PRACTICES OF A "GREEN" FRONT END OF INNOVATION

A gateway to environmental innovation

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Abstract

Activities in the fuzzy front end of the innovation process (FFE) are the root of success for any company hoping to compete on the basis of innovations. Considering the importance of the FFE, it would seem logical to bring the environmental considerations already to the activities of the early stages of the innovation process in order to generate environmental innovations. However, there is still little understanding on how to, in practice, best bring environmental considerations into this part of the innovation process. There are two central questions considered in this paper: are companies integrating environmental considerations into the FFE activities and if yes, how? In this paper we illustrate the current FFE practices from the perspective of environmental considerations. The paper is based on in-depth interviews with eight multinational companies, based in Europe. The interviews reveal that most companies do have experience with considering the environmental requirements in the FFE, but there are significant differences in the “green” FFE practices in terms of frequency, structure and the role the environmental requirements play in the activities of the FFE. The paper also initiates discussion into what type of opportunities for environmental innovations could become apparent when environmental considerations are integrated into the FFE.

Keywords

Front end of innovation, design, environmental sustainability, environmental innovation, goal finding

1. Introduction

Environmental requirements have changed the competitive landscape for companies. A mindset that started with pollution prevention has evolved towards a direction, where the

rethinking of business models, products, technologies and processes is called after (Hart, 1997; Nidumolu, Prahalad, and Rangaswami, 2009). New regulations and standards, pressure from stakeholders and developments in technologies keep the competitive scenario around environmental issues in a continuous change (e.g. Albino, Balice and Dangelico, 2009; Bansal & Roth, 2000). There are several strategies to face these requirements (see e.g. Albino et al., 2009; Orsato, 2006; Hart, 1997), but there are also different mindsets. One of the managers interviewed for the research in this paper, gives a rough description of some three options for viewing the environmental requirements; denial, business as usual but playing by the new rules or, truly considering how one could make these requirements commercially viable.

Although the need for products with a significantly lower environmental impact has been there for some time, viewing greener products as an opportunity for business has not yet become the general trend - even when a study of the sustainability initiatives of 30 large corporations shows that sustainability is a source of organizational and technological innovations that yield both bottom-line and top-line returns (Nidumolu et al., 2009). Companies taking steps to lower the environmental impact of their products (goods and services) often go for incremental improvements instead of exploring the larger opportunities for the business (Pujari, 2006) or taking part in generating a more system-level change (Elzen & Wieczorek, 2005). As O'Hare (2010) points out, there are a number of possible explanations for this tendency. Companies may simply not be interested in developing environmentally innovative products, or alternatively they are not able to develop environmentally innovative products. The latter can result from e.g. the lack of environmental expertise, difficulties in understanding the market need for environmentally innovative products, or a lack of appropriate design and innovation tools (O'Hare, 2010).

The front end of the innovation process is often described as being the root of success for any company hoping to compete on the basis of innovations (e.g. Reid & Brentani, 2004). Therefore the activities of this phase are crucial also in terms of developing environmentally innovative products. Existing literature has suggested the need for further understanding of this phase of the innovation process and for the development of appropriate methods, in order to produce products with a lower environmental impact. (O'Hare, 2010; Wever & Boks, 2007; Ölundh & Ritzin, 2004; Charter & Tischner, 2001). Building on eight in-depth interviews with managers within large multinationals, this paper looks into the current innovation processes of large companies, and portrays how environmental considerations have been taken into the activities of the front end of the innovation processes. The central questions of the research conducted were: are environmental considerations brought into

the activities of the front end, and if yes, how is it done, and what is the role of these considerations? The focus of the research was the activities of the front end of the innovation process and the development of environmentally innovative products. Here, we define environmentally innovative products as a product (good or service) that has a significantly lower environmental impact throughout its life-cycle compared to an alternative, competing product.

Next, we introduce the context of this paper – the innovation process – and look into the characteristics of the front end of the process. Thereafter, we explain the research conducted and present the findings. The findings are then further discussed and areas for future research are presented at the end of the paper.

2. Background

2.1 Innovation

Already in the early 20th century, Schumpeter (1934) argued how economic development is driven by innovation. The importance of innovations remains today, as does the complexity of the concept. The definitions of innovation in the literature are vague, and there are several descriptions of it, often depending on the discipline defining it. OECD (2005a) defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." Central in this definition is the emphasis on "implementation", e.g. the introduction of the new or improved product on the market. This 2005 definition differs from their earlier definition, which placed more importance on the process: "Innovation is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention" (OECD, 1991). This earlier definition presents two central elements; first, it covers the entire process from opportunity identification to the commercial introduction, and secondly, it brings up the iterative process of innovation.

Innovations can be categorized along several different dimensions, for example the level of novelty (e.g. incremental, really new and radical innovation by Garcia and Calantone, 2002), the source of the innovation (user innovation and lead users by von Hippel, 2005), or the focus of the innovation (e.g. management innovation by Hamel, 2006). In the definition of innovation by OECD (2005a), four types of innovations can be distinguished: product innovation, process innovation, marketing innovation, and organizational innovation. In this

paper we focus on product innovation, which according to OECD (2005a, p.48) is “the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.”

2.2 The Innovation Process

Innovation is a collection of a number of activities and actors. One context for innovation to take place is an organization, and it is also the focus of this paper. According to OECD, (2005a, p. 47) innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations.

The ultimate reason for companies to innovate is to improve their performance (OECD, 2005a, p. 29). Several kinds of innovation processes, in various forms are covered in existing literature. Rothwell (1994) describes the evolution of the best practice in the innovation process through five generations, from the simple technology push models from the 1950’s to the parallel and integrated model of the 1980’s. An example of an innovation process is the stage-gate model developed by Cooper in 1986. In this model the process goes through five stages after idea discovery: from scoping, building a business case, development, testing & validation, to launch. Between each stage there is a “gate”, a point for evaluation. (Cooper, 1990)

The innovation process can be seen as not just one innovation process, but rather a set of different parallel, competing and conflicting processes occurring at the same time (Buijs, 2007). Often, however, the innovation process is presented as a sequence of three more or less distinct phases:

- the front-end phase,
- product development phase (NPD), and
- commercialization phase (e.g. Buckler 1997; Koen et al. 2001).

During each phase, specific activities are executed to improve the quality of the idea and to let the idea grow (Buijs, 2007). The phases differ in nature and purpose (Koen et al. 2001); where the front end of the process is often chaotic and unpredictable, the product development phase is more structured, goal oriented and predictable (ibid). Therefore, the different phases of the innovation process need to be addressed differently – with different sets of techniques, tools and human talent.

2.3 The Front End of the Innovation Process

The first phase of the innovation process is often called the front end or the fuzzy front end (FFE) - the latter term being coined by Reinertsen in 1985. “Fuzzy” refers to the unpredictable, uncertain, often non-linear nature of the phase (e.g. Koen et al., 2001). The front end activities take place before the formal new product development phase (NPD) (Nobelius & Trygg, 2002; Koen et al., 2001). These two consecutive phases, FFE and NPD, are fundamentally different and require different methodologies, tools, and techniques (Buijs, 2007; Koen et al. 2001). Unlike in NPD, work in the FFE is not structured but rather experimental (Koen et al., 2002).

According to Buijs (2003), there is no one best way to describe the “process” of the FFE, and it is not possible to advice which model and which level of detailing is best in a given situation. However, one approach is presented by Koen et al. (2001), who describe the front end through the New Concept Development model (NCD). The NCD model consists of three main parts: the engine (leadership, culture, and business strategy), the activity elements (opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition), and the influencing factors (organizational capabilities, the out- side world, and the enabling sciences that may be involved). Although the FFE is influenced by several factors, in this paper, we will focus on the activities that take place in the FFE.

Whereas the activities in the FFE defined by Koen et al. (2001) are opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition, Khurana and Rosenthal (1998) include also strategy formulation and communication, project planning, and executive reviews. It is important to note, that these activities are not separate, but rather interrelated. Also Buijs (2003) observes how in reality, the different steps in the FFE are executed in a parallel fashion. The FFE can be considered to end e.g. in the concept definition (Koen et al., 2001) or as “a strategically sound design brief for future products and services for a specific company” (Buijs, 2008).

Activities in the FFE are the root of success for any company hoping to compete on the basis of innovations (Reid & Brentani, 2004). Although an innovative company must be proficient in all phases of the new product development process, the most significant benefits can be achieved through improvements in the performance of the front end activities (Khurana & Rosenthal, 1998). Also, a study by Koen et al. (2001) identified the front end as the key-contributing factor for large numbers of truly new products introduced annually. Therefore, FFE presents one of the greatest opportunities for improving the overall innovation process (Koen et al. 2001).

The importance of the FFE follows from its position in the innovation process: as the first phase, it influences all the subsequent phases of the innovation process. However, “catching” the opportunities available at the FFE does not come without a challenge. Figure 1 shows how three elements affect the innovation process; the influence on the outcome of the project, costs of changes made to the outcome and the information available. These elements change over the course of the innovation process. At the beginning of the process, i.e. during the FFE, the degree of freedom in design and influence on the outcome of the project are high. At that time, the costs of change are still low. As one moves further in the innovation process, more information is gained on the offering developed but also the costs to make changes in the design are increasing.

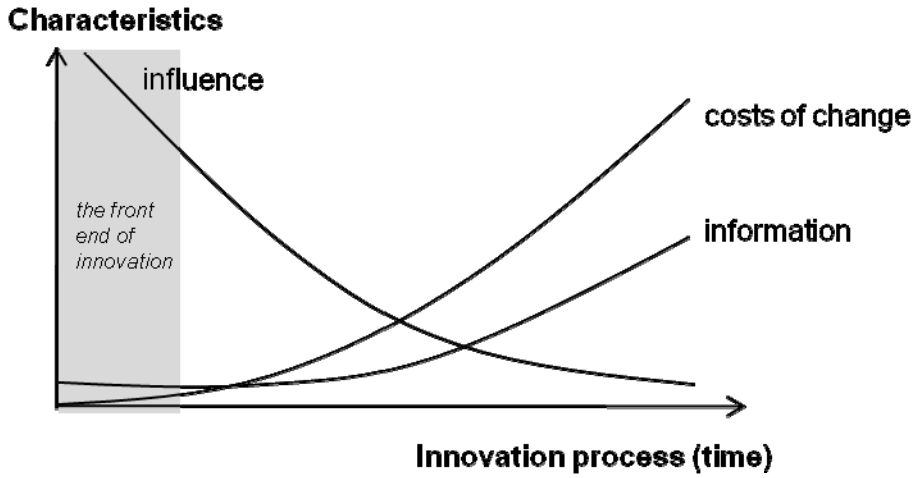

Figure 1: Evolution of influence, costs of changes, and information during the innovation process. (after Hippel, 1993, modified by Herstatt & Verworn, 2001)

Thus, it can be argued, that of all the actions companies can take to improve their innovation process, the ones taken at the FFE provide the greatest time savings for the least expenses (Smith & Reinertsen, 1991). However, the flip side of the coin is the low amount of information and certainty in the FFE, when compared to the later phases of the innovation process.

2.4 The FFE and Environmental Considerations

The FFE is the stage of the innovation process where decisions about new product development are taken (see e.g.Buijs, 2003; Khurana & Rosenthal, 1998). Although the role of the FFE is crucial in the creation of innovations (see e.g. Khurana & Rosenthal, 1998; Smith & Reinertsen, 1991), there is still little understanding on how to best bring environmental considerations into this part of the innovation process (Wever & Boks, 2007;

Ölundh & Ritzin, 2004). The front end of the innovation process is of a strategic nature, and it is argued that successful sustainable design requires both strategic and operational activities (Ölundh & Ritzin, 2004), i.e. to be taken into account both in the FFE and NPD.

A number of ecodesign tools have been developed to guide the designer in the design process after the specification for the product is already set, i.e. after the crucial FFE phase (Ölundh & Ritzin, 2004). However, many of the practices that aid the NPD process do not apply to the FFE (Koen et al., 2001). The same applies when we consider ways to support environmental considerations at the FFE; the tools for NPD do not necessarily fit the circumstances of the FFE. On the other hand, there are also many methods for the work done in the FFE already, but understanding on how to best integrate environmental requirements into this part of the process requires further research (Wever, Boks & Bakker, 2008). Recent research in this area was conducted by O'Hare (2010), who considered how eco-innovation tools could be introduced within a company in order to increase the likelihood that the tool will eventually be adopted within the working practices of the company. O'Hare (ibid) reviewed existing innovation tools, adapted nine of them for eco-innovation purposes and conducted in-house trials. The findings showed that it is possible to customize tools to the eco-innovation requirements of companies, but more eco-innovation tools are needed and they need to be customized to the specific needs of the company. Additionally, companies need to ensure that design teams play a more significant role in the application of strategy-focused eco-innovation tools if they want to access the latent knowledge and ideas the staff hold and thereby deliver more successful, eco-innovative products. (O'Hare, 2010)

The FFE is when a company realizes its need for innovation, but does not yet have a clear idea about the offering that needs to be designed (Koen et al. 2001). The characteristics of the FFE (little information, but large influence on the outcome) affect also the decision making related to environmental issues; once the specification for the future offering is set at the end of the FFE, only relatively minor changes in the environmental impact of the products are possible – or they will be very expensive and time consuming. For this reason – the high influence on the offering being designed - it is central to consider the possibilities and best means of considering environmental aspects already in the FFE. This "front-loading" of eco-innovation in the FFE seems a logical step in order to have a greatest chance of making a significant improvement (O'Hare, 2010).

3. Research Design and Methodology

The research in this paper looks into the current practices of the FFE with special focus on the environmental considerations. In the following chapter we will describe the research

questions in more detail. For fluency reasons, in this paper a FFE process, where environmental requirements have been taken into the activities of the FFE, will at times be called “green” FFE.

During the period of January 2010 to June 2010 we interviewed nine managers involved in the early stages of the innovation process, from eight companies. All companies interviewed were established multinationals, with operations in Europe. All companies were large, as defined by the OECD; more than 250 employees, and turnover over 50 million Euro (OECD, 2005b). Established large companies were chosen because their innovation process has been in place for a long time, which in turn, is more likely to result in an acknowledged process, and they will have experience from numerous cases, providing good grounds for discussion. The companies originate from Finland, Netherlands, USA and, Japan, but the interviews were conducted in the company offices in Finland, the Netherlands, or Germany. The interviews were semi-structured, lasting from 80 minutes to 120 minutes. They were all face-to-face interviews, except for one that was conducted via video conference.

Due to the limited literature on the practices of introducing environmental considerations to the activities of the front end of the product development (Wever & Boks, 2007; Öhlund & Ritzin, 2004), the research was exploratory in nature. The goal of the research was to provide insight on two main areas: 1) Are environmental considerations brought into the activities of the FFE, and if yes 2) how is it done? The intention was to draw an overall picture of the current state of a “green” FFE; to see whether it existed and when it did, in which forms. The first questions aimed at gaining understanding of the current situation in the corporate innovation process, and to identify successful cases for further research. The second question aimed to bring the research on a practical level, to find alternative solutions, and see how companies tackle the issue of environmental considerations in the conceptual phase of the FFE.

Considering the explorative nature and aims of the research, cross-industry interviews were conducted, including companies from technology, raw-material, automotive, textile, and forest industry (see table X). The majority of the companies operate mostly in the business-to-business (B2B) context and are manufacturing companies. Companies B and D operate mainly in the consumer markets (B-2-C), and company E operates strongly in both, B2B and consumer markets.

Table 1: Companies involved in the interviews

Company	Size	Industry	Clientele	Focus of the interviewee
A	large	electronics	B-2-B	technology
B	large	electronics	B-2-C	design
C	large	automobile	B-2-B	design
D	large	textile	B-2-C	design / CSR
E	large	technology	B-2-B / B-2-C	technology
F	large	technology	B-2-B	business
G	large	forest	B-2-B	technology
H	large	forest	B-2-B	business

The focus of analysis for the interviews was the front end *process* of new product development. The interviewees were all managers of the early phase of the innovation process, except in company D, where the manager of the innovation process was accompanied by the Corporate Social Responsibility Manager. However, depending on the business in question, the disciplinary background and focus area of the interviewees varied from design, to business, to technology, and job descriptions included, among others e.g. business development, concept design, research, and product development. The expertise required in the FFE depends on the line of business the company is in, and this is naturally reflected in the background of the managers working in the FFE.

For this study, we were interested in interviewing employees of the companies working in the FFE. Identifying the most suitable person to interview was challenging. The process, terminology, and organization related to the innovation process vary from company to company. People working in the area of the front end can be found with nearly any kind of an organizational title. Therefore, in order to identify the most appropriate candidate for the interviews, we first contacted a person from the research and development or business development area, and described the set of activities we were interested to discuss (opportunity identification, idea generation, idea selection, concept development). We were thereafter further instructed whom to contact within the company. This proved to be a good approach for the subject of front end, which is organized and approached differently from company to company.

Although all interviewees worked within the front end, there seemed to be some difference in the nature of their work that was not dependent on the industry or the business; some interviewees were involved in activities that were closer to what could be called “the early front end”, including more conceptual work, where as some interviewees were closer to the beginning of the NPD, and their work had more concrete elements. Therefore, although

aiming to find people working in as similar activities as possible, some differences remained. This resulted mainly in differences in the set of methods the interviewees mentioned.

The semi-structured interviews started with discussing the role of the interviewee in the company. From there, we proceeded to discussing the innovation process in the company in general, then towards the activities of the FFE and how they are organized within the company, and then finally discuss the front end in the light of environmental sustainability. The terminology related to the innovation process and its phases varies from company to company. To avoid imposing external terminology and models from innovation theory, the interviews began by asking the interviewees to describe the innovation process, identify activities, and name phases the way it is done in their company. The interview then carried out using the terminology of the company in question.

As the interviews were conducted in a certain department of a large, multinational corporation, the interviews describe the activities within the particular office and department. Furthermore, the practices within these particular companies were discussed only with a single representative of each company. This was deemed sufficient for this study, as the aim is to explore the current state of sustainability within the FFE process, and not to compare companies or industries.

The interviews were recorded and transcripts were made by the interviewer. They were analyzed for commonalities while keeping in mind the variety and ambiguity of the terminology used.

4. Findings

In all companies except for company C, there were examples of bringing environmental sustainability to the front end. However, these examples vary significantly in nature, along two dimensions: first, the frequency of how often environmental requirements were taken into the activities of the FFE, and second, what was the role of these requirements within the FFE. The frequency ranges from a constant practice to random or coincidental considerations – though in one company, there were no examples of sustainability being part of the FFE. Furthermore, the role of environmental sustainability ranges from being seen as a source of new opportunities to a checklist brought in at the end of the FFE to assist generating the design brief for the NPD.

4.1. Frequency: from practice to no practice

Half of the companies had made a constant practice of having environmental issues considered already in the FFE. Table 2 presents the differences in the frequency of integrating environmental sustainability to the practices of the FFE.

Table 2: How often are environmental requirements considered in the FFE and how structured is the practice.

Company	Constant practice	Sometimes	Never
A	Checklist, internal standards		
B		Guiding "theme" or leading idea	
C			
D		Guiding" theme" or leading idea	
E	Defined list of requirements and actions, for each product a person in charge of environmental issues		
F		Guiding theme, core value	
G	Checklist		
H	General guidelines, mindset		

Companies A, E, G, and H introduced environmental requirements in the FFE in all of their projects. Although, the practice was continuous in the sense that it took place in every project, there were significant differences in how structured the practice was. For instance, company E had the most structured integration of sustainability considerations; the practice took place in every project, in a similar manner, and it included a structured set of requirements, actions and clearly set responsibilities. The practice of integrating environmental considerations into the activities of the FFE in companies A, and G was also structured, although not as fundamentally as in company E, where e.g. there was per each product a dedicated person in charge of the environmental issues. In companies A and G the structure came mainly from following through with a checklist. In company H the practice of considering environmental issues in the FFE was in the form of general guidelines and a mindset rather than step-by-step guidelines or technical specifications that would be repeated in a similar manner each time.

In companies B, D, and F, environmental issues were brought to the FFE randomly; not in every project, and not in a continuous, structured manner. In companies B and D there had been one project so far where environmental considerations were part of the FFE. In company F there had been few projects with a "green" FFE. But it was common for these three companies that there were no clearly set guidelines or practices to support the environmental considerations in the FFE activities. Typical examples of these cases were programs of one year that aim to raise awareness, internal idea competition or a single workshop with an environmental focus.

4.2. The Role of Environmental Sustainability in the FFE

In addition to the differences on the frequency of taking environmental issues into the activities of the FFE, there are differences on the role of these issues; either they are seen and treated as a source of new opportunities for the business, as potentially leading to improvements in the existing offering, or as a set of requirements to comply with. This difference can be seen in whether the environmental considerations are involved in the practices of opportunity identification and idea generation, or as a point of validation after an idea has been generated. Table 3 shows the inclination of each company.

Table 3: The role of sustainability in the FFE and description of the roles.

Company	**'Driving force':** Source of business opportunity, strategic, no specific technical requirements, qualitative-focused	**'Guiding idea':** Innovative improvements and redesigns in existing offerings, qualitative-focused, no established guidelines	**'Gatekeeper':** A point for validating choices made, a set of specific requirements, structured, quantitative-focused	**'No role':** Environmental issues not present in the FFE.
A				
B				
C				
D				
E				
F				
G				
H				

Additionally, the role of environmental issues could be divided in “qualitative-focused” and “quantitative-focused”. The first represents an approach that emphasizes using a set of general aims, broad goals and central sustainability issues for the company, and the latter emphasizes measurable, technical set of specifications. However, all participating companies use both quantitative and qualitative methods in the FFE, but the role of either one is emphasized according to the focus.

We propose the following classification of the role of sustainability in the FFE:

- Environmental sustainability as driving force
- Environmental sustainability as guiding idea
- Environmental sustainability as gatekeeper
- Environmental sustainability has no role

We will now describe each group. Companies in this research typically apply one of these approaches for a “green” FFE, and other methods for integrating environmental requirements into the product development are brought in at the following phases after FFE.

4.2.1. Environmental sustainability as a driving force: new business

In companies F and H, the environmental requirements affecting the business were treated as a source of business opportunities, as a driver for innovation - although, managers from both companies commented that this approach “…still needs further development.” The role of sustainability was rather ‘strategic’; it was seen as source for competitive advantage. As a starting point in the FFE in these companies, there were no specific technical requirements presented, rather directions the company should go towards. These directions were areas for development indicated by the central environmental issues the company was facing. Therefore, instead of quantitative specifications at a “gate” in the process, this approach was more qualitative-focused.

In company F there were a few projects where sustainability requirements had been brought to the FFE. The main idea had been to make ‘green’ a core value and communicate it consistently through words and actions. The manner how sustainability considerations were brought to the FFE was about raising the sustainability awareness of the employees and communicating that the company values ‘green’; “We have several sustainability themes that are well known throughout the company.” For example, the company arranged an internal competition to collect ‘green’ ideas, evaluated them with experts and “send” the winning ideas forward in the FFE; “…now our people know we value ‘green’ and that these ideas will receive support.” There had also been a group of researchers working specifically on

different themes of sustainability and the future directions of the company; ”Through this research we noticed how our products can be harnessed to serve the environmental needs of our clients…We identified new needs that our products could satisfy. We are now continuing with this search and the project is growing.”

Company H was the one company where sustainability was both continuously present in the FFE and seen as a source for business opportunities. The interviewee explained how, “The question for sustainability at the FFE is what commercial opportunities or barriers does sustainability bring with the existing products.” The interviewee described how the general environmental drivers are usually very explicit already in the FFE and therefore sustainability is a prevailing mindset; “The intention is to become increasingly better at seeing how we could make these [environmental requirements] commercially viable…and to do that, we have to change our mindset.”

4.2.2. Sustainability as the guiding idea: innovative improvements

The role of sustainability in companies B and D was that of a guiding idea – an idea to keep in mind during the activities in the FFE. Similarly as the Driver-approach, this one is qualitative-focused, but the main difference between this approach and the Driver-approach is the result expected; whereas companies F and H aimed to generate new business opportunities, companies B and D were looking for improvements in the existing offerings, redesigning them or adding features. In other words, in the Driver-approach the role of sustainability was more ‘strategic’, while in companies B and D sustainability was seen more as a boundary condition than a source for opportunities, and there was no widely acknowledged ‘culture of sustainability’. As the manager from company B said: “Only about 5% of people working in this phase even know that there are corporate [sustainability] guidelines.”

In companies B and D the projects where sustainability had been taken into consideration in the FFE, the approach was described as a general “theme”, or “an idea to keep in mind” while working. As the interviewee in company B said, “…in the case of that green project there were no guidelines to follow…we tried to identify the most environmentally harmful areas of that product first, then we simply tried to keep these things in mind while observing the user and identifying opportunities and designing concepts. No guidelines exist and we came up with some guiding ideas along the way.”

The manager from company B explained the experience with using existing eco-design tools in the FFE: “…we tried to use the LiDS wheel as some support…but it was too difficult…It’s developed on a product life cycle perspective. When you are designing based on a human-

centered design philosophy you cannot design from a product life cycle perspective because the product life cycle design comes later. You are designing based on an unmet need, and there are thousands of possibilities to consider. And at this early stage it is so difficult to quantify things for the life cycle design."

4.2.3. Sustainability as the gatekeeper

In companies A, E, and G the role of sustainability was seen as a set of requirements to base an evaluation upon; a checklist to reflect the evolving idea against. Compared to the previous two approaches, this approach is quantitative-focused (e.g. LCA was conducted), and is significantly more structured. Here, environmental sustainability is not a starting point for opportunity identification or idea generation, but rather a point of validation for the choices made. As the representative of company E explains, "This [environmental sustainability] evaluation can be started the moment there is an idea of technologies you might include in the product…of course you cannot have a complete analysis ready when you are dealing with prototypes in the front end but if you are looking at different materials to be used in the prototype, you can already make decisions between the different alternatives…" Company E has appointed persons, 'liaisons', responsible for following a product through the FFE process, ensuring that the evaluation is conducted and appropriate choices made.

In this group of companies, the mindset was driven by the idea of validation, and considering environmental sustainability as a lens to search for new opportunities was an approach to still be developed. As the manager from company G explained: "The environmental aspects are incorporated into the product at a later stage…after the idea generation." When thinking of ways to make environmental requirements a source for new opportunities, he continued "…maybe sustainability could be considered as a starting point [for innovating] in situations where you start off a project by benchmarking and comparing different materials…and you may pinpoint the benefits of your material and advance those…that's the only way I can think of as having sustainability as a starting point."

In company G the environmental aspects come into consideration as a list of requirements at the end of the FFE, before the project enters the NPD. The checklist acts as a "gatekeeper", setting the minimum requirements for a project passing through to NPD. As the interviewee described "It [sustainability] is a prerequisite for NPD…but they [environmental requirements] are not used as the spearhead of innovation." But a checklist is not always seen as an imposed set of requirements to meet, but a chance to explore alternative possibilities. As the manager from company A describes "A checklist based on own internal standards is

introduced early in the fuzzy front end…but in these standards there is room for iteration and it is not just a checklist that needs to be fulfilled…" And, it seems as a result of this room for iteration "…most of the opportunity identification for sustainable innovations takes place in the prototyping stage of the FFE…I have seen projects where during prototyping people notice they can solve the situation in another way…then they make a plan how it will be different from the initial plan." Although in this approach, environmental requirements are more in the role of a "gatekeeper" rather than driving force for the initial idea of the offering, the commercial opportunities offered by the solutions are also taken into account, and when possible, as in company A, "we then try to turn the requirements into an unique selling point", to differentiate from competitors.

4.2.4. Sustainability has no role

Company C did not have projects where sustainability requirements would have been present in the FFE. These requirements do come in later, during the NPD, and at that stage they are very detailed. As the manager from company C explained, there was no significant pressure from the market: "Our customers do not ask for greener products…Only for things that might potentially harm their own products or cause them costs." But more than the lack of market-pressure, the interviewee described his personal frustration: "...I do not know what would be a clear environmental driver that would initiate the planning for a new model or a new product…It would be great to know what would be the central problem areas in our activities environment wise."

4.3. Environmental sustainability as a business opportunity or boundary condition

When asked "Do you see environmental sustainability as a business opportunity?" companies F and H said they do, the rest did not. The interviewed managers from these two companies also described their current attempts to become increasingly better at finding the opportunities created by the changes in the operating environment, i.e. the environmental requirements. In company F there were several environmental themes, specific areas, and in each theme the company is working to identify new business opportunities. Both companies had examples of new business created from the increasing environmental requirements. However, regardless of seeing environmental requirements as a source of business opportunities, the manager from company H said how ultimately "…it is regulation that drives sustainable innovation." The difference therefore lies with how the company views the regulations: as a driver or a boundary condition.

In the other companies besides F and H, environmental sustainability did not have such a central role in the FFE. It was recognized as e.g. being 'important to the brand', a 'core value for the company', or a 'well known set of requirements mainly to serve the NPD'. As the interviewee from company B said "environmental issues never come as the number one driver for innovation." The manager from company G continues along the same line: "I would say that sustainability can drive technological development, e.g. the banning of toxic compounds etc. but not necessarily innovating for a new offering." In several interviews it was pointed out that unless regulation or customers ask for improvement in the environmental performance, it does not happen.

Pressure from competitors and the complexity of the whole issue of environmental sustainability make the integration of sustainability requirements to the FFE a challenge. E.g. time-to-market -requirements can set some limits to the environmental ambitions. As the manager from company A explained: "Products that are very new…the first generation is usually built to comply with regulation but nothing beyond…because…you have to get the product to market before competitors. The next generation then will be made more environmentally friendly…" Furthermore, the complex nature of environmental issues was mentioned in several companies; it's not clear how, where and with what to start if you would want to improve the environmental performance. As the participant from company G said "It [environmental sustainability] is a too complex issue that keeps evolving and changing…it's like jelly, and as long as it remains as this evolving issue it will never become the spearhead of innovation."

5. Discussion

The goal of this research was to gain insight into the current situation of environmental considerations at the front end of the innovation process. The two questions guiding the research were

- Are environmental consideration be integrated into the activities of the FFE?
- If yes, how is it done? (cases, and examples of successful projects)

In the following sections we will discuss the findings of the research.

5. 1. Environmental considerations in the activities of the FFE

In the research presented in this paper there were several examples of practices for bringing environmental considerations into the activities of the FFE. Table 4 summarizes the results.

Table 4: Summary of the results.

Company	**'Driving Force'**: Source of business opportunity, strategic, no specific technical requirements, qualitative-focused	**'Guiding Idea'**: Innovative improvements and redesigns in existing offerings, qualitative-focused, no established guidelines	**'Gatekeeper'**: A point for validating choices made, a set of specific requirements, structured, quantitative-focused	**'No Role'**: Environmental issues not present in the FFE.
A			Green FFE constant practice, structured	
B		Green FFE applied sometimes, little structure		
C				
D		Green FFE applied sometimes, little structure		
E			Green FFE constant practice, highly structured	
F	Green FFE applied sometimes, little structure			
G			Green FFE constant practice, structured	
H	Green FFE constant practice, little structure			

All but one company had experience of having environmental requirements as part of the activities of the FFE – opportunity identification, idea generation, idea selection, concept creation, etc. Half of the companies had made it a constant practice.

However none of the companies described having both a structured, continuous practice of a "green" FFE and environmental considerations as the starting point for FFE activities. Companies A, E, and G have a more structured approach to the "green" FFE, but environmental considerations were not the starting point for opportunity identification or idea generation. On the other hand, companies B, D, F, and H regard environmental issues as the starting point for idea generation or concept creation, but these approaches lack structure.

The companies represent a variety of industries. Based on this research, it does not seem there is any significant difference between the "green" FFE practices of companies

depending on their industry. Nevertheless, the manager from company E evaluated the differences by saying: "…the environmental considerations come easy to us because we are always dealing with something concrete. We are not a software company or a service company, so things for us are always concrete and therefore simpler." This is an interesting notion to consider. If we compare e.g. the producer of a certain material with a producer of software, it is possible to say that they can innovate for the environment by different means. Whereas the material developer can improve the intrinsic characteristics of the material, the developer of software can offer a function that lowers or assists in lowering the environmental impact of the product. It could be said that the first type of reduction of environmental impact is "passive", in the sense that it reduces the environmental impact through its own characteristics, and the latter type of reduction is "active" in the sense that it reduces the environmental impact through a function, or action. We will return to these concepts later in this chapter.

In addition to the lack of industry-specific differences, there also does not seem to be significant differences depending on whether a company serves consumer or industrial market. However, because the only two companies in this research serving mainly consumer markets were the least constant in their "green" FFE practices, it would be interesting to do further research into the possible "green" FFE differences between B2B and consumer business. However, based on this research it is too early to hypothesize about any tendency.

5.2. Ways of realizing the "green" FFE

One of the aims of this research was to gain understanding on the ways how environmental considerations could be taken into account in FFE; a phase that is conceptual, abstract, explorative and non-linear. As the manager from company C explained, "The front end is a pretty fuzzy process. Ideas do not come at any specific moment. They can come anytime, anywhere." The manager from company A continues along the same line: "idea generation or idea capture is never a structured process." Now, considering these characteristics of the FFE, how could environmental requirements best be brought into the activities of this phase? And furthermore, what would be the most appropriate approach? One central question with the FFE is its management; can you, or should you manage the FFE, and if yes, up to which point? The manager from company E is skeptical: "To be very provocative, you do not manage the front end…You give people the freedom to mess around and then let them do that." Also the level of systematization is a question; the process of the FFE rarely follows the same path, therefore, how to ensure the continuous consideration of certain requirements? Perhaps the integration of quality or safety issues have been a similar

situation, and the integration of these considerations could be searched for analogies to the integration of environmental issues.

All companies in this study, except for one, had experience with bringing environmental considerations to the activities of the FFE, and they represented a variety of ways for doing it: checklists, guidelines, workshops, responsibility liaisons, research projects, clearly communicated values and competitions to spur idea generation. Some approaches were more structured than others. In most of the companies where the “green” FFE was a constant practice, the approach was structured, with the exception of company H where the “green” FFE was less structured, and more of a general mindset. On the other hand, companies A, E, and G that have a more structured approach do not take environmental sustainability as a the starting point for innovating. Companies F and H, that regard environmental requirements as a source for new business opportunities, do not have a structured approach for the “green” FFE; the approach is more about a certain mindset, clearly communicated values, or temporary activities to raise the awareness of environmental issues among the employees. In these companies the “greenness” is somehow in the DNA of the FFE activities, through a mindset. Now, a question that remains is what is the relationship between the role of environmental considerations in the FFE and the frequency of a “green” FFE with actually producing environmentally innovative offerings? E.g. does the approach of companies F and H in reality lead to new businesses stemming from environmental improvements more often that the approaches of the other companies? Additionally, under which conditions could the different approaches support each other? For example, how could ‘driving force’ and ‘gatekeeper’ approaches work together?

There was no methodological support in use for the opportunity identification and idea generation phase, in terms of environmental considerations. A central challenge with the FFE is that at the early activities of the FFE, there is little information on the offering that will be finally produced (unless the product in questions is a second generation, and the data from the first generation can be used as a starting point). As the project moves forward in the FFE and then in the NPD, more information becomes available. Naturally this affects also the decision making regarding the environmental impact of the offering. The FFE requires primarily more qualitative methods, but the closer the process gets to the NPD, the more quantitative methods can be used.

It can be questioned to what extent the unstructured and varied nature of the FFE combined with the incomplete information about the final product allows for a systematic inclusion of environmental considerations. However, in the light of this research, there is a role for environmental requirements to play in this phase. A good example was provided by the

manger from company E: “At the FFE there is not yet a complete picture of what the outcome is going to be, but you can steer the boat in broader terms and make some initial selections.” In addition to “steering the boat”, environmental requirements can be approached at the FFE through rethinking how the value of the offering is produced to the customer, e.g. can the need be satisfied by a function with a lower environmental impact. Product-service systems (PSS) is one example. As Mont (2002) describes “In a functional economy, consumers are buying mobility instead of cars, cleaning services instead of washing powders.” Company D is taking steps in developing a “green” FFE: “We are considering ways to bring environmental consideration into the FFE…we see possibilities especially in reconsidering the use-phase and take back of products and how we could affect those already when designing the purpose of the product.” This type of rethinking may lead to an entirely new offering or even new business and identifying the opportunities requires considerations already at the FFE, because this is where the idea for the offering is designed.

Two specific, interesting aspects of organizing for the “green” FFE came up repeatedly in the interviews. One is the importance of the innovation network – or innovation eco-system –, and the other multidisciplinary co-operation within the company that spreads over the organizational structures. Innovation ecosystems are the collaborative arrangements through which companies combine their individual offerings into a coherent, customer-facing solution (Adner, 2006). When the system works, they allow companies to create value that no single firm could have created alone (ibid). Innovating with customers, suppliers and companies downstream in the value chain were considered essential in creating environmentally more sustainable offerings. Company D was also looking across the industry boundaries: “…we are interested in co-innovating with other industries and look for possibilities for cross-fertilization of ideas, especially in terms of new greener materials.” Multidisciplinary project teams across departments were already the practice in some companies. The experience showed how these teams provide a more holistic view on the issues and possibilities regarding the project in question. Considering the complex nature of environmental issues, the involvement of multidisciplinary work and utilization of the innovation ecosystem do seem justified; the issue can be approached from several directions at once, and the team is more likely to come up with a coherent and novel solution.

In addition to these two general approaches to “tuning” the FFE, there was still one practice that seemed particularly interesting: prototyping in order to generate new ideas. As is the case of company A, most of the opportunity identification for sustainable innovation takes

place at the prototyping phase. This non-linear, iterative practice provides the team a chance to evaluate the evolving ideas quickly, learn from them, and improve the next trial.

Perhaps then, instead of for example converting existing FFE methods towards a “greener” direction or creating new “green” methods for the FFE, the solution for a “green” FFE could be found from the type of general FFE methods used (e.g. prototyping, multidisciplinary collaborative thinking) and the general organization and mindset of the FFE. Early, instant experimentations with the evolving idea, multidisciplinary and cross-functional teams, and collaboration to create a system-level view of the issue at hand, represent some characteristics of the organization of the FFE that could ensure the development of more environmentally sound ideas.

5.3. Potential results from bringing environmental considerations to the FFE

Why then, should environmental considerations be taken into the activities of the FFE? The earlier the phase of the FFE, the more freedom there is to design the solution, and also the more room for finding alternative solutions from the environmental perspective. Considering the environmental aspects in the FFE, may lead to environmental innovations that are not possible to reach if environmental considerations are brought in only in the NPD. Sustainable innovations can be divided for example into product improvement, product re-design, function innovation, and system innovation (Brezet, 1998 and Rathenau Institute, 1996). When considering what kind of decisions regarding the environment can be done in the FFE, we divided environmentally sustainable innovations into “passive” and “active”. Here, by “passive” it is meant an offering that presents the lower environmental impact through e.g. the material selection and manufacturing choices, i.e. through the characteristics of the product itself (resembles product improvement and product redesign (ibid)). By “active” it is meant an offering that leads to a lower environmental impact through the function of the product and its use (resembles function and system innovation (ibid)).

A product of company H offers an example of a “passive” environmental innovation. A composite material was created from their own industrial waste material, replacing the use of a product with a higher environmental impact. On the other hand, an example of an “active” environmental innovation is a case from company F. They provided their client with a system that helps the client optimize the amount of daily production of a deteriorating product in order to reduce waste. With a simple system the client can produce an amount that matches the daily demand, and avoid the situation where they would be out of the product, while there are customers still willing to buy.

A thought that arises from this categorization into “passive” and “active” environmental innovation, is whether the “active” innovations can only be generated in the FFE, as the decisions about the function and use of the product are mostly made in the FFE, before the brief for NPD is compiled. If this is the case, it can be argued that to lower the environmental impact of an offering through its use and function, the environmental considerations need to be integrated into the FFE, and the opportunity identification and idea generation phase. Therefore, “greening” the function would take place in the FFE, while making the product green would take place at the end of the FFE and after it.

6. Conclusions

In this paper we show the results of interviews with eight companies. The research looked into the current practices of taking environmental considerations into the activities of the front end of the innovation process.

The main conclusions of this research are:

1. There are several practices of bringing environmental considerations into the activities of the front end, ranging from internal idea competitions to checklists.
2. However, these practices differ in frequency, structure and by the role environmental considerations play in the FFE.
3. The frequency of the “green” FFE varies from ‘always’ to ‘never’, and the structure of the practices varies from ‘high’ to ‘low’.
4. We proposed a classifying the role of environmental requirements in the FFE into the following groups: a ‘driving force’, a ‘guiding idea’, a ‘gatekeeper’, and ‘no role’.

The research presented here identified differences in the role and frequency of including environmental requirements to the FFE. However, the relationship of these two with the environmental innovativeness of the final offering remains a subject for further research.

Theoretically, the stage of the innovation process at which the environmental considerations come in, should affect the type of environmental innovations that will be possible. The later the environmental requirements are taken into account in the innovation process, the more likely it will produce a “passive” environmental innovation. However, this aspect still requires empirical evidence. Also the relationship between the different roles of environmental considerations in the FFE and the so called “active” and “passive” environmental innovations requires further investigation. Does a certain role more likely lead to a certain type of innovation? Are the so called “active” environmental improvements more likely to result from the ‘driving force’ or ‘guiding idea’ approach, and is the ‘gatekeeper’ approach more likely to lead to so called “passive” environmental improvements?

The most suitable manner(s) of “greening” the FFE stands still open. Questions such as “under which conditions” and “how” it is beneficial and viable to take environmental requirements into the FFE remain for further research. Initial propositions were already presented in this paper; one option is to build the mindset and the process of the FFE towards a direction that allows and supports working styles, which are likely to lead towards more environmentally sound ideas. For example collaborative and multidisciplinary work, early prototyping, systems thinking could be elements of this “greener” FFE. The first author of this paper will continue with her doctoral research in this area.

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