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THE APPLICATION OF THE ECODESIGN PILOT AND METHODICAL SUPPORT FOR THE IMPLEMENTATION OF ECODESIGN IN PRODUCTS

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1. Motivation

The question nowadays is how to bring environmental information to engineers in product development in order to support the decision making process towards more environmentally conscious products. From industry we frequently hear questions like:
What is ECODESIGN all about? Where to integrate ECODESIGN along product development? How to improve products with ECODESIGN? Where should we start?
First experience was made with the ECODESIGN Checklist Method (ECM) [Wimmer, 2000], later on a multimedia tool on CD ROM, the ECODESIGN Product Investigation, Learning and Optimization Tool (PILOT) [Wimmer et.al, 2001], [Wimmer, Züst, 2001] was developed and implemented in companies. Recently also an online version of this tool is available in the Internet [Wimmer, 2001].
The paper describes experiences from applications of this new ECODESIGN approach to product case studies. Additionally a model for the whole product development process combining ECODESIGN with general engineering design methods is presented.

2. Objectives

The ECODESIGN PILOT is designed as a product improvement tool, that supports the decision making process to find appropriate ECODESIGN measures to improve products. Therefore, the ECODESIGN PILOT offers a design assessment procedure to carry out product evaluation as well as a learning approach to broaden the understanding of the complex subject of ECODESIGN. The objective is to stimulate interest in environment-related product innovation and to give clear advice how to implement ECODESIGN in specific products. The target group for this tool includes engineers in product development; environmental experts and designers as well as employees involved in the implementation of environmental management systems.

3. The application of the ECODESIGN PILOT

The aim is to identify measures that have the strongest leverage for an ecology-oriented improvement of a product. The first step consists in identifying the phases in the product life cycle that have the largest environmental impact. Then, ECODESIGN strategies can be identified and appropriate ECODESIGN measures for a concrete product can be selected and adapted for implementation. ECODESIGN how-to-do instructions were then formulated, illustrated by examples, and linked to the different product improvement strategies.

Applying the ECODESIGN PILOT to specific products consists in a procedure in six steps, explained as follows:

3.1 Life Cycle Thinking

The goal of the process of Life Cycle Thinking (LCT) is to identify phases and processes within the product life cycle which have or could have significant environmental impacts. The result of this environmental evaluation is a specific description of the product. The ECODESIGN PILOT characterizes products by means of "basic types" as they are:

- raw material intensive product
- manufacture intensive product
- transportation intensive product
- use intensive product
- disposal intensive product

Life Cycle Thinking could be supported by:

- using full life cycle assessment (LCA)
- abridged LCA in form of indicators
- evaluating energy and material consumption over the whole product life cycle
- using the ECODESIGN PILOT Assistant (under http://www.ecodesign.at/pilot)

The characterization in five basic types helps to find the appropriate improvement strategies within the ECODESIGN PILOT. For each improvement strategy a checklist is available to work on detailed design changes for the analyzed product.

3.1.1 Example aluminum chair

The aluminum chair consists of 2,0 kg of aluminum metal sheet, 2,5 kg of aluminum tubes and 0,5 kg of steel bolts, screws and fasteners. The total weight of this chair is 5,0 kg. The lifetime of the chair is assumed to be over 10 years. The chair is designed for outdoor use e.g. in the garden of a restaurant. The LCT expressed in relative numbers of the environmental impact results in a profile as shown in Figure 1. Therefore the product can be characterized as a *raw material intensive* product.

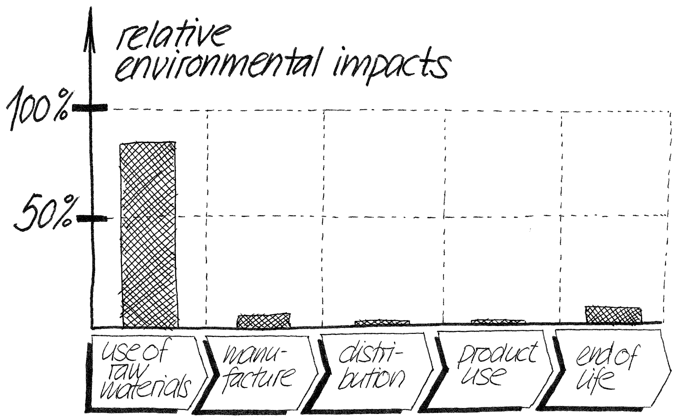

Figure 1. LCT profile of an aluminum chair

3.1.2 Example water kettle

The water kettle analyzed consists of an injection mould PP housing with a PA switch unit and a PP ground plate, an heating element made from high alloy steel and a regular electric cable (PVC and copper). The total weight of the kettle is 0,87 kg the packaging weights 0,2 kg and consists of cardboard. The assumption made for the using phase was the boiling of ½ a liter of water 3 times a day, 5 times a week, 50 times a year. The total lifetime of the kettle then was assumed to be 3 years.

The result of this LCT is expressed in Figure 2. The water kettle turns out to be a *use intensive* product.

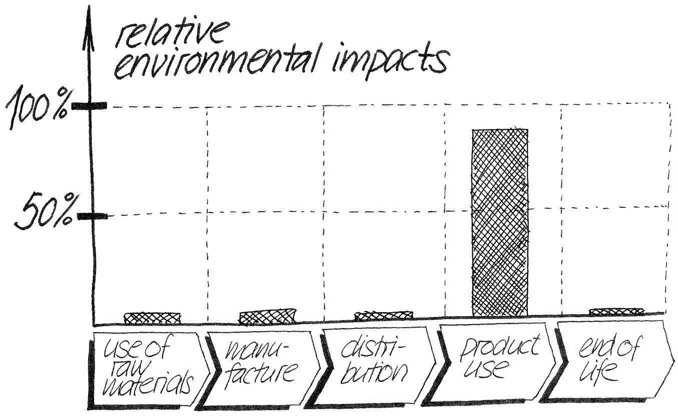

Figure 2. LCT - profile of a water kettle

3.1.3 Example washing machine

The washing machine analyzed is a regular washing machine with a total weight of 80 kg. The materials used are concrete, steel sheet, stainless steel, plastics (PA, PP, PVC), as well as cast iron and copper. The standard washing cycle is washing 5 kg of textiles with 60°C, that consumes 1,2 kWh of energy. Two use scenarios were assumed. The one reflects the needs of a family with 3 children: 2 washes per day 6 days per week, 50 weeks per year. The total lifetime for this machine is 16 years. In total around 10.000 uses over the whole product lifetime are assumed. A second use scenario reflecting the needs of a single person household was defined with: 1 wash per week, 50 weeks per year. Although supposing a longer lifetime for this machine (20 years) the total uses are summing up to around 1.000 only.

The influence of the actual using scenario on the overall environmental performance of the product along its life cycle can be demonstrated by this example. Generally speaking the LCT of an intensively used washing machine (around 10.000 uses over the whole product life) would result in a life cycle profile similar to the one of a water kettle as shown in Figure 2. It can be characterized as *use intensive* product. Considering a distinguished use scenario as described for a single person household with around 1000 uses over the whole life cycle this results in a different profile as shown in Figure 3. So this washing machine tends to be a hybrid type a mixture of a *raw material intensive* product and *use intensive* product.

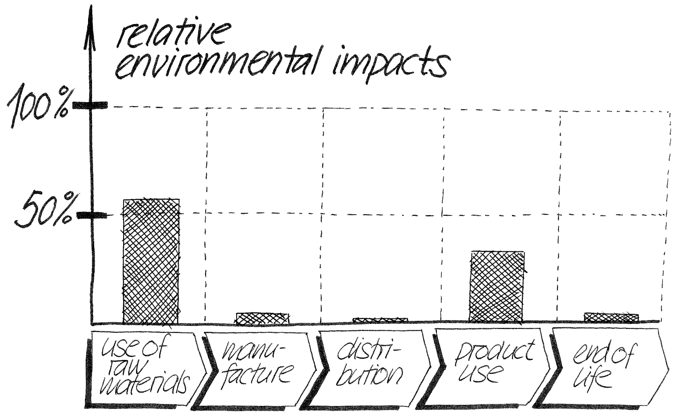

Figure 3. LCT - profile of less intensively used washing machine

3.2 Selecting improvement objectives and strategies

Finding the appropriate strategy for a certain product type requires first an evaluation of the different improvement objectives. The improvement objectives have to be discussed in the cross functional team (CFT) and possible ways to go should be distinguished from those who are not open for any further development. Several reasons might determine such a decision process, like customer requirements, company policy or technological reasons.

As an example the aluminum chair can be seen. Although the improvement objectives "*Use alternative materials*, *Make intensive use of resources*, *Use resources as long as possible*" are mentioned in the ECODESIGN PILOT for raw material intensive products the discussion showed, that marketing insisted on aluminum as material for the chair – this was a customer requirement, a more intensive and longer use of the resources was not a target at all since the product requires no maintenance and the lifetime of the chair is already very long. So two improvement objectives remain – see Table 1.

The discussion for the water kettle showed that "*Realize a high degree of functionality* and *Ensure safe use of the product*" did not match at all. The remaining "*Reduce energy and material input at use stage*" was clearly pointed out by the CFT.

The decision made for the washing machine was to choose the use scenario for the 1000 washing cycles. The strategies selected are therefore aiming not only at reducing the energy and water consumption during use, but also at reduced material input respectively at re-using materials and parts if possible. The appropriate strategies for each objective can be found in Table 1.

Table 1. ECODESIGN PILOT improvement objectives and strategies

example	improvement objectives	improvement strategies
aluminum chair	• Use less of a given type of material • Reuse materials contained in the product	- Reducing material inputs - Improving disassembly - Recycling of materials
water kettle	• Reduce energy and material input at use stage	- Reducing consumption at use stage
washing machine	• Use alternative materials • Use less of a given type of material • Reuse materials contained in the product • Reduce energy and material input at use stage	- Selecting the right materials - Improving disassembly - Reducing material inputs - Reuse of product parts - Reducing consumption at use stage

3.3 Identifying of ECODESIGN guidelines

Working with the checklists to each strategy leads to detailed ECODESIGN measures for the improvement of a product. The result of this is shown in Table 2, where also a priority setting for each measure is given.

Table 2. ECODESIGN PILOT improvement measures including priority

example	improvement measures	priority
…		
water kettle	• prevent environmentally harmful abuse of product • indicate consumption of product along use stage • minimize energy consumption at use stage by increasing efficiency of product • minimize energy demand at use stage by choosing an adequate principle of function • make possible use of renewable energy resources at use stage …	- high - high - high - low - low …

3.4 Transforming ECODESIGN guidelines into individual product design changes

The transformation from the generally formulated ECODESIGN guidelines into product related measures requires experience and creativity as well as methodical support. For example the searching for physical effects and related working principles shown in Table 3 was started in a brainstorming session and was further elaborated with elements of TRIZ [Terninko et.al, 1998] (see chapter 4, Figure 5).

Table 3. ECODESIGN PILOT improvement measures transformed into design changes

example	improvement measures	detailed design change
…		
water kettle	• prevent environmentally harmful abuse of product • indicate consumption of product along use stage • minimize energy consumption at use stage by increasing efficiency of product	- avoid re-boiling by insulation of pot - temperature adjustment for the holding temperature - installation of lamp or signal for readiness of water - guidance for right amount of water - reducing the lag time of the switch off sensor - improving the efficiency of the heater

3.5 Evaluating and carrying out design changes

The evaluation that has to be done is a comparison of the potential environmental improvement and the potential risk to be expected for an implementation of measures. This should be done again by the CFT and should lead to the decision which ECODESIGN measures can be implemented at once, later or never.

3.6 Decision and organization of the identified measures

Setting a time frame to carry out the measures and determine a person or department responsible for the realization is the last step here. The idea is to integrate the evaluated ECODESIGN measures in the managing process of an Environmental Management System (EMS). An EMS according to ISO 14001 is part of the interdisciplinary management-system containing the organizational structure, planning activities, responsibilities, methods, actions, processes and resources for development, implementation, fulfillment, evaluation and sustainment of environmental policy (Figure 4). The application of the ECODESIGN PILOT provides important information for the continual improvement process in an EMS.

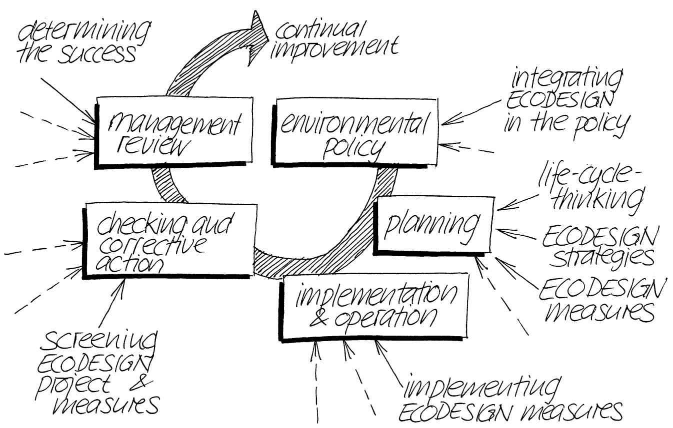

Figure 4. Structure of an EMS and the corresponding links to ECODESIGN

4. Methodical support within the product development process

The results of an analysis with the ECODESIGN PILOT have to be integrated now in the overall product development process (PDP) especially when the improvement measures lead to substantial design changes or when designing new products. For this integration general available design and creativity methods are used to support the implementation of ECODESIGN guidelines. This procedure of identifying customer needs and requirements, setting up design parameters, generating the functional structure, solution and concept generation, concept evaluation and testing up to the elaboration of the final design is outlined in Figure 5. The procedure is based on literature studies e.g. [Albers, Schweinberger, 1999], [Daenzer, Huber, 1999], [Hubka, Eder, 1996], [Pighini, Fargnoli, 2001] and own practical experience. The links to the ECODESIGN PILOT as well as to Methods in product development are pointed out.

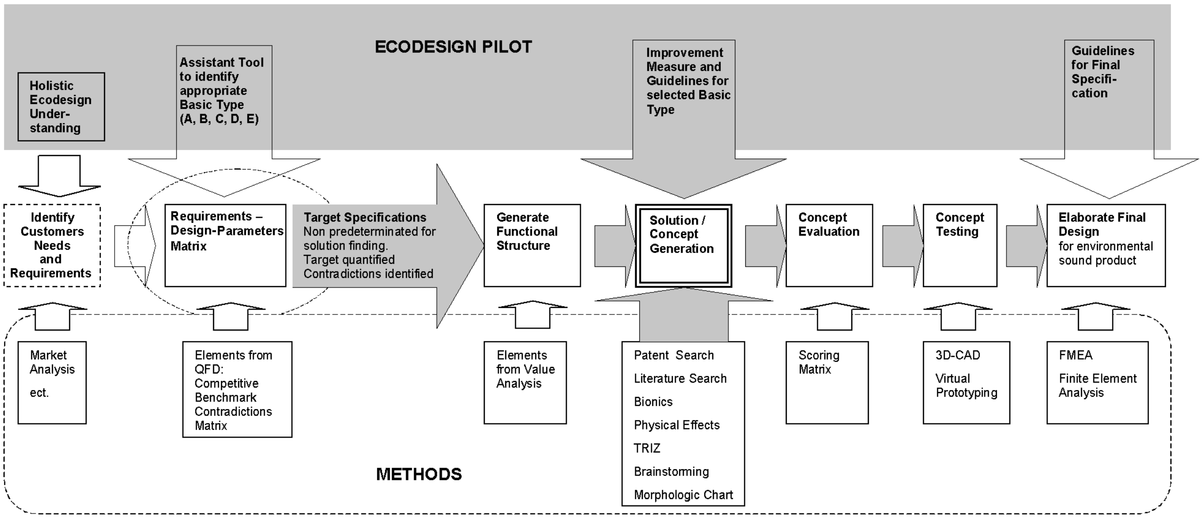

Figure 5. Integration of ECODESIGN in the product development process

4.1 Process description

For successful and marketable products the first step is to identify customers needs and requirements when planning and starting a new product development. The term customer not only includes a single user, but also stakeholders and society. Society requirements can be expressed e.g. by environmental related requirements.

In this important early phase of development the ECODESIGN PILOT can be used as a learning tool for life cycle thinking and to create an holistic understanding of the possibilities of ECODESIGN e.g. measures for product positioning. Following then the concept of Quality Function Deployment (QFD) [Akao, 1990], customer needs and requirements, generally expressed in the “voice of the customer” have to be transformed into the “language of engineers”. The design strategies provided by the ECODESIGN PILOT can be used to express the environmental related needs and requirements in representing the relationship between requirements and design-parameters (Table 4). A dot in a cell of Table 4 means that the need in the row and the parameter in the column are related. Every identified design-parameters can be the quantified then with a target value for the concept evaluation in a later phase of the PDP. To find out for a given product which environmental requirements are very important, the *Assistant* of the online version of the ECODESIGN PILOT can be used (see chapter 3.1). After this prioritization, the development of product design-parameters should be based on those relevant improvement strategies. For additional information the relation between the different design-parameters can be marked in terms of positive or negative correlation. This helps to find contradicting design-parameters. The so weighted design-parameters can be used as target specifications for the PDP.

This bringing together of ECODESIGN guidelines and methodical support of the product development also applies for the later stages in the PDP as shown in Figure 5.

Table 4. Needs and Requirements – Design-Parameters Matrix

	Design-Parameters / Needs and Requirements	....	Classification of Materials	Product weight kg	KWh Production	Classification of process materials for manufacturing	Amount of production waste	Classification of external components	Amount of packaging material	km Transport	Use intensity n/year	Availability	Product durability years	Amout of hazardous substances	KWh Use stage	Classification of auxiliary material for procuct use	Amount of waste for use stage	Time to maintenance h	Time to repair h	Time to disassemble h	Time to refurbish h	....
	Direction of Improvement		↓	↓	↓	↓	↓	↓	↓	↓	↑	↑	↑	↓	↓	↓	↓	↓	↓	↓	↓	
Other	....																					
Environmental	Selecting the right materials		•				•	•		•				•								
	Reducing material inputs			•			•			•				•								
	Reducing energy consumption in production process				•																	
	Optimizing type and amount of process materials					•	•															
	Avoiding waste in the production process						•															
	Ecological procurement of external components							•						•								
	Reduction of packaging								•	•												
	Reduction of transportation									•												
	Optimizing product use										•											
	Optimizing product functionality										•	•										
	Increasing product durability							•			•		•									
	Ensuring environmental safety performance							•						•								
	Reducing consumption at use stage							•			•				•	•						
	Avoidance of waste at use stage										•						•					
	Improving maintenance											•	•					•		•		
	Improving reparability												•						•			
	Improving disassembly																			•		
	Reuse of product parts									•											•	
	Recycling of materials		•																	•	•	
Other	....																					
	Target Value																					

This combination of the ECODESIGN PILOT with general product development methods must not be considered as a closed model, it should be regarded as a flexible and adjustable aid for specific situations and tasks. Therefore it is no problem to integrate other methods if suitable. The focus on some preselected methods is an attempt for a manageable model.

5. Conclusion

Our lessons learnt form the case studies have shown, that ECODESIGN is a multidisciplinary task and requires an adequate learning environment and creativity techniques, whereby:

- the ECODESIGN PILOT has the potential to transform the term "environment" from a vague understanding to detailed how-to-do guidelines in the language of product development
- the ECODESIGN methodology is easily understandable for most people (also for people without engineering design experiences)
- people are able to develop successful strategies and measures within short time
- the combination with general methods is very useful to find detailed design changes

The ECODESIGN PILOT is showing the potential for eco-innovation in product design and development. It addresses environmental issues in product development and motivates the target group to promote the implementation of ECODESIGN in their companies. This new tool has the potential to develop detailed how-to-do guidelines in the language of product development. Thus, ECODESIGN becomes easy to use and understand in daily design work and can be integrated in the product development process and ECODESIGN product improvements can be carried out straightforward.

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