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SYSTEMATIZATION OF BEST PRACTICES FOR ECODESIGN IMPLEMENTATION

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1. Introduction

Ecodesign is a proactive environmental management approach that integrates environmental issues into the product development and related processes (such as manufacturing, purchasing and quality) in order to improve products' environmental performance [Johansson 2002], [Weenen 1995]. By bringing a holistic life cycle perspective to product development, ecodesign application creates environmental value in addition to the traditional requirements for a product such as performance, functionality, quality and cost.

Despite the recognition of ecodesign potential benefits, its application has not reached companies worldwide over the last decades mainly due to difficulties in ecodesign implementation and management. The lack of a systematization of existing ecodesign practices; and the intense development of new ecodesign techniques and tools in detriment to the study and improvement of existing ones and their integration into the product development process are some of the issues contributing to this scenario [Bey et al. 2013], [Boks 2006], [Bovea and Pérez-Belis 2012].

In order to support companies in dealing with those challenges and provide academy with a structured classification of ecodesign practices, a systematic literature review was performed in this research for the identification and classification of the existing ecodesign practices, supporting companies in the selection of the most suitable ones according to their specific needs and characteristics. This research was performed in the context of the Ecodesign Maturity Model (EcoM2) [Pigosso et al. 2013] a management framework with an evolutionary (step-by-step) approach to support the managers responsible for ecodesign implementation to identify and implement a strategic roadmap for ecodesign implementation.

The research methodology for the systematic literature review is described in section 2. Section 3 presents the ecodesign practices clustered into three main groups and classified according to a set of criteria to support companies' selection. Finally, in section 4, final remarks and discussions about the ecodesign practices are addressed. Sections 5 and 6 contain acknowledgements and references.

2. Research methodology

The ecodesign practices were identified and systematized by means of a systematic literature review. The systematic review is the way by which the researcher can map existing knowledge and initiatives in a specific research area. Besides the analysis of previous discovery, techniques, ideas and ways to explore topics, the systematic review also allows the evaluation of the information relevance to the issue, its synthesis and summarization [Biolchini et al. 2005], [Brereton et al. 2007]. The systematic review model adopted in this research comprises three phases, namely: (1) planning, (2) execution, and (3) analysis of the results [Biolchini et al. 2005].

The planning step: consists of the definition of the review protocol, which contains the problem formulation and the way in which data is going to be collected, evaluated, analyzed and interpreted, including also the definition of how the conclusions should be drawn and how the results will be presented. The focus of interest of the systematic review, i.e., the research objective, was the identification and classification of the existing ecodesign practices. The databases researched during the systematic review were Web of Knowledge (ISI Web of Science); Engineering Village; Scopus; Google Scholar; Emerald; Science Direct, and IEEE Explore.
The selection of keywords and logical terms was performed iteratively. To begin with, there was a set of 21 articles from which the initial keywords were extracted. As the review proceeded, new keywords emerged and were added to the initial set, resulting in new searches in the databases. Additionally, cross searches on the relevant authors and journals was performed, in order to find papers not initially obtained. The search string was developed by a combination of 19 ecodesign synonymous (such as "Design for environment" and "Environmentally friendly design") combined with 10 terms for the identification of the practices: "practice", "activity", "strategy", "task", "routine", "guideline", "process", "method", "tool" and "technique".
The studies to be included into the review were selected by applying the inclusion/exclusion criteria, which was related to the selection of studies that presented ecodesign practices either in an explicit or implicit way (e.g. development and or/case studies of new tools, procedures, activities, industrial experience with ecodesign implementation, etc.). Studies out of this scope that could not contribute to achieve the goal of the research were excluded from the review. The procedure for selecting studies using the inclusion and exclusion criteria was a reading of their title and abstracts. Whenever this reading proved insufficient to include or exclude a study, the entire study has been considered. In order to standardize the representation of the information, forms were created to collect and record the data of the study and the ecodesign practices (database).
The execution step involved the application of the concepts defined in the review protocol, including the initial identification, selection and evaluation of studies according to the inclusion and exclusion criteria previously defined. This step involves the search for studies in databases using the pre-established keywords, as well as the selection of valid studies through the application of the inclusion and exclusion criteria. As a result of the search process, a total amount of 5342 studies (including papers, books, thesis, dissertations and book reviews) was identified during the execution of the systematic literature review). After applying the inclusion/exclusion criteria, 2341 valid studies were further analyzed in order to extract the ecodesign practices.
Finally, the analysis of the results involved the data extraction from relevant studies that are pertinent to the objective of the systematic review, using the data representation standards defined in the review protocol and the criteria defined for the classification. The identification and categorization of the ecodesign practices was performed adopting the grounded theory technique (the qualitative data is analyzed in order to identify key themes, patterns and categories from the data itself [Lancaster 2005]).

3. Best practices for ecodesign implementation

During the systematic literature review, the need for the distinction among the ecodesign practices in relation to the subject of interest (either the product itself or the process to develop the products) was observed in order to support the understanding of the focus of the practice and on how it should be applied in order to develop products with a better environmental performance. The distinction among the ecodesign practices is supported by Pascual and Stevels [2004], which divides ecodesign into two dimensions:

- Managerial dimension: related to the business aspects of the discipline (including the alignment of ecodesign with traditional business perspectives, supply chain, green marketing, etc.) and
- Environmental dimension: related to the technicalities of the product (like physical units, materials, energy, efficiency, environmental load, etc.).

Moreover, Pascual et al. [2003] also suggest the existence of product and process related activities to ecodesign. Fiksel and McDaniel [1998] establish differences among organizational and technical issues for ecodesign implementation:

- Organizational issues include the establishment of appropriate company policies and incentives, modification of existing business processes, capture and dissemination of sustainable design knowledge via training and information technology, and achievement of consistent practices across diverse business units;
- Technical issues include the implementation of various design strategies e.g., modifying the material composition of products so that they generate less pollution and waste, or changing the assembly requirements so that fewer material and energy resources are consumed per product unit as well as systematic adoption of sustainable design guidelines, metrics, and tools.

These organizational and technical issues are equally important, and must be addressed from the strategic, tactical and operational perspectives [Fiksel and McDaniel 1998]. Successful ecodesign requires a double level activity: strategic, in order to define the problematic within the organization as a whole, and operational so as to be able to implement decisions concretely [Ney 2008].
In summary, the Ecodesign Maturity Model (EcoM2) classifies the ecodesign practices into three main groups according to their characteristics in relation to the subject of interest of the practice [Pigosso et al. 2013]: Ecodesign Management Practices; Ecodesign Operational Practices; Ecodesign techniques and tools. The ecodesign management practices defined in the EcoM2 are related to managerial [Pascual et al. 2003] and organizational [Fiksel and McDaniel 1998] dimensions while the ecodesign operational practices are related to the environmental [Pascual et al. 2003] and technical issues [Fiksel and McDaniel 1998].

3.1 Ecodesign management practices

The ecodesign management practices are those practices that are related to the activities of the product development and related processes that address the environmental concerns [Pigosso et al. 2013]. They are generic and can be applied by any company, regardless the type of products developed. The ecodesign management practices are process-related and not product-related practices.
The Ecodesign Maturity Model (EcoM2) contains a set of 62 ecodesign management practices obtained from studies that deals with the ecodesign management, its integration into the product development process and its implementation into companies including studies on success factors and barriers for ecodesign implementation [Pigosso et al. 2013]. The ecodesign management practices of the EcoM2 are presented in Table 1.

Table 1. Ecodesign management practices

Code	Ecodesign management practices
10020	Structure a systematic procedure to gather ecodesign-related knowledge
10009	Perform internal and external benchmarking of the environmental performance of products and/or ecodesign best practices
40004	Examine the relevant internal and external drivers for the development of products with a better environmental performance
60004	Collect information about applicable legal issues and standards related to the environmental performance of products
10001	Formulate the company environmental policy and/or strategy
10002	Deploy and maintain an environmental policy and/or strategy in the product level
10003	Establish a prioritized program for the implementation and management of ecodesign

10022	Select relevant people from functions across the company to be involved in the ecodesign activities
30005	Define and measure performance indicators for the performance of the ecodesign program
10006	Increase consciousness and awareness of the company in regards to the application opportunities and benefits of ecodesign
10011	Ensure commitment, support and resources to conduct the activities related to ecodesign
10012	Deploy the responsibilities and authorities among people of different areas and hierarchical levels
10013	Ensure appropriate communication among departments and different hierarchical levels concerning ecodesign
10018	Select and customize ecodesign methods and tools according to the company's needs
10014	Provide ecodesign-related training for the employees involved in product development
10019	Formulate, update and monitor mandatory rules (internal standards) and/or product requirements in order to comply with environmental product-related legislations and/or regulations
10023	Implement the Life Cycle Thinking into the product development and related processes
20001	Evaluate the environmental performance of products during the product development process
40005	Assess technological and market trends (including new customer requirements) related to ecodesign
60001	Identify customers' and stakeholders' requirements and priorities concerning the environmental performance of products
80005	Develop and customize environmentally product-related guidelines to support product development
80007	Incorporate environmental aspects in the identification, qualification and management of suppliers
90001	Optimize the existing production processes in order to improve the environmental performance of products during manufacturing
100005	Improve the environmental performance of packaging and distribution during the product development and related processes
10015	Make environmental considerations a part of the daily routine of the employees involved with product development
80013	Develop a "green" incentive scheme for the ecodesign implementation and management
10016	Integrate ecodesign into the product development and related processes standards and procedures
30001	Measure and monitor the environmental feasibility of new product development projects
30002	Define the environmental indicators and the methodology for the gates (phase assessments)
30003	Check the environmental performance of products during the phase assessments (gates)
40011	Ensure alignment among strategic and operational dimensions concerning ecodesign
20004	Establish priorities on the environmental impacts to be minimized over the product life cycle
40013	Clearly define the goals to improve environmental performance of the products under development
40012	Include the environmental goals into the product target specifications

30004	Define and measure environmental performance indicators for product improvement
80002	Consider the trade-offs among the environmental requirements and the traditional requirements of a product (such as quality and cost)
80004	Identify the ecodesign guidelines that can be applied in product design in order to increase the environmental performance of the product under development
80015	Select and develop manufacturing and assembly processes with better environmental performance
60008	Identify and/or develop new technologies that can contribute to improve the environmental performance of the developed products
70011	Evaluate the environmental performance of technologies
110005	Define and measure performance indicators for the environmental performance of stakeholders such as suppliers, after sales, service providers, recyclers, etc.
100007	Communicate the environmental performance and benefits as part of the total value proposition of the product, exploring the green marketing opportunities
10004	Clearly define the product-related environmental goals for the whole company
10017	Conduct management reviews to evaluate the effectiveness of the environmental issues consideration in the product development and related processes
70001	Perform functionality analysis to determine requirements for a product and find new ways to deliver the functions with a better environmental performance
70006	Improve the interaction between product and service developments in order to explore the potential to offer solutions with a better environmental performance
70012	Consider environmental performance as a selection criteria for the product concept/design options
80008	Consider and involve the total value chain for improving the environmental performance of products
80010	Establish cooperation programs and joint goals with suppliers and partners aiming to improve the environmental performance of products
100002	Develop the technical support processes (e.g. maintenance, change of spare parts, etc.) aiming to improve the environmental performance of the product over its entire life cycle
100003	Define the end-of-life and reverse logistics strategies to be addressed during product development in order to improve the environmental performance of the product in the end-of-life phase
100006	Elaborate and communicate recommendations to consumers on how to improve the environmental performance of the product during the use and end-of-life phases
110003	Communicate to customer and stakeholders the improvements on the product environmental performance and consequent economic gains
110001	Monitor the product environmental performance during use and end-of-life phases of the life cycle
110004	Supply the product development process with information related to the environmental performance of materials, processes and components in the whole product life cycle phases
10021	Effectively integrate product-related environmental goals into the corporate strategy
40001	Integrate the environmental dimension in the strategic decision making process jointly with the

	traditional aspects
40003	Establish product-related vision, strategy and environmental roadmaps in the strategic level
40016	Strategically consider the product environmental performance in the company portfolio management
40014	Develop business, product and market strategies considering the environmental trends
40015	Incorporate product-related environmental goals into the technological strategy
70009	Define a strategic roadmap for the development and implementation of new technologies that allows a better environmental performance over the product life cycle

In order to locate the user whether the management practice should be preferably applied in the context of the product development process, the practices were classified according to the group of activities of a reference model for the product development process [Rozenfeld 2007] based on a cross content analysis (Table 2). Although product development process significantly vary between different companies and product types, generic design process such as high-level reference models can be used to tailor the specific ecodesign procedures [Dewulf and Duflou 2004].

Table 2. Code scheme for ecodesign management practices classification

100xx	Change management for ecodesign	700xx	Concept design
200xx	Environmental impact assessment	800xx	Detailed design
300xx	Generic activities	900xx	Production preparation
400xx	Product strategic planning	1000xx	Product launch
500xx	Project planning	1100xx	Product accompanying and monitoring
600xx	Informational design		

The ecodesign management practices are, additionally, classified according to the ecodesign evolution levels for ecodesign implementation, as defined by the Ecodesign Maturity Model (EcoM2) [Pigosso et al. 2013]. It represents the evolution from getting knowledge on ecodesign to the strategically incorporation into the company strategic planning and decision processes. The ecodesign evolution levels present, in this sense, the path that a company should follow in order to improve the environmental performance of their processes. The classification of the ecodesign management practices into the evolution levels defined by the EcoM2 was accomplished by means of the development of a correlation matrix in which each management practice was compared to the characteristics of the evolution levels established. The synthesis of the correlation matrix enabled the classification of the ecodesign management practices into the evolution levels, which were subsequently evaluated by the ecodesign experts and further improved. The ecodesign management practices are used to assess the maturity profile of the companies in the ecodesign application [Pigosso et al. 2013].

3.2 Ecodesign operational practices

The Ecodesign operational practices deals with the technical issues of product design and are directly related to the material life cycle of a product, i.e., to the most relevant environmental impacts of a product across its life cycle (from raw material extraction to end-of-life) [Pigosso et al. 2013]. It provides guidelines for the development of products with better environmental performance and can be linked to ecodesign techniques and tools (see sections 3.3 and 3.4).

The ecodesign operational practices were obtained by the consolidation of ecodesign guidelines and checklists (types of tools identified during the review – see section 3.3) and proposals of Vezzoli and Manzini (2008) for product design into a unique list of operational practices. The unique list provides the advantage of eliminating redundancies and provides a complete and broad overview of the existing

guidelines and checklists on ecodesign. Furthermore, it enables the establishment of relationships with ecodesign techniques/tools that can support their application.
The nomenclature proposed by Vezzoli and Manzini (2008) for the classification of the ecodesign operational practices in strategy, guidelines and design options was adopted in this research. In total, 468 operational practices were identified and systematized in the Ecodesign Maturity Model (EcoM2) as a result of the systematic literature review.
Some examples of ecodesign operational practices, classified into strategies (level 1 – **bold**), guidelines (level 2 – *italic*) and design option (level 3 – normal) are presented in Table 3.

Table 3. Examples of ecodesign operational practices

Minimize Material Consumption
Minimize Material Content
Dematerialize the product or some of its components
Digitalize the product or some of its components
Avoid over-sized dimensions
Reduce thickness
Apply ribbed structures to increase structural stiffness
Avoid extra components with little functionality
Minimize material content of discarded products
Reduce the material content by integrating functions
Minimize cabling and wiring between subassemblies by appropriate product architecture
Minimize Scraps and Discards
Select processes that reduce scraps and discarded materials during production
Engage simulation systems to optimize transformation processes
Use as much recyclable material in the process as possible
Optimize the reuse of scraps and discards during manufacturing
Minimize or avoid Packaging
Avoid the use of packaging that do not have a specific function
Design the package to be part (or to become a part) of the product
Use recyclable, reusable and returnable packaging
Extend the Lifespan of Materials
Adopt the Cascade Approach
Arrange and facilitate recycling of materials in components with lower mechanical requirements
Arrange and facilitate energy recovery from materials throughout combustion
Use recycled materials wherever possible

Develop considering the use of secondary materials after recycling
Develop products to be managed in closed loops
Select Materials with the Most Efficient Recycling Technologies
Select materials that easily recover after recycling the original performance characteristics
Avoid composite materials or, when necessary, choose easily recyclable ones
Prefer thermoplastic polymers to thermosetting
Design considering the secondary use of the materials once recycled
Prefer heat-proof thermoplastic polymers to fireproof additives
Avoid waste of materials which consume much energy for recycling

The application of the ecodesign operational practices varies depending on the product characteristics (concerning life cycle phases/environmental aspects that present the greatest potential environmental impact) and/or on the priorities for minimizing impacts determined by the company (for example, if the focus is to minimize the global warming impact, the ecodesign operational practices to be prioritized will focus on the minimization of greenhouse gases emissions, such as carbon dioxide).
The ecodesign operational practices should be customized by a company, according to the characteristics of the developed products (for example, if the product is designed to have a long life span, it does not make sense to have a guideline for using biodegradable materials). Additionally, there may be specific and customized design options according to the product under development.

3.3 Ecodesign techniques and tools

The ecodesign techniques and tools are defined as any systematic means for the application of ecodesign [Baumann et al. 2002] that can support both ecodesign management and operational practices. A total amount of 107 ecodesign techniques and tools were identified by means of the systematic literature review. Some examples of ecodesign techniques and tools identified are presented in Table 4.

Table 4. Examples of ecodesign techniques and tools

10 Guidelines for Ecodesign	Environmental Product Life Cycle Matrix (EPLC)
ABC Analysis	Environmental Value Chain Analysis (EVCA)
Alternative Function Fulfillment (AFF)	Environmentally Conscious QFD (ECQFD)
ATROiD EcoDesign Tool	Environmentally conscious quality function
BOM Check	ENVRIZ
Business Process Reengineering (BPR)	Factor X Tool 2001
C2P (Compliance to Products)	euroMat
Checklist-Based Assessment Support System for Ecodesign (CHASSE)	Environmentally responsible product/product assessment matrix (ERP)
Corporate Integration of Voluntary Initiatives for Sustainability (CIVIS)	Readiness Assessment for Implementing DfE Strategies (RAILS)
D4N	grEEEn Technique

Design Abacus	Green Design Advisor (GDA)
Design for Recycling Methodology	Green QFD
DfE Matrix	House of Ecology, HoE
Eco Communication Matrix	Information/Inspiration web-based tool
EcoBenchmarking	Instep-DfE
ECODESIGN Checklist method (ECM)	LiDs Wheel
Eco-design Matrix	SimaPro
Ecodesign Online	Life Cycle Check (LCC)
EcoDesign Pilot	Life Cycle Quality Function Deployment (LC-QFD)
Ecoquest	Life Cycle Scenario Description Support Tool
Ecodesign Technique for Electronics Products	LIME technique
Ecodesign Web	Matrix Element Checklist
ECOFAIRE	MATto Material Library
Eco-Function Matrix	MECO Matrix
Eco-indicator 99	MET Matrix
Eco-indicator tool (Eco-it)	Packaging Impact Quick Evaluation Tool (PIQET)
Eco-Innovative Tool	Philips Fast Five Awareness
Eco-material evaluation diagram	Product Improvement Matrix
Econcept Spiderweb	Product Life Cycle Planning (LCP)
Eco-QFD (Ecological QFD)	Quality Function Deployment for Env (QFDE)
Eco-Re-design	Recyclability evaluation technique
Eco-roadmap	Remanufacturing Guideline
EcoValue	Ten Golden Rules
EIAtrack	Total REACH Score
EIME software	Upgrade Cycle Explorer
Environmental Effect Analysis (EEA)	GaBi
Environmental impact and factor analysis	Umberto
Environmental Objective Deployment (EOD)	SustainableMinds

Despite the existence of a large amount of ecodesign techniques and tools in literature, they are not organized and systematized and they are still not being used in a systematic way by companies in the product development process [Baumann et al. 2002], [Bey et al. 2013], [Bovea and Pérez-Belis 2012], [Knight and Jenkins 2009]. One of the most influencing factors is that companies do not have information to support the selection of the most suitable techniques and tools according to their needs

[Baumann et al. 2002]. In this sense, a classification that aims to support companies in the selection of the most suitable ecodesign techniques/tools is proposed.
The criteria for classification of ecodesign techniques/tools were selected by the understanding of their main functions, characteristics and application possibilities in the product development process [Pigosso et al. 2011]. The classification of the ecodesign techniques/tools using the defined criteria was registered in an online database, which enables the filter according to the desired criteria.
It is important to notice that, once selected, the ecodesign techniques/tools must be adapted and customized by the company, according to its specific product development process and tools in order to be more easily accepted and used by development engineers and designers [Quella 2003]. According to Knight and Jenkins [2009], such tools and techniques are not necessarily generic and immediately applicable, but instead require some sort of process-specific customization prior to use, considering the common language, culture and current systems at a company. This can be addressed at two levels: firstly, choice of the tools which will ultimately support the ecodesign procedure that is to be implemented, and secondly, the detailed adaptation of those tools to the specific needs of the design process under consideration Knight and Jenkins [2009].

3.4 Relationship among ecodesign practices

The ecodesign management and operational practices are interrelated among them and can be supported by a set of ecodesign techniques/tools. In other words, there are relationships and dependences among the ecodesign practices of the Ecodesign Maturity Model (EcoM2) [Pigosso et al. 2013].
The relationship of the ecodesign techniques and tools to ecodesign management and operational practices proposed in this research can contribute to provide a link to the product development process, which could not be achieved just by incorporating the tools into the PDP since their functionalities do not include integration in the process of the enterprise [Le Pochat et al. 2007].
Relations of dependence among the ecodesign management practices can be established, i.e., there can have pre-requisites for the application of certain ecodesign management practices. For example, in order to apply the practice “Deploy and maintain an environmental policy/strategy for products” it is required to have previously applied the practice “Formulate a company environmental policy/strategy”. The practice “Evaluate the environmental performance of products” is also a pre-requirement for the application of the management practice “Establish priorities on the environmental impacts to be minimized (invest time and effort in activities with significant contribution)”, since it supports the identification of the environmental hot spots of the product under analysis.
An analysis was performed to identify which ecodesign techniques/tools could support the application of the ecodesign management practices. The analysis was performed based on the evaluation of the main goal of each technique/tool (for example, “deploy the environmental requirements of the customers” is the main goal of the tool “Environmental Quality Function Deployment (EQFD)” and subsequent correlation with the ecodesign management practices (in this example, the ecodesign management practice associated with EQFD is “Identify the customers’ and stakeholders’ requirements and priorities concerning the environmental issues”). The application of ecodesign management practices can also be linked to the ecodesign operational practices.
The ecodesign operational practices are also associated to ecodesign techniques and tools, which can support their application. The relationships among the ecodesign operational practices and the ecodesign techniques and tools were established by comparing the main goals of the tools/techniques with each given guideline/design option. For example, to support the application of the guideline “Facilitating Remanufacturing”, there are a set of ecodesign techniques and tools such as EDIT (Environmental Design Industrial Template) and ELDA (End-of-Life Advisor) that can support its application.
Since there are several techniques and tools with similar goals (for example, evaluate the environmental performance of products or facilitating disassembly), the same ecodesign practice may be associated with more than one technique/tool. Additionally, there are some ecodesign management and operational practices that do not present any relationship/dependence and are not supported by techniques and tools. In this case, the company must implement the practice considering its own

culture, tools and processes for implementation . Furthermore, it must be noted that there are some ecodesign techniques and tools that can be applied in more than one ecodesign management or operational practices. It usually happens when the ecodesign technique/tool has broader goals and applications.
The establishment of relationships among ecodesign management practices, tools/techniques and operational practices enables the deployment of strategic activities into tactical and operational ones – it allows the link between management and product specification, providing guidance on how the ecodesign management practices should be implemented and deployed into an organization.

4. Final Remarks

The paper presented the results of the systematization of the ecodesign practices by means of a systematic literature review. The research was developed in the context of the Ecodesign Maturity Model (EcoM2), a framework that aims to support companies on ecodesign implementation and management. The research proposes the classification of the ecodesign practices into three main groups, according to their characteristics and focus: Ecodesign Management Practices; Ecodesign Operational Practices; and Ecodesign Techniques and Tools. The classification of the Ecodesign Practices into these three groups reinforces the importance of the consideration of strategic, tactic and operational levels when implementing and managing ecodesign in an organizational context.
Based on the literature review, it could be observed a clear evolution of ecodesign implementation from a technical perspective (dealing mainly with the improvement of the environmental performance of products) to an organizational perspective, in which business process-related activities and change management are presented as essential elements for an effective and consistent ecodesign implementation. This evolution is clearly reflected in the identified ecodesign practices. While the ecodesign operational practices are already relatively well established in the literature, with the existence of books and tools that systematizes the knowledge, the management practices are not yet systematized, being spread across different studies that deals with ecodesign implementation and management.
A similar conclusion can be drawn from the analysis of the ecodesign techniques and tools. Most of the 107 identified techniques/tools are primarily related to the implementation of the ecodesign operational practices (such as to support design for remanufacturing and/or selection of materials), being technic-oriented tools. Only few of them can be used as a support to the ecodesign management practices, with exception to techniques/tools for the evaluation of the environment performance of products (more than 40 different techniques/tools can be employed).
Additionally, the research proposes a set of classification criteria to each group of the ecodesign practices (i.e. to the ecodesign management practices, ecodesign operational practices and ecodesign techniques and tools), which can support the selection of the most suitable practices to be applied by the company, according to their specific needs and goals. The research also comprised the establishment of relationships and dependences among the ecodesign practices by analyzing the goals of each practice and comparing them to each other in order to identify possible relationships.
Based on the analysis of the relationship among the ecodesign practices, it has been identified the need for the development of techniques/tools that can support the application of ecodesign management practices, especially in regards to the change management for ecodesign implementation. There is a lack of techniques/tools and/or guidelines that can support companies in dealing with change management (practices 100xx); and with the organizational issues for ecodesign implementation (such as the establishment of a green incentive scheme).
Furthermore, since the level of detail of the ecodesign management practices is still low, future research should focus on the definition of clear procedures and success factors for the implementation of each one of the 62 ecodesign management practices (e.g. how to develop successfully deploy the environmental strategy/policy to the product level?), developing a comprehensive body of knowledge that will enable companies to implement ecodesign in a systematic and consistent way.
In order to incorporate the new developments in the field, the ecodesign practices database obtained by the aforementioned systematic literature review should be continually updated based on new developments in the academia and industry.

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