

IMPLEMENTATION OF AN ECO-EFFICIENCY APPROACH INTO THE METHODOLOGY ROADMAP FOR INTEGRATED PRODUCT DEVELOPMENT

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ABSTRACT

The worldwide growing attention for the environmental impacts of new products causes a growing concern for sustainable design in the new product development (NPD) processes. This paper describes the integration of the ecodesign methodology of Brezet *et al.* (1997) into the methodology for integrated product development proposed by Verhaert *et al.* (1998), which is applied at the Higher Institute of Product Development in Antwerp, Belgium. The analysis indicated the importance of sufficient attention to eco-efficient topics in the early stages of the NPD.

Keywords: Eco-efficient design, design methodology, integrated new product development roadmap

1. INTRODUCTION

In the last decade the NPD process is stressed because of the increasing technological complexity of products, the rapidly changing markets, users' expectations and the growing attention for the environmental impacts of new products. Specific roadmaps and methodologies for integrated NPD optimize the added value and the quality of the new product [1]. Moreover, they enable a reduction of the development time and cost of the process. These methods are based on an interdisciplinary approach that focuses on all relevant technological, economical and user-related design aspects during all stages of the design process.

The roadmap followed at the Higher Institute of Product Development in Antwerp, Belgium is based on the stage gate model as proposed by Verhaert *et al.* (1998) [2]. The roadmap provides an integrated approach through creative methods and research tools which support the ideation, the interdisciplinary analysis and the systematic verification of technological, economical and human aspects at the end of every stage. This methodology is the guideline for our project based educational model: Bachelor students are trained in using several design and verification techniques during the design projects. Master students have to be able to manage a NPD project by defining the most appropriate methodology and by selecting and implementing a set of relevant tools and techniques to support the interdisciplinary approach.

Despite the fact that environmental aspects are included in this approach, a systematic and consistent implementation of an eco-design methodology into the existing NPD roadmap does not seem evident both in an educational and industrial context.

This paper describes the integration of a well-accepted ecodesign methodology (Brezet *et al.* 1997) [3] into the methodology for integrated NPD which is proposed by Verhaert *et al.* (1998) [2]. By comparing and combining the currently used approach with the specific ecodesign roadmap, ecological aspects are more systematically taken into consideration during the design projects. This new methodology is currently applied by Master students in product development who use it as guidance in master proofs with an emphasis on sustainable aspects. This evolution leads to industrial designers which implement eco-efficiency in a natural way.

2. BACKGROUND OF THE TWO METHODOLOGIES

2.1 Fundamentals of the integrated design roadmap of Verhaert *et al.* (1998)

The methodology roadmap by Verhaert *et al.* [2], has been developed within the company ‘Verhaert, Masters in Innovation’ and has been inspired by models of Roozenburg and Eekels (1995) [4] and Pahl and Beitz (1996) [5]. Roozenburg and Eekels’ methodology emphasises the repetitiveness of several design steps and the spiral-like view on the process. Since 1970, Pahl and Beitz state that design problem-solving is a variant of general problem solving [6].

Verhaert *et al.* [2] combines various views on design processes into their own specific NPD process. This design roadmap contains four main principles which always have to be taken into consideration when developing a new product. These fundamentals are:

- Reverse the learning effort and the expense curve.
- Acknowledge the interdisciplinary aspects of design.
- Iteration between configuration and verification.
- Valorisation of new specifications through the integration of Quality Function Deployment.

The four main phases are ‘*Stage 0: NPD Policy*’, ‘*Stage 1: Idea Generation for New Products*’, ‘*Stage 2: Conceptual Design*’, and ‘*Stage 3: Detailed Design*’.

Despite of the four main stages, the NPD process has to be considered as an integrated approach. This approach provides resources for the industrial designer to identify all critical aspects (economical, human and technological) and makes it possible to point them all out for verification throughout the complete process.

Verifications are performed during and after each design stage, aiming to provide feedback about previous steps and to save time by adjusting the proposed design solutions where necessary.

In Figure 1 the different stages are visualized with equal attention for all three design disciplines (T/H/E), together with the repetitive verification steps after each stage. The circular shape indicates this uniformity in disciplines and indicates the freedom inside every phase. This means that the designer can determine himself in

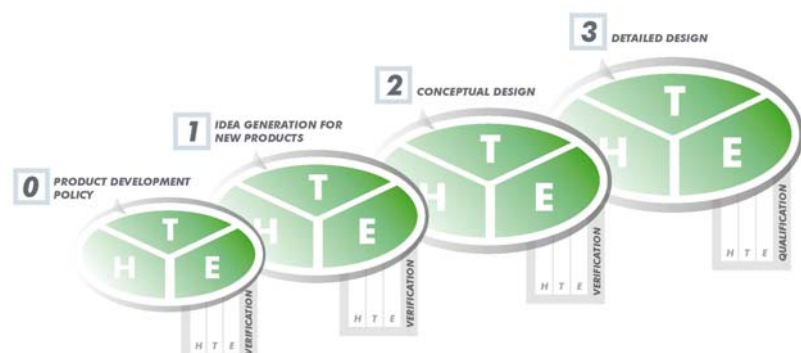


Figure 1. The interdisciplinary design aspects in all stages of the NPD process (Verhaert *et al.* [2])

which order to use the design tools or techniques that he finds sufficient to apply for the development of his product. The gradual enlargement of each circle shows the raising level of detail through the whole process.

2.2 The Ecodesign roadmap of Brezet et al. (1997)

The Ecodesign roadmap is a part of the complete Ecodesign Manual [3], which is based on the PROMISE manual composed by NOTA (Rathenau Institute - The Hague, Technical University of Delft – Delft, both in The Netherlands) in 1994. Despite of its publication date in 1997, the manual is known as one of the most complete ecodesign manuals.

The ecodesign roadmap which is proposed in the manual is based on the same basic principles as a general NPD process, but distinguishes itself from the latter in the following ways:

- Think in life cycles of the product [3],[7].
- Consider the whole system chain of the product.
- Analyse the current environmental impact and define ecodesign strategies.
- Ecodesign = ecological + economical.

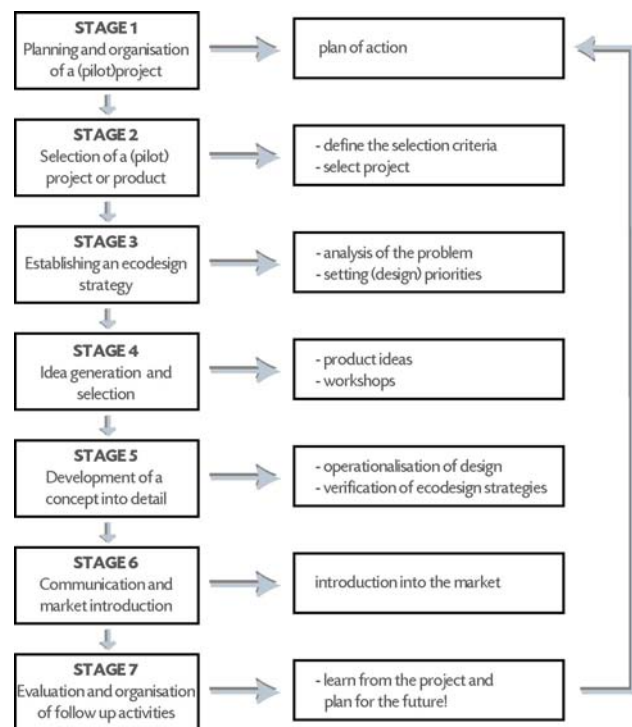


Figure 2. The main stages of the ecodesign methodology according to Brezet et al. [3]

Figure 2 gives a general overview of the seven ecodesign stages according to Brezet *et al*[3]. Implementing ecodesign in the NPD process will have the largest influence in the early stages of the roadmap, where a more profound analysis will have to be executed to define the further evolution of each project. Apart from a repetitive environmental verification and the monitoring of the defined ecodesign strategies, the next stages in the design roadmap are considered as almost equivalent.

3. IMPLEMENTATION OF THE TWO METHODOLOGIES

3.1 Procedure of converging the roadmaps

The two roadmaps were combined in order to increase the systematic application of eco-efficiency in the design projects that are assigned to master students in product development. This implementation has been done with respect to the integrated design approach which is applied at the institute.

To achieve this, the main stages of the ecodesign methodology of Brezet *et al.* [3] have been compared with those of the roadmap of Verhaert *et al.* [2]. Similarities and differences have been detected; overlapping stages have been combined and steps like eco-tools, techniques and environmental verifications have been added.

A schematic overview of the implemented eco-efficient NPD roadmap methodologies is given in the attachment ‘implemented eco-efficient NPD roadmap’ at the end of the paper.

3.2 Observations on the implemented roadmap

The implementation of the ecodesign roadmap caused the largest changes in the early stages of the NPD process (see attachment). The following adjustments are eligible to be mentioned:

- **Commitment of the management (Stage 0).** In stage zero, the NPD policy phase, the commitment of the management has to be guaranteed. If this is not the case, it will be difficult for a designer to impose his ecodesign solutions in later stages in the process.
- **Selection criteria for project selection (Stage 1).** Selection criteria have to be drawn up to ease the decision-making process of the project selection. These measures can be seen as a strategic translation of the company's NPD policy and its goals.
- **Analysis of the product's environmental profile (Stage 2).** The concept design stage is enlarged, especially in the first steps of the phase. Apart from the general analysis of the product, a profound environmental analysis of the product should be performed, in order to define the selected ecodesign strategy for the project. These activities are very important, considering that the design team determines to which extend and how they will try to improve the product environmentally. The gathered information will be converted into specifications of the new product.
- **Operative ecodesign strategies and verification of ecodesign strategies (Stage 2).** In the system and concept design stages, the product developers try to solve design problems to fulfil the specifications of the product. It is at this stage that they have to find eco-efficient solutions to meet the determined ecodesign strategies. Verifications after each phase (system design – concept design) are extended with the verification of the premised ecodesign strategies.
- **Promotion of new ecodesign (Stage 3).** After the concept stage, when the product is developed and a definite design is selected after trade-off, it is of great value to promote the new (eco)design. Communication on the new design should be performed first in-house the company and subsequently external to the company, accordant to a promotion plan.
- **Follow-up activities (Stage 4).** The follow-up activities are scarcely discussed in the integrated NPD process. In order to ensure a continuous attention towards the environment in design projects, it is necessary to evaluate the design product (i.e. did we reach our ecodesign goals?) and the complete project (i.e. did the project developed as we expected it?). Afterwards, feedback can be passed on to the next project team and an ecodesign programme specified for the company can be developed.

This analysis shows that the more attention is paid for the early stages in the implemented process, the shorter development times of the design process will be. Furthermore one can notice that new types of information are needed, e.g. data on the environmental impact of materials, components and processes. Therefore new information providers should be addressed, both inside and outside the company. This information exchange is part of the whole system chain which has been mentioned in paragraph 2.4. A last diversification in the process concerns the type of decisions that have to be made. When performing a verification or trade-off of design solutions, the Master students in Product Development have to motivate decisions regarding the choice between environmental and other requirements or the choice between several environmental requirements.

3.3 Succession of the research

The implemented roadmap is used in several practical applications in design projects, in order to test and adjust the adapted methodology and to measure the willingness of the students to include environmental aspects into the interdisciplinary design approach.

3.4 Limitations of the adjusted methodology

Some important evolutions in ecodesign have occurred since the publication of the Ecodesign manual [3] in 1997. The most outstanding new trends since then are the shift towards the development of product-service systems (PSS), the creation of eco-value instead of the 'negative' environmental impact approach, and the rising attention for the social aspects of design. Ecodesign is thus shifting clearly towards sustainable design.

4. CONCLUSION

This paper presents a valid way to implement the internationally recognized eco-efficient design methodology of Brezet *et al.* into the NPD methodology of Verhaert *et al.* The output of this work results in a step-by-step methodology which is applied by Master students in integrated product development in their NPD processes. This adapted methodology offers a profound basis for the implementation of a new methodology in product development, which monitors the environmental awareness of new product developers. In conclusion, it is of crucial importance to pay sufficient attention to the early stages of eco-efficient topics in the early stages of NPD.

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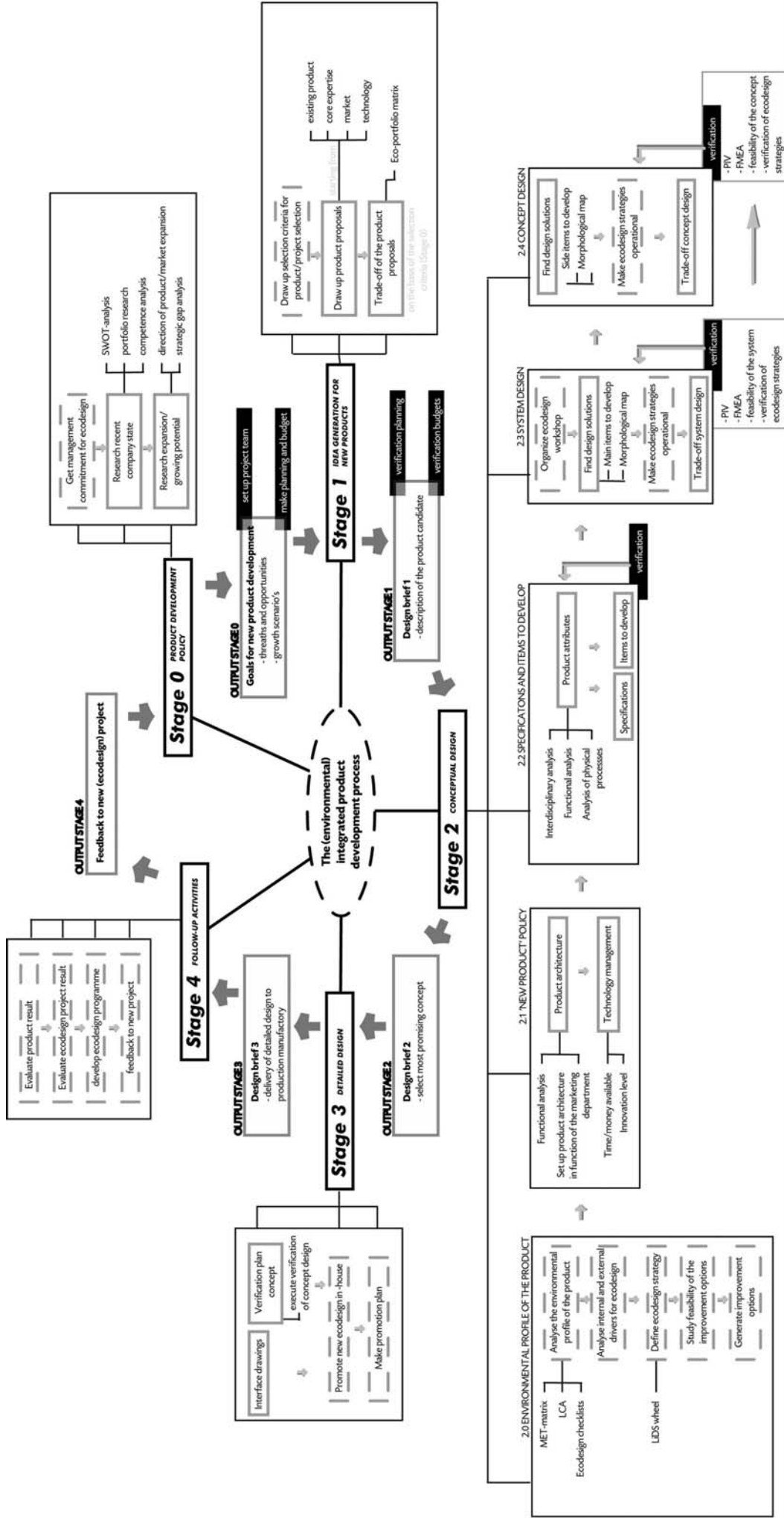
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Attachment: schematic overview of the implemented eco-efficient NPD roadmap