 4. This table also lists the modules of “Eco-tool-seeker” allowing to obtain the characteristics required for an information system.

As shown by Table 4, module 7 (the Internet interface) illustrates most of the processes of an information system: since it is accessible with a simple internet connection, it allows easy availability, manipulation, dissemination, and exchange of contents of the guide.

To further verify these four processes, module 7 was tested on a sample (not representative) of 20 professionals of the RENO network, representing Universities, consulting firms, large and small businesses, Chambers of commerce and industry, trade associations, and ADEME. After an oral presentation of the purpose and principle of the guide, the audience was asked individually to try the online version of the “Eco-tool-seeker” and to answer the following questions:

- What do you think of the ergonomics of the guide?
- What do you think its strengths, weaknesses, opportunities, and threats are?
- Do you have suggestions for tools to bring into this guide?
- What do you think of its applicability in your business?

This experiment helped to improve the formulation of the “Eco-tool-seeker” questionnaire, to settle computing points, to use our tools box, to create new applications (e.g. the possibility to report missing or misplaced tools), making the “Eco-tool-seeker” a truly collaborative and living guide for companies and experts mindful of environmental issues. The only suggestion we were unable to take into account with the actual format of “Eco-tool-seeker”, was the addition of a search function. Their answers also helped us to complete the strategic analysis presented in §5.1.

Module 7 combined with module 6, enables an adaptation of the information for businesses since the guide has been set up according to a logical network tree classification (Fig. 2). This means the tool provides guidance for choosing the appropriate ecodesign tool according to:

1. The department within the company,
2. The type of business operation or ecodesign target (product/process or management or communication),
3. The aim, and hence the corresponding type of tool,
4. The characteristics of the tool (normative, sectorial, etc), and if necessary,

Post-it® notes have been used in a particular form of brainstorming. Participants wrote their responses on Post-it® notes and then stuck them on a paper-board. It has been then possible to group them by theme and also in direct exchange for technical aspects.

Most of the testers were interested by “Eco-tool-seeker” and discover unknown tools. They found “Eco-tool-seeker” rapid and simple to use. They suggested some modifications, such as:

- The correction of some typographical errors;
- The formulation of the different propositions;
- The addition of twenty missing tools. The database was composed of 423 tools upon this test;
- The addition of return function (“make a new search”) inside the results pages;
- The addition of communication functions (“Give/correct information about a tool”) inside the results pages;
- The addition of search function.

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Corresponding processes</th>
<th>Modules number of “Eco-tool-seeker” (Fig. 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of knowledge</td>
<td>Capture</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Store</td>
<td>5 &amp; 7</td>
</tr>
<tr>
<td></td>
<td>Make available</td>
<td>7</td>
</tr>
<tr>
<td>Representation of knowledge</td>
<td>Make understandable</td>
<td>12 &amp; 3</td>
</tr>
<tr>
<td></td>
<td>Adapt (to business)</td>
<td>6</td>
</tr>
<tr>
<td>Interaction of communication</td>
<td>Manipulate</td>
<td>6 &amp; 7</td>
</tr>
<tr>
<td>Communication</td>
<td>Update</td>
<td>4, 5, 6 &amp; 7</td>
</tr>
<tr>
<td></td>
<td>Disseminate</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Exchange</td>
<td>6 &amp; 7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information system for ecodesign</td>
<td>Completeness of references is difficult to assess</td>
</tr>
<tr>
<td>Can be used by many users</td>
<td>Exhaustiveness is not possible</td>
</tr>
<tr>
<td>A strong overview of existing tools</td>
<td>Requires regular updates</td>
</tr>
<tr>
<td>A comprehensive guide for organizations to discover, create awareness of, and implement ecodesign</td>
<td>Implementing tools from the guide requires significant organizational and operational changes in the company</td>
</tr>
<tr>
<td>Available online</td>
<td>The use of the guide especially for SMEs requires an environmental specialist assistance</td>
</tr>
<tr>
<td>Collaborative interdisciplinary teamwork</td>
<td>The cost of computerized tools</td>
</tr>
<tr>
<td>Consideration of typical organizations specific departments</td>
<td></td>
</tr>
<tr>
<td>Free, easy and quick to acquire</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
</tr>
<tr>
<td>Complementary to other ecodesign guides</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong basis to be completed</td>
<td>Updating references</td>
</tr>
<tr>
<td>(international cooperation: UNEP, etc.)</td>
<td></td>
</tr>
<tr>
<td>Ready for diffusion to organizations</td>
<td>Financial support to update and improve</td>
</tr>
<tr>
<td>Potential for sectorial specialization</td>
<td>Business user's interpretation could be biased</td>
</tr>
<tr>
<td>Can be used to define an ecodesign training program for every function of the company</td>
<td>Secrecy (no promotion support currently)</td>
</tr>
<tr>
<td>Can be used to identify sectorial gaps to define a research topic (§ 4.1)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 Characteristics of the information system, inspired from Reix et al. (2011).

Table 5 SWOT matrix.
5. The nature of the tool (computerized or not).

For example, a QSE manager looking for a Product/Process Ecodesign tool in order to perform a quantitative environmental diagnosis using normative generic tools, would be suggested, in five “clicks” on the computer screen, to refer to a list of tools E05 (Appendix C), which are referenced in the appendix B by the following numbers: 4, 5, 7, 8, [20–23], 26, 28, 59, 60, 66, 67, 71, 72, 81.

Module 7 also contains a “back office” section (not available to the public since it would only complicate the user’s experience) that is used to store the guide (the results and the methodology used to reach them) as well as update it.

The processes “Update”, “Disseminate”, and “Exchange”, will be better fulfilled if a relevant actor manages module 7. For that purpose, negotiations with national and international bodies have been engaged for the development as well as for the dissemination and the promotion within companies of “Eco-tool-seeker” while making sure it remains free.

5. Discussion

In order to better describe the guide’s coverage and interest, a strategic analysis (§5.1) has been carried out. Finally a value-added analysis (§5.2) aimed at describing the value of this paper in relation to state-of-the-art.

5.1. Strategic analysis

Classical analysis of Pros/Cons is presented here in a more comprehensive way through a SWOT analysis which determines strengths, weaknesses, opportunities and threats of the guide. SWOT is a marketing analysis tool commonly used in business allowing to get an overview of the “Eco-tool-seeker” guide and to draw its strategic diagnosis. This analysis is conducted considering potential users of the guide. The synthesis obtained through the SWOT matrix (Table 5) can identify:

- The strengths and opportunities of the guide, in order to maximize them by the company;
- The weaknesses and threats of the guide in order to take them into account before using the guide so the company can overcome them.

It can be said that a large number of tools offered by “Eco-tool-seeker” is a barrier to ecodesign uptake, and would be counter-productive. This is less the case than before because “Eco-tool-seeker” establishes the composition of Ei according to the filters of business operation, corporate function, and activity sector so facilitating the choice and the appropriation of the tool by the user.

Most internal strengths therefore provide external opportunities in terms of diffusion and communication. On the other hand, weaknesses such as updating references and the risk of biased interpretation for neophytes could become an obstacle to wider adoption, especially in the absence of promotion. However, sectorial or functional specialization could offer potential to specific users for appropriation and customization. Likewise online shared access could in any case ease the updating process and cross-sector benchmarking.

It has to be noted, that the majority of computerized tools are not free; thus, the user needs to pay a certain amount of money in order to get the license and access to use the tool. Consequently, the information on such tools and their methodological processes provided by this guide can sometimes be limited.

5.2. Value-added analysis

5.2.1. Classification of EDT

There is no hierarchical relationship between the categories of classifications proposed by the literature (§3.1.2), meaning it contains typologies but no taxonomies. As explained by Sauvé (1993), a taxonomy is a systematic and hierarchical classification system.

The classification proposed here is a taxonomy, which appears to be the first one in the field of the ecodesign.

Most authors do not give much information about the methodology which they used to develop their typology. A number of them proceeded in a rather inductive way, by leaving out the purpose e.g. “Assessment”, “Prioritization”, “Creativity” and “Decision” for Charter and Tischner (2001), the objective e.g. “Environmental” and “Improvement” for Janin (2000) and of the type of tool e.g. “Framework”, “Checklist”, etc. for Baumann et al. (2002). Others proceeded the opposite way — starting from a theoretical model —, they offer a typology, for example, “use-oriented” typology from a framework to characterizing both ecodesign projects and EDT (Hernandez-Pardo et al., 2011), and typology from conceptual framework connected with several systemic levels (macro, meso, and micro scales) (Briones and de Carvalho, 2015).

To establish the taxonomy, the followed methodological approach lies in an empirical classification based on a multi-variated analysis in several sizes which correspond to the various levels presented in Fig. 1. The widening of the scope of ecodesign (§3.1) allow the elaboration of a taxonomy as complete as possible. In the proposed taxonomy EDT are included in class (or taxon) according to their similarities from the classification algorithm presented in Fig. 2.

The typology classes, as currently presented in the literature, include EDT with the same studied characteristics. The classes proposed here share a large number of common characteristics. Concretely, a class in this taxonomy is a branch of the tree presented in Fig. 1. One of the biggest advantages of the proposed taxonomy lies in its capacity to handle a large number of entries by taking into account their interactions and by generating relatively homogeneous groups of EDT based on a strong internal coherence. This characteristic is important considering the number of tools -or entries- listed here that is 2–4 times bigger than in reviews realized so far (§2) for the guides proceeds from a widened scope of ecodesign (§3.1).

In conclusion, the classification the EDT provided by this study presents an educational potential and represents an interest for the organizational research.

5.2.2. Guide to choose EDT

Guides proposed by the literature (§4.2) are technical systems, which consider only scientific and methodological criteria and address primarily engineering designers.

“Eco-tool-seeker” is a managerial or socio-technical system otherwise named Information system. The social sub-system considers the organizational structure of the company and the people who work on it (§4.2). The technical sub-system considers processes concerned by the information system and the computing technologies (software) and the equipment of communication (Internet) (§4.3).

The technical purpose of the guides already present within the literature is to give engineering designers the scientific and technical help they need to design, in a given context, “ecoproducts” offering a service comparable to the already present products on the market (quality, feature, accessibility, safety, etc.) while lowering their environmental impacts.

The purpose of “Eco-tool-seeker” is double:
- A functional purpose: it is a tool of communication and coordination between the various departments of the company presented in §4.2; therefore, its audience is wider. It produces and disseminates information about EDT necessary for the operations (described in §3.1.2) on one hand and in the strategic and tactical choices on the other. It helps tool selection by any company regardless of size or economic sector; and makes them understandable, not only to designers, but also to all the actors of the company. It aims to be exhaustive since it points out tools relevant for industrial branches existing within companies as well as tools applicable at the level of the various departments they include, whether they are concerned directly or indirectly by the environment. Therefore, it allows non-professionals of eodesign to be able to take ownership of the relevant notions easily and quickly in order to implement them to their function within the company. To facilitate the selection of EDT, an accessible free guide is offered on the Internet.

- A social purpose: It increases the “green” knowledge of the company and the understanding of related strategic choices by the entire staff. Furthermore, it allows the development of an “entrepreneurial spirit” amongst the employees facilitating the broadcasting of “ecocompany” culture.

The idea that eodesign results should be incorporated into the various functions of the company does not provide, from a scientific point of view, new conceptual elements for Ecodesign, but this idea should facilitate communication between services and stimulate a synergy capable of promoting the development of eodesign in companies.

Finally, “Eco-tool-seeker” appears as the first information system in the field of the eodesign and is complementary to the technical guides proposed so far by the literature.

The elaboration of this taxonomy and “Eco-tool-seeker” could not be achieved without interdisciplinary research. Even though interdisciplinary research carries an epistemological risk related to the compartmentalization of thought and knowledge, it proposes an original approach to eodesign. Interdisciplinary research is, unfortunately, very rare in academic research, although it is unavoidable considering the principle of SD.

6. Conclusion

As the number of EDT increases, the choice of tools becomes more difficult for companies. This paper is a novel contribution which classifies EDT by taxonomy. This classification integrates different types of EDT: 36.6% normative tools and 63.4% non-normative tools. These tools can be classified as generic (48%) or sectorial (52%) as well as “environmental” or “improvement” tools. Six hundred twenty-nine EDT are listed after a review of the literature of these tools. The sectorial tools concern largely industrial sectors, in particular “Electrical/electronic equipment”, “Packaging”, “Automotive” and “Mechanical”.

The potential of this guide is found in the increase of its use and effectiveness in practice and in company context, regardless of the size or sector of a company. Its originality resides in helping any company to choose the most relevant EDT based on their applicability to the various company departments which are directly or indirectly concerned by the environment. This new guide has been designed as an information system, namely a managerial or socio-technical system. The name of computer application is “Eco-tool-seeker”.

This guide can be used by someone with a good understanding of their company, its needs and its concerns. It carries great benefits in terms of time savings, money savings and empowerment of the companies leading towards the democratization of eodesign. Furthermore, the guide can also be used by experts and allow them to increase their knowledge with new tools and/or new applications and areas of expertise.

Such an expansion of the use of tools will also coincide with the democratization of eodesign. “Eco-tool-seeker” is a collaborative guide. Access to the computerized version of the guide “Eco-tool-seeker” is currently free and its perspectives of development concern essentially the update of its tool box.

Finally, an academic prospect of this study would be considered in economic and social dimensions of SD. Tools for these two dimensions would partially or fully consider the life cycle and the different corresponding impacts to limit socio-economic poverty transfers. For the economic dimension, these impacts are the different internal and external costs; “Life Cycle Costing” is the reference tool (Woodward, 1997). For the social dimension, six “impact categories” have been proposed by UNEP et al. (2009): Human rights, Working Conditions, Health & safety, Cultural heritage, Governance, and Socio-economic repercussions. This academic prospect would identify, classify, and make available to businesses socio-economic design tools like “Eco-tool-seeker” for EDT.

Appendix A. Integration of eodesign in French companies (BVA, ADEME, 2010)

- Companies incorporating a systematic approach to eco-design
- Companies just starting the process
- Companies being interested, but not taking action due to lack of organizational, financial and technical means (tools, data)
- Companies being not interested or feeling not concerned as not carrying out the design of their products
Appendix B. Ecodesign tools list

NORMATIVE GENERIC TOOLS

International standards


Furnishing
French standards/Reference document for good practices
Reference document for good practices

Sporting Goods
French standards/Reference document for good practices
Collection of French standards

Building & Construction
International standards

French standards

Practical Guide

Shippyard
French standards

Shoes
French standards

Shoes/French standards/Reference document for good practices
Local authorities

French standards


Communication


French standards


Wastes


Packaging


Energy


Audio/video for information technology and communication

**International standards**


**American national standards**


**French standards**


**International standards**


**German standards**


**American standards**


**English standards**


**French standards/Reference document for good practices**


**Meetings, Events & Trade Shows**


International standards

French standards

Printing & Graphics Technology
International standards

French standards

Materials
Technical report

Mechanical
International standards

French standards

Technical report

Plastics
International standards

Collection of French standards

Hygiene products
Reference document for good practices

(continued on next page)
(continued)

Collection of French standards


Human health

International standards


French standards


Welding

French standards


Transport

International standards


American standards


French standards


Reference document for good practices


NON NORMATIVE GENERIC TOOLS

EU regulations


Complete LCA i.e. following ISO 14044


283. MIPS (Material Input Per Unit of Service), (2002). RITTHOFF, M., ROHN, H. & EPUB.WUPPERINST.ORG/F OORDOOR/INDEX/INDEX/DOCID/1577.
577. Guidelines, frameworks & monitoring
354. Guidelines, frameworks & monitoring


548. BtoGreen®/Expérience, (2009). Weenov Performance & le Pole Ecoconception. The objective of BtoGreen method is to help companies to define their environment strategy for products and services. Available on http://www.btogreen.com


Check-lists


Exclusion lists


Ecodesign manuals


309. ECODESIGN PILOT, (2001). From a simplified LCA, an ecodesign action list is proposed, available on http://www.ecodesignat.pilot/ONLINE/FRANCAIS/INDEX.HTM


(continued on next page)


512.DAS. Delft University of Technology (Netherlands), Faculty of Industrial Design Engineering, available on http://www.d4s-sbs.org/


531.DeS. Delft University of Technology (Netherlands), Faculty of Industrial Design Engineering, available on http://www.d4s-sbs.org/


Data bases


316. EPM LCA Database. Center for Environmental Assessment of Product and Material Systems, available on http://cpmdbase.cpm.chalmers.se


319. IVAM LCA Data 4. IVAM, University of Amsterdam (Netherlands), available on http://www.ivam.uva.nl


Specialized external communication tools


Specialized internal communication tools


328. Internet portal of the association OREE. Available on http://ecocreation.oree.org


NON NORMATIVE SECTORIAL TOOLS

Office Activities


Agribusiness & Food


Furnishing


Vacuum cleaners


Building & Construction


347. La démarche HQE (French acronym for High Environmental Quality). Available on http://www.assobmqe.org/accueil/


349. ENVEST 2. BRE, available on http://envest2.bre.co.uk


361. ENVEST 2. BRE, available on http://envest2.bre.co.uk


364. Shipyard

365. Shipyard

366. Shipyard

367. Shipyard

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383. Shipyard

384. Shipyard

385. Shipyard

386. Shipyard

387. Shipyard


Chemistry


Pharmacy

Packaging


400. Ecodesign PILOT. The tool helps product developers to find suitable strategies and measures in order to improve its product in such a way that it corresponds to the requirements of the WEEE and the RoHS directive, available on http://www.ecodesign.at/pilot/eeg/ENGLISH/INDEX.HTM.


Meetings, Events &Trade Shows


Printing & Graphics Technology


Vehicle equipment


Transports


Urbanism

### Appendix C. Composition of Ei sets by function within a company

<table>
<thead>
<tr>
<th>Purchasing</th>
<th>R&amp;D and Product development</th>
<th>QSE management and Sustainable Dev.</th>
<th>Production and manufacturing</th>
<th>Legal, Sales, Marketing and Communication</th>
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<tr>
<td><strong>E01</strong></td>
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<td>[1–3],[5,9,13,18,53,54,72]</td>
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<td>277,493</td>
<td>493</td>
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References


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