THE ORGANIZATION OF GREENING
THE INTEGRATION OF ENVIRONMENTAL MANAGEMENT IN NEW PRODUCT DEVELOPMENT

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The Organization of Greening

The Integration of Environmental Management in New Product Development

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De Organisatie van Vergroening
De Integratie van Milieumanagement in Productontwikkeling

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Preface and acknowledgements

When I started my PhD research I was especially triggered by my own observations in the Decopaint study for the European Commission. We were asked to assess the feasibility of a new directive to reduce the solvent content in decorative paint and it was my task to study the potential economic impact on the industry. The industry was very much willing to cooperate with our research and so we spoke with many managers in the paint chain, including managers from the oil industry, retail stores and professional painters. To my surprise we hardly spoke with environmental managers. Until then I had believed that especially large industrial companies employed environmental managers to negotiate environmental issues with regulatory bodies and to manage the integration of environmental issues in product development. It made me wonder whether the lack of involvement by environmental managers in product development was unique for the paint chain or that this was a more common phenomenon. I am grateful that I received the opportunity to study the organization of environmental concerns in depth and to learn about the great complexity and diversity of ecodesign practices.

Although I am working for the Universiteit van Amsterdam, it was Wim Hafkamp at the Erasmus Universiteit Rotterdam who challenged me to write a PhD thesis. With support of the NWO (Netherlands Organisation for Scientific Research) he also offered part of the necessary funding for the research. Without Wim, I would probably never have started. And without Ed Peelen I probably would not have finished my research. Ed insisted on including more quantitative analyses in my research and it was a pleasure to see him travelling through the data and to learn from him. I am grateful for their helpful and stimulating comments.

I would like to thank Anniek, Susanne, Fabienne, Jonatan for their company and advise. And I would like to thank Paolo especially for providing some of the articles that became fundamental in my research model. Ans, thank you for your patience and for your personal support. I like to thank Karin (and Michael as her advisor) who was so kind to edit my thesis.

I am also grateful to the managers of 3M, Ahold, AkzoNobel, Avebe, DAF Trucks, DSM, Ecostyle, Ecover, Forbo, Hycail, Philips Lighting and Philips Medical Systems, Shell, Ursa Paint and Valma. I should mention Bert and Nico (AkzoNobel) especially for their great efforts and feed back. Although academic research is not their main interest, they have spent the time for the interviews and the questionnaires and to involve their colleagues in this research.

During all the years of my academic life, there was one man who always kept asking about my plans for writing a PhD thesis. My father hoped so strongly that he would still be with us during the defence and I would have been much happier with him around this day. I know it was important to him and I am sorry that I did not manage to finish my thesis some months earlier. I also know my parents love is unconditional, certainly not depending on a degree or career, and I deeply respect them for this.

My father was involved in investment projects in the paper industry both the Netherlands and France with considerable impact on the recycling capacity. There probably are not many managers who have contributed more to the success of recycling than my father, albeit more for reasons of efficiency than for saving trees. Recycling is generally regarded as environmentally friendly. But if you wanted, he could also argue that the paper industry contributed to forestation by their investments in plantation and recycling in fact would result in deforestation. In retrospect, I always knew about the complexity of ecodesign.

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1 Introduction

When filling out a questionnaire consumers will often respond that they are willing to pay a premium for a more sustainable product. The actual behavior of consumers is however often disappointing to the companies that have invested in the greening of their products. Even products that are not only greener but are also more economic in use like energy saving lighting seem to need the support of regulation to find the market place. Even worse are the cases where we will find a trade-of between product quality and environmental performance and the products are therefore even more difficult to sell. The development of successful green products is not that easy.

The integration of environmental considerations in the product development process (or *ecodesign*) has become an important issue within the environmental policies of both industry and national governments. Recently this is most clearly illustrated by the market introductions of several types of fuel efficient and electric cars in the automotive sector which may be part of the answer to climate change and the problem of air pollution in urban areas. The Dutch government supports the buying of hybrid cars with considerable tax reductions. By integrating environmental considerations in the product development process the environmental impacts of the whole lifecycle of the product can be improved, from the exploration of raw materials, the transport and production to the use of the product and the recycling of waste materials. Both at national and European level, environmental policies have been implemented to support or even to impose the development of greener products by industry. Both in the theory and the practice of corporate environmental management the relevance of ecodesign is widely acknowledged. Within the field of environmental management we can distinguish a special section of ecodesign literature which has focused especially on the development of tools to support the designers in the development process. These tools are helpful to make an inventory of environmental impacts throughout the life-cycle and to generate and prioritize improvement options. In everyday life we can see the results of many of these improvement projects; hybrid cars, energy saving lights, waterborne paints, green electricity and organic food have become almost conventional products being produced and sold by the same companies that sell less green alternatives.

1.1 The challenge of ecodesign to organizations

So ecodesign is important for business and regulators, but how relevant is it for a researcher in management? The motivation for this research originates from the Decopaint study in which I was involved as an economist. This study was an assignment from the European Commission to assess the
feasibility of a directive to reduce the solvent content of decorative paint. During this study I learned that environmental improvements were a vital research strategy in this industry in which considerable financial and human resources were involved. To my surprise I saw hardly any involvement of environmental specialists with product development in this industry. It made me wonder how the development of greener products was actually organized and what the role of the relatively new environmental function was in this

process. What are the tasks in the development of greener products and who is doing which task? Was the lack of involvement of environmental managers unique for the paint industry or a more common phenomenon?

In the literature on corporate environmental management, ecodesign is identified as a major element of a pro-active strategy[1]. It is also described as a higher stage in the development process of corporate environmental management, where environmental management has started with a compliance driven strategy to clean up the production processed to a market oriented strategy in which the development of green products is a key issue. According to this literature a pro-active strategy is more demanding to the organization than compliance driven reactive strategies. The literature states that pro-active organizations need to develop their own environmental knowledge, they have to allocate environmental tasks to almost all functions and departments and they have to manage the development of strategies and the coordination of environmental tasks.

Although there is much literature on ecodesign on the one hand and on the organization of environmental management on the other, there is still little insight in the actual organization of ecodesign. This seems all the more relevant as it is noted by several researchers that the actual implementation of the tools of ecodesign is still very modest, even in the most pro-active firms. The literature on ecodesign had focused for many years on the development of tools and as far as there was an organizational focus, it has hardly been linked to the theory of the organization of new product development. The main goal of this thesis is to contribute to the understanding of the implementation of ecodesign and to link research on ecodesign to the literature on environmental management and of new product development.

Ecodesign is defined at several ambition levels, from the rather neutral level of "considering environmental aspects during the development of new products" to the highest level of "minimizing the environmental impacts in every stage of the life-cycle of a product". Because the actual implementation of ecodesign is low according to several international studies, and because the aim of this study is to gain insight in the organizational aspects of the actual implementation and not to develop new tools, ecodesign is defined at the neutral level to include projects at differing ambition levels.

Even at this neutral level one may expect that ecodesign is challenging to the organization. Organizations need to build environmental knowledge bases on environmental policy and regulation and on the technologies to improve the environmental performance in many different fields. The technological challenge may be low when there are alternative raw materials available with the same production characteristics as the material that should be replaced. The challenge may also be considerable when strict legislation is expected but still uncertain and new technologies have to be developed to meet this requirement. The greener product should of course also be marketable. The organization needs to know if the client has any preferences for a greener product, if the client is willing to pay a premium or accept a loss of quality. In some cases the client may not even notice any of the environmental improvements while in other cases the improvement will have to be communicated extensively. It seems obvious that the organizational requirements will not

[1] literature references are included in the body text and not in this introductory chapter

be the same in every ecodesign project, but they may be considerable, requiring the active involvement of several departments and significant resources.

Chapter 4 (*The greening of new product development*) will present an overview of the challenges and tools of ecodesign and it will discuss the literature on the organizational dimension of ecodesign. The literature on the organization of ecodesign has proposed specific roles for the environmental department in the design process. A major role for this department would be to manage the communication with environmental authorities and to pass regulatory information to the organization. It is concluded that there is actually still little insight in the actual organization of ecodesign.

The actual organization of environmental management has long been neglected. The environmental management literature has a strong focus on the integration of environmental issues in the strategy and is much less related to the organizational requirements. Especially the earlier environmental literature is very explicit on how the organization should be changed for the successful implementation of a pro-active environmental strategy. Some contributions have provided detailed overviews on which department should perform what environmental task and environmental management systems are suggested as an important tool. Apart from these more formal management mechanisms it is also acknowledged that informal forces such as the culture and the awareness of environmental issues may be decisive success factors.

A resource-based perspective has been applied frequently in environmental management research. This body of research describes how pro-active strategies have contributed to the competitive advantages of companies and it has identified critical organizational capabilities such as stakeholder integration, continuous innovation and higher-order learning. More recently it has been suggested that the optimal design of the environmental organization will also depend on the uncertainties surrounding the environmental issue. Several publications have identified sources of uncertainty but they differ in both the selection and in the assessment of their relevance. This contingency perspective is still new in the environmental management literature.

This thesis aims to link ecodesign research to the literature on the organization of new product development. The new product development literature has emphasized that product development is a fundamentally multidisciplinary process and that success depends especially on the co-operation between the R&D and marketing function. Although the necessity of this co-operation is obvious, there are many obstacles in the practice of new product development. The functions differ in language and time-horizons, they are located at distant locations and may have few informal contacts.

The new product development literature suggests several formal management mechanisms to facilitate the communication. It also suggests actions that are directed at the informal forces that may hinder co-operation. These management actions and the communication itself are not without cost, and communication is not equally effective in every stage of the development process. It is therefore necessary to tailor these integrating mechanisms to the individual situation. The contingency perspective that has just recently been applied in environmental management research is a common framework in the new product development literature. It is commonly acknowledged that the effectiveness of integrating

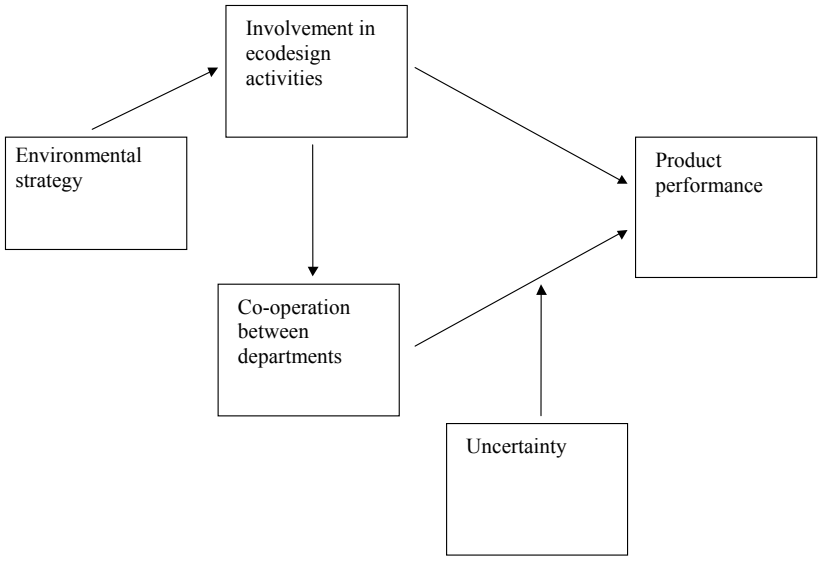
mechanisms is dependant on the uncertainties in the market and the technology that are unique for every project.

1.2 Research model

The main goal of this research is to gain more insight in the organizational dimensions of ecodesign. The research model builds on three bodies of literature: ecodesign, environmental management and new product development. The ecodesign literature is used especially to define the scope of projects that should be included in the study and to gain insight in the potential tasks and organizational solutions that may be relevant for the success of ecodesign. The environmental management literature suggests a direct relation between environmental strategy and organizational solutions, while later contributions also acknowledge the necessity to apply a contingency perspective. Both the ecodesign and the environmental management literature contain claims for a specific role for the environmental department. The contingency perspective is more advanced in the new product development literature. Effective co-operation between especially marketing and R&D is generally seen as a success factor for new product development. This co-operation can be improved by managing both formal and informal factors. Although some literature suggests that informal factors may be more important, they are also more difficult to manage or to analyse. Therefore researchers have focused on applying a contingency perspective on studies on the formal management mechanisms.

In this research it will be assumed that the environmental strategy of a company will have an influence on whether departments will be involved in any ecodesign activity. The environmental management literature has identified ecodesign as a major feature of a pro-active environmental strategy. Probably there will be a general relation between the deployment of ecodesign activities of the organization and the product performance. The levels of involvement of functional departments in ecodesign activities will have an influence on the levels of communication between the departments. In itself the effective co-operation between the departments during the green product development process may be expected to be a success factor, as it is for any new product development process. It will be interesting to see whether the role of the environmental function and the level of co-operation with this function is also related to the product performance. Finally, in applying a contingency perspective, it will be analyzed whether the effectiveness of co-operation is moderated by levels of uncertainty that are surrounding the project. This model is visualized in figure 1.1.

Figure 1.1 Research model



The central question of the research is defined as:

How, why and with what results do functional departments interact in the context of green product development?

How do functional departments interact in the context of green product development? The research will contribute to the knowledge of how green product development tasks are divided between functional departments. The research will also contribute to the knowledge of the actual integration of environmental management in using the dimensions that are used in other organizational studies. New product development and cross-functional team research seem to provide appropriate frameworks.

Why do functional departments interact in the context of green product development
The environmental management literature assumes that companies with a pro-active environmental strategy will allocate environmental responsibilities to all departments, which will probably also result in patterns of interaction different from those in companies with more reactive strategies. It does indeed make sense to predict that in proactive environmental strategies, the environmental department desires a higher level of integration with marketing and R&D. However, organizational theory would predict that integration is especially important with high levels of uncertainty. It may be that marketing and R&D find it so easy to predict environmental legislation and green consumer demand that they do not feel the need of frequent communication.

With what results do functional departments interact in the context of green product development? Although it is difficult to measure environmental performance, the research will make an attempt to relate levels of integration to both economic and environment

results. Low levels of integration could frustrate the successful realization of proactive strategies, but the adoption of environmental management tools without a real need for integration, would equally be ineffective. Of course, such insights are highly relevant for the practice of environmental management.

To study the actual organization of ecodesign 34 projects were selected in 17 companies (16 in the Netherlands, 1 in Belgium). A total of 33 interviews was conducted with managers who were responsible for the selected projects. The interviews served to gain more insight in the context of the ecodesign projects such as the environmental strategy and organization and the uncertainties surrounding the projects. The interviews also provided information on the motivations for the development projects and on the final results.

The manager was also asked to select 3 managers from Marketing, Environment and R&D that had been involved with the project and who could fill out the questionnaire. The questionnaire contained questions about the level of involvement in specific ecodesign tasks, the level of communication with the other 2 functional managers during the respective stages of the development process and the level of satisfaction with the product performance. A total of 96 questionnaires has been returned, meaning that the response rate was 94%.

1.3 Structure of this thesis

Chapter 2 will give an overview of the environmental management literature. It will show how ecodesign is positioned as a crucial element of pro-active environmental strategy and as a more advanced stage in the development process of environmental management. Chapter 3 will provide an overview of the literature on the organization of new product development. The contingency approach to the communication between departments has been applied frequently in new product development research and this chapter will therefore provide the main elements of the research model. Chapter 4 will introduce the concept of ecodesign and it will discuss some of the literature on its organizational aspects. Chapter 5 will present the research model. Chapter 6 will discuss the context of the selected companies and ecodesign projects. This chapter is based primarily on the interview results. The results of the questionnaire will be presented in chapter 7.

1.4 Academic and managerial relevance

This research will contribute to gain more insight in the actual organization of ecodesign, not by studying the implementation of tools but by departing from the common practices in companies that have developed greener products. There is still little insight in the roles of different functions in the company with regard to environmental management and ecodesign. It will also test whether the cooperation between the departments is a critical organizational capability contributing to the competitiveness of the company. In this sense the study contributes to the application of a resource based perspective in the environmental management literature. The study will also contribute by linking the literature on ecodesign to the innovation literature.

The relevance for managers is that the results can provide guidance on the success factors of ecodesign and on how the tasks can be organized most effectively. More insight in the actual organization of ecodesign may also be helpful for environmental authorities for whom the development of greener products is an important policy target. Is it necessary to support the implementation of ecodesign tools? What has been the impact of legislation on the development of greener products? Who should we address in the company to discuss the feasibility of product improvements?

One of the limitations of the study is that only companies have been involved that actually had developed greener products. These companies may be considered as being more pro-active than some of their competitors. The companies in the study are representing a large share in the Dutch economy however, including companies like Shell, Philips, AkzoNobel, Ahold, DAF and DSM and also small companies like 3B and EcoStyle.

2 The organization of environmental management

This chapter will provide a review of the literature on pro-active environmental management strategies and organization. The literature on environmental management strategy often uses typologies that rank environmental strategies from less to more pro-active. Especially pro-active strategies are relevant for this study and will therefore be discussed in more detail. Organizations with pro-active strategies have a strong commitment to go beyond compliance, both at process and at product level. Much of the literature discusses why and how pro-active strategies should be implemented, including how to adapt the organizational structure and qualities such as the leadership style, decision making, management control and communication. In the early environmental management literature it was often assumed that there is a simple one tot one relation between the strategy and the necessary organizational characteristics. A limited number of researchers has focused on the relation between the actual design of the organization and specific uncertainties for individual companies. There still is not much insight in which factors have an influence in the selection and effectiveness of actual designs. It seems obvious that if the technology of environmental improvements is simple, proven technology, or if consumers have stable (not too demanding) expectations of the environmental performance of products, or if a redesign has no negative consequences for price or performance, there may not be a need to have much internal communication while there can still be an effective launching of a greener product. A closer look at the uncertainties that surround environmental management is needed to explain the actual organization of environmental management.

2.1 The emergence of pro-active environmental management strategies

The integration of environmental aspects in management strategies is a major topic in the environmental management literature. This literature describes the business responses towards environmental legislation and emerging environmental issues, explains why companies employ more pro-active strategies and explores the relations with business performance (Pinkse, 2006). It seems obvious that environmental aspects have become a more important factor for strategic management in the last decades, if only as a result of an increasing body of environmental standards and regulations both for products and processes. The actual and potential economic impact of environmental legislation for business has become more significant over the years. The emergence of environmental management as an academic field may be understood from this increasing impact of environmental pressures on the business society. Starik and Marcus (2000) note that the attention for the organizational aspects of environmental management was late in comparison with other academic fields. They explain the emergence of environmental management as an academic field also by "*the evolving outcome of the environmental and social movements" in the 1960s and 1970s and the perception that organizations can have a significant impact (positive and/or negative) on the natural environment* (Starik and Marcus, 2000). This also means that the expectations about the environmental management of companies would have increased over the years.

The development of the business practice of corporate environmentalism is often described as a process of three or four stages (e.g. Berry and Rondinelli, 1998; Mauser (2001)) and evolving from "compliance" to "competitive advantage" (Dechant and Altman, 1994). The first stage of corporate environmentalism is situated in the 1960s and 1970s when industry is primarily focused on coping with crises and incidents. Examples of incidents that received attention on a global scale are the mercury pollution in Minamata Bay, Japan, the dioxin leak in Seveso, Italy, the oil spill by Amoco Cadiz, France, and the nuclear incident in Harrisburg, USA. At the national level companies were involved in a great number of incidents causing soil and water pollution scandals. These incidents and the publication of the Club of Rome report (1972) have had a major impact on the public awareness. (Kolk, 2000). At this first stage, corporate responses are "*typically reluctant, technical and compliance-oriented"* (Winsemius and Guntram, 2002).

In response to the environmental incidents new environmental agencies are established and new environmental legislation is implemented. In the second stage of corporate environmentalism which is placed in the 1980s, compliance with the rapidly increasing body of environmental legislation and minimizing the costs of compliance became central issues for corporations. A pioneer in the cost-saving approach is the 3M company (USA), saving about 500 million dollar by preventing environmental pollution (Walley and Whitehead, 1994). The 'pollution prevention pays'- principle is followed successfully worldwide by many more companies, like in the PRISMA project in the Netherlands (Dieleman and De Hoo, 1993). Cost-saving approaches are further enabled by changes in regulation, after governments become more open for initiatives from industry for process-integrated solutions that may result in the same or better environmental improvements at lower costs. Cost saving and compliance are key elements of the second type of environmental strategy which is referred to as the pollution prevention strategy (Buysse and Verbeke, 2003). In comparison with the fire-fighting type of environmental management from the 1960s and 1970s, this type requires a more strategic approach. It is more demanding to the levels of involvement for corporate managers who should now have knowledge of environmental legislation and standards and become more involved in environmental planning.

As a third stage of corporate environmentalism, from the 1990s onwards a more pro-active type of corporate environmentalism develops that anticipates regulation and takes advantage of business opportunities. The emergence of this proactive strategy is clearly evidenced by a large number of green-labeled products, the trends in corporate environmental reporting and the massive implementation and certification of environmental management systems (KPMG, 2002). In this type of strategy, companies are aiming for competitive advantages through product differentiation, "*(...) whereby products and manufacturing processes are designed so as to minimize the negative environmental burden during the products' entire life cycle"* (Buysse and Verbeke, 2003). The emergence of more pro-active strategies is accompanied by ongoing regulatory developments that allow more freedom for companies on how to comply with environmental policies and regulations. Regulation that used to be focused on single environmental media (air, water, land) is replaced by more holistic regulation. Economic instruments like emissions permit trading schemes are introduced and environmental standards are based on outcomes rather than current technology (Starik and Marcus, 2000). Business is thus allowed to take more responsibility for the actual design of its environmental policy. In doing so they can select

or develop technologies that meet environmental standards at the lowest costs or in accordance with the preferences of their stakeholders. Pro-active environmental strategies are more complex and demanding to the organization than reacting to prescriptive environmental regulations.

A well-documented example of the evolution of environmental management is provided in a study by Hoffman (1999) for the US chemical industry in the period 1960-93. Hoffman analyzed federal legal cases and the contents of the trade journal Chemical Week, and found four stages (table 2.1). The study supports the idea of increasing attention and integration of environmental concerns for the chemical industry.

Table 2.1 Stages in the integration of environmental concerns for the chemical industry

stage 1: 1962-70	Environmentalism as a challenge to the existing institutional order. Journal focused on self-reliance and technological optimism.
stage 2: 1971-82	Environmentalism as a regulative institution. Journal focused on legal compliance and resistance to additional regulation.
stage 3: 1983-88	Environmentalism as a normative institution. Journal focused on social responsibility and cooperation with EPA.
stage 4:	Environmentalism beginning to become a cognitive institution. Journal focused on managerial solutions, merging economic and environmental concerns and field wide cooperation.

adapted from Hoffman (1999)

Classifications of environmental management strategies

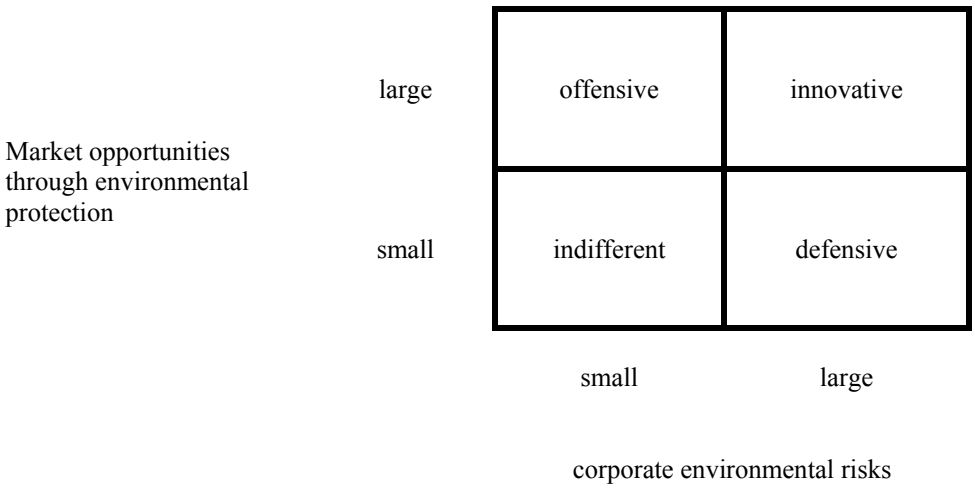
A classification of environmental strategies from compliant to pro-active is useful to describe the development of corporate environmentalism over time, but there are more ways to classify the strategies. Kolk and Mauser (2002) made an inventory of 50 models that have been developed to characterize corporate environmental management strategies. The environmental management literature uses three major types of classifications to describe the variations in environmental strategies. A first type of classification is a "continuum" (Pinkse, 2006) or "stage-model" (Kolk and Mauser, 2002) which is used to describe the development of environmental management strategies over time. A second type of classification is a "typology" which describes an ideal type of environmental management strategy at one point in time. Both stage-models and typologies include classes of pro-active (or innovative) strategies as ideal types or ultimate stages where environmental considerations are fully integrated in the corporate strategy. The third type of classification differentiates strategies according to the organizational or strategic level to which they are applied.

The stage model of Koppen and Hagelaar (1998) (also used by Kolk (2000) and Bakker (2001) provides a representative overview of the major characteristics of the different types of environmental strategies. Pro-active strategies are defined in this model as strategies with a focus on preventive measures demanding both product and process modifications in the entire product chain. In this model environmental management for pro-active strategies is a crucial part of strategic management and the company has formulated its own environmental policy with a limited role for the government and environmental regulation. Environmental management is an integral aspect for the whole organization and employees show considerable awareness. The company has their own environmental knowledge, perceives environment as a challenge and initiates projects to improve its environmental performance.

While the stage-model identifies the pro-active strategy as the most advanced stage in corporate environmentalism, a well-known classification by Steger (1993) identifies the innovative type. This model is linking 4 types of environmental strategy to 4 different combinations of environmental risk and market opportunity levels (figure 2.1). In the case of a company that faces low environmental risk and small market opportunities through environmental protection, it would not make sense to implement any significant environmental actions and the strategy is classified by Steger as “indifferent”. Defensive strategies are associated with combinations of large environmental risks but small market opportunities. In this case the company could be forced to implement an environmental strategy because of legislation but not go beyond a level of compliance. A business with small environmental risks and large market opportunities may be driven by market forces alone and implement an offensive strategy, involving slight environmental improvements. Finally innovative strategies are associated with both large environmental risk and large market opportunities through environmental protection. Innovative strategies will entail more radical changes of product and process design. This type seems similar to the pro-active type in other models.

Although models of strategic environmental management may differ in the exact number and content of the stages, greening of the product development process is a major element in many models as part of the "higher" and "later" stages or types, often referred to as a pro-active strategies (Hunt and Auster (1990), Steger (1993), Banerjee (1999), Hart (1997), Stead and Stead (1996), Koppen and Hagelaar (1998), Berry and Rondinelli (1998), Kolk (2000), Bakker (2001). This is a major justification for focusing on the product development process in studying the organizational aspects of pro-active environmental management strategies.

Figure 2.1 Strategies based on market opportunities and environmental risks



(Steger, 1993)

The third type of categorization is the classification according to different strategic levels. Banerjee (1999) defines environmental management strategies at enterprise, corporate, business and functional levels. At the enterprise level, environmental goals can be part of the mission of the company, while environmental agencies and the public are acknowledged as important stakeholders. Such companies are exclusively producing green products, often for green niche-markets. The second level of strategy is the corporate level, at which level the company decides in which businesses it should operate to meet its enterprise strategy goals. According to Banerjee, at this level "*possible corporate strategic options are to enter environmental protection businesses or to develop minimum-environmental-impact technologies*." The third level of strategy is the business strategy level, which involves decisions about how the company competes in the selected businesses. Environmental management offers many options to gain competitive advantage, including the development of green products. The fourth level is the functional level, at which the activities of different departments are co-ordinated. Environmental strategies that involve the development of greener products will also affect the marketing of the product.

Theoretical perspectives

The environmental management literature points at many possible drivers for the development of more pro-active strategies. Both institutional theory and the resource-based view are frequently applied in environmental management research. Institutionalist approaches aim to explain the nature and development of environmental management by the influence of regulative, normative and cognitive pressures and by the influence of stakeholders. Resource based perspectives are adopted to analyze the competitive implications of environmental management (Pinkse 2006).

The most salient stakeholders in the case of environmental management are environmental authorities, at local, regional national and, increasingly, at international levels. Pressure may also come from employees, consumers, business relations, industrial organizations, local communities, media, pressure groups, banks, insurance companies or shareholders, each of course with its own interest in the compliance with its own, specific environmental claim. More researcher have found a strong influence by governmental stakeholders and NGO's, while evidence for the influence of economic stakeholders on environmental strategies is mixed (Pinkse 2006). Research by Henriques and Sadorsky (1999) and Buysse and Verbeke (2003) has confirmed a relation between relatively proactive environmental strategies and the perceived importance of economic stakeholders (customers, suppliers, employees, shareholders and financial institutions).

A resource based perspective is also frequently applied in environmental management research. The environmental management literature is rich in case-studies and theories of how pro-active environmental strategies can contribute to gaining competitive advantage. Welford and Gouldson (1993, Environmental management and business strategy) list improved materials efficiency, positive pressure group relations, improved media coverage, assured present and future compliance, reduced risk exposure, lower insurance premiums, cheaper finance, improved community relations, increased staff commitment and improved product quality. Pro-active environmental strategies would therefore result in better financial performance and stock value, the empirical evidence for this claim is however debated (Perego and Hartmann, 2000).

Sharma and Vredenburg (1998) have identified three organizational capabilities that are resulting from proactive environmental management: stakeholder integration, continuous innovation and higher-order learning. They found that these capabilities also lead to competitive benefits including cost reductions, operational improvements and product improvements and innovation. Resource-based studies on the relation between environmental strategies and competitiveness have shown positive relations (Pinkse, 2006). It is noted however that environmental strategies are not implemented in isolation of other strategic issues. Non-environmental resources and capabilities such as process innovation can have a moderating effect on the relationship.

In a more recent contribution Aragon-Correa and Sharma (2003) have added a contingency perspective to the resource-based view on environmental management. This means that they have acknowledged that the efficacy of environmental capabilities may be moderated by factors in the general business environment such as uncertainty and complexity. They point at the characteristics of the business environment both to explain the development of proactive environmental strategies and capabilities and to explain why two firms with similar strategies and resources may obtain different levels of competitive advantage. One of their propositions is that, when uncertainties about the potential impact of environmental legislation become larger, companies will start to develop pro-active strategies and will decentralize decision making, allowing managers to anticipate future developments. They also propose that environmental capabilities that result from a pro-active strategy, such as the development of innovative systems for recycling, may lead to first-mover advantages when legislation will later make it obligatory to do so. The extension of the resource-base view on environmental management with a contingency perspective is new and should be followed by empirical research. The earlier environmental management literature lacked a

contingency perspective and has formulated organizational requirements that are directly related to the successful implementation of pro-active strategies. These requirements will be discussed in more detail in the following paragraph.

2.2 Organizational requirements for pro-active strategies

In the early stages environmental management actions are limited to relatively simple end-of-pipe technologies that have only limited effects on the design of processes and products. In these stages there is no need to make any significant redesign of the organization. Environmental expertise may remain external and embedded in the environmental technologies that are purchased from elsewhere. This situation changes according to the literature in environmental management, when companies develop more pro-active environmental strategies (e.g. Shrivastava and Hart (1995); Koppen and Hagelaar (1998). When processes and products become subject to environmental management, production engineers, R&D managers and marketing managers will have to be consulted about the formulation and implementation of the environmental strategy. New production technologies may also have consequences for the HRM policy when the new technology becomes more complex and thus will be more demanding for the production personnel. And when major product characteristics will change or the sales price will increase due to environmental measures, there will be a clear task for the marketing manager to assess the commercial feasibility and to redefine the marketing strategy. The number of business functions involved in the definition and implementation of the environmental strategy thus increases when the strategy becomes more pro-active. Together with this increasing involvement, it seems likely that the need for communication between functions will increase as well. This logical relation between the pro-activeness of environmental strategy and level of involvement of functions is reflected in the environmental management literature.

The environmental management literature covers a wide range of organizational qualities that may help the successful implementation of pro-active strategies. Berry and Rondinelli (1998) define the following six "*critical elements*":

- top management leadership
- environmental strategies and policies
- environmental goals, targets and metrics
- participatory decision-making and implementation
- environmental monitoring, auditing and reporting
- assessment and communications

According to Berry and Rondinelli, proactive environmental management requires a "*champion*" and "*success depends on securing the backing of top management*." They provide examples of companies such as DuPont where the CEO has led the drive toward pro-active environmental management. Environmental strategies and policies should reflect "*sound environmental goals and secure top management commitment and long-term funding"*. Concerning 'participatory decision-making and implementation' they claim that

Table 2.2 Environmental tasks per department according to Hutchinson

DEPARTMENT	TASKS
Purchasing	• find sustainable raw materials • reduce packaging and use more recycled materials
R&D	• find new uses for waste products • create long life goods
Marketing	• find out more about "*the growing consumer preference for environmentally friendly goods"* • define new business opportunities • find marketing, distribution and selling methods which reduce environmental impact • *"more radical":"(…) setting up new ventures and using franchising arrangements more creatively"*
Production	• devise processes which are more efficient and less costly in energy and resource use • *"more radical":"(…) seeking ways in which machines can be used to enhance human skills and develop their potential"*
Finance & Accounting	• investigate the benefits • find new performance measures
Office and Site Management	• look at efficient use of energy and lighting • reduce paper use by electronic mail • reduce traveling for meetings by the use of *"telephones and fax machines"*
Personnel	• look at company car schemes • *"appreciate the scale and speed of the requirement for new learning at all levels"*
Health and Safety	• *"find that the growing consciousness about the environment will add to the importance of their roles and strengthen it in terms of third part risks"*
Legal Department	• find ways to keep abreast of legislation and how best to disseminate this information
Public Affairs	• *"keep up-to-date with all the above activities"*

Hutchinson, 1992

"*successful companies have found (…) environmental management works only if it is decentralized"* Also, policies should be implemented in all departments, to make "*the environmental perspective part of the organizational culture and of every business decision'. (pp. 47)* Monitoring, auditing and reporting systems should be based on accurate emission inventories and can be used to measure compliance and to improve environmental performance. Berry and Rondinelli finally also stress the importance of business intelligence and external communication. Communication about the environmental performance is important for the corporate image and to gain stakeholder support.

Much of the environmental management literature states that every aspect of the organization should be changed for the successful implementation of pro-active strategies (Berry and Rondinelli (1998), Hart (1995), Shrivastava and Hart (1995)). Likewise, Hutchinson (1992) states that "*in order to respond to the environmental challenge in terms of new business opportunities and to build for the future, management needs to recognize that the issues will pervade all departments."* Hutchinson lists the tasks that stem from this environmental challenge for Purchasing, R&D, Marketing, Production, Finance and Accounting, Office and Site Management, Personnel and Legal Departments. (table 2.2)

Russo and Fouts (1997) have also stated that "improved environmental performance" requires a shift in the firm's culture and human resources and the organizational capabilities to manage them. They are explicitly listing R&D, production and marketing as business functions that need to be involved and committed to environmental management. They state that prevention is more comprehensive and complex and necessitates "significant employee involvement, cross-disciplinary coordination and integration and a forward-thinking management style" (pp: 538).

We can conclude that the environmental management literature prescribes a wide set of organizational issues that should be managed properly to implement a pro-active environmental management strategy effectively. Environmental management should be more than the sole responsibility of a specialised department and in fact may require the involvement of all departments in the company. The literature also prescribes top management leadership, effective environmental strategies and policies, environmental goals, targets and metrics, participatory decision-making, environmental monitoring, auditing and reporting, assessment and communication. One might put it also differently by simply stating that to implement a pro-active strategy environmental management should be an integral aspect of management.

Within the environmental management literature as it is discussed in this chapter we can distinguish three main categories of factors that are related to the successful implementation of pro-active strategies. The first category is about the integration of environmental considerations in the strategy of the organization. The second category is about the formal management practices such as an environmental management system to steer the organization and achieve the environmental goals. The third category is about informal forces such as the organizational culture that unite the organization. The categories and the examples that were cited in this paragraph are listed in table 2.3.

2.3 The actual organization of environmental management

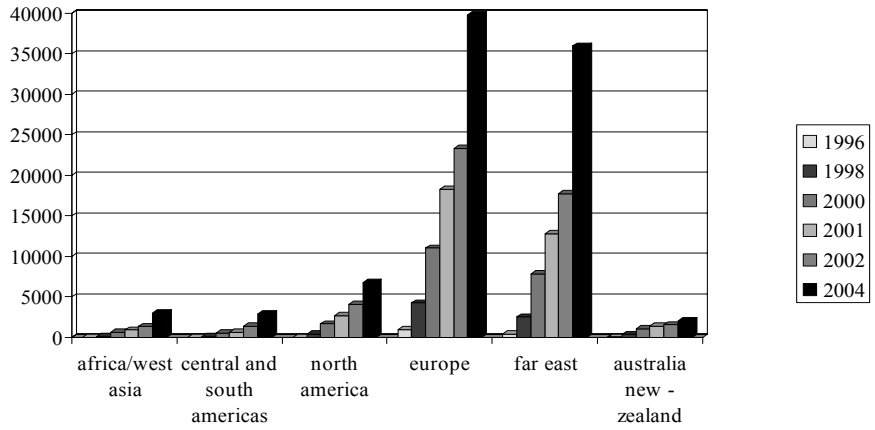
There is much empirical research that describes the actual implementation of pro-active environmental strategies and that analyses the relations between organizational qualities and the success of the implementation for individual cases or industries (e.g. Mauser, 2001 for the dairy industry; Van de Wateringen, 2005 for the oil industry). On national and international levels it are especially the surveys on corporate reporting (KPMG, 2005), the adoption of codes of conduct (Kolk 2003) and on the implementation of environmental management systems (ISO, 2005) that provide insight on trends in the actual organization of environmental management.

Table 2.3 Success factors for the implementation of a pro-active strategy

Environmental strategy: - top management leadership - environmental strategies and policies - long term funding
Formal management: - environmental goals, targets and metrics - participatory decision making and implementation - environmental monitoring, auditing and reporting - assessment and communications - allocation of environmental tasks - cross-disciplinary coordination
Informal forces: - organizational culture - commitment with environmental goals

Although limited to the formal aspects of environmental management, the implementation of environmental management systems according to the ISO 14001 standard is probably the most visible evidence of how organizations have been adapted to manage the environment. Environmental management systems emerged as a tool to ensure compliance with regulation and in response to concerns in society related to environmental incidents (Kolk, 2000). Environmental management systems standards, like EMAS and many industry specific standards, were developed in close collaboration between governmental authorities and industry organizations. Certificated systems are a proof for self-regulation and may prevent industry for stricter or unworkable precise regulations. The implementation of pro-active environmental strategies requires more than the changes in the formal organization that are needed for ISO 14001 certification. So trends in certification can only show part of the developments in the actual organization of environmental management. There probably are also many businesses that have implemented a pro-active strategy without the implementation of an environmental management system, or without asking for certification of their management system. The evidence concerning the implementation of environmental management systems legitimizes the focusing of the research in environmental management on the formal organizational aspects.

Figure 2.2 ISO 14000 certifications worldwide



Source: ISO (2005) The ISO Survey of Certifications 2004

The massive use of standards all over the world may easily lead to the false conclusion that all corporations have organized their environmental affairs in the same way. The ISO 14001 standard is however a very concise and generally stated set of demands, that leaves much room to the individual company on how it will organize its environmental affairs. One of the demands, for example, is that the responsibility for environmental training are assigned and documented, not which department should be responsible or how it should be documented.

Despite the trends in standardization, there is actually much variety in the organizational structures that have been adopted. The actual organization of environmental management ranges from firms that have created separate environmental departments, to others that have integrated the responsibilities for the environment into existing organizational roles (King, 1995). And even between the companies with separate environmental departments, the definition of tasks and responsibilities for environmental staff differs highly. Environmental managers and consultants in the Netherlands reported over 15 different responsibilities and 30 tasks, ranging from strategic to very operational levels (Van der Veen, 1999). Implementation and maintenance of the EMS, external communication and compliance were most often mentioned as the main responsibilities. Internal communication and consultations with environmental authorities appeared to dominate the agenda's. Pujari and Wright (1999) conclude from their research that where environmental management is not organized in a separate department, many different combinations can be found. The additional responsibilities of environmental managers in these cases, cover a varied range: technical, development, legal, quality, corporate affairs, R&D, operations, product safety, managing directorship and training.

Figure 2.3 Examples of the ISO 14001 standard's paragraphs on organization

"4.4.1 Structure and responsibility
Roles, responsibility and authorities shall be defined, documented and communicated in order to facilitate effective environmental management.
Management shall provide resources essential to the implementation and control of the environmental management system. Resources include human resources and specialized skills, technology and financial resources.

The organization's top management shall appoint (a) specific management representative(s) who, irrespective of other responsibilities, shall have defined roles, responsibilities and authority for

a) ensuring that environmental management system requirements are established, implemented and maintained in accordance with this International Standard;

b) reporting on the performance of the environmental management system to top management for review and as a basis for improvement of the environmental management system."

"4.4.6 Operational control
The organization shall identify those operations and activities that are associated with the identified significant environmental aspects in line with its policy, objectives and targets. The organization shall plan these activities, including maintenance, in order to ensure that they are carried out under specified conditions by

a) establishing and maintaining documented procedures to cover situations where their absence could lead to deviations from the environmental policy and the objectives and targets;

b) stipulating operating criteria in the procedures;

c) establishing and maintaining procedures related to the identifiable significant environmental aspects of goods and services used by the organization and communicating relevant procedures and requirements to suppliers and contractors."

The resource-based perspective in environmental management research has been a fruitful theoretical approach in analyzing the claim that it pays to be green (Sharma 2002). The focus of this research should now shift to the questions of *when* and *how* it pays to be green. *"What type of competitive benefits are associated with design for the environment and product stewardship? What competitive benefits does environmental certification create for organizations?".* Starik (2002) concludes that there are still many attributes of the environmental organization that need more empirical research such as "*the size, position, resources and responsibilities of EHS departments".* It is also noted that environmental research is often based on surveys that have been sent to EHS departments while the

involvement of other functions and departments is relatively unexplored. "*While a number of (...) studies have focused on manufacturing processes, and a more limited number on research and development and on marketing functions, most other organizational departments, processes or systems, including their relationships to one another, to headquarters and to key external stakeholders, are only beginning to be explored. (Starik, 2002, pp 332)"*

The literature on organizational structure and environmental management is scarce (Starik 2002, Atkinson, Schaefer and Viney, 2000) and there are only a few publications about environmental management and the cooperation between departments. Among these are publications by King (1995, 2000), which are based on research in the US printed circuits industry. King (1995) applies organizational theory to explain the actual formation and behavior of "pollution control departments". Based on organizational theory, King expected to find that environmental departments would function as *"boundary spanning"* departments, being created to protect the organization against any change that could have a negative impact on efficiency. King found that contrary to this prediction pollution control departments not only helped to reduce pollution but also to improve efficiency and were in fact highly appreciated by operations management. In a 2000 publication, King uses the same case studies to test theories on organizational change. The research shows that the manager's first reaction to environmental regulation is merely to protect the organization against change. The interaction of environmental managers and manufacturing that followed caused more fundamental change.

While King focuses on the integration of environmental management with manufacturing or product development (Lenox, King and Ehrenfeld, 2000), Fryxell and Vryza (1999) involve seven functional departments in their empirical work. Underlying this more complete coverage of departments is their assumption that for the development of environmental programs to go beyond compliance, environmental departments face heightened demands to integrate their activities. This is in line with the general idea in the environmental management literature that all departments will have to be involved to come to a successful implementation of a pro-active strategy. They suggest that along with the development of environmental management, the role of the environmental department has developed from being a "corporate policeman" to that of being a "change agent". They assume that the level of integration desired by environmental departments will be closely aligned with the environmental goal set of the organization. In line with their assumption that the primary focus of environmental management was risk or compliance oriented, they expected that functions that are more strongly associated with compliance such as production and legal departments, will have had more time to attain adequate levels of integration. Their research confirms that integration disparities are especially large for departments that are associated with a more proactive role, such as product development, purchasing and marketing. An interesting outcome of their research is that environmental directors seek the strongest integration with production and legal departments and significantly less with accounting and marketing functions. This suggests that environmental strategies are still primarily focused on compliance with regulation.

Fryxell and Vryza (1999) conclude that *"despite a sizable amount of literature cajoling environmental managers toward ever-greater integration, the literature fails to provide adequate guidance about how integration should be accomplished."* They suggest that this

failure may be caused by the fact that the relationship of integration mechanisms to environmental performance is rather complex, stating that *"what works for integrating with one function (e.g. accounting) could be ineffective with another (e.g. product development)."* Integration is often mentioned in environmental management literature, but it is seldom clearly defined. Fryxell and Vryza refer to integration as it is defined in organization theory where integration is about the interaction between specialized departments, in this case between the environmental and the other departments. However most of the environmental management literature refers to integration as the involvement of other than the environmental department (e.g. Hutchinson, 1992), not referring to the interaction between the departments, but to the division of environmental tasks and responsibilities.

In organization theory *integration* was defined by Lawrence and Lorsch (1967) as "*the process of achieving unity of effort among the various subsystems in the accomplishment of the organization's task*". Integration should be understood as the counterbalance to departmental specialization. Dividing tasks among specialized departments (or subsystems) enables increasing efficiency, but it may also lead to differentiation in priorities and cultures and it will certainly necessitate coordination between the departments. Integration is thus more than coordination and it is defined in relation to departmental specialization and differentiation. Applying this concept of integration to environmental management it would mean that it may be efficient in some organizations to have a specialized environmental department, with a minimum of environmental tasks for other departments, while in other organizations environmental tasks should be spread out over several departments. Both solutions would result both in different environmental management structures and in other patterns of coordination between these departments.

When the environmental management literature pleads for integration, they often plead for spreading environmental tasks and responsibilities over the departments, so against concentrating the tasks and responsibilities in one specialized department. The literature on environmental managements offers limited insight in the actual forms and levels of integration and in the effectiveness of specific tools that are advocated to achieve higher levels of integration. While the more prescriptive environmental literature is stressing the importance of spreading environmental tasks over all departments, Fryxell and Vryza are focusing on the interaction between the departments. Fryxell and Vryza and King have contributed by their empirical research and have shown the potential of applying organizational theory to environmental management research. The work of King provides insights in the relationships of the environmental departments with manufacturing or product development, while Fryxell and Vryza provide a more complete but relatively limited view on integration.

Covering both the interests and definitions from the environmental management and the organization theory literature, integration of environmental management is about the establishment of specialized environmental functions, the assignment of environmental tasks to other departments and the process of achieving unity of effort among the involved departments in the accomplishment of the tasks. Achieving unity of effort may be accomplished both by formal management practices and informal forces.

This paragraph on the actual organization of environmental management has focused on the formal organization and more specifically on the allocation of environmental tasks and the coordination between departments. This is a narrow approach in comparison with the organizational aspects that were listed before, including top management leadership and other factors that were identified as critical for the successful implementation of a pro-active strategy. Considering the massive implementation of environmental management systems all over world, a focus on the formal organization is legitimate. A further justification is found in the fact that despite this massive implementation, there is actually still little evidence of the effectiveness of formal environmental management practices.

2.4 A contingency perspective on environmental management

Aragon-Correa and Sharma (2003) have stated that the research on strategic environmental management needs to incorporate more contingency perspectives. Although it does make sense to expect a relation between the "pro-activeness" of a strategy and the level to which environmental responsibilities are assigned, it will most probably be a unique relation for every organization. There is also no reason why in every pro-active company every single employee should be involved in environmental management. Even if a company sells only highly sustainable ice-cream, when it can sell this ice-cream successfully using the same recipe for a decade or more, it is probably not necessary for all staff to be aware of environmental issues. And if consumer preferences with regard to the environment are stable, why should the marketer include this aspect in market surveys or even share these results with other staff members? If the production process of this ice-cream is generally regarded as harmless to the environment and is not subject to governmental environmental policies, why should the environmental department continuously monitor environmental legislation? And if all these aspects are relatively stable, why should these managers bother to communicate internally about the impact of the environment for their business?

Much of the earlier environmental management literature describes the necessary organizational structure as if it follows solely from the chosen environmental strategy. A pro-active strategy should be followed by the complete greening of the organization. However, organizational structures and thus the need for integration should also fit in the context of the organization, such as the age and size of an organization and the dynamics in the market and technology. The notion that there is not one best structure for organizations and that the effectiveness depends not only on the strategy but also on such factors as the uncertainties surrounding the organization is a major element of contingency theory.

The more uncertainty there is concerning the execution of a task, the more information will have to be processed at the time of execution to accomplish a defined target. Uncertainty is thus a major aspect to explain the effectiveness of organizational structures. Uncertainty was defined by Galbraith (1973) as "*the difference between the amount of information required to perform the task and the amount of information already possessed by the organization."* If two departments have to exchange much information in performing a task, organizational structures that facilitate this communication will be needed, such as regular meetings or project teams. If however, in the case of environmental management, environmental regulation is known at the start of a project and will not change during the project, there will be no need for communication on the related environmental issues.

De Groene has discussed the relevance of uncertainty for the organization of environmental management in great detail in her 1995 dissertation. She hypothesized that environmental issues cause a high degree of uncertainty for corporations. Her research acknowledges two dimensions of uncertainty: complexity and dynamics. Complexity refers to the number of factors taken into consideration in decision-making, where more factors (e.g. number of markets and suppliers, competitors and legislation) lead to increasing uncertainty. The dynamics of environment refer to the degree to which factors change and the level to which these changes are predictable. De Groene concluded that the natural environment is not highly complex in most cases because the number of actors with environmental claims is often very limited. Most uncertainty is caused by the dynamics of environmental aspects, especially environmental legislation (De Groene, 1995).

It might be that the conclusions of De Groene especially hold for reactive companies. They are driven by regulation, which in time becomes increasingly predictable and restricts the number of external parties to the environmental authorities. More pro-active strategies that include the development of greener products will lead to an increasing number of internal and external parties that should be considered, such as customers, suppliers, manufacturing, R&D and marketing. When companies have to deal both with new technologies and the unpredictable green consumers, this may lead to much higher uncertainties than in the case of a company that installs well-known environmental technology according to the conditions of its environmental permit. The research suggests a general relation between the "pro-activeness" of a firm and the level of uncertainty, but it also acknowledges that the relation will be unique for every company as they have to cope with different sources of uncertainty.

Another research on the relevance of uncertainty for environmental management comes from Lewis and Harvey (2001). But contrary to researchers that claim why environmental management should be fully integrated in the corporate strategy, they have stressed the importance of perceived uncertainty to explain why business corporations "*are not integrating the natural environment into their strategic thinking"*. Lewis and Harvey developed a scale to measure the perceived environmental uncertainty for the natural environment. The scale was successfully tested and applied in a study of the UK textiles industry. A complete overview of the scale is provided in table 2.3. The results of the study show that executives, especially in businesses at the end of the chain, perceive higher levels

of uncertainty in the natural environment. Uncertainty would make it more difficult to integrate green issues in strategic decision-making.

In a later study Lewis (2004) compares perceived uncertainty levels between industries in the UK and Germany and between the natural and the commercial environment. He concludes that the natural environment contributes to higher levels of uncertainty than the commercial environment for both countries. Lewis also includes the concept of "equivocality" in his study. Equivocality means that information is ambiguous, which according to Lewis is often the case for information about the natural environment. This equivocality might result in the neglect of environmental aspects in decision making. Uncertainty and equivocality set different requirements for the organization structure. Organizations in highly uncertain environments need formal and impersonal media such as

Table 2.4 Lewis and Harvey's scale to measure perceived environmental uncertainty in the natural environment

Government environmental policy
- environmental tax policies
- national environmental laws affecting international business
- environmental regulations affecting the business sector
- enforcement of existing environmental laws

Environmental resources and services used by your organization
- availability of trained environmental personnel
- environmental impact of inputs (e.g. energy, material, components)
- environmental impact of outputs (e.g. waste, effluent, emissions)
- availability of disposal capacity for waste, effluent and emissions
- prices of disposal capacity for waste, effluent and emissions
- environmental impact of natural (renewable) resource use
- availability of natural (renewable) resources
- prices of natural (renewable) resources

Environmental products, markets and demand
- customer environmental preferences
- environmental product demand
- availability of substitute environmental products
- availability of complementary environmental products

Green competition
- changes in the environmental markets served by competitors
- changes in the competitor's environmental strategies
- entry of new firms into the environmental market

Environmental technology in your industry
- changes in product environmental attributes
- changes in product environmental impact
- new product introductions with environmental attributes
- changes in the production process (e.g. end-of-pipe, clean technology)

The behavior of environmental stakeholders in your organization
- investors (e.g. shareholders, banks, financial analysts)
- community (e.g. households, schools, welfare groups)
- supply chain (including suppliers, customers, retailers, consumers)
- industry (e.g. employees,, unions, associations, peer companies)
- opinion formers (e.g. media, NGOs, pressure groups, scientists)
- regulators (e.g. insurers, watchdogs, agencies, government, EU)

How major environmental issues are affecting your organization
- climate change (e.g. global warming, ozone depletion)
- pollution of air, water, soil (e.g. by emission/discharges)
- loss of biodiversity (e.g. extinctions, genetic pool, deforestation)
- eco-efficiency (e.g. re-use, recycle, reduction, minimization)
- resource depletion (e.g. water, energy, metals, forests, land fill)
- social welfare (e.g. population, poverty, urbanization, auto mobility)
- eco-sufficiency (e.g. elimination of toxins, decimation of resource use

rules and regulations. Organizations in environments with high levels of equivocality need rich and personal media such as group meetings. In the case where organizations have both high levels of uncertainty and equivocality, Lewis recommends the "*inclusion of all employees in the search for information and a more intensive information exchange between employees"*.

The studies of De Groene, Lewis and Harvey and Lewis have shown that the natural environment does contribute to the perceived levels of uncertainty in organizations and that the levels and nature of this uncertainty is not the same for every company. De Groene found that although the natural environment is not highly complex, it does add to the perceived uncertainties of managers. Lewis points at equivocality as a factor in addition to uncertainty. Because organizational structures should be designed to deal with uncertainty, complexity and equivocality, we can expect different organizational solutions between companies even if they share the same pro-active environmental strategy.

2.5 Conclusion

A review of the environmental management literature shows that many authors believe that the success of implementation of pro-active strategies depends on a wide range of organizational qualities. Berry and Rondinelli have defined "*six critical elements"* and Hutchinson defined the tasks for every functional department to implement a pro-active strategy successfully. This literature implicitly assumes a one to one relationship between strategy and organizational qualities. Empirical research on the actual organization of environmental management is scarce and much less common than research on environmental management strategies. There are just a few contributions in which the effectiveness of specific organizational characteristics is related to the unique context of the organization's strategy and the uncertainties around environmental issues. Further research is needed to gain insight in the relations between both strategy and uncertainties and the effectiveness of environmental management. Studies on the role of uncertainties for environmental management provide a good basis for further research.

This research will focus on the process of green product development, because this is generally seen as a major element of pro-active environmental strategies. Also, it is expected that product development is more demanding for the organization than the installation of relatively simple end-of-pipe technology. The environment for organizations with pro-active strategies developing greener products for a commercial environment will often be both more complex (involving not only authorities but also clients and competitors) and more dynamic and therefore more uncertain than for reactive organizations. It will be interesting to analyse the perceived need and actual levels of coordination in organizations that face different levels of uncertainty. In this way we can gain more empirically based insight in the optimal design for pro-active organizations.

Finally this research will also focus on the requirements to the more formal aspects of organization. As will be seen in the next chapter, a contingency perspective has been applied extensively in the new product development literature. It makes sense to build on these same frameworks in research on the integration of environmental considerations in new product development. A focus on the formal aspects of environmental management is

also legitimate because despite the massive adoption of environmental management systems all over the world, little empirical research still has been done on the efficacy of different structural designs.

3 The organization of new product development

This chapter provides an overview of research on the organization of new product development and will focus on the contingency perspective on integration between especially Marketing and R&D. The idea that the effectiveness of specific forms and levels of integration is dependent on strategy and uncertainties is widely acknowledged and is the subject of much empirical research.

3.1 The process of new product development

Before we define new product development, we should first define what a new product is. Even a simple and old product like milk has many characteristics that might be subject of innovation. In this case innovation might be focused on the price, taste, fat percentage, nutrition value, more sustainable production methods or packaging. Kahn (2001) defines six types of new products: cost improvements, product improvements, line extensions, market extensions, new category entries and new-to-the-world products. In the case of cost improvements, the changes to the product may not be noticed by the client. Product improvements are enhancements of the form and function of a product and will often be explicitly communicated to the customer. Line extensions are products with new characteristics that do not replace the old product but are offered additionally. Product improvements always serve to replace the old product. Market extensions concern products that have the same or almost the same characteristics as the old product while they are introduced on new markets. New category entries are product that are new to the company, but not to the customer. New-to-the-world products are technological innovations creating completely new markets. The definition of new product development thus covers a high variety in levels of marketing and technical development challenges.

New product development is the process whereby the product or service is conceived, developed, produced and tested. It is the "up-front" part of the product planning process, which also includes the launch of the product or service to the marketplace. (Kahn, 2001). Textbooks on new product planning and development are often structured according to the similar sets of stages in the development process, starting with strategy or idea generation and ending with launch or commercialization. Table 3.1 shows similar processes from three mainstream textbooks.

The process of product development starts with strategic planning (Crawford, 1997). Strategic planning receives input from ongoing marketing, corporate planning (e.g. decisions to enter a new market) and opportunity analysis. Opportunities may arise from underutilised resources or new resources such as technical discoveries. There may also be external developments that suggest a new line of innovation or the management concludes that innovation is necessary to meet the sales target. It is important to note that the opportunities for new products may come from many different internal and external sources. Opportunities should be screened to see if they actually exist and it will be necessary to make a selection based on the fit with the strategy and available resources.
During the next stage the product concept should be generated, ranging from vague ideas to working prototypes. The product concept should state the major benefits of the new

Table 3.1 Stages of new product development in leading textbooks

Cooper (2005) in *Product Leadership*	Kahn (2001) in *Product Planning Essentials*	Crawford (1997) in *New Products Management*
1. Scoping *quick preliminary investigation of the project"* 2. Build the Business Case *more detailed investigation involving primary research – both market and technical; result includes product definition, project justification and project plan* 3. Development *detailed development and design of the product, includes some lab-testing and the development of production and marketing plans* 4. Testing and Validation *test or trials in lab, plant and the marketplace for validation* 5. Launch *commercialization – full operations or production, marketing and selling*	1. Opportunity Identification *delineate the direction for the product development initiative* 2. Concept Generation *put together a set of new product ideas* 3. Pretechnical Evaluation *evaluation and prioritization of product concepts, definitions of product protocols* 4. Technical Development *development and testing of technology, development of a viable business/marketing plan* 5. Launch *solidifying market acceptance, including market testing and launch* 6. Life Cycle Management *continuous monitoring and possible refinement and augmentation*	1. Strategic Planning *ongoing marketing and planning and opportunity analysis* 2. Concept Generation *identifying problems and suggesting solutions* 3. Pretechnical Evaluation *entry screen and more formal evaluation of product concepts, selection and definition of product protocol* 4. Technical Development *resource preparation, technical development of product and development of the marketing plan, evaluation at various stages* 5. Commercialization *scaling-up production capacity, market test and planning for launch control* 6. Launch *full scale production and marketing*

product, the form and the technology applied. Concept generation is a creative process for which several techniques (e.g. need assessment and scenario analysis) can be used. It should be concluded with an evaluation process in which the most promising concepts are selected for technical development. During concept evaluation the product concepts can be tested by involving customers, using checklists with evaluation criteria and a forecast of the economic impacts.

After the concept generation stage it is common to use a product protocol to guide the technical development (Kahn, 2001). The protocol is a signed document containing the criteria on which senior managers from all involved departments have agreed. Typical elements of a protocol are the target market, the product positioning, product attributes, competitive comparisons, augmentation dimensions (differentiation and competitive advantages), timing, marketing requirements, financial requirements, production requirements, regulatory requirements, corporate strategy requirements and any foreseeable problems in the product development process. The technical development stage involves a detailed product design, manufacturing engineering and the development of a market plan. The technical development will be the main responsibility of the R&D, Design or Engineering department but involves contributions from other departments as well. In some industries like in Pharmaceuticals the technical development stage may take many years.

3.2 Success factors for new product development

The success rate of developed products is estimated to be about 55 – 65% (Cooper, 2005). Developing new products is difficult because of the uncertainties about the new technology and the market acceptance. It is also difficult because of the involvement of so many functions (Kahn, 2001). Over the years there have been many studies to identify best practices and success factors for new product development. Kahn, Barczak and Moss (2006) have presented a framework of best practices for New Product Development, based on a review of several bench marking studies. Their framework comprises six management dimensions, including strategy, portfolio management, process, market research, people and metrics and performance evaluation. The best practices are summarised in table 3.2.

This overview of success factors is clearly more elaborated than the overview of success factors that was provided for the implementation of pro-active environmental management strategies. It includes strategic factors, formal management practices and informal forces just like the success factors for environmental management, but it is also explicit on the NPD practices and tools that should be applied at the operational level such as the use of intranet for NPD process documentation.

Table 3.2 Best practices in new product development

Strategy	Portfolio Management	Process	Market Research	People	Metrics and Performance Evaluation
Mission and strategic plan help define strategic arenas for new opportunities Opportunity identification is ongoing and can redirect the strategic plan real-time in order to respond to market forces and new technologies There are strategic buckets of resources to facilitate innovation and futuring Long-term, strategic view of NPD	A formal and systematic portfolio management process is in place There is keen consideration for balancing the number of projects and available resources There is a ranking or prioritization of projects There is a balanced variety of projects All projects must be aligned with the organization's mission/strategic plan An idea bank exists	One formal stage-gate type process is employed for the entire organization The NPD process is quite visible and well documented Personnel are very disciplined in using the process to develop all new offerings Go/No-Go criteria are clear and pre-defined for each review gate The NPD process is flexible and adaptable to meet the needs, size, and risk of individual projects There is an intranet for NPD process documentation	Product definitions are based on market research with customers/stakeholders Customer/user is an integral part of the NPD process Market studies are ongoing Concept, product and market testing is consistently undertaken and expected with all NPD projects Anticipate/identify future customer needs and problems through ongoing market research Market research has an integral relationship with NPD activity	Cross-functional teams underlie the NPD process Each project has a core team which remains on the project from the beginning to end NPD is team-focused Clearly identifiable project leader A NPD group exists and is dedicated to just NPD work Use of project management software and techniques to manage projects Ongoing NPD training and NPD awareness	There is a standard set of criteria for individually evaluating NPD projects There is a standard set of criteria for evaluating the overall NPD effort Multiple reviews and reviewers are used to evaluate NPD projects and NPD progress There is a group charged with the task of evaluation An evaluation software tool is employed Metric data is tracked and stored Metric data can be readily accessed for analyses

compiled from Kahn, Barczak and Moss (2006)

3.3 Organizational requirements for new product development

As can be seen from the inventory of best practices in the table above there are actually many requirements to the organization for the successful development of new products. When we limit ourselves to the "people" dimension, we can see that several of these requirements are referring to the quality of team work. For the successful development of a new product, it is necessary that especially R&D, Marketing and Manufacturing co-operate

and exchange information. R&D needs information from Marketing on emerging customer preferences and from Manufacturing on their limitations and capabilities in producing the new product. Marketing may also want to know in an early stage which new products or product improvements would be conceivable, based on new technologies, to test whether there could be a market for it. Although the importance of this co-operation is rather obvious, in practice there are many obstacles that prohibit effective relationships between the departments. A major challenge of new product development lies in the fact that the process cuts across many departmental lines (Urban, Hauser and Dholakia, 1987). The need for intensive cooperation between the departments is so urgent that multifunctional teams are a common solution.

Functional specialization and departmentalization can contribute significantly to increasing efficiency, however, they also create coordinating difficulties. These difficulties may arise from a number of factors that will be discussed later in this chapter in more detail, such as physical distances between the departments, differences in functional goals and time horizon or differences in language and culture. The term 'integration' will be used as the counterbalance of departmental specialization, like it was introduced in the previous chapter. Integration can be achieved through formal management mechanisms that increase the communication and coordination between departments, such as meetings, reporting procedures, targets and directives. Or it may be achieved through actions that are directed at informal forces such as the culture or at fostering informal contacts between departments. Organizational theory may explain under which circumstances the need for integration is especially high and when certain integrating mechanisms may be more effective.

"Even today in entrepreneurial firms, the producer-inventor frequently combines the knowledge of what is needed with how to develop it. But as the firm grows, the marketing and R&D functions become specialized. Scientists are hired to maintain and develop technology; marketing specialists are hired to sell the product, talk to customers, and communicate product benefits. Over time these groups grow apart, each expert at their own function, but less aware of the other's contribution. As integration and communication between these critical functions decreases, their ability to combine skills to develop and produce successful products decreases. The firm suffers.

Griffin and Hauser (1996), pp 192

Griffin and Hauser (1996) note that despite strong evidence for the positive influence of integration on NPD success, there are still *"numerous barriers to communication and cooperation*" and that *"disharmony between marketing and R&D is the rule, rather than the exception".* They hypothesize that integration approaches should be directed at eliminating these barriers. Table 3.3 summarizes the 5 types of barriers listed by Griffin and Hauser.

Table 3.3 Barriers to communication and cooperation between R&D and Marketing

Personality Differences mainly exist in time orientation. Research suggests that the true barrier may be a perceptual barrier of stereotypes rather than of actual personality differences
Cultural thought worlds Marketers prefer the short time horizon of incremental projects, focus on the market, accept a high degree of bureaucracy and feel loyalty to the firm. R&D staff prefers the long time horizon of advanced projects, focuses on scientific development with a loyalty to their scientific profession and has low tolerances for ambiguity and bureaucracy.
Language Marketing and R&D use own sets of technical terms and different levels of detail.
Organizational responsibilities Differences in task priorities and responsibilities. Functional success measures are unsupportive of integration. Lack of top management support rewarding integration.
Physical barriers Separation decreases face-to-face communication and solidifies barriers from personality, cultural thought worlds and language.

Griffin and Hauser, 1996

To counter the negative effects of functional specialization, management can choose from a range of "integrating mechanisms". Moenaert and Souder (1990) classify integration mechanisms into three categories, depending on whether they involve task specification, organization structure or organizational climate. The first two involve the formal management practices while the third is directed at informal forces. In task specification, the various functional activities and roles are planned and coordinated in advance and it is therefore limited to stable and predictable situations. The second category consists of organization structural design. In the case of boundary spanning approaches (e.g. direct contact, liaison roles, task forces, teams, integrating roles, matrix design), the functional differentiation is preserved. In the case of boundary elimination, the functional boundaries are redefined on the basis of output. Organizational climate methods are the third and "*may be the most effective*" integration mechanism. Moenaert and Souder state that the major responsibility for a climate of "openness, harmony and trust" rests with top management. *"Even stating a goal of innovation creates a climate that stimulates innovation"*. Griffin and Hauser (1996) identify six general approaches to integrate the efforts of Marketing and R&D. While Moenaert and Souder have categorized the integrating mechanisms based on their applicability to situations of increasing uncertainty, the mechanisms that are listed by Griffin and Hauser are directly linked to specific integration barriers. Both categorizations include a differentiation between formal and informal mechanisms.

Relocation and physical facilities may be an effective approach for integration because the physical distance between departments has much influence on the level of communication. The probability of interdepartmental communication drops already dramatically after a separating distance of only 10 meters (Kahn and Mc, 1997). Kahn lists several cases where corporations successfully brought together the managers from different departments to

develop a new product. Physical distance is an important factor in integration because most knowledge reaches the practitioners in NPD through face-to-face contact with colleagues (Allen, 2001).

Table 3.4 Integrating mechanisms according to Griffin and Hauser

• relocation and physical facilities • personnel movement • informal social systems and culture • organizational structure • incentive and rewards • formal integrative management processes

Griffin and Hauser, 1996

Personnel movement contributes in several ways to integration. People moving from one department to another have a better understanding of why decisions are made, they know the other group's jargon and bring formal and informal contacts (Griffin and Hauser, 1996).

It is often suggested that informal contact frequently substitutes for formal new product processes, and that the latter are not the primary means by which product development decisions are influenced (Griffin and Hauser, 1996). Informal social systems may help overcoming barriers for integration like differing thought worlds and languages, and physical separation between departments.
The optimal culture for integrated innovation is characterized by a high tolerance for calculated risks, is open to communication, shares rewards, and is decentralized.

There are many ways in which changes in the organizational structure can contribute to a better integration. One of the simpler ways is the formal appointment of an integrator, or project leader, to manage the development process. An alternative solution may be to assign a joint responsibility for the project, for both an R&D and a marketing manager. More drastic measures include the implementation of a matrix organization, coordinating groups and project teams. These structures could impact upon product development success by overcoming barriers from departmental differences in language, thought worlds and responsibilities. To be effective, changes in organizational structure should be supported by other measures, such as co-location, personnel rotation and formal integrative management processes (Griffin and Hauser, 1996).

Marketing and R&D managers are often evaluated on their individual functionally based performance. Marketing managers receive bonuses that depend on the increase market share, while R&D managers may receive their bonuses based on technology improvements. By stressing the functional goals of the departments, these individual reward schemes create barriers to effective integration.

Formal integrative management processes specify what tasks should be completed in what order and by whom. Specific product-development processes have been developed that

involve Marketing, R&D and Manufacturing in a joint decision-making process. These processes may define the main tasks per department for several stages, provide guidelines for selecting the members of (cross-functional) teams, set requirement for the communication between departments and to the management. Even if formal processes are not on paper, they may very well exist in the routines of experienced project leaders. Formal integrative management processes may help overcome the barriers that result from differences between the functional groups in languages and thought worlds and organizational responsibilities (Griffin and Hauser, 1996). So formal management processes have an effect on informal forces too.

3.4 A contingency perspective on new product development

Structural contingency theory states that there is no single organizational structure that is highly effective for all organizations (Donaldson, 1996). The effectiveness of a structure depends on contingency factors such as strategy, size, task uncertainty and technology. A certain aspect of the organizational structure is contingent on one or more of these factors. It is the task of contingency research to identify the factor or factors to which a particular aspect of organizational structure needs to fit. Contingency theories can be used to explain organizational structures or as basis for prescriptive advise to managers who will be interested in effective structures. The use of contingency theory to explain existing organizational structures is a form 'sociological functionalism', that explains social structures by their effective functioning and contribution to the well-being of society. Variations in organizational structures are explained by each different organizational structure functioning effectively in a specific situation. Organizations are seen as being forced to move into fit by adjusting their structure to their contingencies (Donaldson, 1996). Contingency theory has little attention for the managers who are making the decisions on the design of organizational structure, for their beliefs, ideals, values, interests, power and tactics. *"Much of the criticism from outside of the paradigm revolved around the perceived neglect of an action-level analysis in structural contingency theory research"*. Structural contingency theory is deterministic in that contingency factors would only allow one type of organization. Child (1972) acknowledges the importance of contingency factors, but argues that managers have a substantial degree of 'strategic choice'. Organizations may be less effective because of a "misfit", but this loss of effectiveness may be small relative to other causes of performance.

Many studies have found empirical evidence for the hypothesis that integration of marketing and R&D enhances the success of new product development, but not at the same rate under all circumstances. Following the contingency approach, Gupta, Raj and Willemon (1986) propose that "*the greater the environmental uncertainty perceived by an organization, the greater the need for R&D-marketing integration.*" It is easy to understand that when technology and market demand are not easy to predict at the start of a product development project, the need for communication during the development process will be higher. Organizational strategy is proposed as a second determinant of the need for integration. It is reasoned that if a firm's innovation strategy involves being first with new products, markets and technologies, this requires a higher degree of integration. The model confronts this need for integration with how much integration is actually achieved and

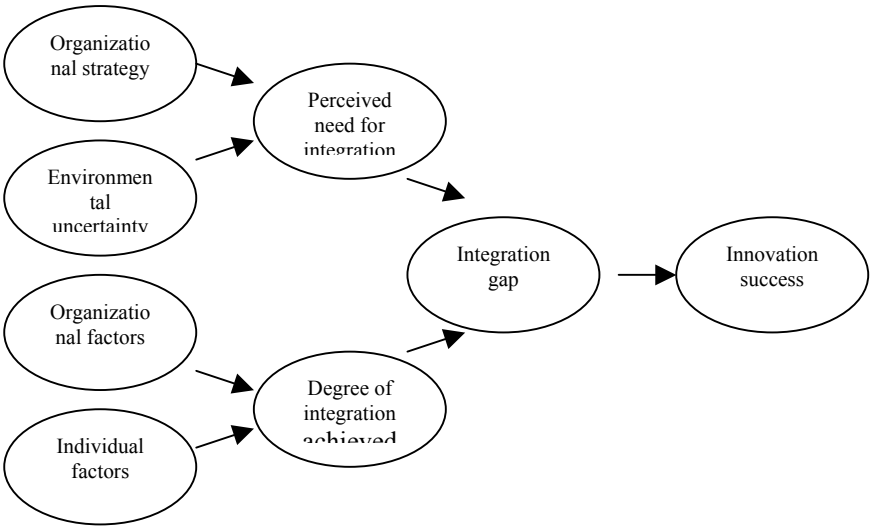
proposes that this is dependent on organizational structure, senior management's attitude and sociocultural differences between R&D and marketing managers.

Gupta, Raj and Willemon note that the definition of Lawrence and Lorsch is not very clear and operationalize the definition of integration as *"the extent of R&D-marketing involvement in the following stages of the new product development process"*. The organization's structure is regarded as a critical variable that determines the information processing potential between subunits and with external parties. It is proposed that lower degrees of formalization and centralization will result in greater degrees of integration, while participation is positively related to integration. This seems to conflict with the suggested positive impact of both formal and informal integrating mechanisms that were suggested by Moenaert and Souder and Griffin and Hauser. Griffin and Hauser however both pointed at formal organization (differences in organizational responsibilities) as a barrier and as an integrating mechanism (e.g. formal integrating mechanisms). The factors that determine the level of integration achieved in the model of Gupta, Raj and Willemon (Figure 3.1) are similar to those identified by Griffin and Hauser. The "individual factors" in the model of Gupta (et al) are similar to the "personality" and "cultural thought world" barriers in the model of Griffin and Hauser and relate to the informal forces in the organization. The "organizational factors" in the one model are similar to the "integrating mechanisms" in the other and relate especially to the formal management mechanisms.

Where much of the previous research on R&D-Marketing had found a general, positive relationship between integration and NPD success, Gupta, Raj and Willemon propose that the level of integration should follow from an organization's innovation strategy and perceived levels of uncertainty. *"Thus, instead of trying to maximize the R&D-marketing integration level, organizations must first assess the need for integration and then attempt to reduce the gap between the degree of integration ideally required and currently achieved."* This approach makes more sense than previous theories. Integration between departments is not for free and can't be maximized without considerable organizational cost. The model of Gupta et al. is in line with contingency theory. The cost of integration are also stressed by Song, Thieme and Xie (1998). Managers should adopt *"an approach to cross-functional integration that strikes a balance between efficiency and effectiveness."* They note that a contingency perspective in research on integration is gaining attention, at the loss of research that suggests a general relationship with NPD success. They further propose that the right mix may differ depending on the stage of the NPD process.

Ruekert and Walker (1987) developed a *"generalizable framework"* for studying how and why marketing personnel interact with personnel from other functional departments. Their framework is not limited to R&D-Marketing integration and was also tested for the relationships with Accounting and Manufacturing. Like Gupta et al, Ruekert and Walker refer to the work of Lawrence and Lorsch and state that *"complex and changing environments (...) create a greater need for people in various functional areas to interact"*.

Figure 3.1 Integration model of Gupta, Raj and Wilemon



Factors that influence the perceived need for integration		Factors that influence the degree of integration achieved	
Organizational strategy	Perceived environmental uncertainty	Organizational factors	Individual factors
Prospector Analyzer Defender Reactor	Competition Consumer requirements Technological changes Regulatory constraints	1. Structural: - formalization - centralization - participative - method of organizing new product activity - physical proximity 2. Senior management - values integration - encourages risk-taking - establishes joint reward system - tolerates failures 3. R&D-marketing operating characteristics	Sociocultural differences between R&D and marketing managers with respect to: - professional / bureaucratic orientation - tolerance for ambiguity - time orientation - types of products / projects preferred

(adapted from Gupta, Raj and Willemon, 1986)

The model of Ruekert and Walker is more detailed than the model of Gupta on how and why marketing interfaces operate. Resource dependency, not included in the model of Gupta, is considered to be the key internal variable influencing marketing's interaction. *"Because marketing personnel do not have all of the monetary, informational, or human*

resources necessary to do their jobs, they must seek such resources from people in other functional areas.(Ruekert and Walker, 1987, pp 3)" Other influencing variables are similar to that of the model of Gupta et al. Ruekert and Walker divide integration into transactions, communication flows and coordination mechanisms. Moenaert and Souder focus on interfunctional information transfer in operationalising integration. The information transfer is seen as a function of task specification, structural design and the climate orientation. The outcome dimensions in the model of Ruekert and Walker are more generally defined as "functional outcomes" because the model is not only developed to analyze NDP and also consist of psychosocial outcomes. With regard to this last dimension it is proposed that conflict, conflict resolution mechanisms and communication difficulty influence the perceived effectiveness of the relationship between functions.

One choice that has to be made in the research design is between operationalising integration as merely information exchange or to also include aspects that are related to collaboration. Information exchange can easily be managed by formal management mechanisms such as meetings and procedures. Collaboration is more dependant on the informal forces and is related to how the exchanged information will be perceived. Collaboration receives special attention in studies on the relative effectiveness of integration approaches, such as by by Kahn (1996). Kahn divides integration in interaction (e.g. meetings, committees, telephone calls, electronic mail, standard forms, memoranda and reports) and collaboration (collective goals, mutual understanding, informal activity, shared resources, common vision and *"esprit de corps"*). He finds that collaboration has a strong, positive effect on performance, while the effect of interaction is not significant and might even be negative. Olson (2001) concludes that the many researchers that have studied the correlation between functional integration and NPD success, seldom agree on what integration means or on how it should be measured. Part of the research focuses on the frequency or amount of communication between the departments (e.g. Griffin and Hauser, Ruekert and Walker) while other research focuses on collaborative behavior and attitudes (e.g. Kahn). It seems likely that effective integration will be dependent on both communication and collaboration. And the pure fact that two departments frequently exchange information does not guarantee the quality of this information. For research on the relative effectiveness of integrating mechanisms (e.g. Kahn, Moenaert and Souder) a more complete coverage is needed than for research on the relation between general levels of integration and success (e.g. Olson). Olson limits the scope of his study to "cooperation" which he defines as "*the frequency of interaction and the amount of information and resources shared between a pair of functions*". A first defense for this focus is that these behaviors are easier for management to quantify, influence and change than attitudes. The frequency of information exchange can easily be increased by planning some additional meetings. And secondly, *"any relationships observed between behavioral cooperation and project performance would likely be further strengthened by attitudinal affinities across departments, such as a shared vision, common values, and collective goals"*. When research is not focused on the relative effectiveness of integration mechanisms but on the general relation between integration and functional outcomes, operationalising integration as sharing information may be the more appropriate choice.

Another concept that needs to be clearly defined in the research model is 'uncertainty'. Researchers on new product development are using the concept of 'perceived uncertainty' to explain effective levels of integration. Because the behavior of managers follows their

perceptions of reality, it is more relevant to measure perceptions of uncertainty than objective measures. The same objective uncertainties may also be higher for firms that just enter the market, and they do not need to correlate with real market dynamics (Souder and Song, 1997). Gupta, Raj and Willemon (1986), define perceived environmental uncertainty as an organization's ability to anticipate changes in competitors' strategies, consumers' new product requirements, technology, emergence of new competitive forces in the market, and new regulatory constraints on product performance and design. For NPD 4 types of uncertainty can be distinguished: consumer, technological, competitive and resource uncertainty (Souder and Moenaert, 1992). Market uncertainty is measured by assessing the firm's perceived familiarity with the market for that product, the understanding of the customer's needs and the ability to translate those needs into product performance specifications. The third item is in fact a combination of market and technological uncertainty (Souder and Song, 1997).

3.5 Conclusion

The success of new product development depends on many factors, including strategic planning, the way that projects are prioritized, the implementation of a structured development process and use of teams. Several authors have stressed that new product development is a fundamentally multidisciplinary process and that success depends especially on the integration between the R&D and marketing function. A wide range of integrating mechanisms is available for managers who want to overcome the barriers that result from functional specialization. Integration can be improved by changing the task specification, the organization structure or the organizational climate. Integration also has a price however and should be tailored depending on the strategy and the uncertainties surrounding the project and the organization. This contingency perspective is similar to the more recent development in environmental management.

Researchers have formulated operational definitions of integration that differ from an exclusive focus on formal management mechanisms and information transfer or communication to definitions that primarily focus on the informal forces or collaboration. A wide focus should be applied if the aim of the research is merely to compare the relative effectiveness of different integrating mechanisms. The advantage of a narrow focus on cooperation that Olson defines as "the frequency of interaction and the amount of information and resources shared between a pair of functions", is that this is easier to measure and to manage than collaboration. It is also appropriate for studies that are merely interested in the relation between integration between specific functions and success, rather than in the relative effectiveness of different integrating mechanisms.

4 The greening of new product development

Greening the design of new products can contribute significantly to improving the environmental performance of an organization. Not only because of the improvements in the product itself, but also because the product design will have an impact on the effects of the resources used, the production process and the effects of disposal after use. EU member states began to formulate product-oriented environmental policies in the 1990s. In 2001 the European Commission adopted the Green Paper on Integrated Product Policy (EC 2004). In the Commission's view the promotion of life-cycle thinking within companies should be a major component of a product-oriented environmental policy. This should then be realised by improving the availability of life-cycle information tools such as LCA and by giving consumers the information to enable them to select greener products. Also, obligations for producers are considered with regard to the product design process. The greening of new product development is also a major topic in the environmental management literature. This chapter will provide a brief discussion of the literature on green product development. In the light of the previous chapters, special attention will be given to the allocation of tasks to the departments, and the relations between the departments that are most closely involved in this process: R&D, marketing and the environmental department. But first, the basics of the ecodesign process will be discussed.

4.1 Ecodesign strategies

There are several labels to refer to the greening of new product development. Tischner and Charter (2001) list 'sustainable product design', 'ecodesign' and 'design for environment'. Ecodesign and design for environment are defined by Tischner and Charter (pp. 121) as "*strategies that aim to integrate environmental considerations into product design and development"*. Design for Environment is described by Van Hemel in her 1998 thesis as considering "*the environmental aspects in each stage of the product development process, striving to achieve products which have the lowest possible environmental impact throughout their entire life cycle*". A difference between these two descriptions is that the ambition level in the definition of Van Hemel is purely environmental and high, while the description of ecodesign could apply to compliance driven strategies as well. The "integration of environmental aspects" in the design process may be necessary to achieve the "lowest possible impact", it is however not a guarantee. In this study ecodesign will be defined as *the integration of environmental considerations in product development* because the aim of this study is not to evaluate tools that minimize the environmental impact, but to analyse the integration of environmental aspects in new product development in different organizations and projects. A focus on only the most ambitious projects would also be a serious limitation because the actual implementation of Design for Environment (DfE) is still very modest (Handfield et al, 2001; Tukker et al, 2001)

Lowering the environmental impact can be achieved in many different ways, as is clearly illustrated by Van Hemel's inventory of "DfE strategies and principles" (table 4.1). The available strategies may be directed at every single stage of the life cycle, from the selection of low-impact materials to the redesign of the product to enable recycling or re-use. The ecodesign strategy can even go beyond improving the product characteristics when

Table 4.1 DfE strategies and principles

Selection of low-impact materials - clean materials - renewable materials - low energy materials - recycled materials Reduction of materials usage - reduction in weight - reduction in volume Optimization in production techniques - clean production techniques - fewer production steps - low/clean production energy - less production waste - few/clean production consumables optimization of initial life time - high reliability and durability - easy maintenance and repair - modular/adaptable product structure - classic design - strong product-user relation optimization of end-of-life system - reuse of product - remanufacturing/refurbishing - recycling of materials - safe incineration/energy recovery - safe disposal of product remains new concept development - dematerialization - shared product use - integration of functions - functional optimization

Van Hemel, 1998

new concepts are developed in which the product is replaced by different products and services. Examples of this type of strategy are the development of systems for car-sharing or web conferencing to reduce car traffic. Van Hemel reviewed as many as 596 improvement options in 77 small and medium-sized companies, categorizing them on DfE principles applied. The study showed that the companies mainly focused on end-of-life issues (recycling, refurbishing, remanufacuring), reducing product weight and the selection

of low-impact materials. It appeared that the most frequently adopted strategies were often more compatible with "traditional" product requirements.

A European study on the implementation of ecodesign shows similar results (Tukker et al, 2001). In most ecodesign project, the activities are limited using "*green procurement lists, applying good housekeeping, and changing to a less toxic or harmful raw materials*". Most projects appear to be focused on the environmental optimization by redesign of existing products rather than on the development of new concepts. A study in the US (Handfield et al, 2001) produced similar results and reports that in the US "*recyclability and material substitution*" are the most common orientations in ecodesign. It appears that the approach in which the optimal environmental strategy is selected on the basis of an LCA-study is not common at all.

4.2 Ecodesign tools

The ecodesign literature describes many tools that are available for the implementation of ecodesign strategies. These tools can help to analyse, collect information, be creative, decide, communicate, monitor and review. Tischner (2001/sust.sol) made an inventory of 35 of Ecodesign methods and tools, divided over four categories:

- analysis of environmental strengths and weaknesses
- priority-setting and selection of the most important potential improvement
- idea generation (brainstorming), design and draft specification
- inclusion of other important criteria: cost-benefit analysis, economic feasibility studies

Most of the tools identified by Tischner fall under the first category and are LCA-like approaches. These tools help to identify, quantify, evaluate and prioritize the negative environmental impacts that are related to a product throughout its entire lifecycle. LCA studies may involve extensive analysis for which external expertise needs to be involved. The tools differ in the level of detail, support by software or by the weights and indicators that are used to aggregate different environmental effects into a final assessment of the environmental performance. LCA software is available that calculates the environmental impacts of an individual product making use of databases with the environmental characteristics of many standard processes and raw materials.

Once the designer has gained more insight in the overall environmental impact of a product, a second category of tools can be used to prioritize environmental goals in the further design activities. Such tools may enable the user to set priorities based on the potential of the company to make significant improvements, expected legislation or consumer preferences. This type of tools includes spider-diagrams and decision matrices. The third type of tools helps to generate ideas for product improvements. This type includes simple checklists, expert rules and guidelines for brainstorming. The forth type of tools consists of multi-criteria tools, enabling the designer to evaluate the generated options with regard to profitability, marketability and technical feasibility.

Empirical research in the US found that tools such like LCA and green purchasing are not widely used and evidence of successful applications is limited to case studies (Handfield et

al, 2001). A European study concludes that "*even in the front runner countries practical application was still limited* (and) *even in these cases, ecodesign is mainly practiced by several dozen 'champion' firms*". It appears that there is a large gap between the development of advanced tools for ecodesign and the actual implementation and that this gap occurs in many countries and industries.

4.3 Ecodesign and the organization

Berchicci and Bodewes (2005) concluded that the ecodesign literature has been successful in developing tools and methods to help firms develop greener products but that it has failed to draw on established theories on new product development. They argue that this omission may be an explanation for the "mixed experiences" of firms that have tried to develop more sustainable products. They suggest that research on the success of ecodesign should now be linked with three areas in the NPD literature. The first area should be focused on the design specifications and the trade-offs between environmental and other product attributes that create value for clients. The second area should be focused on the coordination and alignment within multifunctional ecodesign teams. And the third area should be focused on the role of management support as a success factor for ecodesign.

Some of the earlier ecodesign literature has also stated that research has placed too much emphasis on the development of tools (e.g. Lenox and Ehrenfeld, 1997). Charter and Tischner (2001) note that *"Ecodesign has evolved primarily from the engineering and life-cycle assessment (LCA) communities and has therefore often been technically rather than business or organisationally focused."* And several authors have noted that most literature does not account for the organizational consequences of "green design" (Noci and Verganti, 1999; Green et al., 1994; Foster and Green, 2000; Winn and Roome, 1993) and that few of it relates to empirical research (Pujari and Wright, 1996). Considering the gap between the development of advanced tools and the actual implementation is seems to make sense to shift the focus to organizational issues and link the ecodesign literature to theoretical frameworks from the NPD literature such as suggested by Berchicci and Bodewes..

Considering the wide range of "DFE strategies and principles" it is clear that DFE is not limited to a few environmental technologies and that the responsibility cannot be limited to the environmental manager. With regard to the organizational consequences, the selection of low-impact raw materials for example, could have consequences for procurement, logistics, production and maybe even for marketing if it effects the price or quality of the product. The successful implementation of ecodesign will logically be dependant on the involvement and coordination of several functions in the company.

The TU Delft (Rocha and Sylvester, 2001) has listed 15 operational activities that should be carried out for successful ecodesign (table 4.2). The listed activities can be related to different functional specialists. For some of the tasks one may very well imagine that they will be accomplished by an environmental expert, such as conducting life-cycle analyses, consulting partners in the product chain, benchmarking the environmental qualities with a product of a competitor and confronting the current product characteristics with regulatory standards. When environmental improvement objectives have to be defined, it seems inappropriate to do so without involving at least a R&D manager to ensure that the

objectives are technologically feasible. And when different improvement options have to be evaluated for their economic feasibility, this will certainly ask for the involvement of a marketing manager to assess the marketing potential of the new product.

Table 4.2 Operational ecodesign activities

1. Evaluation of products' environmental impacts in the life cycle
2. Consultation of partners in the product chain in order to identify and implement environmental improvements in the products
3. Eco-benchmarking for the products
4. Evaluation of implications of existing/expected requirements for the products' environmental performance: legal requirements, agreements, codes of practice, etc.
5. Definition of environmental performance indicators for the products
6. Definition of operational objectives to improve the products eco-efficiency in the life-cycle
7. Generation of "green" options to improve the products at the early stage of the product development process
8. Environmental, economic and technical validation of the "green" options
9. R&D to improve the environmental performance of the products, along the life-cycle
10. Inclusion of environmental requirements in the products' programme of requirements
11. Definition of ecodesign guidelines for product development
12. Consideration of ecodesign implications in manufacturing, aiming at cleaner production
13. Eco-marketing of the products
14. Advice of clients/consumers in order to prevent and minimize impacts in the use phase of the products
15. Monitoring of the products environmental performance and comparison with the defined objectives

Source: Rocha and Sylvester, 2001 (life-cycle management conference proceedings, Copenhagen)

The need for communication between different hierarchical levels and functions will not be the same for every type of ecodesign strategy because they will not be equal in their potential market and technological impact. Brezet and Rocha (2001/sust.sol) define four levels of ecodesign that are related to increasing levels of change and eco-efficiency. Product improvements involve partial changes and improvements to products that are already on the market. The product itself and the production technology does not change at this first level. The second level is the redesign of products. At this level the components are improved while the product concept remains the same. The third level of ecodesign is called 'function innovation'. Here the product concept and the way that the function is fulfilled are changed. A shift from material products to services is an example of this level. At the fourth and highest level, called 'system innovation', the entire technological system (product, production chain and infrastructure and institutional structure) is replaced by a

new system. According to Brezet and Rocha, most of the ecodesign practices can be categorized at the first two levels. At these first two levels there would not be a need for "*significant interference or involvement from the strategic or top management level of a company*". The higher levels of ecodesign do demand policy changes from top management, *"sometimes including the establishment of new sustainable business units and 'green coalitions' outside the existing companies in order to be successful."*

The need to involve other functions than just the environmental experts in the ecodesign process may be obvious for many categories of ecodesign, the actual practice seems to be less than ideal. Reviewing surveys into the management of ecodesign, Charter (2001) concludes that Ecodesign is owned and driven by environmental management rather than by marketing personnel. Even in some of the largest companies, programmes are still in the early stages of development and objectives and targets are often vague and unclear. Charter has found that many transnational companies have established centralized units that are responsible for the development and implementation of corporate ecodesign policies. IBM has an ecodesign center in the USA that distributes policies, guidelines and tools to the business units worldwide. It is concluded that the level of centralization of ecodesign follows the approach to environmental management in general. At the one extreme there are companies that act like holding companies and manage the business units largely on financial performance, while there are also companies that exert substantial control, including goals, management methods and monitoring. Charter (2001(sust.sol) lists many internal barriers to ecodesign that need to be overcome among which are also "*poor communications"* and organizational structures. Charter suggest to establish cross-functional teams to help ensure that there is early consideration of environmental aspects in product development.

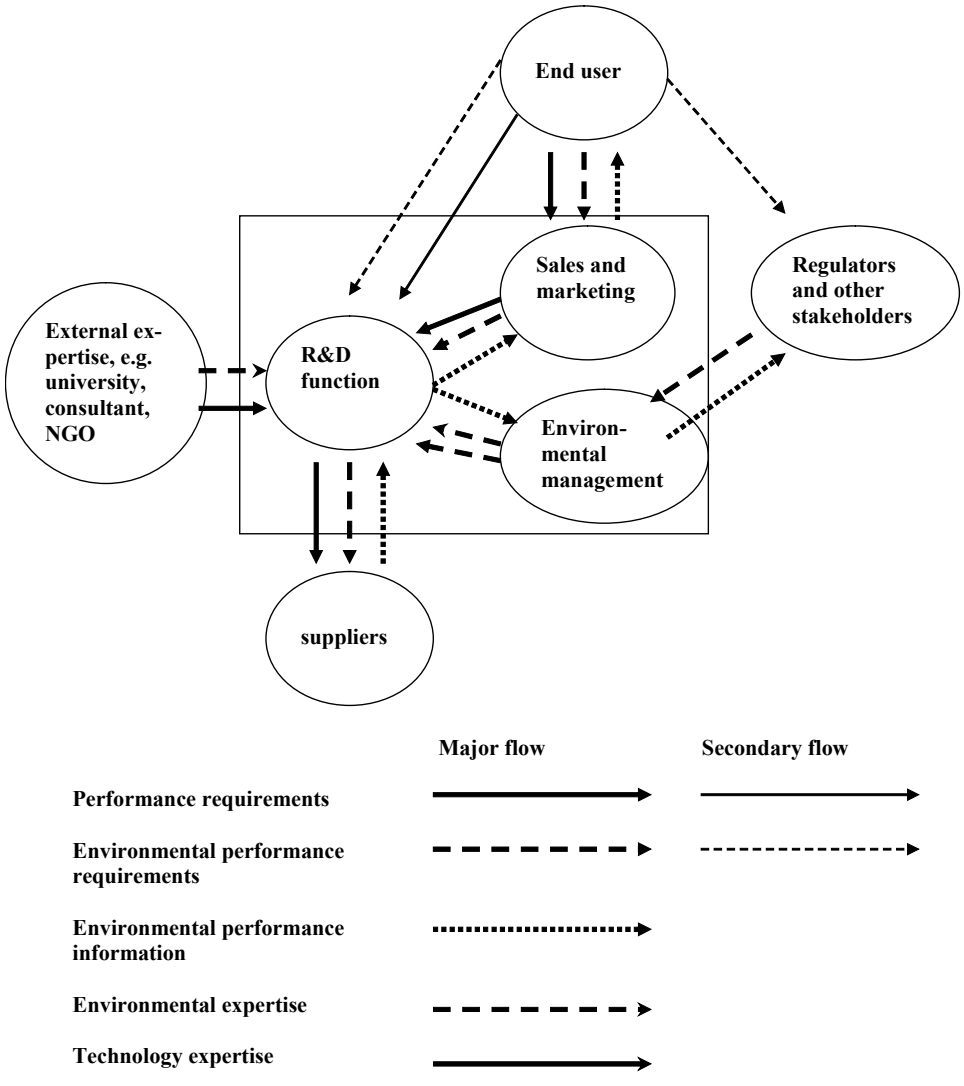
4.4 Ecodesign and functional specialization

In addition to the more general research on the organisation of ecodesign, some researchers have analysed the specific roles of functional departments and their communication. Foster and Green (2000) have developed a model that specifies the roles for 'Sales and marketing', the 'R&D function' and the 'environmental manager'. The model shows how signals (i.e. prompts for innovation) from outside groups may reach the organization and how such signals may then flow between the functions internally. This model is shown in figure 4.1. In this model the environmental department, is a "source of environmental expertise" to R&D and the communication link between R&D and regulators. The marketing department is the principal interface between the firm and its customers and "*of course, end users may also have requirements relating to environmental performance of products and services"*. Foster and Green suppose that some environmental regulatory and customer demands may flow directly to R&D, but that information flowing in the opposite direction will not happen for reasons of confidentiality.

Foster and Green interviewed R&D and other managers in nine UK companies, all of which were affected by environmental issues, mainly through legislation and consumer pressure. In all nine firms they found links between the R&D function and environmental management. In three companies much of the expertise needed for the companies' environmental programs is held in the R&D department. In companies with weaker links

between R&D and environmental management, R&D at least was responsible for gathering ecotoxicity data on products. In the largest companies, R&D was involved in the environmental management system of the company, but typically lagged behind other departments. Only in two companies with an environmental management system, the role for the R&D function was specified as "provider of greener products" (pp 295). More common is the inclusion of environmental considerations (mainly compliance checks) in existing R&D selection and review procedures.

Figure 4.1 Information flows in ecodesign according to Foster and Green



Foster and Green (2000) concluded that none of the nine company cases corresponded exactly to their idealized model. *"There is much more variety between businesses in the ways that 'green' signals enter, leave and flow around them, then is the case for other signals relating to product performance. This may reflect the different forces that different businesses find to be pushing them most strongly in addressing the green agenda."*

Lenox and Ehrenfeld (1997) have evaluated the effectiveness of Design for Environment approaches in 4 US electronics firms. Based on this research they propose that the environmental design capability of a firm depends on:

- internal and external knowledge resources on the environmental impacts and demands (e.g. corporate environmental research centers or programs);
- communication linkages between product development team members and these resources (e.g. gatekeepers and the transfer of design tools) and
- interpretive structures through which environmental information is understood and valued by product development team members (e.g. training, engineers as gatekeepers or gatekeepers as member of the design team).

The concepts of communication linkages and interpretive structures fit well into the integration mechanisms that are presented in the NPD literature. In the NPD literature it is, however, the more informal factors such as time horizon and language that is said to have an influence on how information from another department is processed. Lenox and Ehrenfeld are focusing on the existing distribution of knowledge of environmental issues as a factor. The proposed solution to improve the co-operation between the departments is to provide training. New is the combination with internal and external knowledge resources and gatekeepers, a role that according to their model should be primarily located at the EHS department. The role of the environmental manager as a gatekeeper was also confirmed in a research by Pujari and Wright (1999).

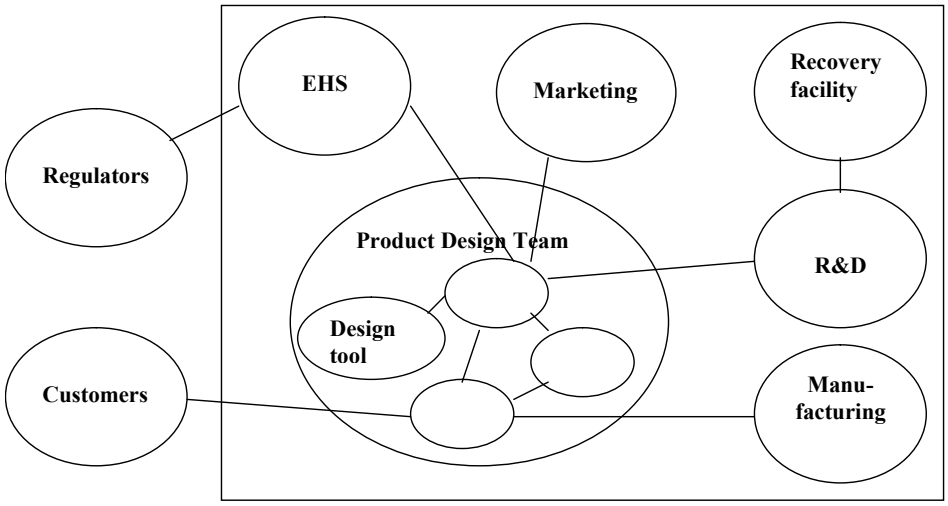
The model of Lenox and Ehrenfeld is not presented as an "idealized model" like with Foster and Green, but just as "an example information network". It differs in many ways from the model of Foster and Green, especially in that it includes a product design team, but it resembles it in the central role for an environmental department in passing on regulatory information to the product design team.

A major conclusion from their research is that knowledge resources (e.g. a corporate environmental research center) are in themselves insufficient, if they are not accompanied by effective communicative linkages and interpretive structures. Their case studies indicate that a "variety of support functions on the corporate level while coordinating them with product development teams through training and extensive use of gatekeepers" is the most effective way to organize DfE. In another paper that discusses the same case studies (Lenox, King and Ehrenfeld, 2000), it is concluded that providing "living specialists" is far more effective than providing environmental design tools. The tools were too time consuming, too specific for general use, not translating environmental issues into costs and benefits for the firm, too difficult to use or "*unworkably simplistic"*.

As a general conclusion Lenox, King and Ehrenfeld find that *"even under the best of circumstances – high levels of demand for environmental benign activities – sustainable*

practices are still new and not well embedded in firm structures". This conclusion is also supported by the research of Charter.

Figure 4.2 Model of Lenox and Ehrenfeld



While the literature discussed above, allocates major responsibilities at the environmental department or propagates environmental design tools, Florida (1996) suggests quite different success factors for the greening of product design. According to Florida, innovative firms that are continuously improving their products, will have more opportunities and incentives to take environmental consideration into account. He found that "green-design plants" tend to be larger, more R&D intensive, introduce more new products and have more worker involvement. So referring to Lenox and Ehrenfeld, it may not be the environmental design capabilities, but conventional design capabilities that are most critical for Design for Environment.

The position of Florida also relates to the observation of Foster and Green (2000), that it is very hard to measure the extent to which the "green agenda" drives R&D activity. Environmental performance improvements are often linked with other product improvements or production costs, so greener products may very well be the outcome of non-green R&D. Foster and Green also found that if environmental objectives were leading R&D, these were often very specific, regulatory targets. Such research protocols in themselves will not lead to the more radical environmental innovations that are typically addressed as Design for Environment.

4.5 Conclusion

The concept of ecodesign covers both compliance driven strategies and strategies to improve the environmental performance of products (or even product concepts, functions and systems) to the absolute maximum. Most of the practice of ecodesign can be positioned at the lower levels of which it is believed that they are not very demanding for the organization. This might explain why ecodesign practices are not well embedded in firm structures

Although the literature on ecodesign mainly focuses on technical aspects and tools, some interesting contributions on the organization of ecodesign were also found. Poor communication was identified as an important barrier for the effective implementation of ecodesign. Charter has suggested cross-functional teams, clear objectives, targets and performance criteria and training and "awareness raising" as strategies to overcome this barrier. These strategies are maybe less complete but certainly rather familiar to the solutions that are also suggested in the new product development literature. It appears that there has been little attention for the organizational dimension of ecodesign and even less for the influence of informal forces than for formal management mechanisms.

Two models were found that assign ecodesign tasks to marketing, R&D and environmental management. The role of the environmental department seems mainly related to passing regulatory information to the design process. Research points at relatively week positions for environmental managers in comparison with especially marketing, which is regarded as the most influential. Providing "living specialist" and gatekeepers that are responsible to bring environmental knowledge into the design teams is said to be more effective than providing the tools that are so dominant in the ecodesign literature.

Having a specialized environmental department, or even a specialized ecodesign department is sometimes presented as an ideal situation. The literature on new product development made clear however, that specialization also has negative effects and that the necessary integration mechanisms are not without a price. Some of the literature acknowledges that the way ecodesign is organized should fit to the ecodesign strategy and the structure of the company. No literature was found that linked the optimal design to the uncertainties surrounding the company or the design process. Both the presented models assigned the task of protecting the organization from uncertainties that stem from environmental regulation, to a specialized environmental department. The existence of even strict environmental regulation in itself however does not mean that there is a high level of uncertainty, if the number of parties involved and the dynamics in the standards are relatively constant or predictable.

Integration as it is defined in new product development studies, is the counterbalance of functional specialization. Integration is operationalized as cooperation and can be observed in the presence of integrating mechanisms and the resulting levels of interaction. In contrast to the new product development literature, for ecodesign it is much less clear how the departments should divide the ecodesign activities that were listed by Rocha and Sylvester. When tasks like the evaluation of implications of expected legal requirements or the evaluation of consumer preferences are assigned to a specialized environmental department,

integration mechanisms will have to be implemented between this department and R&D and Marketing. Integration therefore has to be studied in relation to the division of ecodesign tasks among the departments.

Much of the ecodesign literature deals with the development of tools or demonstrates the application with a limited number of case studies. It appears from empirical research that the actual implementation of ecodesign tools is poor even in "*front running"* countries. Berchicci and Bodewes (2005) have emphasized that researchers need to embed their studies in the established theoretical frameworks of NPD to find explanations for the successes and failures in the implementation of ecodesign. Next to balancing environmental and other design specifications and the role of management support, project team coordination is identified as a major factor that may contribute to the success of ecodesign.

5 Research model

5.1 Introduction

An increasing number of organizations all over the world has adopted more pro-active environmental strategies. This increase is most visibly evidenced by large numbers of environmental reports, introductions of eco-labelled products and environmental management systems certificates. Much of the environmental management literature states that the successful implementation of pro-active strategies is only possible when "greening" the organization. Greening the organization is then further specified as the involvement of all functional departments and hierarchical levels in accomplishing specific environmental tasks. The role of environmental managers and environmental management systems in the green organization is to take care of the internal co-ordination of the environmental tasks, and to manage the communication with external stakeholders on environmental aspects.

Ecodesign is a major element in pro-active strategies and in line with the environmental management literature, the ecodesign literature proposes that the organization of new product development should be greened. Environmental managers or even specialized ecodesign departments should be highly involved in the product development process. Research in this field however suggests that the actual implementation of these practices is at a very low level, even "*under the best of circumstances"*. Both the Dutch government and the European Commission have granted programmes to support a better implementation of Ecodesign practices and organizational involvement. The observations however that environmental managers are not highly involved in ecodesign, not even in companies with a good reputation with regard to their green products, raises the need to explore the relationship between the organizational involvement and the results.

The literature on the organization of new product development, especially on the topic of integration, supports the relation between strategy and organization that is assumed by the ecodesign literature. Highly innovative companies are requiring an organization that facilitates frequent and intense communication between specialised departments. A typical element of organizational structure that can be found in innovative organizations is a multidisciplinary team in which managers from R&D, Marketing and Manufacturing are working closely together in developing a new product. Such organizational solutions should resolve the barriers to co-operation and collaboration that result from functional specialisation. Many empirical studies have confirmed a positive relation between the success of new product development and intense communication between especially R&D and Marketing. Much of this research also points at the moderating effect of environmental uncertainty: intense communication is especially important for the success of projects when there are high levels of technological or market uncertainty.

One aim of this research is to gain more insight in the actual organization of environmental management in businesses with pro-active environmental strategies. There have been many studies on environmental strategy, but there is still little insight in the organisational aspects of environmental management. This research has focused on ecodesign because it is generally seen as a major element of pro-active environmental strategy. Another aim of this research is to gain understanding of the effectiveness of different organizational

solutions. If intense communication between R&D and Marketing leads to more successful innovations, will intense communication of these departments with the new environmental function lead to more successful green products? Or is it more important that R&D and Marketing are actively involved themselves in executing environmental tasks? And is intense communication between the functions more important when the uncertainties about environmental legislation, the technology or the appreciation by clients are higher?

The central research question for this research is defined as:

How, why and with what results do functional departments interact in the context of green product development?

Ecodesign will be studied at the project level for several reasons. First, the amount and the nature of uncertainty will be different between projects, even within one organization. Secondly, the differences between individual team members representing different functional areas, are relevant for the project process and outcomes. Thirdly, the complexity and environmental ambition or innovativeness of the project may influence the magnitude of functional challenges. This focus on the project level is in line with current NPD studies and was also applied by a recent study by Olson et al. (2001).

The research will focus on the cooperation between Environmental Management, Marketing and R&D. The cooperation between Marketing and R&D will be studied for the obvious reason, that this relationship is generally seen to be critical for NPD success. The broadening of the scope to include the environmental department is relevant because of the explicit claims in the environmental management literature about the role of this department. In comparison with other environmental management studies that are often based on surveys among environmental managers, including Marketing and R&D will provide a new research angle.

This research will define ecodesign as *the inclusion of environmental goals into product design and development*. This definition acknowleges that there are more ambition levels than only the most ambitious one that aims at minimizing the environmental impacts at all possible stages of the life cycle. A broader definition of ecodesign is more appropriate because several studies have shown that the actual level of ecodesign in business is still weak: ecodesign tools are not often used and ecodesign strategies seem to be more oriented on small product improvements than system changes.

5.2 Questions and hypotheses

This research is a combination of exploratory and confirmative study. Exploratory research methods are applied especially to learn more about the motivation for and the nature of the ecodesign projects, the organization of the environmental function, the strategies involved and the uncertainties surrounding the projects. The body of empirical research on these organizational aspects of ecodesign is still limited and these aspects are therefore assessed through semi-structured interviews and the review of company documentation.

The interviews served to gain more insight in the following aspects:

- the environmental strategy of the company
- the consideration of environmental aspects in new product development projects
- the ecodesign strategy that is applied in new product development projects
- the allocation of environmental tasks and responsibilities
- perceived levels of uncertainty (technology, legal, market)
- satisfaction with the project performance

Confirmative research methods were applied to the aspect of communication between the functions involved in the product development process. Especially the communication between Marketing and R&D in relation to external uncertainties and success is the main focus of a large body of academic research on new product development. Major concepts from these studies will be applied in this research, while the focus will be broadened to include also the environmental function.

Environmental management strategy and ecodesign

By developing greener products, a company can improve the environmental performance in all stages of the product's life cycle, from the extraction of raw materials and production, to the transportation, use and waste stage. Ecodesign is therefore generally seen as a major element of pro-active environmental management strategies (e.g. Steger (1993), Hart (1997), Stead and Stead (1996), Berry and Rondinelli (1998)). It will be proposed that companies with more pro-active strategies are also more active in implementing ecodesign, showing higher levels of functional involvement in ecodesign practices.

H1: The involvement of departments with ecodesign tasks is higher in companies with pro-active strategies than in companies with reactive strategies.

Involvement in ecodesign tasks

The environmental management literature states that all functional departments should be involved for the successful implementation of pro-active environmental strategies. In this research the assumption is made that this wide functional involvement holds also for the development of successful green products. A successful green product should not only be green, it should also be of a good quality and attractive for the customer. Expertise on legal environmental requirements and standards, consumer preferences and technological opportunities will have to be brought in from different departments.

H2: High levels of involvement in ecodesign tasks for R&D, Marketing and Environment are positively related to product performance.

The environmental management literature suggests specific tasks for the environmental department or environmental manager, such as the communication with environmental authorities, collecting information on environmental legislation and passing this information onto other departments in the organization. Both in the models of Foster and

Green (2000) and Lenox and Ehrenfeld about functional specialization in ecodesign projects, the environmental department has an exclusive contact with regulatory bodies.

H3: The level of involvement of the Environmental Management department with regulation related tasks is higher than that of other departments.

According to Charter (2001) ecodesign appears to be owned and driven by environmental management rather than by marketing personnel. Research by Langerak, Peelen and Van der Veen (1998) also suggests that marketers are not highly involved with environmental management. It may be expected that as soon as green product development projects are initiated, marketing will become involved automatically because they will have the same formal responsibilities for green products as for conventional products. But given the observations that environmental managers and not marketers are driving environmental management, it is expected that marketers are less active in initiating Ecodesign projects than environmental managers.

H4: The level of involvement of Marketing within the first stages of new product development, is lower than for the environmental department.

Cooperation with the environmental department

Integration as it is defined in environmental management and ecodesign literature is similar to the level of involvement of all departments with environmental issues. The more environmental tasks functional departments are executing, the higher the level of integration. If the R&D department uses LCA-tools, the environmental management literature would regard this as a higher level of integration than when an environmental department conducts the LCA and passes the results to R&D.

According to the new product development literature, integration can be measured by the levels of cooperation between specialised functions. In an organisation with a specialised environmental design department, intense cooperation between this department and R&D and Marketing supposes a high level of integration. Apparently, the environmental expertise is used extensively by the other departments throughout the product development process.

A company may argue that environmental management is so well integrated in the practices of R&D and marketing, that they don't need the involvement of the environmental department in the design process. In that case, cooperation with the environmental department will be low, while there is more cooperation on environmental issues between R&D and Marketing. From the perspective of environmental management, such high levels of departmental involvement in environmental issues would be an ideal case of integration.

While the above hypotheses were dealing with functional involvement, the following hypotheses are related to cooperation. Cooperation is an operationalisation of the concept of integration in the new product development literature. It is easier to measure than collaboration and sufficient to measure levels of integration when the research is not aiming to evaluate the relative effectiveness of different integrating mechanisms (Olson, 2001). The level of cooperation with the environmental department is likely to be related to the

functional involvement of Marketing and R&D with green product development tasks. The more Marketing and R&D are involved in performing ecodesign tasks, the more they will also communicate with specialized environmental staff.

H5:Levels of involvement of marketing and R&D with green product development are positively related to levels of cooperation with the environmental department.

Cooperation and success

Research on new product development has shown that cooperation between the departments is a major determinant of success (Griffin and Hauser (1996), Olson (2001)). Developing a new product is a multidisciplinary task by nature, demanding expertise and cooperation from especially R&D and Marketing. Developing greener products also requires bringing information about the environmental aspects of the product into the design process. If this expertise is concentrated in a specialized environmental department, Marketing and R&D will have to cooperate with this department to develop greener products successfully. The success of green product development should be evaluated in economic, technological and environmental terms.

Olson states that departments do not need to have intense cooperation during the complete product development process, but rather concentrate cooperation during specific stages of the process. The optimal timing of cooperation in new product development will differ between different pairs of functions (Olson, 2001). The need for cooperation between marketing and R&D for example, is higher at the early stages of the process. The idea of optimal timing may also hold for the development of greener products. When the environmental function is responsible for gathering regulatory information and has to pass this information to R&D, optimal timing is expected early in the development project.
According to Olson, the cooperation between Marketing and R&D should also be most intense in the early stage of product development. There is no reason to expect this to be different for environmental than for conventional NPD.

H6: The levels of cooperation between the functional departments are positively related to product performance and the strength of this relation will differ between early and late stages of the new product development process.

The effects of uncertainty

Following the model of Gupta, Raj and Willemon, it will be supposed that the need for cooperation is dependant on the level of environmental uncertainty. Uncertainty is thus a moderating factor to the relation between cooperation and success. In new product development, major uncertainties stem from the limited capabilities of managers to predict future market or technological developments. In the case of green product development, these uncertainties can be extended with uncertainties about environmental standards and legislation.

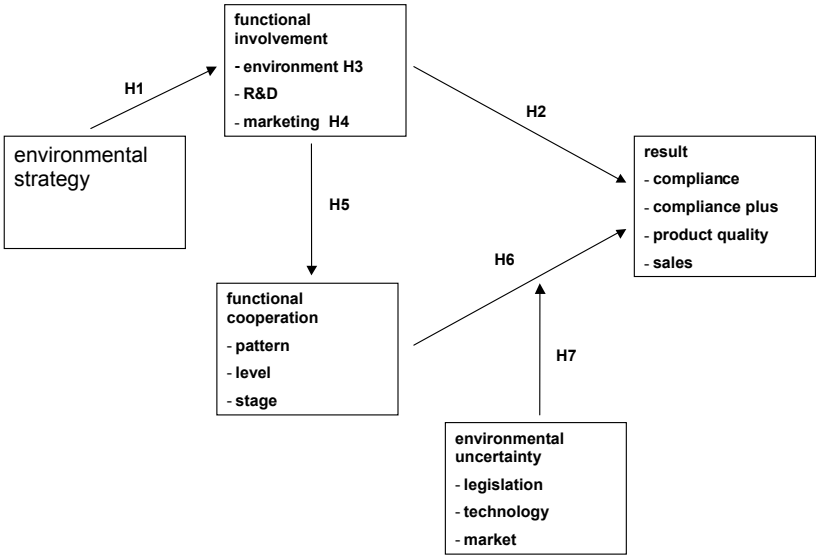
It is not environmental regulation in itself, but the dynamics and complexity of it that determine the level of uncertainty. Likewise, it will also not be the mere existence of environmental technology or a demand for green products that adds to the uncertainties

surrounding a project. If green products are successfully developed while the actual level of integration is low, this may be explained by a low need for integration because of low uncertainties.

H7a: The positive impact on product performance from high levels of cooperation between departments will be greater for projects with higher levels of uncertainty.

H7b: In projects with higher levels of uncertainty we will also find higher levels of cooperation between the departments.

Figure 5.1 Research model



5.3 Measures

Pro-active environmental strategies

According to the typologies in chapter 2, a company with a pro-active environmental strategy anticipates environmental legislation and has integrated environmental management in product development. Not every company with a green product is a pro-active company, but we may expect that a relatively large share of the sample companies with green products have more have pro-active corporate environmental strategies. To differentiate within this sample between levels of pro-activity, the research identifies 2 levels of pro-activity. High levels of pro-activity will be assigned to companies for which environmental goals are part of the corporate strategy, environmental improvements are not reserved to a limited range of products and environmental legislation is not the immediate driver for innovations. Low levels of pro-activity will be assigned to companies for which

the development of a green product is a more isolated event and the development of the product was initiated for reasons other than environmental goals.

Involvement in ecodesign tasks

The involvement in ecodesign tasks will be measured by asking functional managers to rate their involvement in 18 operational ecodesign tasks as they have been listed by Rocha and Sylvester.

Cooperation

The literature on new product development provides a wide range of organizational factors that have been studied in relation to the strategy, the uncertainties and the success of the innovation. Success is related to the match between the level of integration needed and the level of integration achieved. The main interest in this study is not to evaluate the relative effectiveness of certain types of integrating mechanisms, but to gain more insight in the relation between results and overall levels of involvement of and the cooperation between departments. This justifies a focus on a selection of integrating mechanisms and the use of the relatively more limited approach of integration that is also used in the new product development literature. Following Olson (2001) the focus of the study will be on the behavioral construct (as apposed to attitudinal) of functional integration, which will also be called cooperation. A limitation of the focus on co-operation is that it that it does not account for aspects such as sociocultural differences between departments that may in fact be highly relevant. Cooperation is however more easy to measure and it is assumed that relations between the cooperation of departments and product performance will also hold for relations between collaboration and product performance. It is also relatively easy to improve cooperation, for example by increasing the frequency of meetings or the establishment of multifunctional teams.

Cooperation will be measured as the product of the frequency of communication and the amount of information exchanged between two departments.

Stages in product development

Early stages in the product development process include idea generation, concept development and business assessment. Later stages in the process include prototype development, production process design, product testing and commercialization.

Product performance

Product performance is measured by the satisfaction of managers with regard to:
- compliance with environmental regulation;
- environmental impact beyond compliance;
- product quality against company standards;
- achievement of sales objectives.

Uncertainty

Uncertainty is defined as environmental uncertainty and will be assessed by the researcher, based on the interview results with regard to the following three questions:

- Is the relevant environmental legislation uncertain and demanding?
- Is the technology new to the company?
- Is the market new to the company?

This results in 4 levels of uncertainy, from "0" (three times no) to "3" (three times yes). The level of uncertainty is assessed by the researcher and not by the respondents, because the researcher can make better judgements about the relative differences of environmental uncertainties between the projects in different companies.

5.4 Sampling and data collection

Because the research is directed at cooperation in the context of green product development, a selection had to be made of companies that were known to the researcher for developing green products and with a certain degree op departmentalization. 16 Dutch and 1 Belgian company from different industries and sizes, that are known for their activities in green product development, were willing to co-operate in the research. The research involves 5 of the largest Dutch multinational companies and also five companies with less than 100 employees. The sample also represents different industries and different types of environmental strategy. A relatively large part of the projects was found in the paint industry and the related resin manufacturing industry (12 projects, 3 companies). The reason for this is that the researcher has a good network in this industry because of previous studies for the European Commission. Other projects were found in other than the chemical industry to improve the representativeness of the sample.

From the 17 companies, 14 companies sent in usable questionnaires, covering 34 projects. In most companies only one or two projects were analyzed, in two of the largest companies 4 to 7 projects were studied. 33 interviews were conducted with environmental managers, R&D managers, marketing managers and managing directors.

At the start of the empirical research the first letters and e-mails asking for co-operation were sent to the environmental managers. They were forwarded in all cases to the R&D manager or general managers. In latter cases the company was called first to ask who was the most appropriate manager for an interview about the organization of new product development and the environment.

The interviewees were selected for their overall knowledge of project, being managers from Marketing (12), R&D (9), EHS (9) and Managing Directors (3), while also considerable spread over the functional departments was accomplished. In two cases where the managing director was interviewed this concerned very small companies where the director was personally involved in the development process. In the case of Ahold (Coffee Company) the managing director was highly committed to the sustainability goals of his company and he had been involved in the development process in his previous function.

Table 5.1 Overview of participating companies

Company	Size (number of employees)	Industry	Interviews	Interviewee's department	Number of projects in survey
1. 3B	45	Furniture	1	EHS	1
2. Ahold	248.000	Retail	1	GM	1
3. Ahrend	2.700	Furniture	1	EHS	0
4. Akzo Nobel	68.000	Paint	11	R&D (2),EHS (2) Marketing (7)	7
5. Avebe	2.700	Starch	2	EHS, R&D	3
6. DAF Trucks	6.500	Trucks	2	EHS (2)	4
7. DSM	18.000	Resins (for paint)	1	R&D	3
8. EcoStyle	50	Natural products	1	GM	4
9. Ecover	60	Soap	1	Marketing	1
10. Forbo	5.100	Flooring	1	R&D	2
11. Hycail	25	Biodegradable plastic	1	GM	1
12. NUON	10.000	Energy	1	EHS	0
13. OCE	3.000	Copiers	1	R&D	0
14. Philips	164.000	Electronics	5	EHS, R&D (2), Marketing (2)	3
15. Shell	115.000	Oil	1	Marketing	1
16. U&P	64	Paint	1	R&D	2
17. Valma/Turtle Wax	1.300	Soap	1	Marketing	1
			33		34

Semi-structured interviews were used to collect information on the context of the project (drivers, strategy, uncertainties), project results (both in technological, economic and environmental terms) and organization (departmental organization and involvement). Some structure was necessary because the interviews had to provide both deeper insight in the actual organization and context of the projects and also were meant to prepare and support the survey. The projects were confirmed or selected during the interview. The manager was asked to select one or more projects that were completed in the last three years and in which the improvement of the environmental quality of the product had been a major aspect. If the company was able (and willing) to participate with more than one project, the manager was

asked to select projects that differed in the level of uncertainties surrounding the project, the motivation or the successfulness.

The interviewees were asked to identify project team members from R&D, Marketing and the Environmental department that could fill out a questionnaire on behalf of their departments. The questionnaire asked for the levels of functional involvement and interdepartmental communication during the different stages of the development process, and also included questions on the perceived level of success. The questionnaires were personalized for the functional managers and handed to the interviewee for further distribution. It often took several months before all questionnaires were returned. In several cases the researcher had to travel back to the company to collect the questionnaires. Although the questionnaire was very simple and could be filled out in 10 minutes, the fact that three managers per company had to reply proofed to be demanding both for the companies and for the researcher.

6 The context of ecodesign projects

6.1 Introduction

This chapter will discuss the 34 projects and 14 companies that were included in the survey. The chapter is based on the interviews with the project managers and in part on the surveys. The chapter will start with an introduction of the projects and companies providing some basic information about the industry, size, environmental issues and organizational aspects. Subsequently this chapter will then discuss the ecodesign strategies and activities that were applied in the projects, the uncertainties surrounding the projects, the corporate environmental strategies, the environmental management organization and the product performance. For reasons of confidentiality, the level of technical detail will be limited and not all findings can be reported in direct relation to the participating company. Also no information on the success or failure will be provided that could be related directly to the individual projects. Where applicable the findings will be compared with insights from the environmental management literature. The chapter has a descriptive nature and is aimed primarily at providing more information on the sample in the survey. This chapter will not discuss the communication between the departments and in general the discussion at the departmental level is reserved for chapter 7.

6.2 The companies and the projects

3B is a small (45 employees) factory producing traditional furniture for the consumer market. Major environmental issues for the company are the reduction of waste and the emissions from painting. One staff member is responsible for the management of environment, quality, health and safety. Environmental affairs are discussed in the "environmental team" of which also the general manager and two production managers are members. The company states that their clients show no interest in environmental issues and the environmental quality of the products is not part of the marketing communications. The environmental manager mentions regulation as the main motivation for several environmental actions and for implementing an environmental management system. The project that has been included in this study is the "standardization of product design". The project started as the result of an environmental audit and aimed to reduce the volume of production waste.

Ahold Coffee Company is a company of Ahold, a multinational retail corporation with almost 250.000 employees world-wide in 2003. Ahold Coffee Company produces home brand coffee and tea for retail companies both within and outside the Ahold group. Environmental issues and especially labor conditions at the "growers" are major concerns for the management of the Ahold Coffee.Company. The managing director has been involved in the establishment of a foundation to set up a certification system for more sustainable coffee (Utz Kapeh). Utz Kapeh certification requires the producers to minimize the environmental impact such as from the use of water energy and pesticides. All the home brand coffee of Albert Heijn is now participating in this certification scheme. The labeling had no effect on the sales prices. The certification has not only resulted in the improvement

of environmental performance but also in more tracebility which is well appreciated by retailers to manage foodsafety issues. The project that has been included in this study is the development of certified coffee.

Akzo Nobel Decorative Coatings Europe is part of AkzoNobel which employed 68.000 people in 2003. Akzo Nobel has leading market positions both on DIY and the professional market. Environmental and health regulations are important factors in the formulation of paint. One major issue is the trend towards more waterborne paint to reduce the emissions of organic solvents during use. DCE has anticipated on this trend since many years already and has developed low solvent and waterborne paints. Several additives in paints for special applications are also regulated and need to be reduced or even phased out. The use of solvents and additives may result in the legal obligation for the producer to label their product as harmful to the environment. For marketing reasons, the company aims to prevent such labeling and will try to adapt the formulations so that it can be sold without a negative label. The projects included in this study are (1) the reduction of solvent use, (2) the product improvement of a waterborne paint system, (3) the environmental harmonization of wall paint formulations, (4) replacing a regulated fungicide in wall paint, (5) development of low-solvent superior quality paint, (6) development of low-solvent, quick drying paint and (7) the development of a water-borne paint at lower cost.

Avebe is a relatively small producer on the European starch market. Most starch is produced for the food industry (40%) and for the paper industry (40%). Avebe is a co-operation, owned by potato farmers. Because of this legal form, Avebe must use the harvest of its owners which restricts the opportunities to make a changeover to other resources with a better environmental performance. The company has made considerable investments in the treatment of waste water to comply with environmental standards. Several processes are certified according to the ISO 14001 guidelines. The projects included in the study are (1) the changeover to a new potato with lower impact, (2) the development of starch with less additives and (3) the development of a starch product for the paper industry that saves water and energy.

Daf Trucks is a subsidiary of the Paccar company, a US based manufacturer of trucks. Daf Trucks employs about 7.000 people and has a market share of around 10% in Europe. Truck emissions and noise are major environmental issues which are strictly regulated in Europe. Truck weight and fuel consumption are environmental issues which are also interesting for commercial reasons. The environmental policy of the company is thus a mixture of compliance targets and environmental targets which also lead to lower cost for the client. Daf Trucks has employed a manager Health, Safety and Environment and has also installed an “Ecodesign-team”. This team provides training for product developers, support developers with special ecodesign tools and screens the “Product Description Book” which provides a key document for the design of new trucks. The projects that are included in this study are (1) the development of a energy saving gearbox, (2) the reduction the frame weight, (3) the development of an energy saving brake system and (4) the development of a new truck. The development of a new engine to cope with the European emissions standards in 2005 and 2008 was withdrawn from the survey because it was being considered too confidential.

DSM is a chemical company employing around 20.000 people. DSM produces ingredients for the food and pharmaceutical industry, industrial chemicals and plastics. The company aims to become acknowledged as leading company in "sustainable entrepreneurship". DSM is major supplier of resins for the paint industry. Clients in this industry have a need for new resins to comply with the environmental regulatory standards. DSM Coating Resins has anticipated the changeover to waterborne paints and other environmental innovations and now holds a strong market position. DSM Coating Resins also assessed the environmental and safety risks of its own production processes and transport and as a result it has made changes in product formulations or even ended the production of some materials. Information about potential and anticipated environmental regulation or political and academic discussions about the environmental and safety impacts of materials is channeled in different ways to the R&D manager. Sales will pass information on the legal requirements for the clients resulting in the need for new materials. A second channel is the "business intelligence manager" who is continuously monitoring the political and academic world and passes information to the R&D managers. The company is also actively involved in the European industry organization CEPE so it is informed at an early stage about new policy plans through the consultation processes. The projects that are included in the survey are (1) the development of a new resin for waterborne paints, (2) the changeover to new solvents and (3) the development of an alternative for propylene oxide.

Ecostyle is a small (50 employees) company producing organic products for agriculture, gardening and animal care. The company produces both for the professional and private market. Environmental goals are key elements of the mission statement and environmental claims are part of marketing communications. Ecostyle used the Dutch ecolabel "Milieukeur" to strengthen its market position. The company is often cited as a success case for sustainable management. The 4 projects included in this study are (1) the development of organic pet food, (2) the development of organic pesticide A, (3) the development of organic pesticide B and (4) the development of an organic herbicide.

Ecover is the only Belgian company in the sample. Ecover is a small (100 employees) company producing natural soaps. Sustainability is a key issue in the mission statement of Ecover. Products are marketed as environmentally friendly and healthier. It is claimed that the natural soap products will cause less allergic reactions than chemical based products. The products are sold in the Netherlands through specialized shops only but in other countries the products are also available in supermarkets. The company has been very successful in the last years. It changed the marketing strategy to make the products more attractive to both the clients in the green niche and the clients in supermarkets. To support this strategy, product development aims to increase the quality of Ecover products to the A-brand level. A "concept manager" is responsible for safeguarding the environmental performance of new Ecover products. The concept manager can stop the further development of a new product concept if he believes that it does not meet the environmental standards of the company. The project that is included in the survey is a stain remover.

Forbo is the largest producer of linoleum (60% of the market), a floor covering made from linseed and other natural materials. The company also produces vinyl floorings, adhesives and industrial belts and employs about 2.500 people. The natural and environmental quality of linoleum are central issues in the marketing communications. The product is certified

according to several national environmental labeling schemes. LCA-studies have shown that linoleum performs well on the environmental aspects “renewable resources”, “durability” and “energy use”. The environmental impact of the growing of linseed could be improved. The company has implemented an environmental management system which is also certified. A procedure for product development is part of the environmental management system, but linoleum is an old product and in fact there are not many product innovations. The 2 projects that are part of the survey are (1) the development of fireproof flooring and (2) the greening of the linseed production.

Hycail is the smallest company in the sample with no more than 25 employees. The company is a spin-off from the Rijksuniversiteit Groningen and has developed biodegradable materials from a by-product of cheese production. The materials are used for packaging, as biodegradable plastic and as basis for chewing gum. Biodegradability is marketed as a functional quality and not for the environmental advantages (less waste, renewable resources). The company hopes to find investors and markets to enable considerable upscaling of production in the coming years. The political environment is highly uncertain. Biodegradable plastics are often favored in the political process, but Hycail is not involved in consultations. The managing director is responsible for marketing and also for information on environmental policy and regulation. The project included in the survey concerns the development of a biodegradable plastic.

Philips is represented with 2 companies: Philips Medical Systems (30.000 employees) and Philips Lighting (44.000 employees). Philips Medical Systems is growing rapidly by taking over other companies. Philips Medical Systems has almost no own production facilities. The company focuses on the research and development, marketing and service while the production itself is outsourced. The environmental coordinator reports both to the corporate legal office and the corporate technology department. Another environmental manager is full-time responsible for Ecodesign and reports to the procurement department. Because the company has little own production, procurement is an important department to control the environmental quality of the products. Suppliers have to provide information about the materials used and about potential hazardous substances. A total of 25 “Ecofacilitators” is currently operating within the product development teams. Ecofacilitators are senior developers who are capable of implementing LCA’s. They have to report the environmental performance of new designs to the environmental coordinator. If the product development teams want to apply hazardous substances in a new product they have to prove that there are no safer alternatives. The corporate environmental policy is the main driver for the ecodesign policy. Clients in Nordic countries do request statements from Philips about the environmental impacts of the products, but in general clients show little interest in the environmental aspects of the products. The environmental manager at Philips Lighting also claims to have an active involvement in new product development. The environmental report of this business unit provides much detail on the environmental performance of the products, such as energy saving and mercury-free lamps. The environmental manager is also responsible for the collection of environmental regulatory information and lobbying. Product development teams have an own responsibility to comply with the environmental standards of the business unit. The environmental manager offers training to the product developers and is also responsible for regular audits.

The projects that have been included in this study are the development of (1) a mercury-free lamp and (2) an energy saving lamp in Philips Lighting and (3) the development of a new Magnetic Resonance system with lower environmental impacts in Philips Medical Systems.

The publications of Stevels, having positions both at the Technische Universiteit Delft and at Philips, provide more detail on the strategies and experiences of Philips concerning ecodesign. According to Stevels, from 1992 to 1996, management involvement in environmental issues was still limited and defensive. Environmental policy was focused on regulatory compliance and avoiding negative publicity. Procedures to check for the environmental characteristics of products were limited to banned substances, packaging, labelling and consumer information. Despite the defensive nature of the policy, Philips was at that time regarded as a first mover in improving the environmental performance of consumer electronics. In the early 1990s, the environmental organization was established, the collection of environmental information began and the efforts created awareness within the company (Ishii and Stevels, 2000).

An internal study of Philips Consumer Electronics in 1996 showed that the environmental department differed considerably from other departments in its prioritising of business issues. The environmental department had little interest in issues such as production cost, the competitive position, environmental communication, or the time to market. They focused on the development of an environmental strategy and environmental scores that were in turn of little interest to other departments. **(**Ishii and Stevels, 2000)

In 1996-2000 the 'Environmental Opportunity Program' was implemented. "The aim was to strengthen the environmental organization and to achieve cost reductions." All factories were required to implement an EMS according to the ISO 14001 standard, reduce energy use by 25% and packaging by 15%. The program also called for more networking and active participation in legislative and regulatory discussions. As an optional part of the program, ecodesign and supplier requirements were proposed. According to Stevels, the program resulted in a more systematic approach by the business groups; made the cost savings through energy and packaging reductions more visible and substantially enhanced the internal reputation of environmental programs. Ecodesign did take off and a design manual was produced. In retrospect, Stevels states that the formal approach of environmental management had at first resulted in a lack of creativity. Also the focus was too much on internal organizational and technical issues and not enough on the needs of external parties such as the customers and suppliers. As an example of this failure, a 'Green TV' had been developed with support from the Dutch Ministry of Environmental Affairs, leading to a product concept with superior environmental performance, but without the qualities for an introduction to the market.

In 1998, Philips implemented the Eco Vision program. A major element of the program is the communication around a set of 'Green Flagship' products, which have significantly better environmental qualities than competitive products. The program was launched at corporate level and supported by a clear commitment of the CEO. Environmental requirements were defined per product division in five focal areas: energy consumption, weight reduction, packaging and transport, hazardous substances and recyclability. The strength of these selected areas is that they can be linked directly to benefits for customers.

These non-environmental benefits are decisive for the commercial success of the products. It is reported that in this way the products were much more easy to market. According to Philips 25% of their customers is "*sensitive to specific green performance of products"* and *"there is a lot of sympathy for green (nice to have)*. These "*warm feelings*" however seem to have a decisive role in only a minority of the buying decisions of customers (Stevels, 2000).

Philips developed a method, called 'Environmental Value Chain Analysis', to facilitate the development of the 'Green Flagships'. The method aims to identify the needs of customers and other stakeholders, their value perceptions and the relationships between these parties in green product and process development. The Eco Vision program thus widened the scope from strictly environmental, to more generally appealing benefits. Environmental goals and measurements, such as LCA-based scores, were replaced by environmental scores relative to major competitors. The new strategy is said to be more successful in that is had led to increasing market shares and margins for green products (Stevels, 2000).

Shell is a large petrochemical company with approximately 109.000 people working in over 140 countries. The company was involved in several incidents such as the planned sinking of the Brent Spar which resulted in much publicity and a poor environmental reputation. Since the mid-1990s, Shell has made considerable efforts to implement a more pro-active environmental strategy and became a frontrunner in environmental reporting. Oil spills and climate change are major environmental issues for the company which have direct effect on both the production and the position Shell products. Shell has started to invest in energy systems such as hydrogen and solar power as alternatives for oil. The project that has been included in the survey is the development of a biodegradable lubricant.

Ursa Paint is a small paint manufacturer with 65 employees. The environmental manager is also responsible for safety and quality management, but has no involvement in product development. Environmental concerns in product development are the responsibility of the R&D manager who is also actively representing the company in the industry organization. This industry organization is a main source of information about future legislation. After a merger the company produces two main brands: Aquamarijn for the DIY-market and Evert Koning for professional painters. Aquamarijn is a "natural" paint, waterborne and made from renewable resources only. Toxic substances are not allowed for the production of Aquamarijn. The product is marketed in several European countries as a natural, eco-friendly paint. Evert Koning is a brand for traditional, high quality professional paint. Due to new legislation the company has also introduced a waterborne paint system for professional use under the brand name of Evert Koning. The projects that are included in this study are (1) the development of a new tinting system for Aquamarijn and (2) the development of a professional waterborne paint for Evert Koning.

Valma is a small but leading company in car care products. It was taken over from Sarah Lee by Turtle Wax (1300 employees) and the production was moved to the UK. Valma sells a car shampoo with an eco-label (Milieukeur). The company also has a product line of natural car care products but these are marketed as exclusive high quality products. The initiative to produce the eco-labeled car shampoo came from the corporate office of Sarah Lee. At that time there was a political discussion about the negative impact of car washing

in the street which finally did not result in new legislation. The project that has been included in this study is the development of the eco-labeled car shampoo.

Table 6.1 Overview of the NPD projects

3B	1. standardization of product design
Ahold	2. certified coffee
AkzoNobel	3. reduction of solvent use 4. product improvement of a waterborne paint system 5. environmental harmonization of wall paint formulations 6. replacing a regulated fungicide in wall paint 7. low-solvent high quality paint 8. low-solvent, quick drying paint 9. water-borne paint at lower cost.
Avebe	10. changeover to a new potato with lower impact 11. starch with less additives 12. starch for the paper industry that saves water and energy.
DAF Trucks	13. energy saving gearbox 14. lightweight frame 15. energy saving brakes 16. truck with lower emissions and fuel consumption
DSM	17. resin for waterborne paint 18. changeover to new solvent 19. alternative for propylene oxide
Ecostyle	20. organic pet food 21. organic pesticide A 22. organic pesticide B 23. organic herbicide
Ecover	24. organic stain remover
Forbo	25. fireproof flooring 26. greening of linseed production
Hycail	27. biodegradable plastic
Philips	28. mercury-free lamp 29. energy saving lamp 30. magnetic resonance system
Shell	31. biodegradable lubricant
Ursa Paint	32. shop tinting system 33. waterborne professional paint
Valma	34. eco-labeled car shampoo

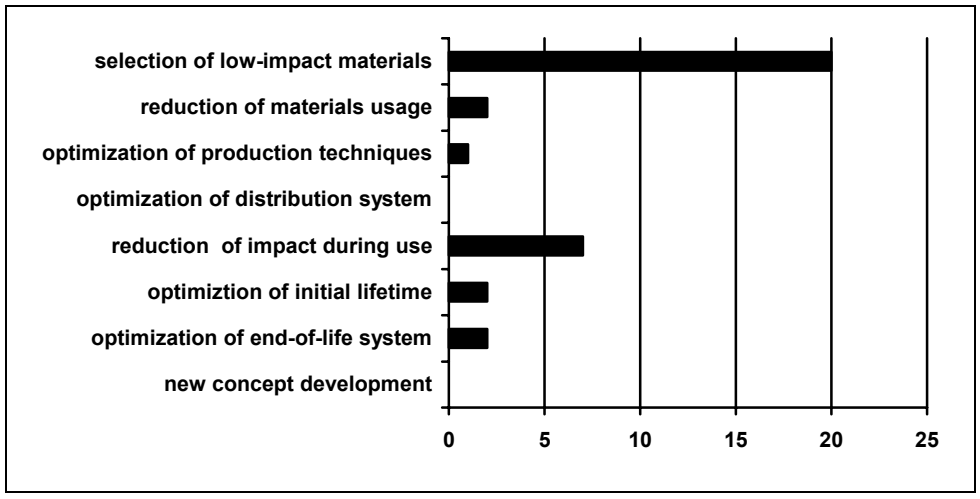
6.3 Ecodesign strategies and activities

In all 34 selected projects the companies have considered the environmental impact of the product and a new product with a better environmental performance was developed. The sample is a clear illustration of the wide variety of technologies that can be applied in ecodesign. Improving the environmental performance of a product may be directed at any

stage of the product's life cycle, from the selection of raw materials to redesigning the product to enable recycling or re-use. Applying the typology of DFE strategy of Van Hemel, 6 of the 8 strategies are represented in the sample. The category that is represented most frequently in the projects is "the selection of low-impact materials". This is explained partly by the fact that many of the cases are related to the paint industry, in which the change over from solvent based to water borne paints leads to many innovations in this category. Also the development of biodegradable products falls in this category. Selecting other raw materials is by no means a simple strategy. The changeover to other raw materials in the selected projects required many years of R&D and also resulted in most cases in considerable changes of the products characteristics. The selection of raw materials was also one of the most selected Ecodesign strategies in the study of Van Hemel and the most frequently adopted strategy according to a European study (Tukker et al, 2001).
The "reduction of impact during use" strategy is also very well represented with 7 cases. In these cases, the products are more energy efficient which is often also a successful strategy commercially. The most radical type of strategy formulated by Van Hemel, *new concept development*, is not represented at all. This is again in line with the findings in the studies of Van Hemel and of Tukker.

In contrast to the study of Van Hemel, the sample does not contain any cases in the category of "optimization of distribution system". This category stands for environmental improvements by changing the packaging material, using more energy efficient transportation modes and logistics. In fact, for many of the innovation in the study some elements of this strategy, especially with regard to packaging, were also considered during the development process. The innovativeness of these aspects seemed to be relatively small however, and was not selected as the major characteristic.

Figure 6.1 Ecodesign strategies



The projects within the *selection of low impact materials* category vary to a considerable degree in the technology applied and the related complexity. In the most simple case, a preservative is left out of the product formulation and sold separately to allow for smaller dosage. In this case it was especially important to inform the client about the product change and to communicate the new user guidelines. In other cases, materials are selected for the product formulation that are already successfully applied in other products. In contrast with these simple cases, selecting low impact materials can also be highly demanding. Developing waterborne paint with the same quality level and production costs as solvent based paint is a major challenge for research laboratories in the paint and resins industry. The price and product characteristics of waterborne paint are not the same as for traditional products and are not easily accepted in the market (Broekhuizen/Decopaint, 2000). For 6 projects, selecting only natural materials was a major element in the marketing strategy where the clients have a preference for organic products.

Almost all of the projects at Philips and Daf Trucks were focused on reducing the environmental impact during the use of the product. For both lighting and trucks, reducing the energy efficiency of the product is a major improvement of environmental performance. In the case of trucks, European directives and user costs are pushing the technology to ever more efficient trucks. The European directives are also very demanding with regard to the quality of emissions. It will only be possible to meet the emissions standard of 2007 by introducing a new technology which was not yet on the market in 2004. The technology implies a redesign of the engine and the addition of the chemical compound urea to the fuel. The development of this technology was not only demanding from a technological perspective, it also required frequent consultations with other truck manufacturers, the European Commission and with the oil industry that will have to distribute the new additive.

Ecodesign Activities

In the survey, managers from R&D, Environment and Marketing were asked to assess their involvement in 18 operational ecodesign activities. The results per function and the differences between functions will be discussed in detail in the next chapter. In this chapter only the general level of involvement in ecodesign activities will be discussed, regardless of the departments. Where all three departments were asked about their involvement, the highest level of involvement of the three departments was taken as an indicator for the level of implementation. If none of the three departments reported any involvement in a specific ecodesign activity, it was assumed that this activity did not take place. The results are shown in table 6.2.

Table 6.2 Ecodesign activities

Operational Ecodesign Activity	maximum levels of involvement (frequencies) none	small	moderate	large	very large	*average*
1. Consultation with environmental authorities	9	11	4	7	3	*2.5*
2. Gathering information on legal environmental requirements	2	2	8	11	11	*3.8*
3. Evaluation of old product's environmental impact	1	5	6	18	4	*3.6*
4. Consultation of partners in the product chain	2	1	4	21	6	*3.8*
5. Environmental benchmarking of products	0	3	5	18	8	*3.9*
6. Evaluation of implication of legal requirements, agreements and codes	3	0	4	16	11	*3.9*
7. Definition of environmental performance indicators for new product	1	4	1	14	14	*4.1*
8. Defintion of environmental objectives for the new product	1	5	1	13	14	*4.1*
9. Generation of green options to improve the product	3	4	4	12	11	*3.7*
10. Environmental assessment of green improvement options	1	4	5	15	9	*3.8*
11. Economic assessment of green improvement options	1	2	7	20	4	*3.7*
12. Technical assessment of green improvement options	1	4	5	12	12	*3.9*
13. Including environmental requirements in product profile	0	5	3	12	14	*4.0*
14. Definition of environmental design	3	4	3	11	13	*3.8*

guidelines for product improvement						
15. Consideration of environmental implications in manufacturing	2	2	9	15	6	*3.6*
16. Marketing of the product	0	0	2	11	21	*4,6*
17. Communcation to clients to minimize environmental impact	1	1	5	14	13	*4,1*
18. Monitoring of new product's environmental performance	6	3	5	17	3	*3,2*

The table shows that for 17 of the 18 operational Ecodesign activities at least one of the departments was involved at a moderate to high level in at least 25 of the 34 projects. The first ecodesign activity, *consultation with environmental authorities*, was least implemented. In 9 projects there was no consultation at all while for 11 projects just a small level of involvement was reported as the maximum. It should be noted that the reported levels are assessed at a project level and it may very well be that consultations took place before the project started or are a responsibility at the business or corporate level. In the case of water borne paint for example, there have been intensive consultations between the industry, the European Commission and the Dutch Ministery for Environment. These consultations have however resulted in general regulations and guidelines for a large range of products and are stable for many years. For individual product development projects consultation will seldom be necessary. The low level of consultation may indicate that environmental legislation is a relatively predictable or certain condition at the project level.

A second ecodesign activity with relatively small involvement levels is the *monitoring of a new product's environmental performance*. For 9 projects the maximum levels reported were "small" or even "no involvement". In just 3 cases, one of the managers reported a very large involvement in this ecodesign activity. The activity with the highest maximum involvement levels is not really a specific ecodesign activity: the *marketing of the product*. Of course every product, green or not, should be marketed and there were no projects where there was no or just small involvement in this task. The assessment of this activity is more relevant in the next chapter, to see in how far environmental managers are involved in this specific task.

Application of tools

There was only one project where an LCA study was the starting point of the product development process. This is a major difference with other ecodesign studies where ecodesign projects start with an LCA study by definition. In some cases LCA studies had

been carried out in the past, resulting in general design guidelines for new products. Especially the large companies do have formal procedures demanding that LCA-like studies are carried out, or at least that project managers have to report the major environmental impacts of new products at different stages of the life cycle.

Highly formalized, standardised ecodesign processes were implemented at Philips Lighting and DAF Trucks. Ecodesign is an important element of environmental management for Philips Lighting, which is also reflected in the unit's environmental report. At DAF Trucks, an Ecodesign Team is especially active in the first stage of the design process. In this team the Product Description Book (a detailed description of the product concept) is discussed before the product is further developed. Because a truck is built from about 10.000 parts, it is not feasible to interfere at later stages. The Ecodesign team offers training and ecodesign tools for the designers and so influences the later development stages. At Philips a corporate environmental office aims to implement ecodesign practices for all business units. The corporate policy of Philips was also the major driver for Philips Medical Systems to start their ecodesign project. The ecodesign practices at Philips are described in more detail in box 6.1.

In developing new paint, managers at Akzo Nobel used a software tool that determines which environmental and safety labelling is compulsory based on the suggested product formulation. The software links product formulations with environmental and safety regulation for all the countries where the product will be marketed. In practice the tool is not only used to determine which labels should be applied, but also to guide the development process. Because marketing managers want to evade negative labelling, the software proves to be an effective tool for considering the environmental impact during the development process.

6.4 Uncertainty

The interviewees were asked for information about the major uncertainties surrounding the project, especially resulting from legislation, technology and market developments. They were asked whether it was hard to predict such developments and if these factors had changed during the project. With regard to the technology applied the managers were asked whether the technology was new to the company and if it was clear at the beginning of the project which technology should be applied. Based on these results, the levels of uncertainty were assessed (table 6.3). For each of the aspects the level was rated as certain or uncertain. The highest level of uncertainty corresponds with uncertainty for all aspects.

Table 6.3 Levels of uncertainty

total level of uncertainty	frequency
certain	12
somewhat uncertain	17
uncertain	4
highly uncertain	1

The least uncertain factor in the projects was the market demand (table 6.4). In 32 cases, a new product was sold on a market that was already well known to the company. In one case the producer was seeking for completely new product/market combinations for its biodegradable plastic. In another case a green niche company added a new product category, selling it through the same distribution channels. The companies had seldom been surprised by sudden shifts in consumer preferences with regard to environmental aspects. Only in the case of one green niche company, the market developments in especially the UK and France were much better than predicted. A sudden growth in demand for these countries resulted from changing positions of consumers and retailers with regard to organic products as a result of food safety crises. In most cases however, clients showed little interest in the environmental performance of the products.

Table 6.4 Factors of uncertainty

	uncertain	certain
Legislation	7	27
Technology	19	15
Market	2	32

Environmental legislation was uncertain for only 7 projects. In three cases this was related to long and costly admission procedures for organic biocides of which the outcome was never sure from the beginning. In one case a new biodegradable soap was developed in anticipation of potential legislation, but this legislation was never implemented. In the paint industry environmental legislation is challenging but not unpredictable. One of the managers who was interviewed remembered that when he was hired in 1980 he was already told to work on the development of low-solvent paint. The reduction of the solvent content and the change-over to waterborne systems are stable elements of national and European policy. Companies like AkzoNobel and DSM are actively involved in consultations with environmental authorities about the design of new legislation and in general have no problems with compliance. European standards are also reducing the uncertainty because they replace less predictable national standards. The development of European standards for the paint sector has taken many years in which national governments and industry organizations have been consulted. The proposed standards are implemented in phases, providing enough time for most of the industry to adapt to the new technology. For two projects in this research there was some uncertainty with regard to the exact maximum levels of solvent content and the time frame of implementation.

The same kind of consultation between industry and the European Commission was found in the truck industry. In this case (not included in the study because it was still in an early stage of development and it was considered highly confidential) compliance with very ambitious standards for emissions is only possible with a new type of engine and additives that should be supplied by all gas stations in Europe. Although the necessary innovations may be regarded as radical, the cooperation within the truck industry and the consultation process with the authorities, make the process more predictable.

Most uncertainty resulted from working with new technologies, although only in a few cases developing times of more than one year were reported, or technologies were used that had not been foreseen from the start of the project. In two cases the product development project was a redesign without any new technology applied. In one of these cases lead was replaced by concrete to stabilize the product, in the other case the designs in a product range were standardised to reduce production losses. Projects for the development of low solvent paints were also assessed as having low technological uncertainty because the companies were already familiar with the technology.

Lewis and Harvey's scale

As discussed in chapter 2, Lewis and Harvey (2001) have developed a scale to measure the perceived levels of uncertainty in the natural environment. The first category of uncertainty comes from governmental environmental policy. This source of uncertainty was found in the projects especially at the European level more than on the national level. In several cases (e.g. the reduction of solvent in paint, the development of biodegradable plastic, natural car shampoo) the company had anticipated legislation that was never implemented or implemented much later than expected.

The second source of uncertainty is about the environmental resources and services used by the organisation. It includes uncertainty about the environmental impacts of inputs and outputs. AkzoNobel and DSM perceived such uncertainty especially for the toxicity of their materials and actively monitored new insights in the field. These examples show that the different categories of uncertainty are also linked to each other. Uncertainty about the toxicity or environmental impact of a material also means uncertainty about the regulation and the behaviour of stakeholders. New insights in the toxicity may obviously lead to political pressure and regulation.

The third source of perceived environmental uncertainty in the scale of Lewis and Harvey is related to environmental products, markets and demands. The case of Ecover illustrates that consumer preferences may suddenly shift to the advantage of organic products. The case of Hycail illustrates that it can also be difficult to find a market that appreciates a green product, but the uncertainty is related to the preferences for the functional advantage of biodegradability and not to the environmental preferences. In general the interviewees stated that customers showed little preference for environmental products and that this was rather stable.

The fourth source of uncertainty is about green competition. In the scale this is specified as unexpected changes in the environmental markets served by competitors, changes in the environmental strategies of competitors or the entry of new firms into the environmental market. In the case of Avebe the introduction of a new starch with lower environmental impacts by a competitor triggered the development of the new product. In other cases there was no evidence for such environmental competition or uncertainty in this regard.

Environmental technology is the fifth source of perceived uncertainty according to Lewis and Harvey. Technology was the most uncertain factor in the projects in the survey. The uncertainties were however not related to the environmental impacts of a new technology, but to the feasibility of new technology with less environmental impact to deliver similar or better quality. Just like the third source of uncertainty (the market) this source illustrates that the uncertainties surrounding ecodesign are often not specific for the natural environment, but are the same as for any new product development project.

The behaviour of environmental stakeholders is the sixth source of perceived uncertainty. This type of uncertainty was perceived by Hycail in the search for new investors and clients for biodegradable plastic. Also the opinions in the political debate and regulatory developments were uncertain. DSM and AkzoNobel also perceived uncertainty in this respect about opinion on the toxicity of materials and had staff members to follow any discussion about their materials.
The last source of perceived uncertainty in the scale is related to how environmental issues like climate change, pollution and biodiversity are affecting the business. These general concerns were not mentioned during the interviews and are perhaps more relevant for strategy formulation than for the development of new products.
The conclusion is that many sources of uncertainty in the scale of Lewis and Harvey can be found in the selected ecodesign projects. It should be noted that these uncertainties are often linked and that when a manager perceives uncertainty about the environmental impact of a product, the same manager will also be uncertain about the public reaction and possible legislation. The discussion of the uncertainty surrounding the projects makes clear that much of the uncertainty is not specific for ecodesign but can be regarded as the normal uncertainties surrounding any new product development project.

6.5 Corporate environmental strategies

Especially the large multinational companies had pro-active formulations of their corporate environmental strategy, or even a formal sustainability strategy. These formulations were not always known to the managers that were interviewed. In one case the R&D manager had to take a step-stool to read the strategy which was in the framed guidelines above his door and discovered it was far more pro-active than he had thought. On the other hand, this same R&D manager spent a large part of his unallocated research budget on environmental improvements because he believed environmental concerns would become more important in the future. He did not report it as such, as he was afraid that the board of directors would not approve it. The company had invested in environmental research in anticipation of regulation, but this regulation had never been implemented or implementation was not foreseen for the near future. These companies tried to market their environmental friendly products in an early stage, but clients appeared to be conservative and not sensitive to environmental quality.

Another company that was known to the researcher because it sold a green product, appeared equally to own businesses with completely other profiles. The green product was one product in a larger portfolio, and a major concern of the management was basically to increase the market share for both green and conventional products. In at least 8 cases the new product design resulted in a lower energy use for the user. These energy innovations were communicated externally as major achievements of the ecodesign practices. There is of course no question about the importance of energy use as an ecodesign issue. But especially in the business to business market, these low energy products were developed and sold primarily with efficiency arguments and the clients accepted higher prices as long as these were more than offset by lower operational costs. It becomes arbitrary to label such product development projects as Ecodesign. In some cases the managers involved were surprised that their projects were included in external environmental management communications.

Similar to the low energy cases are cases in which the quality of the product was improved or operational costs were reduced simultaneously. These improvements range from higher gloss or longer durability for paint, a reduction of additives needed in production, or the prevention of negative labelling for the clients' products. The opportunities to combine economic and environmental improvements makes it hard to see how important environmental goals have been in a strategy. Was the strategy a good illustration of the win-win opportunities, or were practices that were already being developed labelled as "ecodesign" by opportunistic managers?

The innovativeness and the explicit green claims in introducing the product may not always be evidence of a pro-active strategy as was shown in one case. The company had in fact just one green product, which had been developed in anticipation of expected regulation. A manager even stated that it was developed also in the hope that the Ministry of Environment would deem regulation not necessary. When the anticipated regulation was not introduced, the innovation was not further developed or used for other products. This case suggests that the development of green products can be part of a rather reactive strategy too.

All the companies that took part in the survey were selected because of the fact that they had developed greener products, they all have therefore at least one important characteristic of a pro-active environmental strategy: a product oriented environmental policy. Almost all companies employ an environmental manager, while the only one company that does not, has the development of biodegradable plastic as its core business and environmental issues are the responsibility of the managing director. The companies clearly have integrated environmental concerns in their organizational structures and a second characteristic of pro-active environmental strategies therefore also holds for all companies. Finally, all companies were aware of future regulatory developments and anticipated these regulations. It may thus be concluded that all companies have pro-active corporate environmental strategies.

At the business strategy level, a differentiation can be made between 3 categories of pro-active strategy. A first group of companies is marketing all its products as green, which is also supported by an actively communicated green company image. These companies operate in green niche markets, where a minority of the market has strong preferences for green or natural products. An outstanding environmental performance is an obvious prerequisite for every single product. The projects of companies in this category were sometimes mainly oriented at the improvement of the quality or at lowering the production cost of a product that was already green. Environmental regulation has another role in these companies than for companies in other categories. Environmental regulation is sometimes not so relevant at the project level because they are far ahead of regulation or because the use of natural materials is less regulated. This first category will be labelled as the *green niche* companies. The strategies of Hycail, Ecover, Ecostyle and U&P are labelled as green niche strategies. The most typical examples of this strategy are Ecover and Ecostyle. U&P is operating two separate businesses of which only Aquamarijn has implemented a green niche strategy. Hycail is exclusively operating in a market for biodegradable products but in its marketing it focuses on the functional aspects of the product and not on the environmental quality.

For a second category of proactive companies, environmental concerns are also a major issue in product development, but environmental performance is not a distinctive factor in marketing the product. Philips, AkzoNobel, Ahold, DSM, Forbo and Shell follow this strategy. These companies are years ahead of legislation and sometimes even lobby for stricter legislation. The pace of green innovation is determined by the demand for greener products and regulatory developments. Green products are introduced at the company's own initiative and withdrawn when there is insufficient demand. This category will be labelled as the *green proactive companies*.

A third category of pro-active companies has focussed its ecodesign practices on a selected range of products where it takes advantage of green business opportunities. Environmental design targets are set for the most significant environmental aspects, but it is restricted to compliance plus aspects that also lead to non-environmental advantages for the client such as energy saving or the reduction of service costs. This strategy can be found with Avebe, DAF Trucks, 3B and Valma. This category of companies will be named *opportunistic pro-active*.

Table 6.5 Environmental strategies, levels of pro-activeness

Environmental strategy	Companies	Projects
Green Niche	4	8
Green Pro-active	6	17
Opportunistic Pro-active	4	9

At the project level of new product development, a wide variety of direct motivations was mentioned by the interviewees (table 6.6). Most frequently, the product was developed because the market asked for it. This should not be understood to mean that if the market was asking for a greener product. Paint companies are for example developing waterborne paints because painters are regulated; the paint companies in their turn need new types of resins from the resin manufacturers. Only in two cases the innovation was a direct follow up from an LCA study. In two other cases the project was started by an individual employee who was strongly committed to solving environmental issues. Improving the quality or lowering the production cost appeared to be a major trigger for the companies wanting to improve the market position of an existing green product.

6.6 Environmental management organization

Environmental Managers

Almost all companies do employ an environmental manager, there is however considerable variation in the tasks and responsibilities. From the 14 companies in the survey, 13 companies had created a function for a specialised environmental manager or environmental management department. The environmental management functions that were found in the companies under study may be divided roughly in 2 categories. A first type of environmental manager is primarily responsible for the environmental aspects of the production process and typically combines environmental affairs with health and safety

issues. A second type of environmental manager is active at a corporate or business unit level, being responsible for the formulation and implementation of a corporate environmental policy.

Table 6.6 Motivations for product development

Major motivation for the development of products	frequency
Market demand	13
Reduction of user operational cost (energy and service)	4
Technological development	3
Environmental concern, LCA study	2
Prevention of regulatory labelling	2
Competitor entered the market with greener product	1
Following corporate policy	1
Advice of environmental consultant	1
Preventing legislation	1
Product follow-up	1
Product quality improvement	1
Reduction of production cost	1
Reduction of regulatory cost	1
Reduction of operational risk	1
Ethical, reduction of reputation risk	1
Total	34

It was surprising to see that in 19 of the 34 projects, environmental managers had only small or even no involvement at all (table 6.7) in ecodesign activities. Environmental managers with responsibilities for the environmental aspects of production at the business site level are even less involved in product development. This type of operational environmental managers was involved in just 4 companies or 6 projects. Especially the larger companies employ two types of environmental manager, both at the operational and at the corporate level. Even corporate environmental managers are not always directly involved in ecodesign projects, but they do have responsibilities for the development of corporate ecodesign guidelines.

Table 6.7 Involvement of environmental managers

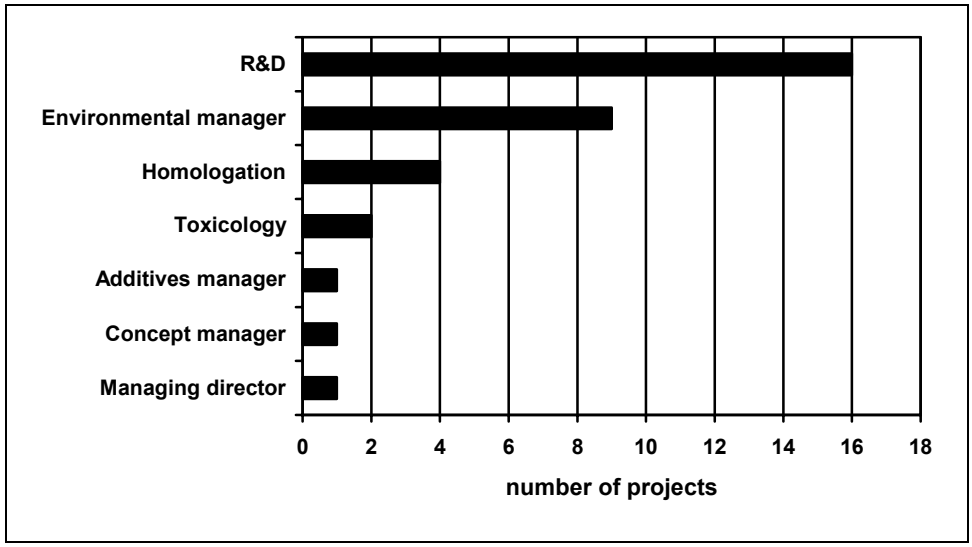
Average involvement of environmental managers in ecodesign activities	frequency
none or very small	15
Small	4
Regular	12
Large	2
very large	1
Total	*34*

A corporate environmental manager was also found in Ecover, which is one of the smaller organizations, where this manager is named the “concept manager”. At Ecover the nproduct proposals are discussed between marketing and the concept manager. The concept manager is responsible for maintaining the companies environmental and health standards in the business and had the power to stop the development of new products. With this powerful position for the concept manager, Ecover prevents the development of products that would not be in line with the ecological profile of the company.

The management of environmental aspects in product development is sometimes combined with another major aspect that should be managed by a specialist. At AkzoNobel the environmental aspects were managed by a toxicologist in 2 projects. This seems to be a logical combination because health risks and environmental risks are sometimes related to the use of the same raw materials. At DAF Trucks some of the environmental responsibilities were located at the homologation department, which is responsible for the testing of components against legal and industry standards in different fields like safety, environment and quality. The head of this department also represents the company in the industry organization for environmental policy issues.

Consultation with environmental authorities and keeping information about environmental legislation up-to-date, are often reported as major responsibilities of environmental managers. In the projects under study however, these responsibilities were taken care of most frequently by a R&D manager. The allocation of regulatory responsibilities seems to be more company than project specific. Only at Akzo Nobel and Avebe, a different allocation was found in different projects. The allocation of regulatory responsibilities to the R&D department was found especially in the paint companies, the resin company and the detergents company, which may indicate that the organizational solution is related to the type of industry.

Figure 6.2 Allocation of regulatory responsibilities



The one company where no environmental manager was employed, was also the smallest company in the sample. In this company, environmental issues were managed by the managing director himself. This company also was still in a start-up phase, developing the new product and the production technology and without full-scale production so far.

6.7 Project performance

The selected projects are a clear illustration of the commercial potential of ecodesign. Only a minority of 3 projects was commercially not successful, while in 9 cases the managers reported to be neither dissatisfied not satisfied. For 22 projects the managers reported to be "somewhat" or "completely" satisfied. It should be noted however that the focus of the study is on realized projects and many environmental improvement projects may have been stopped in an early stage because of low market potential. If projects had been selected based on the application of ecodesign tools as is the case in ecodesign studies, evidently a higher number of failures would have been included.

Table 6.7 Satisfaction with sales performance

completely dissatisfied	0
somewhat dissatisfied	3
neither dissatisfied, nor satisfied	9
somewhat satisfied	13
completely satisfied	9
Total	*34*

In 4 of the 9 cases where managers where nor dissatisfied nor satisfied, the environmental innovation had remained unnoticed by the client. In these cases the new developed products have the same functionality as the old products and are not or only slightly more expensive. The results indicate that the success of green product development can be explained to a great extent by the simultaneous improvement of both the environmental aspects and the product quality. This is shown in table 6.8.

The nature of the product quality improvement and the commercial success were discussed in the interviews and also assessed in the surveys where managers could give an indication of their satisfaction with the product quality and sales performance. In table x the results of the survey on the satisfaction with product quality are related to the satisfaction with sales performance. The reported satisfaction levels are the average levels of Marketing, R&D and Environment.

Table 6.8 Satisfaction with product quality and with sales performance

		satisfaction with product quality		
		somewhat dissatisfied to somewhat satisfied	completely satisfied	total
satisfaction with sales performance	somewhat dissatisfied to neither dissatisfied, nor satisfied	8	4	12
	somewhat to completely satisfied	7	15	22
	total	15	19	34

The interviews provide more insight in the nature of quality improvements, showing considerable variation between the projects. Lower energy cost for the user of the product is an important product quality item for lighting and trucks. It was also the major feature of a starch product saving energy in paper production. Five products have energy saving as the major quality improvement. For Ecostyle and Ecover, two of the green niche companies, the use of 100 percent natural materials may be interpreted as key to the product quality in their markets. The managers of these companies were completely satisfied with the quality of their products. For the paint products a range of quality improvements was mentioned, from aesthetic aspects like gloss and colour to a longer durability.

The success of the greener products cannot be explained by a growing interest from clients for environmental aspects. All interviewees, except for the managers of the green niche companies, were rather negative about the business potential of selling products as green. Marketing managers stated that clients are not interested in green products and even when they were interested they were still not willing to pay a premium. In the case of paints it seems that environmental friendliness is strongly associated with quality problems. The penetration of waterborne and high solid paints is the result of regulation that is directed at the product formulation and at labelling. Both for paint and for lighting, the interviewees mentioned that it was difficult to communicate the environmental performance on the product label, because consumers can only cope with a very limited number of product features when they are buying the product. In these consumer market cases but also in some of the business to business cases, marketing managers were reluctant to communicate the environmental quality of the product.

6.8 Discussion

The 34 new product development projects in the sample were found in 14 companies from very small green niche companies to large multinational corporations. The most frequently applied ecodesign strategy is the selection of low-impact materials, which is in line with the results from a European wide study. Almost all of the operational ecodesign activities as they were formulated by Rocha and Sylvester (2001) were adopted in most of the projects. The only activity that was adopted at low levels or not at all in 20 of the 34 projects was the consultation with the environmental authorities. This may be an indication for a low level of uncertainty about the legislation at the project level. At the corporate level large multinational companies did consult with the authorities, especially about future European directives. The literature suggests that the perceived importance of economic stakeholders such as customers and shareholders is higher for pro-active companies (Buysse and Verbeke, 2003). This relation may be illustrated by the interaction between the paint companies and the resin suppliers in the formulation of low-solvent and waterborne paints. This and the automotive industry are also illustrations of the importance of consultations with competitors in negotiating with environmental authorities.

The levels of uncertainty were rather low in most of the projects. In 12 cases the market, the technology and the legislation were well known to the company. Only in 1 case (Hycail) a company was developing a new product for a new market based on a new technology and with considerable uncertainty about future legislation. The large companies in the survey were involved in consultations at the European level. The development of new European directives and the translation of the directives in harmonized national standards is a process that takes many years and in which the technological and financial feasibility are part of the consultation and evaluation process. Companies are also given time to adapt to the new legal standards. The uncertainty about environmental legislation is thus reduced. The highest uncertainty came from the application of new technology while the least uncertain factor was the market demand. The success of the ecodesign projects in companies like AkzoNobel, Philips and DSM illustrates the importance of non-environmental resources for the success of ecodesign. These companies have dominant positions in their markets and have considerable research capacities. The case of the Ahold Coffee company illustrates how environmental capabilities can support non-environmental policies where the certification of coffee production has resulted in improved tracability with regard to food safety management.

All the companies in the survey anticipated regulation, allocated environmental responsibilities and (by definition of the selection for this research) integrated environmental considerations into the product development process and thus may be considered to have proactive corporate environmental strategies. Within this category three different types can be distinguished: green niche companies producing exclusively green products for a small market segment; green pro-active companies developing both conventional and green products, and opportunistic pro-active companies that have limited their focus for environmental product improvements to a limited set of issues which are directly beneficial for the client.

Almost all the companies did establish an environmental function or department, but the allocated responsibilities differed. One type of environmental manager is primarily

responsible for the environmental issues that are related to the production. They combine this responsibility with health and safety. Another type of environmental manager is responsible for environmental affairs at the corporate or business level. In general environmental managers have little involvement in new product development. The consultation with the environmental authorities and the responsibility for up-dating information about environmental legislation in relation to product development are both allocated most frequently to the R&D department. This is not in line with the environmental management literature (e.g. Foster and Green, 2000) that states that the environmental management function is the main contact for regulators and other stakeholders concerning environmental issues. The cases make clear that one should be careful to use the level and allocation of environmental responsibilities as an indicator for "pro-activeness". The green-niche companies had limited environmental functions and a low involvement of the environmental function with product development. Because these companies worked with relatively harmless substances and were not confronted with strict environmental regulation this was not as necessary either in the development of their new products. Where there was no or little involvement from an environmental manager, environmental issues were the responsibility of R&D or the managing director.

In most projects the management was satisfied with the sales performance of the new product. This was especially the case where they were also satisfied with the product quality. The study thus indicates that there are 2 strategies that can lead to commercial success: developing green products for a green niche market and developing green products that also have a good quality. A well documented example of this second strategy is implemented at Philips where the design guidelines have integrated environmental and quality targets.

7 Involvement, cooperation and performance

7.1 Introduction

In this chapter we will discuss the involvement of the functions in the operational ecodesign activities, the new product development process and the cooperation between the departments. We will explore the consequences of these factors for the environmental and business performance of the products. In this way we will aim to provide answers to the "*how*" and "*with what results questions"* of the research. The data for this analysis have been collected through a survey that was sent to 102 managers that were involved in the same 34 projects that have already been discussed in chapter 6. Finally we will also explore whether the results of the survey can be related with environmental strategy and the level of uncertainty surrounding the project, that have been assessed based on the interview results and were also discussed in the preceding chapter. This part of the analysis aims to provide answers to the *"why question"* of this research.

7.2 Response and descriptive statistics

The analyses in this chapter are based on a total of 96 questionnaires that were returned (31 from Environmental Management, 33 from Marketing and 32 from R&D) and 33 interviews with the managers of the 34 projects. The respondents were selected during the company visits in consultation with the project managers because of their involvement in the new product development project. Only 6 questionnaires were not returned, spread over the 3 different functions and over 3 different companies. In 4 of these cases the project manager reported that filling out the questionnaire by all 3 functions would be too time consuming.

Involvement in ecodesign activities

The questionnaire included 18 questions on the involvement in operational ecodesign activities. With the results it was possible to develop 3 multi-item measures that are interpreted as involvement in three successive stages of ecodesign. The results of the factor analysis are reported in table 7.1. The first stage includes items such as consultation, information gathering and the development of guidelines which can all be seen as preparatory activities. The second stage includes the generation of options and several assessments of these options. The third stage includes marketing, communication and monitoring which are all activities that are concentrated in the last stage of ecodesign. The analysis of the reliability of the scales results in values of Cronbach's alpha of 0,95; 0,92 and 0,79 respectively (table 7.2). The reported values in table 7.2 are means for the three departments together. The average levels of involvement in the operational ecodesign activities range between "small" and "moderate". The results per department are reported in paragraph 7.3.

Table 7.1 Involvement in operational ecodesign activities, rotated component matrix

	Component		
	1	2	3
consultation with authorities	,770		
gathering legal information	,755		
evaluation of old impact	,713	,400	
chain consultation	,640	,486	
bench marking	,695		
evaluation of legal impact	,790		
definition of epis	,610	,489	
definition of objectives	,664	,539	
generation of green options	,466	,695	
env assessment of green options		,813	
econ assessment of green options		,788	
tech assessment of green options		,886	
include env in product profile	,645	,549	
definition of env design guide lines	,680	,502	
consider impact of production	,413	,662	
Marketing			,911
Communication			,920
Monitoring	,519		,569

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 7.2 Involvement in operational ecodesign activities, multi-item scale reliability estimates and descriptive statistics

Measure	Items	Cronbach's alpha	Mean	Standard deviation
Involvement in ecodesign in stage 1	10	0,95	2,80	1.13
involvement in ecodesign in stage 2	5	0,92	2,58	1,18
involvement in ecodesign in stage 3	3	0,79	2,54	1.21

n = 96

Involvement in new product development

In addition to the involvement in operational ecodesign activities, the questionnaire also included questions to rate the involvement of the departments in every one of the 7 stages of the new product development process on a 5-points scale. The results show that the average involvement of the departments is between 2,9 and 3,3 for 6 of the 7 stages (table 7.3). The involvement in process design is relatively low with an average score of 2.3 (1 = "none", 5 = "very large").

Table 7.3 Involvement in new product development, descriptive statistics

Item	Mean	Standard deviation
idea generation	3,27	1.51
concept development	3,29	1,33
concept evaluation	3,16	1,37
Prototype	2,89	1,50
process design	2,25	1,19
testing	2,93	1.45
introduction	3,01	1,62

n = 96

Communication

The managers of the three departments all reported the frequency and amount of communication with the other two departments across the 7 stages of product development according to a 5-points scale (1 = "never", 5 = "very often"). The results for "frequency" and "amount" of communication were very similar with an average difference between the two reported values of plus or minus 0,3. The two questions served to enable the respondent to nuance his or her answer for cases where there had been frequent communication, e.g. as result of meetings with a fixed schedule, but the actual amount of information exchanged between the two departments had been small. Because the reported values for the frequency and the amount of information were so similar, the levels of communication have been calculated as the average of these values.

The measures for communication between the departments are multi-item measures differentiating for early (first three) and late (last four) stages of new product development.

All items are average values for the frequency and amount of communication during one of the seven stages of new product development. Cronbach's alpha was used to assess their internal reliability. The coefficients and the means and standard deviations are shown in table 7.4.

Table 7.4 Communication between functions during NPD process, multi-item scale reliability estimates and descriptive statistics

Measure Communication levels between pairs of functions, as reported by the first	Items	Cronbach's alpha	Mean	Standard deviation
R&D – Environment, early	3	0,91	2,13	1,00
R&D – Environment, late	4	0,89	1,76	0,80
Environment – R&D, early	3	0,93	2,30	1,23
Environment – R&D, late	4	0,91	1,89	0,95
Environment – Marketing, early	3	0,79	1,83	0,91
Environment – Marketing, late	4	0,91	1,50	0,72
Marketing – Environment, early	3	0,95	2,23	1,18
Marketing – Environment, late	4	0,92	1,87	0,89
R&D – Marketing, early	3	0,84	3,30	0,73
R&D – Marketing, late	4	0,81	2,90	0,75
Marketing – R&D, early	3	0,93	3,83	0,76
Marketing – R&D, late	4	0,67	3,22	0,65

As in the research we use multiple respondents to measure the communication levels between the departments, it is interesting to see whether the reported levels are consistent within each pair of managers. It may very well be that one of the managers perceives the same absolute level of communication to be more frequent or informative than the other manager. As the table below indicates there was strong agreement on the communication levels of both R&D and Marketing with the environmental department, but less on the communication between R&D and Marketing. The significance of the differences was tested with the Kruskal Wallis Test because the data are not normally distributed. The differences between the Marketing and R&D appear to be significant ($p < 0,01$) according to this test. This means that the level of communication between R&D and Marketing in early stages of the new product development process marketing, is significantly higher according to the perception of the marketing manager than according to the perception of the R&D manager. This finding is in line with the findings of Olson et al. (2001). It may suggest that R&D managers perceive themselves to be more independent during the early stages of development than marketing managers.

Table 7.5 Differences in the managers' perceptions of communication levels between pairs of functions

Communication levels between pairs of functions	Reported by environmental manager	Reported by marketing manager	Reported by R&D manager	Chi-Square	Asymptotic Significance
R&D – Environment, early	2,30		2,13	0,235	0,627
R&D – Environment, late	1,89		1,76	0,128	0,721
Marketing – Environment, early	1,83	2,23		1.835	0,176
Marketing – Environment, late	1,50	1,87		3,107	0,078
R&D – Marketing, early		3,83**	3,30**	7,502	0,006
R&D – Marketing, late		3,22	2,90	3.637	0,057

*** Significant difference in means at the p < 0,01 level, Kruskal Wallis Test, df = 1*

In the final questions of the survey we are asking the managers to report their levels of satisfaction with the product's performance. Table 7.6 shows the satisfaction levels (1= "not satisfied", 5 = "very satisfied") with 4 aspects of product performance: compliance with environmental regulation, environmental performance beyond compliance, product quality and product sales performance. As can be seen in the table the average satisfaction levels do not vary much between the functions except for the satisfaction level of the environmental manager with product sales. A Kruskal Wallis Test shows that the satisfaction of the environmental manager with sales performance is significantly ($p < 0,01$) lower than for the other managers. It should be noted however that the environmental managers were also the least involved in the projects and their satisfaction levels were reported for only 22 of the 34 cases. In addition to the answers of the functional managers the satisfaction levels were also reviewed on the basis of the interviews with the project managers. A comparison of the interview results on product performance and the results of the questionnaire did not show any major discrepancy.

Table 7.6 Satisfaction with product performance, differences between functions

Satisfaction with results	Environmental manager		Marketing manager		R&D Manager		Kruskal Wallis Test, incl. Environment		Kruskal Wallis Test, excl. Environment	
	Mean	SD	Mean	SD	Mean	SD	Chi-Square	Signifi-cance	Chi-Square	Signifi-cance
Environmental compliance	4,45	0,91	4,36	0,82	4,31	0,86	0,740	0,691	0,058	0,810
Environmental performance	4,05	0,89	4,00	0,66	3,97	0,90	0,182	0,913	0,002	0,961
Product quality	4,36	0,85	4,33	0,85	4,35	0,99	0,331	0,847	0,371	0,543
Product sales	3,18**	0,85	4,00	1,11	3,90	1,14	9,806	0,007	0,131	0,718

*** Significant difference in means at the p < 0,01 level, Kruskal Wallis Test, df = 2*

7.3 Involvement

In every project that was included in the survey at least some of the operational ecodesign activities were deployed. In this paragraph the differences in the levels of involvement will be analysed to test the hypotheses of the research model. Both the involvement in operational ecodesign activities and the involvement during the different stages of new product development will be analysed and discussed in relation with strategy and performance. The first hypothesis states that there is a relationship between the environmental strategy of a company and the level of involvement in operational ecodesing activities. Departments in more pro-active companies are expected to be more involved in the ecodesign activities.

H1: The involvement of departments with ecodesign tasks is higher in companies with pro-active strategies than in companies with reactive strategies.

In chapter 6 it was concluded that all the companies in the sample have implemented a pro-active environmental strategy which makes it impossible to test this first hypothesis. Within the sample we can however distinguish different types or levels of pro-activity. Companies with "*opportunistic pro-active*" strategies have a strong focus on compliance plus non-environmental advantages such as cost savings for clients. Companies with a "*green pro-active*" strategy are years ahead of legislation where the pace of environmental improvement is determined by the acceptance of green products on mainstream markets. Companies with "*green niche*" strategies have a green product portfolio that is marketed to a small market segment. The actual strategies were assessed per company based on the interview results (see chapter 6). Table 7.7 shows the average levels of involvement in the operational ecodesign activities of the departments for the three levels of pro-activity.

Table 7.7 Involvement in operational ecodesign and environmental strategy

Level of pro-activity	Average involvement of Environmental Management	Average involvement of R&D	Average involvement of Marketing	Average involvement, all departments
Opportunistic Pro-active (n = 9)	2,6	2,4	2,7	2,6
Green Pro-active (n = 17)	2,5	3,2	3,3	3,0
Green niche (n = 8)	1,0	3,0	2,4	2,1

The most striking result is that the lowest average levels of involvement in ecodesign activities are found in companies with a green niche strategy. A major cause of these low levels is that in these companies there was no involvement at all of the environmental management function with the ecodesign tasks.[2] Also the marketing function was less involved with ecodesign than in other companies. The significance of the differences per operational ecodesign activity are analysed with the Kruskal Wallis Test because the data are not normally distributed. The results of this analysis are shown below in table 7.8.

In comparing the levels of involvement between the 3 pro-active strategies, the results of the Kruskal Wallis Test show significant differences for 9 out of 18 operational ecodesign activities. The significance of the differences is however mainly the result of the low involvement levels in the green niche strategy companies. When we exclude these green niche companies we can find significantly different involvement levels between "opportunistic pro-active" and "green pro-active" companies for only 4 of the 18 ecodesign activities: *bench marking, the definition of environmental performance indicators, the inclusion of environmental requirements in the product profile* and *the definition of environmental design guidelines*.

We may conclude that Hypothesis 1 can be accepted for 4 to 9 of the ecodesign activities for companies with different levels of pro-active strategy. It should be noted that the green niche companies are all among the smallest companies in the sample and their involvement levels may well be related to their size than to the strategy. The 4 activities for which the differences are significant between R&D and Marketing are all preparatory activities in which environmental policy goals are leading. These activities allow to differentiate between pro-active strategies where environmental intentions are the driving force, and more opportunistic strategies.

[2] One environmental manager from a green niche company did not return the questionnaire. According to the interviewee this manager had considerable influence on the ecodesign process. If this questionnaire had been included the results would probably have been slightly higher but would still remain significantly lower than for other strategies.

Table 7.8 Significance of the differences in the involvement in operational ecodesign activities between environmental strategies

	All strategies			Excluding green niche strategies		
	Chi-Square	df	Asymp. Sig.	Chi-Square	df	Asymp. Sig.
1. consultation with authorities	14.721***	2	0.001	3.494	1	0.062
2. gathering legal information	6.538*	2	0.038	0.334	1	0.563
3. evaluation of old impact	3.570	2	0.168	2.045	1	0.153
4. chain consultation	4.915	2	0.086	1.593	1	0.207
5. bench marking	12.549**	2	0.002	10.259***	1	0.001
6. evaluation of legal impact	5.688	2	0.058	0.121	1	0.728
7. definition of epis	12.282**	2	0.002	8.255**	1	0.004
8. definition of objectives	13.768***	2	0.001	2.917	1	0.088
9. generation of green options	5.540	2	0.063	0.501	1	0.479
10. env assessment of green options	4.238	2	0.120	0.750	1	0.386
11. econ assessment of green options	6.887*	2	0.032	2.801	1	0.094
12. tech assessment of green options	1.701	2	0.427	0.274	1	0.601
13. include env in product profile	15.320***	2	0.000	5.837*	1	0.016
14. definition of env design guide lines	12.904**	2	0.002	4.692*	1	0.030
15. consider impact of production	5.156	2	0.076	0.000	1	0.995
16. marketing	0.087	2	0.958	0.067	1	0.796
17. communication	1.509	2	0.470	1.478	1	0.224
18. monitoring	7.583*	2	0.023	0.646	1	0.421

*Significant difference in means at the * = p < 0,05; ** = p < 0,01; *** = p < 0,001 level; Kruskal Wallis Test;*
Grouping; Variable: level of pro-activity

The next question is whether higher levels of involvement in operational ecodesign activities also result in higher product performance levels. According to the environmental management literature high levels of involvement for all functions are a necessary requirement for the successful development of green products. Therefore the second hypothesis is formulated as:

H2: High levels of involvement in ecodesign tasks for HSE, Marketing and Environment are positively related to product performance.

Table 7.9 shows the correlations between the average levels of involvement of all functions together in the three stages of ecodesign and the average levels of satisfaction with product performance. It appears that there is only one significant correlation (0,341 ; $p < 0,05$) between the overall level of involvement in the second stage and the satisfaction with the product's compliance with environmental regulation.

Table 7.9 Correlations between involvement (all functions together) with operational ecodesign activities and satisfaction with product performance

		Average satisfaction with compliance	Average satisfaction with environmental performance	Average satisfaction with product quality	Average satisfaction with product sales
Average involvement in ecodesign in stage 1, all functions together	Pearson Correlation	0,128	-0,030	-0,188	-0,175
	Sig. (2-tailed)	0,469	0,865	0,287	0,323
Average involvement in ecodesign in stage 2, all functions together	Pearson Correlation	0,341(*)	0,264	0,014	-0,038
	Sig. (2-tailed)	0,048	0,132	0,939	0,829
Average involvement in ecodesign in stage 3, all functions together	Pearson Correlation	0,254	0,158	-0,038	-0,102
	Sig. (2-tailed)	0,160	0,387	0,836	0,578

** = correlation is significant at the 0,05 level (1-tailed)*

Instead of assuming that the average level of involvement for all departments together should be related with product performance, it might also be assumed that the involvement of one department in particular should be related to one or more aspects of product performance. One might expect for example that the involvement of the environmental department with ecodesign is more effective in the first prepatory stage and less in the last stage. So the question is whether a functional specialization in the deployment of ecodesign activities could be effective. The correlations at this level are shown in table 7.10.

The results show a positive relation between the involvement of the R&D function in the second stage (the generation and assessment of green options) and both the satisfaction with environmental performance (0,395 ; $p < 0,05$) and the quality (0,357 ; $p < 0,05$) of the product. This is suggesting that the active involvement of the R&D function does result in better product performance. The results suggest a negative relation between the involvement of the Marketing function in the early stage of ecodesign and environmental performance (- 0,353 ; $p < 0,05$) and even more with product quality in both the early stage (- 0,540 ; $p < 0,01$) and the second stage (- 0,459 ; $p < 0,01$) of ecodesign. In identifying the individual cases where strong Marketing involvement is paired with lower satisfaction levels for product quality, it appears that it often concerns projects where there is a strong trade-off between product quality and environmental performance. Marketing may be involved primarily because this function is concerned about the potential loss of product quality as is often the case in the paint industry. This explanation for the correlation seems more likely than the opposite effect that the involvement of marketing in itself would result in lower product quality.

Table 7.10 Correlations between involvement of individual functions with operational ecodesign activities and satisfaction with product performance

		Average satisfaction with compliance	Average satisfaction with environmental performance	Average satisfaction with product quality	Average satisfaction with product sales
involvement of environmental management with ecodesign in stage 1	Pearson Correlation	,157	,118	,148	,116
	Sig. (2-tailed)	,400	,527	,427	,535
involvement of environmental management with ecodesign in stage 2	Pearson Correlation	,146	,120	,169	,091
	Sig. (2-tailed)	,432	,519	,365	,627
involvement of environmental management with ecodesign in stage 3	Pearson Correlation	,177	,245	,154	,122
	Sig. (2-tailed)	,340	,185	,408	,514
involvement of R&D with ecodesign in stage 1	Pearson Correlation	,249	,208	,003	-,300
	Sig. (2-tailed)	,169	,254	,986	,095
involvement of R&D with ecodesign in stage 2	Pearson Correlation	,315	,395(*)	,357(*)	-,081
	Sig. (2-tailed)	,079	,025	,045	,660
involvement of R&D with ecodesign in stage 3	Pearson Correlation	,195	,033	-,262	-,213
	Sig. (2-tailed)	,292	,859	,154	,249
involvement of Marketing with ecodesign in stage 1	Pearson Correlation	-,132	-,353(*)	-,540(**)	-,324
	Sig. (2-tailed)	,462	,044	,001	,066

involvement of Marketing with ecodesign in stage 2	Pearson Correlation	,068	-,100	-,459(**)	-,102
	Sig. (2-tailed)	,706	,579	,007	,571
involvement of Marketing with ecodesign in stage 3	Pearson Correlation	,195	,033	-,262	-,213
	Sig. (2-tailed)	,292	,859	,154	,249

*** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

Differences between functions

The following two hypotheses concern the differences in levels of involvement between the functions. Differences between these levels and a focus of a function on a limited number of operational ecodesign activities may provide evidence of functional specialisation. It may also indicate if ecodesign is still the exclusive responsibility of the environmental manager or whether it is a shared responsibility with marketing and R&D managers. Hypothesis 3 is based on the environmental management literature stating that environmental managers have a major responsibility in gathering information on environmental legislation

H3: The level of involvement of Environment with regulation related tasks is significantly higher than of other functions.

If this hypothesis is true we would expect relatively high involvement levels of the environmental management function in comparison with the other functions for the following ecodesign activities: "consultation with environmental authorities"; gathering of legal information" and "evaluation of legal impact". The fourth hypothesis is related to the involvement of the marketing function.

H4: The level of involvement of Marketing in the first stages of new product development, is significantly lower than for the environmental function.

This hypothesis reflects that according to the literature the marketing function has little involvement in environmental management and ecodesign. We would expect that they would be involved in the conventional marketing tasks that have to be performed for the launch of the product but that the involvement in the initiating stages would be lower than for the other functions (Fryxell and Fryza, 1999; Charter, 2001)

Table 7.11 presents the average levels of involvement per function and per ecodesign activity. One of the most striking results is that there is only one activity for which the environmental manager is the manager who is most involved and that is the consultation with the environmental authorities. For all other activities except for the gathering of

regulatory information, the level of involvement is even smaller than that of the marketing manager.

Table 7.11 Differences in involvement in operational ecodesign activities between functions

Ecodesign Activity	Average involvement of Environmental Management with ecodesign	Average involvement of R&D with ecodesign	Average involvement of Marketing with ecodesign	Average involvement, all functions with ecodesign
1. Consultation with environmental authorities	2.3	1.9	1.8	*2.0*
2. Gathering information on legal environmental requirements	2.8	3.3	2.7	*3.0*
3. Evaluation of old product's environmental impact	2.4	2.9	2.5	*2.6*
4. Consultation of partners in the product chain	2.5	2.9	2.7	*2.7*
5. Environmental benchmarking of products	2.6	3.0	2.7	*2.8*
6. Evaluation of implication of legal requirements, agreements and codes	2.8	3.4	3.0	*3.1*
7. Definition of environmental performance indicators for new product	2.4	3.3	3.0	*2.9*
8. Defintion of environmental objectives for the new product	2.5	3.5	3.3	*3.1*
9. Generation of green options to improve the product	2.1	2.9	2.8	*2.6*
10. Environmental assessment of green improvement options	2.2	3.0	2.5	*2.6*
11. Economic assessment of green improvement options	1.9	3.0	2.8	*2.6*
12. Technical assessment of green improvement options	1.7	3.5	2.5	*2.6*
13. Including environmental requirements in product profile	2.3	3.6	3.3	*3.0*
14. Definition of environmental design guidelines for product improvement	2.4	3.1	3.0	*2.8*
15. Consideration of environmental implications in manufacturing	2.2	3.0	2.4	*2.5*
16. Marketing of the product	1.4	2.5	4.4	*2.8*
17. Communcation to clients to minimize environmental impact	1.4	2.0	4.0	*2.5*
18. Monitoring of new product's environmental performance	2.0	2.0	2.9	*2.3*
TOTAL AVERAGE	*2.2*	*2.9*	*2,9*	*2.7*

Not surprisingly, the marketing manager is especially involved with the final activities when the product has to be marketed and environmental information has to be communicated with the client. A more interesting result is that the level of involvement of the environmental manager is the lowest of all for marketing and communication activities. There are no other activities where the differences between functional involvement are so high as between the environmental and the marketing manager in the marketing and communication activities.

Table 7.12 Significance of the differences in involvement in operational ecodesign activities between functions

	Chi-Square	df	Asymp. Sig.	Most involved function
1. consultation with authorities	1.596	2	0.450	
2. gathering legal information	2.731	2	0.255	
3. evaluation of old impact	3.602	2	0.165	
4. chain consultation	1.202	2	0.548	
5. bench marking	1.236	2	0.539	
6. evaluation of legal impact	0.932	2	0.627	
7. definition of epis	5.445	2	0.066	
8. definition of objectives	9.109*	2	0.011	R&D
9. generation of green options	6.014*	2	0.049	R&D
10. env assessment of green options	6.221*	2	0.045	R&D
11. econ assessment of green options	14.351**	2	0.001	R&D
12. tech assessment of green options	25.336***	2	0.000	R&D
13. include env in product profile	13.749**	2	0.001	R&D
14. definition of env design guide lines	3.862	2	0.145	
15. consider impact of production	7.885*	2	0.019	R&D
16. marketing	61.467***	2	0.000	Marketing
17. communication	53.951***	2	0.000	Marketing
18. monitoring	9.756**	2	0.008	Marketing

Kruskal Wallis Test
*significance levels: * < 0,05;**< 0,01;***< 0.001*

The significance of the differences in involvement in ecodesign activities between the functions has been tested with the Kruskal Wallis Test (table 7.12). Significant levels (<

0,05) were found for 10 out of the 18 ecodesign activities. None of the activities that are related to regulation (consultation with authorities, gathering legal information, evaluation of legal impact) are showing significantly different involvement levels which suggest that there is no functional specialisation with regard to these regulatory tasks.

The results give no support to hypothesis 3 and it is therefore rejected. It supports the results from the interviews which already made it clear that regulatory tasks were also performed by R&D managers and Marketing managers. An explanation for this result may be that the regulatory tasks of environmental managers are more related to process than product related environmental aspects or that their regulatory task are more focused on the development policies and guidelines at the company than at the project level.

The average levels of involvement of Marketing are higher than for the environmental manager in all activities where significant differences were found. All the activities for which significant differences were found can be placed in the later stages of product development. R&D managers are the most involved function for 7 operational ecodesign activities. Marketing managers are taking the lead only in the final stage when the product has to be marketed. For the early stage activities, no significant differences between the functions were found, giving no support for hypothesis 4.

Stages in the new product development process

The managers were also asked to rate the involvement of their functions during the stages of the new product development process, so regardless of the implementation of ecodesign activities. The results of the average involvement per function and per stage are shown below in figure 7.1 and table 7.13 (1 = “none”, 5 = “very large”).

Figure 7.1 Involvement of R&D, Environment and Marketing during the new product development process

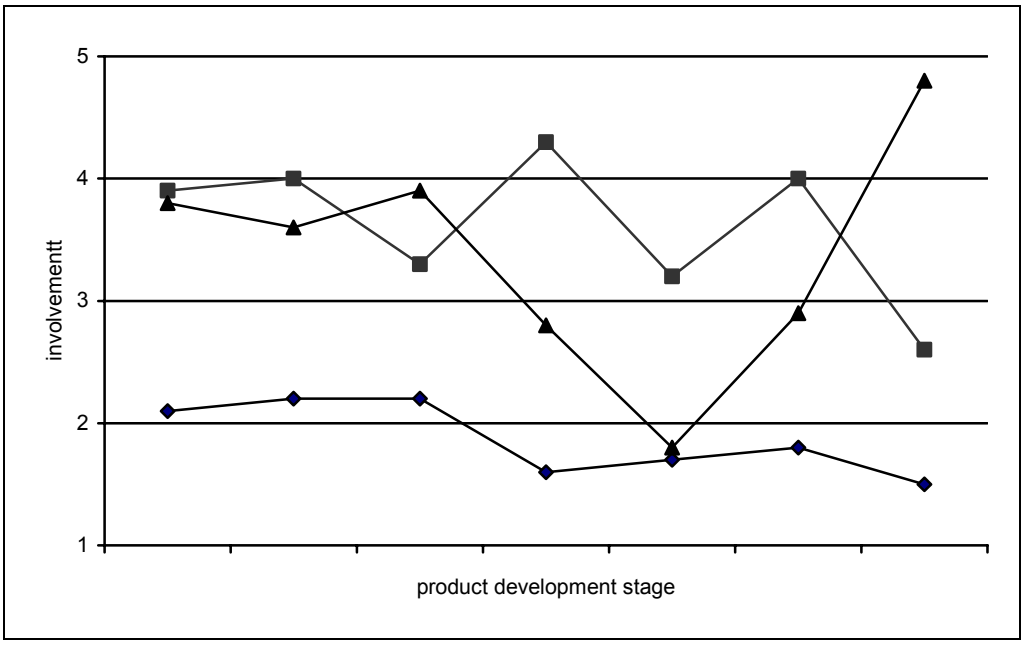


Table 7.13 Involvement of R&D, Environment and Marketing during the new product development process

New product development stage	Average involvement of Environmental Management with NPD	Average involvement of R&D with NPD	Average involvement of Marketing with NPD	Average involvement in NPD, all functions
1. Idea generation	2.1	3.9	3.8	3.3
2. Concept development	2.2	4.0	3.6	3.3
3. Concept evaluation / business assessment	2.2	3.3	3.9	3.2
4. Prototype design and development	1.6	4.3	2.8	2.9
5. Production process design	1.7	3.2	1.8	2.2
6. Product testing	1.8	4.0	2.9	2.9
7. Market introduction	1.5	2.6	4.8	3.0
TOTAL AVERAGE	1.9	3.6	3.4	3.0

The environmental function is considerably less involved with the new product development process than the marketing or R&D function. This may also be a major explanation for the finding that the environmental function is less involved with ecodesign activities. The differences in the overall involvement between marketing and R&D are small, but the involvement levels differ considerably per stage. The differences in involvement between Marketing and R&D are relatively small in the first three stages from idea generation to concept evaluation and business assessment. R&D is the function that is most involved during prototype design and development, production process design and product testing. The largest differences in involvement are found in the market introduction stage, when environment and R&D are least involved and Marketing reaches its maximum level of involvement. The significance of the differences was again tested with the Kruksal Wallis test. The results in table 7.14 show that all differences are highly significant ($p < 0{,}001$). The results again provide no support for hypothesis 4. Marketing is slightly less involved than R&D during the first two stages, but considerably more involved than the environmental management function during all the stages of the product development process.

Table 7.14 Significance of differences in involvement in NPD between the three functions

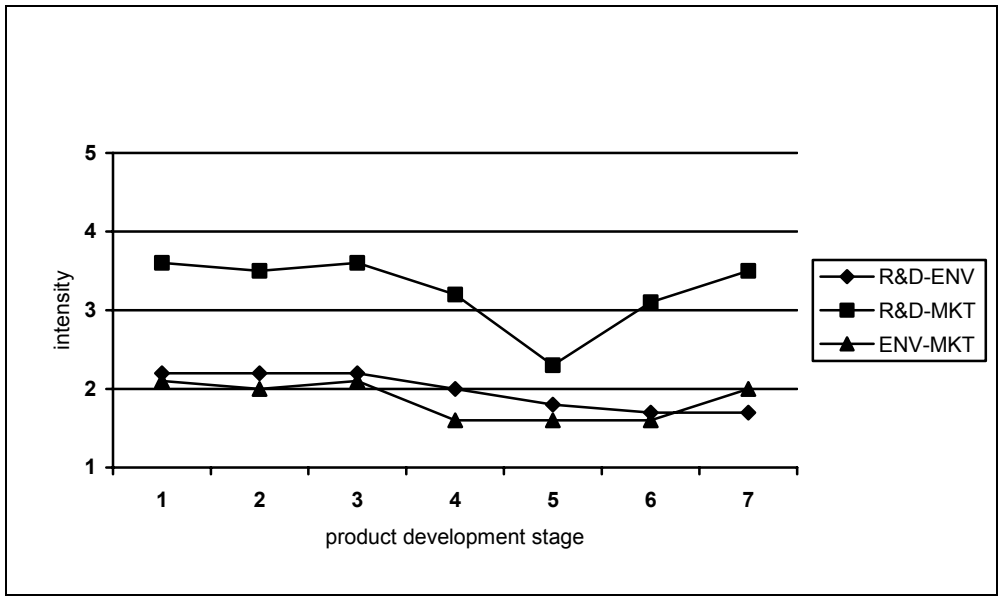
	idea generation	concept development	concept evaulation	prototype	process design	testing	introduction
Chi-Square	29,678***	31,565***	21,136***	51,160***	27,409***	34,966***	66,421***
df	2	2	2	2	2	2	2
Asymp. Sig.	,000	,000	,000	,000	,000	,000	,000

Kruskal Wallis Test; Grouping Variable: function
*significance levels: ***< 0.001*

7.4 Cooperation between the functions

Cooperation was measured by asking managers to assess the frequency of communication and the amount of information exchanged with the other two functions during the new product development process. For every dyad the communication intensity was calculated as the average of the values that were reported by both sides (figure 7.2). The communication between R&D and Marketing is much more intense than for these functions with Environmental Management. The lowest levels of communication are found between Marketing and Environmental Management for every stage except for the market introduction, where the communication between R&D and environment is even lower.

Figure 7.2 Communication intensity between R&D, Environment and Marketing



Analysis of the differences with the Kruksal Wallis Test (table 7.15) shows that the differences are significant in all stages. However if we exlude the communication between R&D and Marketing, the differences of communications of Marketing and R&D with Environmental Management do not differ significantly. This is also visible in figure 7.2 where the lines representing the communication with the environmental function are almost similar.

Table 7.15 Significance of differences in communication between pairs of functions

	idea generation	concept development	concept evaulation	Prototype	process design	testing	introduction
Chi-Square	36,595***	33,837***	31,323***	32,353***	18,202***	43,413***	45,714***
Df	2	2	2	2	2	2	2
Asymp. Sig.	,000	,000	,000	,000	,000	,000	,000

Kruskal Wallis Test; Grouping Variable: function pair
*significance levels:****< 0.001*

The communication intensity between the functions is following a pattern that might well have been predicted from the patterns of functional involvement as they have been reported

in the preceding paragraph. Figure 7.3 illustrates that if we calculate the average levels of involvement in new product development for every pair of functions we can produce a pattern that is very similar to the pattern in communication intensity.

Figure 7.3 Averages in involvement for R&D, Environment and Marketing

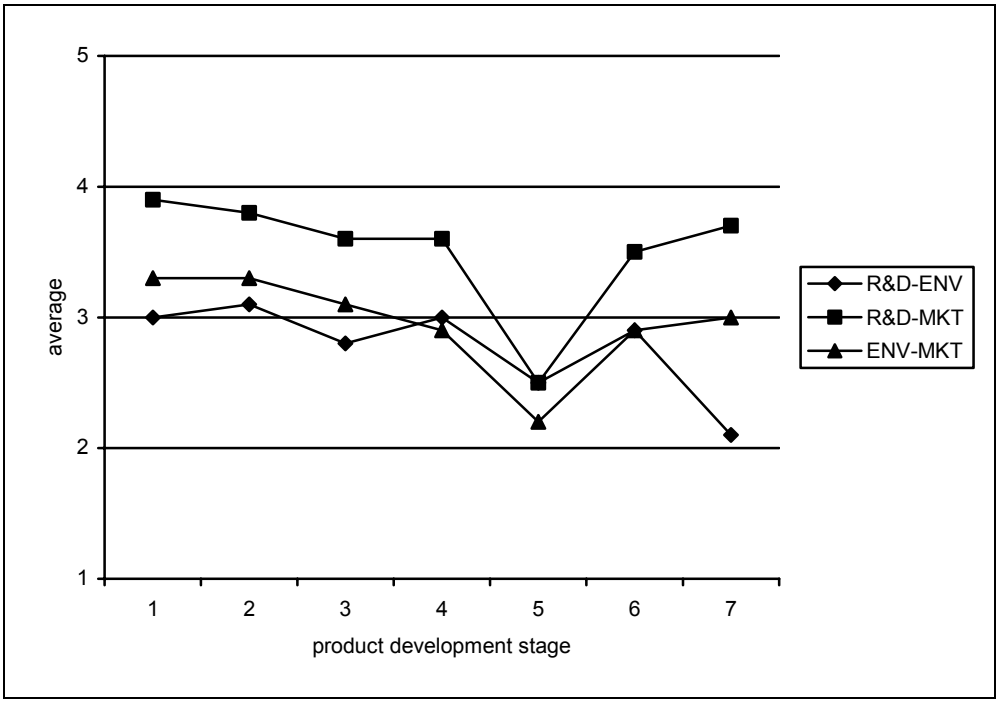


Table 7.16 Averages in involvement for R&D, Environment and Marketing

New product development stage	Average involvement in NPD between R&D and Environmental Management	Average involvement in NPD between R&D and Marketing	Average involvement in NPD between Environmental Management and Marketing
1. Idea generation	3.0	3.9	3.0
2. Concept development	3.1	3.8	3.0
3. Concept evaluation / business assessment	2.8	3.6	3.1
4. Prototype design and development	3.0	3.5	2.2
5. Production process design	2.5	2.5	1.8
6. Product testing	2.9	3.4	2.5
7. Market introduction	2.1	3.7	3.3

The relation between involvement and communication was already predicted in hypothesis 5:

H5:Levels of involvement of marketing and R&D with green product development are positively related to levels of cooperation with the environmental function.

The graphs show the similarity of the patterns in involvement and communication intensity. The relation is further illustrated by the correlations in table 7.17.

Table 7.17 Correlations between involvement and communication intensity during new product development

		communica-tion between environment and R&D in first 3 steps	communication between environment and R&D in last 4 steps	communication between environment and marketing in first 3 steps	communication between environment and marketing in last 4 steps	communication between R&D and marketing in first 3 steps	communication between R&D and marketing in last 4 steps
average involvement in npd between env and rnd, early	Pearson Correlation	,749(**)	,680(**)	,622(**)	,534(**)	,212	-,270
	Sig. (1-tailed)	,000	,000	,000	,001	,123	,067
average involvement in npd between env and rnd, late	Pearson Correlation	,434(**)	,642(**)	,541(**)	,583(**)	,262	,030
	Sig. (1-tailed)	,007	,000	,001	,000	,073	,435
average involvement in npd between env and mkt, early	Pearson Correlation	,710(**)	,731(**)	,634(**)	,635(**)	,091	-,179
	Sig. (1-tailed)	,000	,000	,000	,000	,305	,155
average involvement in npd between env and mkt, late	Pearson Correlation	,452(**)	,637(**)	,595(**)	,765(**)	,017	,179
	Sig. (1-tailed)	,005	,000	,000	,000	,462	,156
average involvement in npd between rnd and mkt, early	Pearson Correlation	,165	,055	,237	,081	,392(*)	-,200
	Sig. (1-tailed)	,183	,382	,089	,324	,011	,128
average involvement in npd between rnd and mkt, late	Pearson Correlation	-,245	-,042	,192	,228	,210	,481(**)
	Sig. (1-tailed)	,088	,410	,139	,098	,117	,002

** Correlation is significant at the 0.05 level (1-tailed); ** is significant at the 0.01 level (1-tailed.*

The relations between average involvement and communication are positive (between 0,392 and 0,765) and significant (between $p < 0,05$ and $p < 0,01$) for all dyads in both the early and the late stages of the developments. Hypothesis 5 is therefore supported. Communication patterns are thus related to the involvement of the functional functions with the new product development process. The following hypothesis concerns the relation between communication and performance. It is expected that more cooperation (measured as the communication intensity) between the functions will result in better performance of the product. As discussed in chapter 3 this relation may vary depending on whether cooperation takes place in the early or the later stages of the development process.

the timing in early or late stages of the development process.

H6: The levels of cooperation between the functional departments are positively related to product performance and the strength of this relation will differ between the early and the late stages of the new product development process.

To test this hypothesis scales were developed that differentiate between cooperation in the early (first 3 steps) and the late (last 4 steps) stages in the new product development process, that are all considered to be reliable with coefficient alpha values between 0,78 and 0,94 (table 7.18).

Table 7.18 Communication between pairs of functions, multi-item scale reliability estimates and descriptive statistics

Measure Communication levels between pairs of functions, averages reported levels by both functions	Items	Cronbach's alpha	Mean	Standard deviation
R&D – Environment, early	3	0,93	2,23	1,04
R&D – Environment, late	4	0,90	1,80	0,75
Marketing – Environment, early	3	0,94	2,07	1,02
Marketing – Environment, late	4	0,92	1,75	0,81
R&D – Marketing, early	3	0,85	3,55	0,53
R&D – Marketing, late	4	0,78	3,06	0,62

The next step was to examine whether the average levels of communication for each stage were related to any of the four aspects of product performance. The results of the analysis did not support any of the predicted relations (see table 7.19). It did show in support of the findings of chapter 6 that the product performance levels are strongly interrelated. The strongest relation was found between the satisfaction with environmental performance and the satisfaction with compliance. This is no surprise because products with a good environmental performance are often products that perform beyond the minimum level of compliance, and thus logically also satisfy the regulatory requirements. More interesting are the relations between the average levels of satisfaction with quality, sales performance and environmental performance. Satisfaction with quality and satisfaction with environmental

performance are positively related (0,468 , p < 0,01) and similarly satisfaction with product quality and satisfaction with product sales show a positive relation. This suggests that environmental quality may well contribute to improved quality of a product and then to sales performance.

Table 7.19 Correlations between communication intensity and satisfaction with product performance

		Average satisfaction with compliance	Average satisfaction with environmental performance	Average satisfaction with product quality	Average satisfaction with product sales
communication between environment and R&D in first 3 steps	Pearson Correlation	,140	,068	,222	-,033
	Sig. (2-tailed)	,444	,710	.223	,858
communication between environment and R&D in last 4 steps	Pearson Correlation	,086	,126	,197	-,037
	Sig. (2-tailed)	,640	,493	,281	,842
communication between environment and marketing in first 3 steps	Pearson Correlation	,226	,106	-,099	,110
	Sig. (2-tailed)	,199	551	,579	535
communication between environment and marketing in last 4 steps	Pearson Correlation	,249	,229	,066	,190
	Sig. (2-tailed)	,155	,193	,712	,283
communication between R&D and marketing in first 3 steps	Pearson Correlation	,065	,026	-,198 ,262	,083 ,640
	Sig. (2-tailed)	,716	,883		
communication between R&D and marketing in last 4 steps	Pearson Correlation	,212	,151	-,035	,068
	Sig. (2-tailed)	,228	,395	,842	,704
Average satisfaction with compliance	Pearson Correlation	1			
Average satisfaction with environmental performance	Pearson Correlation	,783(**)	1		
	Sig. (2-tailed)	,000			
Average satisfaction with product quality	Pearson Correlation	,395(*)	,468(**)	1	
	Sig. (2-tailed)	,021	,005		
Average satisfaction with product sales	Pearson Correlation	,177	,290,	,399(*)	1
	Sig. (2-tailed)	,318	097	,019	

** *Correlation is significant at the 0.01 level (2-tailed).*

* *Correlation is significant at the 0.05 level (2-tailed).*

Analysis of the 34 projects did not produce evidence for any relation between communication and performance. According to the theory of NPD it might be, however, that these relations are moderated by the level of uncertainty. Communication would be especially effective in cases of higher uncertainty. Therefore the 19 cases with higher levels of uncertainty were also analysed separately, however this did not produce any significant relation either (table 7.20).

Table 7.20 Correlations between communication intensity and satisfaction with product performance, 19 cases with higher uncertainty

		Average satisfaction with compliance	Average satisfaction with environmental performance	Average satisfaction with product quality	Average satisfaction with product sales
communication between environment and R&D in first 3 steps	Pearson Correlation	,186	,051	,085	,012
	Sig. (2-tailed)	,459	,839	,737	,962
communication between environment and R&D in last 4 steps	Pearson Correlation	,164	,135	,128	-,067
	Sig. (2-tailed)	,515	,593	,612	,791
communication between environment and marketing in first 3 steps	Pearson Correlation	,135	-,009	-,057	,181
	Sig. (2-tailed)	,582	,972	,815	,459
communication between environment and marketing in last 4 steps	Pearson Correlation	,171	,110	,093	,242
	Sig. (2-tailed)	,485	,655	,705	,318
communication between R&D and marketing in first 3 steps	Pearson Correlation	,026	-,150	-,016	,182
	Sig. (2-tailed)	,916	,540	,948	,456
communication between R&D and marketing in last 4 steps	Pearson Correlation	-,081	-,077	,062	,103
	Sig. (2-tailed)	,742	,754	,802	,676

Hypothesis 7a predicted that the relations between communication levels and performance are even stronger under conditions of high uncertainty. Since no relations were found regardless of the uncertainty levels, this hypothesis can not be supported. This implies that there is no evidence for the statement that communication is more effective under conditions of higher uncertainty. Hypothesis 7b predicts that we will find higher levels of communication between the functions with higher levels of uncertainty.

H7b: In projects with higher levels of uncertainty we will also find higher levels of cooperation between the functions.

This hypothesis was tested with the Kruskal Wallis Test. The 34 products were divided in 2 groups of lower (15 products) and higher (19 products) uncertainty during the NPD process (table 7.21). The differences appear to be significant between R&D and Marketing in the second stage of the NPD process. In the cases with higher uncertainty the level of communication was 3,3 against 2,5 in cases of lower uncertainty. The test does provide support for the hypothesis of a positive relation ($p < 0,01$) between uncertainty and the cooperation between R&D and Marketing during the last 4 steps of the NPD process.

Table 7.21 Significance of differences in communication for 2 levels of uncertainty

	communication between environment and R&D in first 3 steps	communication between environment and R&D in last 4 steps	communication between environment and marketing in first 3 steps	communication between environment and marketing in last 4 steps	communication between R&D and marketing in first 3 steps	communication between R&D and marketing in last 4 steps
Chi-Square	3,136	2,591	,037	,112	3,209	9,142**
df	1	1	1	1	1	1
Asymp. Sig.	,077	,108	,847	,738	,073	,002

Kruskal Wallis Test, Grouping Variable: uncertainty
*significance levels:***< 0,01*

7.5 Discussion

One of the most striking results of the survey is that the average level of involvement of environmental managers with operational ecodesign activities is lower than that of R&D and marketing managers. It is only the consultation with environmental authorities that seems to be a special task for environmental managers where their involvement is higher than that of other managers. The involvement of environmental managers is lower for all other operational ecodesign activities, except for the gathering of information on environmental legislation where the marketing manager is even less involved. R&D managers appear to be the most involved managers in ecodesign.

Managers in more pro-active firms are more involved with ecodesign activities than managers in less proactive companies, but the lowest levels of involvement are found in green niche companies. In this last category of companies Marketing and R&D managers are less involved with the ecodesign activities than in the other companies, while the environmental managers are not involved at all with ecodesign in green niche companies. The explanation for this last finding may be that these companies are also relatively small and these companies therefore have no specialized manager or function for ecodesign or that these cases merely illustrate how well ecodesign is integrated in the normal practice of every product development project.

The levels of communication between the functions across the different stages of the new product development process are closely related to the levels of involvement of the functions. The lowest communication levels are found between the environmental manger and the other functions, the communication levels of the R&D-Marketing dyad being much more intense both in the early and the late stages of new product development. The level of communication between R&D and Marketing is even higher in projects with higher levels of uncertainty during the later stages of the process. This suggests that the organizations are flexible and allow for more intense communication if this is required in individual cases.

Managers from the different functions generally agreed in their assessments of the product's environmental, regulatory, quality and sales performance. The analysis did not provide any evidence for a relation between the involvement of the environmental manager with ecodesign activities and the product performance, nor for a relation between communication and product performance. The survey does provide evidence for a positive effect from the overall involvement of functions with environmental compliance and for a positive effect from the involvement of the R&D manager with the ecodesign activities and the product's quality and environmental performance. An interesting result is the negative relation that was found between the involvement of marketing managers with especially the product's quality. It looks as if the marketing managers get involved when there are concerns over a trade-off between the environmental and functional quality of a product. The survey results do indicate that products with better environmental performance beyond the level of compliance are also more appreciated for their quality and in turn for their sales performance.

A major quality of the survey design is that it uses multiple respondents to examine involvement, communication and satisfaction with results at the project level in addition to the outcomes of the interviews with the project managers. The combination of the

interviews and the survey results in a more reliable and deeper insight at the project level. The limitation of this approach is that it is demanding both for the researcher and the companies and that the number of 34 projects is small. The fact that no evidence was found to support some of the hypotheses may well be resulting from the relatively small sample.

A first direction for future research should be to increase the number of projects. Since the results of this research have shown that there is considerable agreement between the functions, a new research design could allow 2 managers instead of 3 per project to complete the survey. A second direction may be to measure either involvement or communication since these aspects appear to be so strongly related. This would then allow to include questions about personal and informal aspects that might be relevant for the successful cooperation between functions.

8 Reflections

This research has provided more insight in the actual organization of ecodesign. The research shows that the role of environmental managers is small and that they are not the key contacts for environmental authorities. This conclusion differs from other research in this field. An explanation may be that other researchers analysed the implementation of ecodesign tools and primarily approached environmental managers. For this research I have approached the product managers of a wide variety of companies and asked them to provide me with some of the company's major environmental innovations of the last 3 years. So the result was the selection criterion and not the application of an LCA-like tool or the involvement of an environmental specialist.

In some cases like in the development of a new truck that should meet the strict European emission standards or the development of biodegradable plastic for which there was no clearly defined market yet, the uncertainties are considerably high. But in most cases the directions for environmental improvement were predictable and stable and the stakeholders involved in setting the standards were known to the company. In these cases environmental aspects did not add much to the uncertainties surrounding the projects, which may also be an explanation as to why the involvement of an environmental specialist is not always necessary. The uncertainties are probably more considerable for more fundamental environmental system innovations. Other studies in the Netherlands and on a European scale have shown that this type of innovations is still rare, which was also an outcome of this research.

The operational ecodesign tasks are mainly in the hands of the R&D and the marketing manager. R&D managers are leading in most of the ecodesign tasks except in the marketing and communication stage. A surprising result from the survey was a negative relation between the involvement of the marketing manager and the level of satisfaction with product quality. This is an indication that marketing managers are involved especially when there are trade-offs between environmental product performance and product quality. The conclusion of both the interviews and the survey was that product quality and sales performance are linked. A product doesn't sell just because it is greener.

An advantage of the research design was that it allowed to collect more information on the context of the projects and to have some control over the quality of the response. Almost all managers who were selected by the product managers did return the questionnaire. As a result of this approach however the number of products that could be included in this study is small which makes it more difficult to generalise the outcomes.

The survey measured levels of communication because this was thought to be easier to measure than levels of collaboration. Also, if there would be a relation between intense communication and performance, it was suggested that this relation would probably also hold for collaboration. The finding however that the involvement of the marketing manager is related negatively with product performance indicates that more insight in the motivational aspects of co-operation is needed.

In some studies on new product development the researchers have also included the cooperation with the manufacturing department. This might be an interesting extension for research on ecodesign as well. From the interviews with the product managers it became clear, however, that the role of manufacturing in the project was very limited. In one case a chemical company had changed the formulation of a product for the safety of its own workers. In another case the design of furniture had been changed to reduce production waste. Although the role of the manufacturing department is probably small it may be interesting to see whether the environmental specialists have a more close cooperation with this department than with marketing and R&D.

As a recommendation to the practitioners in ecodesign it is suggested to focus product development on environmental improvements that also have other benefits for the customer such as safety and efficiency. Even the environment would not benefit from a green product that is not sold. Finding the synergies between environmental performance and product quality should not be a coincidence or the result of a battle between R&D and marketing; preferably it will be the result of a systematic approach. For environmental authorities it may be helpful to understand that R&D and marketing managers have more influence on the development of green products than the environmental manager. In consulting the companies about the directions for product related environmental policy, R&D managers seem to be the obvious points of contact.

Annexes

Questions for the project manager.

1. Could you please describe recent (last 3 years) Ecodesign projects or NPD projects that resulted in environmental improvements?

2. Could you please describe how the new product was developed?

Start

- What triggered the development process?
- At the start, what seemed to be the major risks and problems involved?
- What was the scope of the innovation (raw materials, process, product features, service, function, system)
- What were the success indicators?
- How important were the following goals for the ecodesign process? (compliance, market demand, corporate environmental goals)
- Were the environmental standards clear? Or hard to predict?
- Were the market conditions/consumer preferences clear? Or hard to predict?
- Was it clear which technology could be used or further developed? Or hard to predict?

Process

- How did the product development process evolve?
- Which were the functions that were involved most?
- Was there any interaction with external stakeholders during the process?
- Were there any changes with regard to market demand, environmental standards, technology or pressures from other stakeholders during the process?
- Has someone been made responsible for DfE? How was this person involved in this project?
- Which function brought environmental information into the project?
- What was the role of the environmental function?
- Were any measures taken to improve the communication between Marketing, R&D and the environmental function?
- Are you aware of any tools (LCA, other) used during the process?
- Which integrating mechanisms were used and between which of the 3 functions (co-location, personnel movement, structural design, incentives and rewards, formal procedures, training)?

3. Could you please indicate if the project was successful?

- compliance with environmental regulation
- limiting environmental impact beyond compliance
- the new product's quality relative to other products developed by the firm
- the degree to which the product achieves its sales objectives

4. Could you please identify managers from Environmental Management, Marketing and R&D that were involved in the project and who could complete the questionnaire?

5. Could you please supply any documentation about the product/project?

Sample questionnaire

Department/Afdeling	**MARKETING**
Project	

A. Please rate the level of involvement of your department with the following EcoDesign activities.

		none	small	regular	large	very large
1	Consultation with environmental authorities	O	O	O	O	O
2	Gathering information on legal environmental requirements	O	O	O	O	O
3	Evaluation of (old) product environmental impact	O	O	O	O	O
4	Consultation of partners in the product chain on environmental aspects	O	O	O	O	O
5	Environmental benchmarking of products	O	O	O	O	O
6	Evaluation of implications of legal requirements, agreements and codes	O	O	O	O	O
7	Definition of environmental performance indicators for the new product	O	O	O	O	O
8	Definition of environmental objectives for the new product	O	O	O	O	O
9	Generation of “green options” to improve the product	O	O	O	O	O
10	Environmental assessment of green options	O	O	O	O	O
11	Economic assessment of green options	O	O	O	O	O
12	Technical assessment of green options	O	O	O	O	O
13	Including environmental requirements in product profile	O	O	O	O	O
14	Definition of environmental design guidelines for product development	O	O	O	O	O

15	Consideration of environmental implications in manufacturing	O	O	O	O	O
16	Marketing of the product	O	O	O	O	O
17	Communication to clients to minimize environmental impact	O	O	O	O	O
18	Monitoring of new product's environmental performance	O	O	O	O	O

B. Please rate the level of involvement of your department with the project during the development process.

		none	small	regular	large	very large
1	idea generation	O	O	O	O	O
2	concept development	O	O	O	O	O
3	concept evaluation, business assessment	O	O	O	O	O
4	prototype design and development	O	O	O	O	O
5	production process design	O	O	O	O	O
6	product testing	O	O	O	O	O
7	market introduction	O	O	O	O	O

PLEASE CONTINUE TO THE NEXT PAGE

C. What was the frequency of communication between your department and R&D during the product development process

	never	rarely	sometimes	often	very often
1. idea generation	O	O	O	O	O
2. concept development	O	O	O	O	O
3. concept evaluation/business assessment	O	O	O	O	O
4. prototype design and development	O	O	O	O	O
5. production process design	O	O	O	O	O
6. product testing	O	O	O	O	O
7. market introduction	O	O	O	O	O

D. What was the frequency of communication between your department and Environment during the product development process

	never	rarely	sometimes	often	very often
1. idea generation	O	O	O	O	O
2. concept development	O	O	O	O	O
3. concept evaluation/business assessment	O	O	O	O	O
4. prototype design and development	O	O	O	O	O
5. production process design	O	O	O	O	O
6. product testing	O	O	O	O	O
7. market introduction	O	O	O	O	O

E. What amount of information was exchanged between your department and R&D during the product development process?

	none	small	regular	large	very large
1. idea generation	O	O	O	O	O
2. concept development	O	O	O	O	O
3. concept evaluation/business assessment	O	O	O	O	O
4. prototype design and development	O	O	O	O	O
5. production process design	O	O	O	O	O
6. product testing	O	O	O	O	O
7. market introduction	O	O	O	O	O

F. What amount of information was exchanged between your department and Environment during the product development process?

	none	small	regular	large	very large
1. idea generation	O	O	O	O	O
2. concept development	O	O	O	O	O
3. concept evaluation/business assessment	O	O	O	O	O
4. prototype design and development	O	O	O	O	O
5. production process design	O	O	O	O	O
6. product testing	O	O	O	O	O
7. market introduction	O	O	O	O	O

G. How satisfied are you with the (expected) results of the project?	completely dissatisfied	somewhat dissatisfied	neither dissatisfied/ nor satisfied	somewhat satisfied	completely satisfied
1. compliance with environmental regulation	O	O	O	O	O
2. environmental impact beyond compliance	O	O	O	O	O
3. product quality against company standards	O	O	O	O	O
4. achievement of sales objectives	O	O	O	O	O

THANKS FOR YOUR COOPERATION!

Summary

The development of greener products is a crucial element of environmental policy. We need new products like clean and energy efficient cars, low-solvent paints and biodegradable plastics to temper the negative environmental impacts of our activities. This PhD thesis provides more insight in the organization of the green product development process. The researcher has studied the development process of 34 green products from different companies.

What was the motivation to start the development process? Which departments were involved? How were the different ecodesign tasks assigned to these departments and how closely were they co-operating during the process? Who was consulting with the environmental authorities; who was keeping the records on environmental standards? Who was communicating with the client about the changes in the product characteristics? And was the product successful?

The research builds on the literature of environmental management, ecodesign and new product development. Based on this literature the following central research question has been defined:

How, why and with what results do functional departments interact in the context of green product development?

The researcher interviewed the managers of 34 projects to gain insight in the nature and context of the projects, such as the environmental technology applied, the business strategy and the performance of the product. The variety among the projects under study is considerable: from the development of a natural pet food till the development of a cleaner and more energy efficient truck. In most cases the environmental improvements are relatively simple changes in the selection of raw materials with minor impacts on the price and quality of the product.

One remarkable finding of the research is that the environmental departments have very little involvement in the development of greener products. The R&D managers have far more involvement and have an initiating and positive contribution in the process. The marketing manager is also more involved in the development process than the environmental manager. The involvement of the marketer however appears to be related with negative evaluations of the product quality. It seems that the involvement of marketers is more dependant on their concerns over the potential trade-off between product quality and environmental performance.

The literature on new product development has identified communication and collaboration between the functional departments as major success factors, especially under conditions of high uncertainty. If the technology or the consumer requirement are developing during the development process, this does require more consultation between the functional departments than in a relatively stable and predictable environment. The uncertainties surrounding most of the projects in this study appear to have been modest and this may be

part of the explanation for the small involvement of the environmental managers and lack of proof for a positive effect from more intense co-operation with this function.

Another finding in this research is a strong correlation between the level of satisfaction about the product quality and the sales performance. Environmental performance on itself does not sell; the product should also have good quality. In this respect the concerns of the marketing managers may well be understood. But instead of screening the environmental suggestions on the potential trade-offs with quality, it is perhaps more productive to guide the process in an earlier stage in directions where one may expect synergy between functional and environmental quality.

Samenvatting

Voor het oplossen van milieuproblemen is het van belang dat er nieuwe, milieuvriendelijkere producten worden ontwikkeld zoals zuinige, schone auto's, verf met minder oplosmiddelen en biologisch afbreekbare plastics. Dit proefschrift beoogt meer inzicht te bieden in de organisatie van groene productontwikkeling. De onderzoeker heeft van 34 milieuvriendelijke producten onderzocht hoe deze tot stand waren gekomen.

Waarom werd het product ontwikkeld? Welke afdelingen waren bij de ontwikkeling betrokken? Hoe werden de taken verdeeld en hoe intensief werd er samengewerkt? Wie overlegde met de overheid, wie hield wijzigingen in de wetgeving bij? Wie communiceerde met de klant over de veranderingen in de productsamenstelling? En was het product succesvol?

Het onderzoek combineert inzichten uit de literatuur over milieumanagement en ecodesign met inzichten uit de literatuur over productontwikkeling. Op basis hiervan is de volgende centrale vraag geformuleerd:

Hoe, waarom en met welke resultaten werken afdelingen samen in de context van het ontwikkelen van milieuvriendelijke producten?

Voor het onderzoek zijn gesprekken gevoerd met de managers van de 34 projecten om inzicht te krijgen in de inhoud en achtergronden van de projecten, zoals de aard van de milieuverbetering, de strategische overwegingen en de tevredenheid over het resultaten van het product. De verschillen tussen de producten die in het onderzoek zijn meegenomen zijn groot: van het ontwikkelen van een natuurlijk hondenvoer tot en met de ontwikkeling van een schonere vrachtwagen. In de meeste gevallen gaat het bij de milieuverbeteringen om relatief eenvoudige aanpassingen van de gebruikte materialen die weinig gevolgen hebben voor de prijs en kwaliteit van het product.

Een opvallende uitkomst van het onderzoek is dat de milieumanager of de gespecialiseerde milieuafdeling van het bedrijf nauwelijks betrokken is bij de productontwikkeling. Een veel grotere rol is weggelegd voor de R&D-manager, die een positieve en initiërende rol lijkt te spelen bij veel van de projecten. Ook de marketingmanagers is sterker betrokken bij de ontwikkeling van milieuvriendelijke producten dan de milieumanager. De betrokkenheid van de marketing manager lijkt echter eerder negatief en ingegeven door zorgen over de gevolgen van de milieuverbeteringen voor de kwaliteit van het product.

Uit diverse onderzoeken naar de organisatie van productontwikkeling blijkt dat communicatie en samenwerking vooral van belang zijn als er veel onzekerheid is rondom het project. Als gedurende het project de eisen van de klant of de technologie nog kan veranderen is er meer afstemming nodig dan in een relatief stabiele omgeving. Het lijkt erop dat de onzekerheden rondom de milieuinnovaties niet zo erg groot waren en dat is wellicht ook een verklaring voor het ontbreken van sterke betrokkenheid van een milieuspecialist en het ontbreken van bewijs voor het belang van samenwerking met de milieuspecialist.

Een andere uitkomst van het onderzoek is dat er een sterk verband is tussen de tevredenheid over de kwaliteit van het milieuvriendelijke product en het commerciële succes. Wat dat betreft lijkt de zorg van de marketingmanager volkomen terecht. Maar in plaats van alleen de suggesties voor milieuverbeteringen te screenen op mogelijke negatieve gevolgen voor de productkwaliteit, is het wellicht beter om al in een vroeg stadium aan te sturen op milieu-innovaties die ook de kwaliteit van het product verbeteren.

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Curriculum Vitae

Mark van der Veen (1964) graduated in Economics at the Universiteit van Amsterdam. He was director of WIMM (foundation for environmental management research and education) and has been involved in research and training projects for the European Commission, including a study on the economic feasibility of environmental standards for decorative paint and several projects on environmental management in seaports in Europe, Cambodia and Vietnam. In collaboration with KPMG Sustainability he was involved in a number of studies on international trends in corporate responsibility reporting. Currently Mark van der Veen is lecturer in Sustainable Management at the Universiteit van Amsterdam and lector (associate professor) Corporate Social Responsibility at the Hogeschool van Amsterdam. His research and teaching interest include sustainable management, corporate social responsibility, new product development and strategic management.