
Improving Product's Environmental Performance by Integrating Ecodesign Methods and Tools into a Reference Model for New Product Development

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Abstract. The new product development (NPD) is considered a critical process for improving company competitiveness. Since environmental impacts generated throughout the entire product lifecycle are considerably determined during the early phase of its development phase, NPD also plays a crucial role in remarkably enhancing the environmental performance of new products. Ecodesign can be defined as the systematic introduction of environmental concerns during product development. Despite the fact that several opportunities for competitive advantage have been associated to ecodesign the implementation of this concept has not reached companies worldwide mainly due to the gap between eco-oriented and product-oriented research. Thus both points of view must come together in order to achieve ecodesign benefits. This paper aims at proposing a systematic approach to do it by introducing some selected ecodesign methods and tools into the early phases of a reference model for NPD. The expected result is a set of structured activities that can successfully combine ecological and business perspectives. This paper presents some preliminary results on the field of sustainable product development (SPD) conducted by the authors.

Keywords. New product development, reference model, ecodesign.

1 Introduction

The rising consumption of products is at the origin of most of the pollution and resources depletion that our society causes [1]. The environmental impacts observed throughout a product lifecycle are, to a large extent, determined during its development phase [2]. Hence, taking environmental aspects into consideration during the new product development (NPD) phase plays an essential role in reducing product lifecycle-related environmental impacts. Ecodesign can be defined as the systematic introduction of environmental concerns into NPD throughout the application of specific methods and tools. Despite the fact that the number of available ecodesign methods and tools has been increasing in the last

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decade, its implementation has not reached companies worldwide mainly due to the gap between eco-oriented and product-oriented researchers [3, 4]. The eco-oriented researchers fail to see NPD as a business process crucial to competitiveness, leading to partial and poor integration of ecodesign methods and tools into NPD, not generating the expected ecodesign competitive advantages [5, 6]. On the other hand, product-oriented researchers pay too little attention to environmental aspects, focusing generally on legal compliance and ‘end-of-pipe’ solutions due to little knowledge about ecodesign methods. This gap generates a lack of systematic use of ecodesign methods and tools in NPD leading companies to low levels of environmental performance. This paper aims at proposing a systematic approach to bridge the aforementioned gap by introducing some ecodesign methods and tools into the early phases of a reference model for NPD, which is a way to structure activities in a business process. The ecodesign methods to be integrated have been selected through literature review using a structured classification method. The reference model, used as integration baseline resulted from experiences accumulated since 1990. The expected result is a set of NPD-oriented structured activities that can successfully combine environmental and business perspectives to help companies worldwide to follow the path of sustainability by making new and “green” products successful into the market. This paper presents some preliminary results conducted by the authors.

2 Literature Review

2.1 New Product Development and Ecodesign

According to [7] new product development (NPD) is “The overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product. Also frequently referred to just as “product development.”. Clark & Fujimoto [8] states that “Product development process is the resulting process when market information is transformed into information and necessary sources to manufacture a product with the aim of commercializing it”. For Pugh [9] “Product development process is the necessary systematic activity from the identification of the market/customer needs until the product sale, an activity that includes product, processes, people and organization”. It is not a new notion that developing products has become one of the key processes for competitiveness in manufacturing. One of the well-known factors of the product development process is that the degree of uncertainty in the beginning of the process is very high, decreasing over time. The decisions in the beginning of the development cycle are responsible for 70% of the cost of the final product [10]. Regarding the product related environmental impacts, considering environmental requirements at the beginning of the product development phase can reduce environment impacts by an estimated 70% [2]. Hence, taking environmental aspects into consideration during the new product development (NPD) phase plays an essential role in reducing product lifecycle-related environmental impacts.

Ecodesign (term used in Europe) or Design for Environment (term used in US) define a new way of developing products where to environment aspects are given

the same status as to functionality, durability, costs, time-to-market, aesthetics, ergonomics and quality. Ecodesign aims at improving the product environmental performance and may be seen as a way of developing products in line with the concept of sustainable development [11-15].

Baumann et al [5] identify more than 150 existing ecodesign methods and tools to implement what they call environmental product development (EPD). In the field of ecodesign research the terms "tool" and "methods" are often interchangeable. Varying accuracy of the results, different methods and tools have been found to be useful. In this paper we selected four methods/tools: Life Cycle Assessment (LCA), Quality Function Deployment for Environment (QFDE), The Ten Golden Rules and Environment Effect Analysis (EEA). Those methods and tools were selected due to the fact there is more available information addressing their definitions and usage in comparison with others. LCA assesses the environmental aspects and potential impacts associated with a product by compiling, evaluating and interpreting an inventory of relevant inputs and outputs. In fact, LCA is a class of methods since there is no single method for conducting LCAs [16, 17]. QFDE analyzes functions required for a product or the product structure to promote these functions, helping design engineers select the best plan among design improvement alternatives and address the voice of the consumer at the same time [18, 19]. The Ten Golden Rules is a summary of guidelines gathered at the company guidelines and in different handbooks [20, 21]. EEA identifies and evaluates potential environmental impacts in all lifecycle phases of the product in a systematic way, assessing each activity in the product lifecycle. EEA shall be done together with Design-FMEAs [22]. Table 1 shows the systematization of its methods/tools according to its input and output data.

Table 1. Methods/tools input and output data

Methods/Tools	Input Data		Output Data	
	Description	Nature	Description	Nature
Life Cycle Assessment (LCA)	Used materials and energy Life cycle inventory Characterization of product	Qualitative and Quantitative	Analysis of contribution of life cycle stages Reveal down- and upstream impacts Ideas for reducing environmental impact	Qualitative and Quantitative
QFDE	Voice of customer Engineering metrics -Product requirements Energy Chemicals used Energy Use Solid Residues Liquid Residues Gaseous Residues	Semi-Quantitative	Important attributes and function units Possibility of design improvements	Semi-Quantitative

The Ten Golden Rules	Product concept	Qualitative	Evaluation of the product	Qualitative
Environment Effect Analysis (EEA)	Earlier LCA	Qualitative	Identify the focus of LCA on specific area	Qualitative
	Environmental function requirements		Verifying legal compliances	
	Legal and other external requirements		EEA on detailed design	
	QFD for customers demand		Design requirements	
	Internal objectives and targets			

However, in order to ensure concrete results with the selected methods and tools, it is necessary to introduce the topic of sustainability into the company's business core as a preliminary measure. Porter [23] indicates that the environmental aspects should be integrated with the strategic and operational activities of a company, be specific for each company and be seen as source for opportunity, innovation and competitive advantage. To put in practice this win-win principle, companies have to identify the intersection aspects between the environmental impacts of the product life cycle and the stakeholders' demands; to define the environmental aspects to be deal with and to integrate the environmental dimension and goals into the company's strategy. In agreement with IISD [24] the following seven steps are required to manage enterprises according to sustainable development principles: 1) Perform a stakeholder analysis; 2) Set sustainable development policies and objectives; 3) Design and execute an implementation plan; 4) Develop a supportive corporate culture; 5) Develop measures and standards of performance; 6) Prepare reports; and 7) Enhance internal monitoring processes. This may be seen as a prerequisite task to all NPD-related activities. Baumann's organizational tools are also suitable for this propose [5].

3 Integrating ecodesign methods and tools into a reference model for NPD

When systematizing a NPD for a company, a pattern is established to define projects for the development of products contributing to the standardization of some practices, to the use of a common language, to the repeatability among projects and to its quality. The NPD process used as a reference for defining the scope of product development projects is normally represented in a reference model, also known as standard process [25]. The presented reference model was created in a joint project of three research institutions based on a community of practice [26] on the Internet for knowledge sharing among universities and companies in product development. Standard processes for some companies have been derived from this model, which helped the researchers to improve it [25]. A

general view of the reference model, divided into macro-phases, is presented in Figure 1.

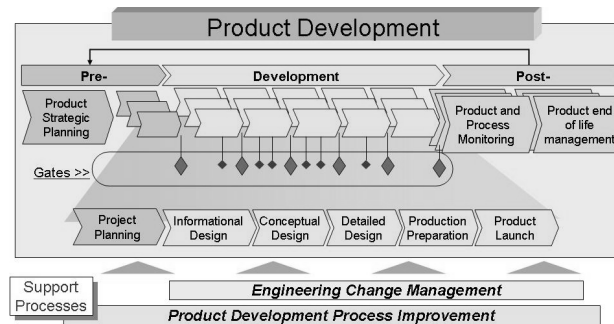


Figure 1. The reference model for product development [25]

The product strategic planning phase includes product portfolio management in accordance to the business strategic plan, taking into consideration market and technological innovations. This phase deal with the whole portfolio of product whereas the following phases are related to a specific product, i.e., a unique project. In the project planning phase, the project scope, resources, people in charge, effort, duration and costs are defined. PMBOK best practices are considered in this phase. If the project plan is approved through a formal gate process [27], the project begins and will end at the product launch phase. The product life cycle, the stakeholders and their requirements are determined in the informational design phase. The product requirements, which must be quantified in measurable variables with target values, derive from the stakeholders' requirements. This is not the first time the requirements are defined, since their definition begins in product strategic planning, when marketing delivers information about the market, which is now detailed in the informational design for a specific product. The product functions (physical, quality, interface, etc.) are established in the conceptual design phase to meet the product requirements. The technological solutions and product architecture are also determined at this point. Creativity methods may be applied in this phase. Innovations may emerge based on new technologies developed by the R&D process (which is complemented by the NPD process). Nevertheless, not all of the projects go through the conceptual design phase, since product architecture is not usually changed into derivative projects. The next phase is the detailed design, which consists of three integrated cycles: detailing, acquiring and improving cycles. Calculations, simulations, product modeling, drafting, bill of materials, process plans, failure analysis, prototypes, evaluations and tests are carried out in this phase. All the manufacturing resources are specified, even a new factory, when necessary. Product handbooks and instructions for technical assistance are also produced, as well as sales support information systems. The supply chain is defined at the beginning of product development, when agreements are made with main strategic partners and co-developers. The last supplier contracts must be signed in the detailed design phase. Based on the prototypes, the product is then certified. In the next phase, production preparation, new equipments defined in the previous phase

are installed and tested. A pilot production is run to certify the production facilities and products being manufactured with the definitive resources, since during the detailed phase prototypes might, for instance, be build with non mass production equipment.. In this phase, a new production business process (or even the whole supply chain process including logistics) can be mapped and established to define, for instance, whether production will be controlled based on orders or Kanban. The product launch phase takes place in parallel to production preparation. Other business processes are mapped in this phase, such as technical assistance and customer service, when, for instance, a new help desk script for the new product must be created. In short, production preparation aims at defining the supply chain from the internal standpoint and the product launch phase to the external standpoint (market and customers). After the product is launched, production and sales business processes begin under the responsibility of other areas of the company. The project phase (development macro-phase – see the Figure 1) is concluded, the team is disbanded, and its members are allocated to other projects or return to their original functional areas. Nevertheless, product life cycle management continues, since efforts must now focus on monitoring the product and its manufacturing process. Ongoing customer support and engineering change management (ECM) must be provided to eliminate failures or improve product performance. At this time, configuration management ensures product information integrity throughout the product life cycle. The ECM process manages product changes, whereas other supporting processes carry out improvements in NPD. At the end of the lifecycle of a product, the product is discontinued and could be reused, remanufactured, recycled, disposed according to the end-of-life (EOL) plan, which is normally developed during the development macro-phase.

This brief description of the process provides only an overall functional vision of NPD, since only the main activities have been mentioned. Other complementary visions have not been addressed here.

The focuses of the proposed integration are the Strategic Product Planning, Informational Design, Conceptual Design and Detailed Design phases. It is due to the fact the entire product life cycle environmental impacts are, to a large extend determined during these phases. Table 2 shows the tools/methods selected by the NPD reference model phases in which their use is suggested.

Table 2. Integration of ecodesign methods and tools into NPD reference model

Phases	Methods/Tools
Strategic Product Planning	Porter's guidelines, the seven steps for managing an enterprise according to sustainable development principles and Baumann's organizing tools
Informational Design	The Ten Golden Rules, QFDE (Phase I), LCA
Conceptual Design	QFDE (Phase II and III), EEA, LCA
Detailed Design	QFDE (Phase IV), LCA

Each phase of the presented model is composed by several activities. Thus one has to exploit the influences of the suggested ecodesign methods and tools on these activities in order to make ecodesign happen. It can be done by developing templates where the usage of one method or tool is described. Select ecodesign methods and tools and decide at which NPD phase it should be used has to be carried out by the design team's members, who in turn should take into account the

dynamics of their activities and their maturity level on ecodesign. This selection may be assisted by a specialist.

The use of selected method and tool depends mainly on the stage of the product development process i.e., how detailed the available information is. Time and cost may be reduced and a more 'environmentally friendly' product produced if ecodesign methods and tools are used early in the design process. Since ecodesign factors of success are, to a large extent, similar to NPD factors of successes [28] the task of integrating the ecodesign concept as a whole will be easier for those companies that have high levels of maturity in NPD

4 Conclusion

NPD plays also an important role in reducing the environment impacts of a product lifecycle. Use a reference model for NPD can contribute to the standardization of some practices, to the use of a common language, to the repeatability among projects and to its quality, increasing the chance to make products successful into the market by structuring this business process. Despite the existence of many ecodesign methods and tools, a systematic way to use them in NPD is lacking. Introducing ecodesign methods and tools into designers' daily activities using a reference model for NPD may bridge this gap. The task of selecting ecodesign methods and tools and deciding at which NPD phase they should be used is something companies have to perform internally. However, in order to ensure concrete results with the implementation of ecodesign methods and tools, it is also necessary to introduce the topic of sustainability into the company's business core as a preliminary measure. The proposed integration is a set of NPD-oriented structured activities that can successfully combine environmental and business perspectives.

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