Design for Sustainability in the Fuzzy Front End

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Abstract

Design for Sustainability has traditionally focused strongly on green fulfilment of a given function, i.e. the process after a design brief has been formulated. The part of the New Product Development process that comes before the formulation of the design brief, is usually referred to as the Fuzzy Front End. Here, the function is determined that the new product should fulfil. From a sustainability perspective this phase is interesting as it may yield sustainable functions, resulting in products that are sustainable because they solve or reduce an external environmental problem. To achieve this, sustainability aspects need to be incorporated in existing tools and methods of the Fuzzy Front End.

This paper discusses the potential for sustainable-function products and the lack of academic attention this type of innovation has received until now. It also discusses the potential adaptations of tools and methods.

Introduction

Current Design for Sustainability tools and methodologies strongly focus on fulfilling a given functionality in a sustainable way (e.g. Brezet & van Hemel 1997; Tischner et al 2000, Remmerswaal 2000, Crul & Diehl 2006). Well-established methodologies such as the Life Cycle Design Strategy Wheel focus on material reduction, sustainable material use, end-of-life improvements, alternative energy sources, and so on. On a product level (as opposed to on a product-service system level) there is however relatively little focus on

the identification of product opportunities that may claim their sustainability because of their function instead of their design.

Take as an example a grey water system for residential homes, which reuses rainwater to flush the toilet. This can be considered as a sustainable product, even if it is made of the same material as a normal drainage system; its sustainability is in its function and not necessarily in its design. Tools and methods in the field of design for sustainability focus very strongly on sustainable fulfilment of a given function, and although manuals for sustainable design occasionally mention the potential for innovation through fulfilling a sustainable function, guidelines or tools to identify such potential are only few, in particular at the level of the individual company. To continue the example: for a building constructor the inclusion of a grey water system contributes to the sustainability of his end-product: a building, i.e. classical green fulfilment of a function.

However, for a supplier of tubing this is not the case, as the 'greenness' is in the function. As such, current Design for Sustainability tools cannot assist the supplier to innovate in such a way. From the perspective of the supplier, there is little guidance in considering and finding opportunities to solve or reduce third party environmental or social problems by providing sustainable-function products or services. If not stimulated otherwise, such companies, which are mainly in a business-to-business market, will be involved in sustainable innovation only when potential clients take the initiative to involve them into sustainable product development. Under the assumption that the expertise present with suppliers is such that their creativity and experience may considerably contribute, and may even be essential, to sustainable product development, this lack of guidance may be regarded as an omission.

The aim of this paper is to point out and discuss, based on empirical findings, a number of research avenues connected with finding and choosing opportunities for strategic sustainable product development, that deserve, to the opinion of the authors, more attention in academic research.

Methodology

Empirical material for this study will be drawn from student work in a design course (Design 5) at Delft University of Technology, in which students form design agencies which are hired by SMEs, typically in the B2B market, to do an innovation process, aiming at sustainable innovation (for an extensive description of the Design 5 course see Boks & Diehl (2006)). This design project focuses on the fuzzy front end of the design phase ending at the point of a detailed concept product. The object is to find good combinations of environment and business, i.e. greening the product portfolio.

Prior to this course students will have followed introductory courses in design for sustainability (focusing on the strategies categorised as 'green fulfilment of functions') and general New Product Development (for an overview of sustainability courses, see Boks et al (2006), for the courses on NPD see Buijs (2003)). Many of the resulting product proposals developed in this course are examples of sustainable-function products. Hence, based on years of project results, an overview can be presented of what sustainable-function products could mean for companies in different industries and how students find such ideas.

The justification for using student work as an empirical basis for discussing industry and academic research challenges is twofold. First, in many ways, SMEs getting involved in greening their product portfolio, will often act like students: they are inexperienced, are looking for fast results under a time (and/or money) constraint, and rely on and/or have access to similar methodological support. This is connected to the fact that, at least in the Dutch context, within SMEs getting involved with greening their product portfolio, it is often ex-industrial design engineering students that will be involved with these challenges.

Green Product Portfolio Management in the Fuzzy Front End

Within a New Product Development (NPD) process, general design theory defines the "start" of an innovation project as the Fuzzy Front End (FFE). In this phase the company realizes its need for innovation through changing or expanding its product portfolio. However, there is not a clear idea yet of the product or service that needs to be developed, nor has a decision been made on the target group of customers. The FFE can be seen as the time prior to an organization's first screen of a new product idea (Reid & De Brentani 2004). General design theory presents several tools and methods for concept generation in the FFE, such as SWOT analysis, road mapping, trend analysis, and scenarios (Koen et al 2002).

One of the important aspects of the FFE is product portfolio management in combination with selecting winning new product ideas. Here, it is determined which products and product lines a company should carry to maintain a competitive position in the market. Product portfolio management deals with a lot of

factors ranging from market trends to capacity utilization of machinery, and increasingly, sustainability will play a role as well.

Suppose a company wishes to increase its efforts towards sustainable product development, be it because of stakeholder requirements, legislation, or a wish for proactive behaviour. From a product portfolio perspective, this company would then have a range of options to visibly 'green' its portfolio:

- To considerably lower the environmental impact of one (or more) of its products;
- To reduce gradually the environmental impact of all products in its portfolio;
- To design and introduce a new product specifically for a low environmental impact, either as an addition to the portfolio or as a replacement for an existing product in the portfolio.
- To aim for more radical forms of innovation, for instance a move to Product Service Systems, getting involved with third parties in the supply chain;
- Or even to focus on (improving) communication of environmental benefits—whether they are real or perceived ones—of existing products in the portfolio.

Companies will find ample guidance in how to address the above list of options, even though it is a (in literature largely neglected) academic question how to choose between the various options in the first place. What these options all have in common is that they focus on green fulfilment of a certain function.

The company continues to fulfil the (perceived) consumer need they have always focused on. However, what should be added to this list is a further option to add a product to the portfolio that aims at fulfilling a green function, which is:

- To increase the relative market share of the current greenest product in the portfolio. (This option is not discussed further in this paper).
- To design a product aimed at reducing or solving a external environmental issue. This option is the focus of this paper.

The grey water system described in the introduction is an example of this option. Such a product would be a sustainable-function product, which is defined here as a product (or service) that reduces a negative impact in its surroundings to such an extent that the reduction exceeds the impact caused by the product's lifecycle itself.

Besides the grey water system, other products fulfilling a sustainable function on the market are for example:

- a floating product to quickly contain accidental oil spilling from yachts,
- office furniture specifically aimed at allowing flex offices,
- the lifestraw, a hand held filter that allows people to drink from contaminated water,
- the Solar Cooker, allowing people in developing countries to cook using sunlight, thereby eliminating the need for using wood stoves (Fuad-Luke 2002, p. 117).

Figure 1 gives a typology of the different options open to a company that wants to green its portfolio.

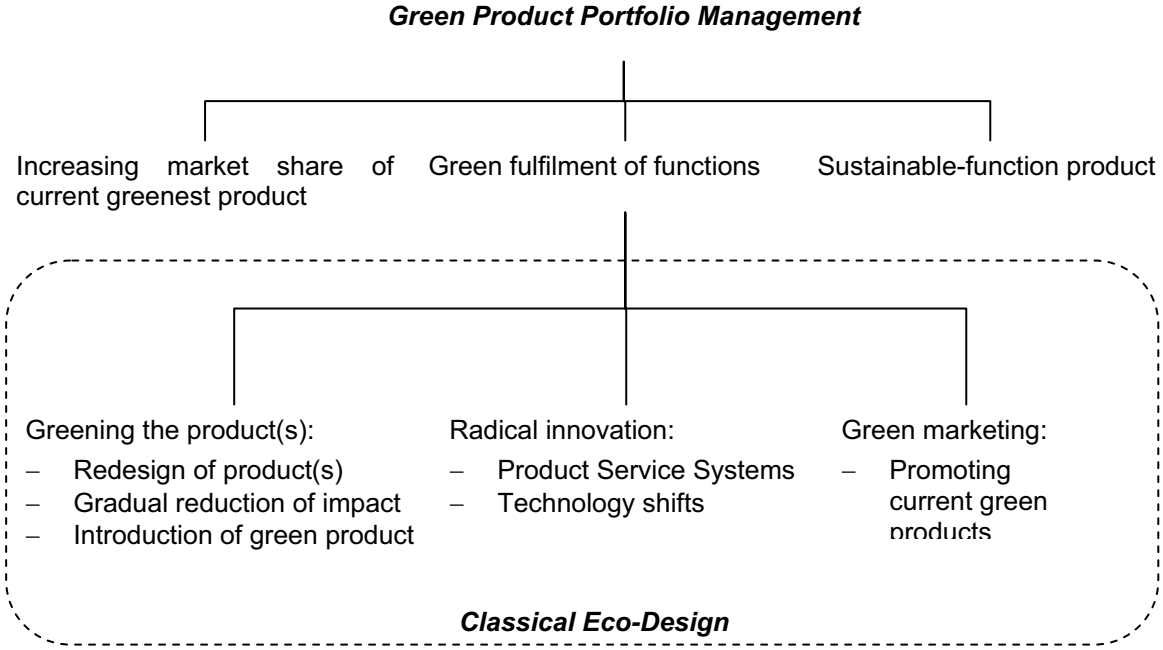

Figure 1: Typology of strategies open to companies wanting to green there product portfolio

Based on the above reasoning and the proposed typology, two observations are made:

- Previous scientific research has largely neglected to address how companies should explore opportunities to create and successfully commercialise products with a sustainable function;
- Previous scientific research has largely neglected to address how companies should determine which product development strategies are most appropriate to their existing needs and wishes to profile themselves as companies active in sustainable product development;

A third, derived observation is that:

- Academic teaching material currently lacks sufficient methods to integrate the above considerations in regular product development courses; the first observation would call for extension of current sustainable product development methodologies, while the second observation would call for integration of sustainability aspects in regular strategic product development and design course material.

Educational perspective

In education, industrial design engineering students typically become acquainted with such tools as SWOT and road-mapping during their education, and are taught how to recognize innovation opportunities (O'Connor & Rice 2001) and to apply screening criteria, such as found by Cooper (1985), for the identification of winning product ideas. Although there is no obvious reason why sustainability issues could or would not be part of such tools and methods, they are, in many cases not. When practically used, at most, general trends like 'the ageing society', ' the increased need for safety', or the increase in one-person households—so, issues increasingly connected with sustainability—are to some extent incorporated in (for example) the identification of trends in society.

A typical example of a case within the Design 5 course involves an imaginary company delivering components and sub-assemblies to home constructors, operating mainly on the B2B market. Its portfolio includes products such as dormers, ventilation registers and rain water drainage. The company takes sustainability serious, working on energy efficiency of their product (e.g. the energy efficiency of the homes

in which their products are applied) and recycling of their products. Furthermore their portfolio includes products such as photovoltaic cells and a lead-free replacement product for roofing lead.

Within the Design 5 course two types of approaches towards determining opportunities for sustainable extension of the company's product portfolio can be observed. Some groups will stick with the separation between general design skills and sustainable product design skills. They determine the function in the normal way and then only include sustainability in the embodiment phase of the project, as in "We have come up with a great idea, and were almost finished with the embodiment, but now we need some sustainability sauce to pour over it".

Second, there are groups—and these usually are the groups that have the nicer results—that do incorporate sustainability into the FFE tools, and this way they frequently come up with a sustainable-function product.

Examples of sustainable-function products in the aforementioned business case are:

- grey-water systems to flush the toilet with rain water or water used for the shower,
- safety products, such as escape in case of fire (social sustainability),
- systems for letting day-light into dark rooms,
- for new markets: water and energy saving products for green houses.

Tool use

To come up with an idea for a sustainable-function product starts with the identification of an external sustainability problem. Clearly, sustainable product design methodologies currently available do not incorporate this identification process. Tools like the MET matrix focus on identification of environmental issues within a given product context, and tools like the Life Cycle Design Strategy (LiDS) Wheel focus on the identification of redesign approaches in, again, a given product context. Even the so-called zero-strategy, which is alternative function fulfilment, is based on finding redesign opportunities, be it in a larger context, for a given function. It can be argued that looking for potential contribution to third party products with environmental issues to be resolved is outside the scope of alternative function fulfilment identification strategies. Elements of typical FFE tools, like SWOT, could however provide the necessary outward-looking approach to bridge this current methodological gap, i.e. the above-mentioned identification of an external sustainability problem. That way, subsequent analysis could be used to determine if the strengths of the company allow for solving or reducing this problem. Experience with the Design 5 course shows that identifying such problems is much easier for B2B companies with a clear target market, because in that case a sustainability scan of that target market can be made. For the imaginary company introduced above, which supplies only to home constructors, this means for example doing a sustainability scan of houses. Working this way resembles original Design for Sustainability methodology, as it starts with a normal environmental assessment, only not of ones own products, but of the larger system of which they are part.

Not all cases used within the Design 5 course are based on companies with such clearly defined markets. One example for instance, is a case of a thermoforming company with an eclectic product portfolio consisting of signage, protection shields and travel suitcases. Finding a good sustainable-function product for such a company is much harder, because every external sustainability problem is a potential start for a new product idea, and selecting a promising one becomes far more difficult that way.

A simple but effective tool used by many student groups is a matrix that combines the strengths of a company with the opportunities in the market. Such a matrix can easily be extended with sustainability related aspects, both regarding strengths of the company (such as a competence in a sustainable technology, efficiency in logistics, participation in innovation networks), and regarding opportunities external to the company (such as increasing customer awareness, opportunities for subsidies for green projects, increased stability in the supply of secondary plastics, increased flexibility of cheaper photovoltaic cells). In that way the potential search space for finding combinations of opportunities and strengths resulting in interesting new product ideas is considerably extended. A similar approach has been found useful in student projects by extending screening criteria like product superiority and marketability (e.g. Cooper 1985) with sustainability perspectives; in particular in case of an explicit wish to incorporate sustainability criteria in NPD decision making, there is no reason why these screening criteria cannot incorporate explicit sustainability aspects, such as 'reduced environmental impact' or 'improved performance on sustainability criteria in reviews from customer organisations', or even the difficult to measure criterion of 'improved public image'.

In short, existing tools and methods for NPD have a potential for incorporating sustainability aspects, to facilitate finding opportunities for new products that can be successful on the market. And even when the

final selection of product ideas originate from ideas that were not motivated by sustainability reasons in the first place, it can still be claimed that sustainability opportunities and criteria were included in the analysis—but that they, in this case, did not lead to the commercially most promising ideas. This remark fuels a discussion whether sustainable product innovation in a highly competitive commercial context should always lead to 'sustainable products' as such. Does the inclusion of sustainable opportunities and criteria in a NPD process have to lead to sustainable products in order to be called sustainable new product development?

Conclusions on Fuzzy Front End of Design for Sustainability

By extending classical Eco-design methodology into Green Product Portfolio Management additional options for sustainable innovations become apparent. Identifying options for such innovations takes place in the fuzzy front end of the New Product Development process, an area that was thus far largely ignored in Eco-design methodology. There are already many tools available for designers working in the fuzzy front end, but these tools do not systematically yield sustainable-function product ideas. It has been motivated that, in particular in the case of an explicit wish for incorporating (more) sustainability in a company's product portfolio, extension to these tools are possible. This may also lead to better opportunities for identification of options for sustainable-function products. These statements are put forward here as suggested avenues for further research.

The question is whether the lack of 'sustainability content' in the results of these existing FFE tools is a tool issue, or rather a tool use issue. Both aspects probably play a role; there is room for extension of existing tools with added sustainability content, but the main prerequisite for integrating sustainability issues in the FFE of product design is the willingness and ability to address sustainability issues with conventional FFE tools. But it appears to be a good idea anyway to show how it can be done.

Coming up with ideas for sustainable-function products is easier for businesses with clearly defined target markets, as it is easier to identify relevant external sustainability issues, and also easier to evaluate the resulting ideas from a business perspective. However, the same is true for normal New Product Development in such businesses.

Conclusions on IDE curriculum

The current design course, on which this paper is partly based, has yielded the insight that the sustainability education has so far focused very strongly on the green fulfilment of a given function. However, in the general curriculum, students work through the entire NPD process from the Fuzzy Front End all the way to the start of production. This paper is written in the context of a revision of an industrial design engineering curriculum, where the aim is to change from 'stand-alone sustainability courses' to courses with integrated sustainability content in 'regular' courses. In this new curriculum the FFE design course remains, but the basic sustainability course is integrated into several other courses. The green-fulfilment-of-function aspects will be integrated into the engineering courses. Sustainability will also play a significant role in the innovation management courses, thus allowing the integration of sustainability as an option for innovation and in particular innovation through the introduction of a sustainable-function product into the courses leading up to the FFE design course.

Future work

Both at NTNU in Trondheim, as well as at Delft University of Technology sustainable innovation through the development of sustainable-function products is seen as an interesting business option for SMEs. It will therefore be subject of further exploration, for instance through identifying sustainable-function products in the market and researching how they came about.

Also the other option identified within green product portfolio management, that of increasing the relative market share of the current greenest product will be subject to further study, as will be the question of how to select the most productive strategy for a given company.

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