

## CREATING SOCIALLY SUSTAINABLE PRODUCTS – EXAMINATING INFLUENCE AND RESPONSIBILITY OF ENGINEERING DESIGNERS

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### 1. Introduction

The development of environmentally sound products has been a research object for considerable time. Nevertheless, at present it seems to be called into question more and more. Politics, society and institutions as the normalization organizations demand the development of not only environmentally friendly but also sustainable products and the assumption of social responsibility. Research programs and research establishments create terms as Design for Sustainability, Sustainable Design and Design for Society, etc. By this means, the impression arises that it is under control of the engineering designers to develop economical, environmentally and socially sustainable products and to let them be distributed by the companies.

For the economical and ecological dimension, a multitude of evaluation criteria and methodological support is available, whereas for the social perspective neither a verified level of knowledge nor an established work approach for the implementation of social sustainability of products seems to exist. Due to this weakness of the social dimension, it is necessary to scrutinize the demand of the engineering design and the placed responsibility for the development of sustainable products.

The present paper gives an overview of the research approach for the development of socially sustainable products of the Department for Product Development and Machine Elements (*pmd*) at the Technische Universität Darmstadt und states the results of the first completed working phases.

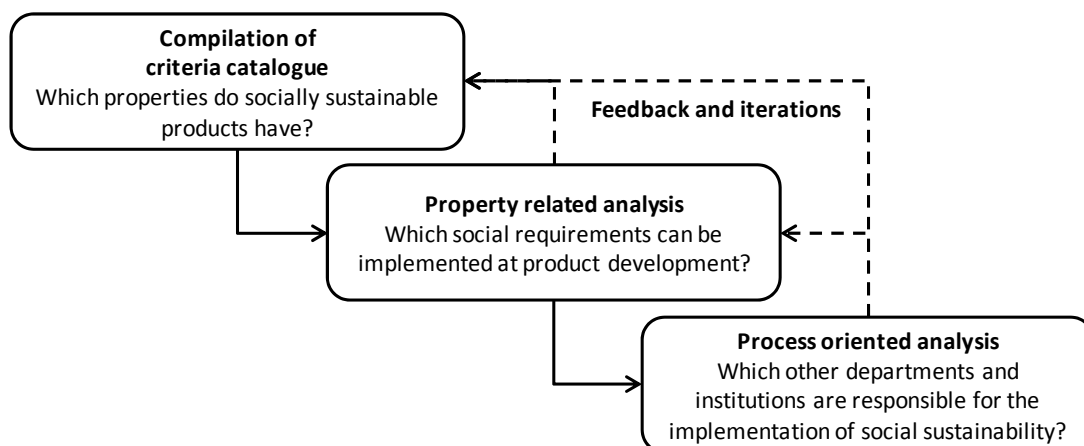


Figure 1. Research approach

The procedure presented in figure 1 and the given results are based on the first iteration for a rough assessment of the circumstances and the applicability of the chosen approach. In a further iteration, the approach will be improved to be more sophisticated based on the first results and the scientific feedback and will be applied in detail.

## 2. Background and motivation

The Department for Product Development and Machine Elements has a long history and great expertise in the research regarding the development of environmentally friendly products. In the Collaborative Research Centre “Design for Environment” - financed by the German Research Foundation (DFG) – and the subsequent Transfer Unit “Optimized Processes, Methods and Instruments for the Development of Environmentally-Friendly Products” important fundamentals for the development of environmentally sound and marketable products and the transfer of the evolved models and methods into industrial use have been acquired. During the work in the transfer unit, it became apparent that especially two aspects would be relevant to the further research of the institute:

1. The implementation of EcoDesign and the conversion of in scientifically achieved knowledge to industrial use need further effort. At present, companies see the consideration of environmental aspects as additional time-consuming effort without adding value to business. Therefore, it seems to be necessary to integrate approaches and models that enable a concurrent viewing of market related, quality related, cost related and environmental related aspects of products. In this way, the inclusion of the environmental dimension should become one of several contributions in daily work.
2. The implementation and communication of measures that deal with the social implications of products are not a subject matter in practice. Certainly, many companies have activities on the field of Corporate Social Responsibility (CSR) and compose sustainability reports, but the society related measures as Corporate Giving or Corporate Volunteering apply to employees and the local surrounding field of the companies. Usually, these are singular, only rarely long-term activities; a relation to the core business as the development and the selling of products are missing. [Leitschuh 2009]

Considering these thoughts, the institute decided to broaden the previous approaches and activities towards the development of sustainable products under consideration of all three pillars of sustainability. For this, the pmd is working on three single research topics.

The present paper deals with the project that examines the basics for the development of socially sustainable products. Research questions are:

- To what extend are engineering design and product development departments responsible for the social sustainability of products?
- Which methods and tools are necessary to implement social sustainability into the product creation process?
- Which approaches and methods can be adopted from EcoDesign and where are the limits for these approaches?

Additionally, two projects in the fields of product service systems (PSS) and sufficiency examine in what way social changes in society are necessary to realise a sustainable use of products or to attain an equivalent value for the customer by other product or service concepts. [Zhao et al. 2009]

Common purpose of the projects is to enhance the knowledge about development of environmentally friendly products so that it is possible to propose an idealized management approach that allows the integrated tracking and examination of all three pillars of sustainability for the whole product creation process from product planning to the delivery to the customer.

## 3. Sustainable products as a research objective

The sustainable organization of economy including the involved companies, customers and business processes is a research object in various scientific disciplines. They examine concepts towards sustainable business as CSR, sustainable production or consumption, green marketing or fair trade from different points of view and suggest specific solutions and approaches. In some cases, the

approaches include the development and the marketing of sustainable products. However, corresponding to their thematic origins they do not supply with detailed hints in which way products can be designed socially sustainable. The answer to this question has to be explored by engineering design research. Certainly, researchers create and use similar-sounding terms as Design for Sustainability, Sustainable Design or Design for Society/Sustainability, but the approaches' contents and the underlying appreciation of sustainability differ to a high degree.

Under the label Design for Sustainability, some research projects and articles in literature deal with urban planning and architecture or with product design from an aesthetic point of view. These aspects are not subject matter of engineering design. The contributions from the field of engineering design often deal with one-dimensional (two-dimensional) approaches that take into account only the ecological sustainability (considering the marketability) of products. For the one-dimensional articles and projects, two groups can be distinguished:

- Partially, the attributes sustainable and environmentally friendly or Design for Environment and Design for Sustainability are used as synonyms, where the terms have the same meanings. The discussed approaches refer to the ecological sustainability of products and to the reduction of their environmental impacts in the entire life cycle.
- Elsewhere, authors differentiate between Sustainable Design and EcoDesign or related/similar terms. They explain and derive the use of the sustainability item from the fact that Sustainable Design in contrast to EcoDesign or Design for Environment does not aim only at the reduction of environmental impacts of physical products. Instead, it also aims at approaches that are more radical and base on real innovation and the objective to fulfil a prospective customer's benefit. An example for this is the creation of Product Service Systems (PSS) without the traditional purchase of physical goods. By this means, Sustainable Design is a kind of broadening of EcoDesign that offers a wider range of possible product concepts and solutions for the ecological optimization of products by conceding fundamental changes of the initial product concept. [Sherwin 2004]

One-dimensional articles with a focus on the social aspects of sustainability seem not to exist. For the three-dimensional approaches, which take into account all three dimensions of sustainability, essential differences exist. These differences concern the context as well as the degree of support they offer.

Some of the three-dimensional approaches do not consider the social dimension to be an independent field of action, which is worth to focus on. Instead, they look at the connections between society and environment or between social and environmental sustainability. For example, the necessary societal changes for the implementation of ecological sustainability are an appropriate topic, such as the changes in consumer buying habits or the impacts on the society and social interactions, that emerge from more ecological product and service concepts. However, only a few approaches treat the society separately and detached from ecological aspects. In these cases, they deal with working and living conditions in the closer surrounding field of the companies, though.

Another difference between the various approaches and articles concerns the degree of support for product development:

- One group deals with the assessment of the sustainability of products only. Based on diverse criteria, they check to what extent sustainability is implemented by the products in the different aspects of sustainability. The majority of the approaches portrayed in literature excel by this assessing characteristic. There are approaches, which check the fulfilment for each pillar of sustainability separately, as well as integrated approaches, which link the three pillars to achieve a comprehensive statement to the sustainability of the product.
- The second group of approaches differ from the assessment approaches in the existence of elements that point out possible actions for the improvement of the sustainability performance. Regarding single criteria, they provide more or less concrete strategies and instructions on how to optimize the products and implement sustainability by the companies. [e.g. Crul/Diehl 2009] Compared to the assessment approaches the action-oriented approaches are outnumbered.
- The third group consists of theoretical approaches that do not only provide concrete strategies and instructions but also name the responsible processes and protagonists in companies and

their surrounding field as exact as possible that should execute the recommended actions. While such approaches already exist for the development of marketable and environmentally friendly products, it is still another situation for the social requirements. Nevertheless, it seems to be clear, that it is not only the product development's responsibility to implement these social requirements. [Sutcliffe et al. 2009]

Summing up, the current situation in research and literature is, that most of the approaches are aimed only on the assessment, but do not provide concrete advices for the optimization of the social performance of products. For the social aspects, only a few rough strategies and instructions exist. The extent of responsibility of product development seems not finally clarified.

Therefore, it is indispensable to examine what product development departments actually can do and which demands other company divisions or external institutions have to implement.

#### 4. Research approach

To clarify the question which departments in companies and which institutions outside of the companies are responsible for the assumption of single social criteria, the *pmd* pursues a scientific approach that combines a property related and a process-oriented consideration (see figure 1).

Contextual starting point for the examinations has been the question "What is a socially sustainable product?" or in engineering design speech "By which properties are socially sustainable products characterized?"

In order to answer these questions criteria for the social sustainability of products have been collected and united in a catalogue. A first analysis of these criteria showed that it is not possible just to adopt them because of their abstract quality and their origin from other scientific disciplines. That is why some well-known and established approaches for the analysis and the structuring of properties and requirements were applied to the criteria. This property related analysis of the criteria generated some findings, that serve as starting point for further examinations. Especially a classification of the criteria regarding their product relation is the basis for a process-oriented analysis.

Objective of the process-oriented approach is to identify the deciding process stages and their actors, which specify the values of the criteria for the social sustainability of the products. In a further step, possible negative influences on the processes and potential ruptures in the process sequences have to be identified, that could lead to an inadequate implementation of sustainability requirements in the products.

##### 4.1 Catalogue of criteria for the social sustainability of products

Starting point for the property related and the process-oriented examinations is a catalogue of criteria for the social sustainability of products. The first idea was to assume an existing catalogue from literature. The evaluation of literature and research projects showed that existing catalogues considerably differ in contents and form and that they are not adequate for use in product development, so that the adoption of one single complete catalogue was impossible. Therefore, the probably most complete catalogue, created at the PROSA project [Grießhammer et al. 2004], served as a basis and has been supplemented by additional criteria and adapted for the further work. In addition to the PROSA catalogue, several sources as the draft guideline ISO 26000, SA 8000 and the guidelines of the Global Reporting Initiative were implemented into the new catalogue. At present, the catalogue consists of more than 120 criteria from different sources, whereas a final consolidation is pending.

**Table 1. Characteristics as component of properties, requirements and criteria**

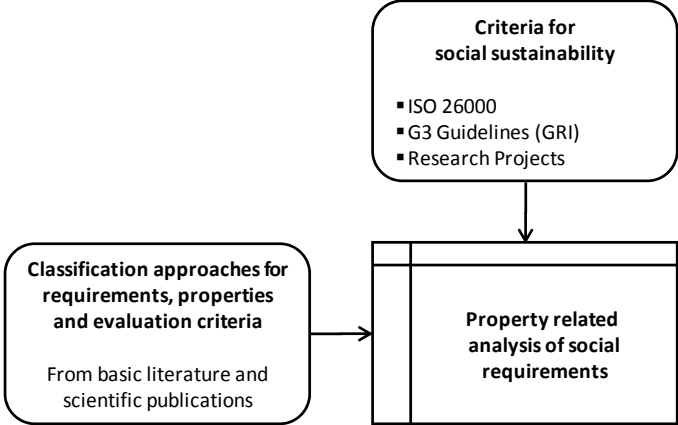
Requirements	<i>Characteristics + Set Values</i>
Properties	<i>Characteristics + Actual Values</i>
Evaluation Criteria	<i>Characteristics + Degree of Fulfilment</i>

For the compilation of the criteria, requirements as well as product properties and evaluation criteria entered into the catalogue, because all three terms base on characteristics: Requirements need characteristics and set values, properties consist of characteristics and actual values and for evaluation criteria, set and actual values are compared among each other.

Therefore, it is possible to use collections of requirements, properties or criteria for the compilation of the criteria catalogue; at the current state of work, a distinction is not necessary.

**4.2 Property related analysis**

After the compilation of the criteria catalogue, the next research step has been an analysis of the collected criteria by means of requirements classifications from the fields of engineering design and requirements engineering.



**Figure 2. Property related analysis of criteria**

In relevant literature, several approaches for the classification of product requirements exist. Mainly, they are used for elicitation, analysis and structuring of requirements. Partially, they serve for the assessment and selection of developed product concepts. Table 2 shows an excerpt of the collected classification approaches. [Hanusch et al. 2009]

Since some classification approaches need concrete formulation of the requirements with defined values or require a specific customer behaviour or opinion, it is not possible to apply all the classification approaches to the criteria of the catalogue at the current abstract stage of work.

Although it was not possible to apply as many classification approaches as expected, the application of the appropriate approaches leads to some interesting points of contact and to indications for possible problems in the creation of socially sustainable products.

**Table 2. Excerpt of Classification approaches for product requirements and criteria**

<b>Requirements elicitation</b>	Stakeholder	internal/external customer/supplier/others
	Mention by the customer	implicit/explicit
	....	
<b>Requirements analysis</b>	Linguistic form	colloquial speech/technical terms
	Effort for implementation	small/normal
	....	
<b>Requirements structuring</b>	Hierarchical level	superior/specifying
	Importance	wish/demand
	Life cycle phase	
	....	

For example, the classification of the criteria into search, experience and credence qualities shows that nearly all criteria for the social sustainability of products are credence qualities. Credence qualities stand for product properties that a customer has to trust in, because he does not have the opportunity to scrutinize the property. [Darby/Karni 1973]

Additionally, the classification by the source of the requirements points out that only small parts of the requirements are origin customer requirements. The rest of them rather are requirements of the

environment or other stakeholders, only communicated by the customers. They act as a kind of transmitter.

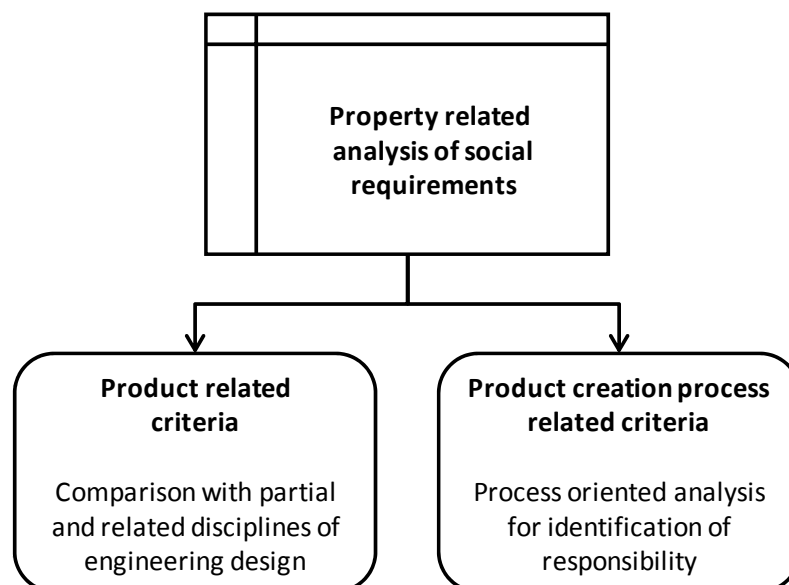
Both issues suggest a considerable role of other company departments as marketing and sales for the implementation of social sustainability in products besides the product development department.

In the framework of the property related analysis, a classification approach can be applied that differentiates whether the properties depend on the construction of the product or rather surrounding circumstances as working and living conditions. Result of this analysis is that only small parts of the criteria actually depend on the construction of the product. However, the majority of the criteria address circumstances, which originate from the design of other stages of the product creation process. In scientific theory on products or technical systems a classification of properties exist, that shows some parallels to the classification into product related and product creation process related properties and criteria. Hubka & Eder divide into internal and external properties and design properties. [Hubka/Eder 1987]

- The external properties contain those properties of technical systems that observers can easily perceive. They describe the connections of the technical system to its environment. For example, they include form, dimension, colour and ergonomic or functional aspects.
- The internal properties describe the inner conditions of a technical system and thus serve professionals for the description of the technical system. They include the relationships between the single parts of the system, and their properties. Examples are durability, strength, corrosion resistance etc.
- The design properties are part of the internal properties. They contain all properties that the designers directly can set to realise the desired external properties. They refer e.g. to the shape, size and material of a technical element.

Regarding this differentiation, the product related criteria for the social sustainability refer to external and internal properties that are determined by the design properties. However, the product creation process related criteria do not depend on design properties of the product.

The application of the described differentiation leads to strong hints for the localization of the responsibility: The product related criteria, that refer to design properties directly, are within the designer's control. This means that the product development is responsible for the implementation of social sustainability for these criteria.



**Figure 3. Classification of criteria for further analysis**

So the distinction of product related and product creation process related criteria is an important result of the property related analysis. It serves as a basis for further examinations and a more detailed iteration of the complete research approach. For this, product related and product creation process related criteria need different kinds of analysis as shown in figure 3.

### **4.3 Enhanced property related analysis**

By a closer inspection of the product related criteria, it is getting obvious that these criteria are not totally new and unknown in engineering design. Instead, many criteria seem to be object of engineering design and its subordinate partial or special disciplines. For example, safety and health of product users fall in the categories ergonomics/human engineering, occupational safety (for investment goods) and product safety. Therefore, the impression emerges that some aspects of the product related criteria for social sustainability are implemented intensely already but not considered as a matter of sustainability.

Expected is, that a detailed comparison of the product related criteria with the objectives and requirements of the single partial and special disciplines of engineering design will bring more results how and with which methods these criteria can be implemented in products by engineering designers. Additional to the disciplines mentioned before, ergonomics, occupational safety and product safety, approaches such as universal or integrated design or the various design guidelines (Design to/for X) are eligible for this comparison.

If some criteria are not covered by any special discipline or design guideline, it will be necessary to scrutinize the criteria and its product relation. That way, the comparison with the subordinate disciplines verifies the criteria catalogue and the classification into product related and product creation process related.

### **4.4 Process oriented Analysis**

The product creation process related criteria, which are not under the direct control of the product development department have to be examined in order to determine, which other departments and institutions inside and outside of the company have to consider the separate criteria and secure their implementation in the product creation process and which support and participation of the product development department might be necessary.

For this, the continuative research steps have to identify and model the product creation process and supplementing business processes in order to be able to identify the points and decisions that support the assumption of social responsibility and to reveal possible breaks in the process chain that hinder the implementation of social sustainability in products.

One of these supporting processes with participation of product development department is the requirements engineering and management process. These processes aim to collect all necessary requirements and provide them to all involved departments on the entire product creation process. Therefore, the social requirements have to be integrated, too. Essential tool of the processes is the requirements list. Basic literature describes the preparation and updating of the requirements list as one main task of product development department. Therefore, in a way, this department is responsible for all social product requirements no matter if they have a direct product relation or just a relation to the product creation process. [Hanusch/Birkhofer 2008]

The identification and analysis of other connected processes will be carried out with the help of modelling tools as swim lane diagrams and process models. Another idea is the adoption of EcoDesign approaches because of the analogous necessity of life cycle thinking.

## **5. Summary and conclusions**

The present paper showed a research approach for the identification of responsibilities for the implementation of social sustainability in the product creation process in order to develop socially sustainable products. The approach consists of the three main steps collection of criteria catalogue, property related analysis of these criteria and process-oriented analysis for the identification of responsible departments and institutions. It is designed for an iterative realisation of the different stages. The first rough iteration showed the following main findings:

1. Existing criteria catalogues for the social sustainability of products differ considerably in form and content and do not succeed the requirements in engineering design. Therefore, a simple adaption of an existing catalogue is not possible. This leads to a compilation of an own catalogue as a starting point for the essential research.

2. The collected criteria are quite inhomogeneous. The analysis of the criteria with the help of requirements classification approaches from requirements engineering and engineering design shows that the classification into product related and product creation process related criteria is useful for the differentiation of the criteria and the identification of responsibilities.
3. The product related criteria seem to be connected with different partial and special disciplines or guidelines of engineering design. The implementation of these criteria might be possible already. However, they are not associated with sustainability aspects.
4. The product creation process related criteria require an analysis of the entire product creation process and linked supporting processes for the identification of other responsible departments and disciplines.

In summary, regarding these first findings it may be said that the chosen research approach seems to be an adequate way for the examinations in the field of creating socially sustainable products and will be pursued for a more detailed analysis.

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