Chapter 4: EcoDesign and Business

4.1 The first wave of EcoDesign

4.1.1 Design Manuals

In 1993 I started Applied EcoDesign from square one with no knowledge, no know-how, just common sense. Like a paratrooper I was dropped over unknown territory. After surviving the landing, the first thing to do is to get some orientation before the accomplishment of the mission can be started.

Applied EcoDesign turned out to be an activity, a kind of profession at best. For sure it is not a scientific discipline; there were (and there are) no fixed rules or agreed ways of working. In 1993, there were only 'principles' which were interpreted in different ways and therefore could be called 'beliefs'. Moreover, there were (and again are) no standards to measure Applied EcoDesign performance in a business context. At the end of the century Life Cycle Analysis methods got widespread application, but this is basically a methodology and not real science. Moreover it gives a limited description of 'green', both from the environmental and the business perspective (see also chapter 6).

In spite of all this confusion, I had to offer something tangible to the Philips Consumer Electronics. Business is digital, either it is done or it is not done, there is no in between. There is no time for lengthy discussions with all kinds of nuances. Messages have to be presented in a simple form to large audiences of non-experts. Therefore the first version of an EcoDesign Manual was a very simple one. Its mission was: raise awareness, let people set the first steps and maybe most important, avoid the environmental stupidities of the past.

Experiences with this manual were reported by the end of 1994, in the following paper *"Towards sustainable development, the Philips Consumer Electronics experience"*. It shows that the first successful steps for practical implementation had been set. Moreover, several tools to support Applied EcoDesign were in the process of development. What was clearly felt to be missing is the link with the business and in particular the incorporation of 'green' in the product strategy.

Towards sustainable development, the Philips Consumer Electronics experience

Ab Stevels

1. Introduction

Environmental issues have been addressed by the industry now for some 25 years. Process oriented environ¬mental care has been put into operation and nowadays programmes to control emissions into the air, water and soil are implemented with increasing sophistication.

Environmentally oriented product development (EPD) has received attention only recently. In the last five years analysis of environmental impacts from the "cradle to grave" of products have begun. Particular reference is made to the use of resources (materials, energy) while issues regarding end-of-life and re-use in any form get substantial attention.

A basic consideration is that EPD should be sustainable, i.e. that production, use and the end-of-life of products should not hamper the well-being of future generations.

There are various types of environmentally oriented product development (EPD):

I. Operational EPD

This considers

- materials, including type, quantity of use, and hazardousness
- materials functionality
- energy consumption
- interconnection/disconnection, end-of-life aspects

II. Strategic EPD

This considers - alternative functionality

- logistics, distribution
- life time of product, repair
- re-use (in any form)

III. Managerial EPD

This considers - integration of EPD in business management

- integration of EPD in procedures for product definition, creation and release
- manuals and their implementation
- internal and external communication

The basis for EPD is Life Cycle Analysis which makes an inventory of environmental effects and classifies them. In this way Eco-profiles of the products concerned are generated. Philips Consumer Electronics has been engaged from the very beginning in the various forms of EPD. In the chapters below progress in the field is reported and outlook for the future is discussed.

2. The Environmental Design Manual

The basic instrument for moving towards sustainable product development is the Environmental Design manual. It essentially serves two purposes:

- to give general background and information on environmental issues relevant for the Consumer Electronics industry.
- to give a survey and consolidate environmental directives.

There are three types of directives

I Mandatory directives. Non-compliance with such directives is not acceptable, will stop further development and release procedures until remediation

II Directives. Non-compliance is only acceptable with good reasons, to be endorsed by management.

III Recommendations

Directives in all classes apply globally, i.e. irrespective of location of development and production sites. The status of directives (class I, II or III) depends on legislations/regulations and (pro-active) Philips policy.
Following aspects are considered in the environmental design manual:

1. Environmental policy and organization
2. Release status of components and materials
3. Power consumption
4. End-of-life
5. Packaging
6. Marking, labelling, customer information
7. Purchasing
8. Production operations
9. Environmental design evaluation

3. Implementation of the Environmental Design Manual

The design manual, as described above, has been written by environmental specialists in a small central group of the Product Division. The same people are in charge of the implementation and the development of supporting tools. Environmental managers in the Business Groups support this process and adapt it to their specific needs.
Kick-off efforts for the implementation of the manual are done through training courses on the spot. One or more products developed/manufactured at the location have been chosen as the carriers. This speeds up the actions of the first level of implementation, which aims at creating awareness and helping the organization to know where it stands with regards to the environmental aspects of their products.
For the second phase improvement actions are formulated on the basis of the issue list resulting from phase 1. In the end full compliance with the manual (as regards all directives of class I, II and III) is to be reached.
Presently, the Environmental Design Manual has been introduced in most locations of Philips Consumer Electronics.This means:

- in various businesses (TV, audio, video recorders, car systems, monitors, business electronics)
- in various disciplines (predevelopment, development, purchasing, production, marketing & sales).
- in various cultural settings around the globe.

There are three critical success factors:
-Integration of the environmental manual in standard procedures and practices. We have from the very beginning chosen for integration rather than environmental issues as a special item: practice shows that we are right.
- How to set priorities. Introduction of a design manual also is a cultural process. It takes time, you cannot turn 'green' overnight. Having success with the first items selected is crucial for the follow-up.
- Insight into cost consequences. Most people think that environmental matters only cost money and cannot bring money. There is still a substantial job to be done to change this mindset.

These matters will be illustrated by various examples.
The process of implementing the manual has also shown that its systematic approach yields a lot of improvement options. A lot has already been gained; there still is a lot more to be gained before limits set by the required functionality of the products - i.e. by the physics, chemistry and electronics to achieve these - are reached.

4. Environmentally oriented product strategy

The environmental design manual, as described in the preceding chapters, chiefly deals with operational issues. Current products are addressed, the catchphrase is "do it better than you did before."
Tools include:

- Chemical content data bank. Eliminate the legislated substances, bring down the amount of environmentally unfriendly materials.
- Design evaluation method. Score higher marks on an LCA oriented scale (above release threshold).
- Packaging assessment. Bring down packaging weight/product weight ratio. Score above release threshold.
- End-of-life cost. Keep end-of-life cost/cost price ratio below certain limit.

Such tools help the manual to operate better and better.
The Consumer Electronics industry still is at the very beginning in developing advanced environmentally oriented product strategies. This is a complicated process in which a large number of often unknown parameters have to be assessed, e.g.
- current products with alternative products for which still a lot of research and predevelopment is to be done.
- life time extension versus refurbishment concepts.
- logistics for sales and take-back.
- sale versus lease concepts.
- scientific (LCA based) 'green' versus customer perceived 'green'.
- chain management issues.

A common denominator in all these matters is the Life Cycle Analysis. Apart from its complexity and its subjective valuation of the Eco-profile results fail to connect properly with the approach in business terms.
An interesting concept therefore is the so-called Life Cycle Cost (or SEED = Support of Environmental Economic Decisions) concept. This methodology gives a description in monetary terms of all cost elements of a product (from "cradle to grave") which refer to non-renewable resources in particular, with reference to material use and energy use.
Such a description allows easy comparison with other business data like cost price, investment, depreciation etc. Easy application will be found in making choice of materials a priority, setting of development programmes, design evaluation and assessing new concepts/alternatives.
A key issue is the extent to which LCC (SEED) correlates with LCA. In a market economy such a correlation is estimated to be (fairly) high, since e.g.
- scarce materials are expensive
- energy use has to be paid for
- waste has to be paid for.

Research and practical tests will be needed to develop such systems. Progress in these matters is urgently needed to make further breakthroughs towards sustainable development.

Personalities, 4

Jacqueline Marian ('Jacqueline') Cramer: radical and realistic

Jacqueline taught me that you should have ideals and be radical in pursuing them, but also that when necessary you should go back to reality and come to practical compromises and solutions.

In the early years in the Ecodesign world, such ideas did not exist. It was a dogmatic world with principles, design rules and strict paradigms, it was almost a religion or at least a set of 'Ecobeliefs'. Jacqueline turned out to be determined but not absolute in her thinking. Soon after I met her for the first time she was hired by Philips Consumer Electronics to enhance 'green' operations, particularly in the product creation processes. She did it - her 'STRETCH' approach laid the basis for radical 'green' innovation in 1995-1997 (see also chapter 4.1). We discovered that the success of this approach depended on how well you manage the boundary conditions. It was the origin of ideas about business integration (see chapter 4), the Ecodesign matrix (see 4.2) and of social issues in sustainability as well.

I very much enjoyed the discussions I had with her. Again, we had different views on society and the world and a different perception of what companies should achieve. 'Amsterdam versus province'. What brought us together at the end of most debates was action, 'do something practical, stop intellectualizing the subject, do something sensible'.

Appointments with Jacqueline always seemed to involve a mix-up. Either the train was late, or there was misunderstanding about the time or the location.

The offices where she used to work at TNO in Apeldoorn were a maze. Gatekeepers there treated you like a criminal and did not point out where to go. I couldn't even find the front door of the building she was working in.

After some fifteen minutes I finally found a backdoor, bewildered I entered her room!

The 'Cramer' Walk: start from Arnhem Central Station, follow the Sonsbeeksingel, enter the Sonsbeekpark at the Daalseweg ahead of you. Keep at left in the park and walk as you like – best is to cross the Parkweg and to include 'Zijpendaal' in your itinerary (you can even walk from there to the Zoo).

4.1.2 Product planning

Apart from discussing the impact and conditions for the success of implementing EcoDesign Manuals, the following paper also flags up the need to put Eco-activities into a wider perspective, which is called Environmentally Oriented Product Strategy and later renamed Strategic 'Green' Product Planning. Outside help was needed to develop this type of planning in such a way that it fit into the operations of Philips Consumer Electronics (at that time still called Philips Sound & Vision) and maintained a clear 'green' focus. Outside help was needed to achieve it and this was provided by Professor Jacqueline Cramer (see also personalities, 4). She was hired for this job and the effect was a tremendous win-win. The Philips environmental activities gained in strategic strength and gathered momentum at the CE Executive Board level. Jacqueline's academic perspective was severely tested from a practical perspective and thus was strengthened.

The results of this cooperation were amazing:

- The four levels of EcoDesign, later well known globally by publications of Brezet et al., were identified for the first time.
- The concept of (radical) environmental brainstorms to be consolidated ('back to reality') in product concepts was generated and practiced in this period.
- Jacqueline Cramer's approach to 'green' product planning was explained in a page hand book called STRETCH (Selection of sTRategic EnvironmenTal Challenges)

A summary of these activities is given in the following publication *"Strategic Environmental Product Planning within Philips Sound & Vision"*.

Strategic Environmental Product Planning within Philips Sound & Vision

J.M. Cramer and A.L.N. Stevels

Until now no structured methodology existed for attuning environmental considerations to the business strategy of companies. The Environmental Competence Centre of Philips Sound & Vision in The Netherlands has developed and tested a methodology for this purpose. This methodology, called Se-lection of Strategic Environmental Challenges (STRETCH), has proven to lead to promising results and should therefore be actively promoted. In this article, the authors show how the application of STRETCN provides the possibility of meeting three main objectives: First, focusing on the incorporation of environmental aspects into the company's business strategy can elicit innovations that may enhance the competitive position of the company by cost reduction and/or higher market shares. Second, the environmental opportunities and threats to be expected in the future can be anticipated in an earlier phase. Through this proactive approach a company can amid external criticism and take the lead in environmental priority set- ting. Third, by applying the STRETCH methodology even higher eco-efficiencies are expected to be reached than through incremental, step-by-step environmental improvements.

Achieving sustainable development presents an enormous challenge to society. It means that within just a few decades we must learn to deal much more efficiently with energy and raw materials. According to some estimates, within the next 50 years the burden on the environment will have to be reduced to an average of one-tenth of the current levels (this means an increase in eco-efficiency by a factor of ten) in the highly industrialized, Western countries. As a first step in this direction, Von Weizsacker, Lovins, and Lovins promote an increase in eco-efficiency by a factor of four (this means one-quarter of current levels). In order to reach this target, co-efficiency improvements will have *to* be made at four different levels:

1. Step-by-step improvement of the offering of present products (the most relative form);
2. Radical redesign based on existing concepts;
3. Product alternatives (other concepts or replacement of products by services); and
4. Design for the fully sustainable society (the most absolute form).

Initiatives have already been taken within the industry to increase the average eco-efficiency of products. Most of these efforts focus on step-by-step, cost-effective environmental improvements of existing working methods, products, and services within a time scale of one to three years. Various techniques and methodologies have been developed to analyze and assess the environmental merits of such product improvements related to level 1.

Incremental improvements provide significant progress in the early stages by capitalizing on "low-hanging fruit" (the easy improvements). After that first period, incremental changes become less profitable in terms of both economic and ecological efficiency. Then, more far-reaching environmental improvements begin to deliver a higher reduction in environmental impact at relatively lower costs. These latter improvements usually require more fundamental, strategic choices both in the techno-economic and cultural senses. However, focusing on such more far-reaching environmental improvements can elicit innovations that may enhance the competitive position of the company by cost reduction and/or higher market shares.

If one wishes to reach the target of a tenfold increase in the average eco-efficiency mentioned above, more far-reaching improvements related to levels 2, 3, and perhaps even 4, are therefore necessary. Contrary to incremental improvements, relatively little experience has been gained within the industry with the implementation of such product improvements. At Philips Sound & Vision more and more attention is being paid to these more far-reaching improvements under the heading of "strategic environmental product planning." Experience is being built up, especially in environmental product improvements at levels 2 and 3.

For the design for the fully sustainable society (level 4), no comprehensive concepts are available yet. Rather than concentrating on this most absolute form of sustainable development, Philips Sound & Vision has chosen to focus on those matters which can be realized now. The philosophy is: Let's first learn to walk, then start running and, after a lot of training, we will finally be able to win the marathon.

This article will report on the way that Philips Sound & Vision has set up its strategic environmental product planning and how involvement has been created across the organization. After an introduction to the history of the

environmental policy developed by Philips Sound & Vision, a methodology will be presented on how to cope with strategic environmental product planning. This methodology, developed at Philips Sound &Vision, will be illustrated using a number of practical examples. The article then reflects on how strategic environmental product planning can be structurally integrated within the business. In a concluding paragraph, the application of this strategic approach is evaluated in terms of the merits both for the environment and the business itself.

The Environmental Policy of Philips Sound & Vision

Philips Sound & Vision is part of the Philips Sound & Vision Business Electronics division. This division is one of the eight divisions of Philips Electronics. Philips Sound & Vision consists of three business groups: BG TV, BG Audio and BG IR3 (VCR). Every BG has its own environmental coordinator, and most industrial facilities have also appointed an environmental coordinator. The Environmental Competence Centre (ECC) was established in the early 1990s to coordinate environmental activities within the whole Sound & Vision/Business Electronics division. The Environmental Competence Centre cooperates closely with the Corporate Environmental & Energy Office (CEEO) at corporate level. Philips's corporate environmental strategy is based on a series of initiatives at both corporate and product division (PD) level and aimed at ensuring that the company's environmental policy is properly implemented.

In 1991, the former CEO of Philips, Mr. Timer, formulated eight environmental objectives to be achieved:

Corporate projects: Setting operational target5

- Implementation of certifiable environmental management systems (according to the BS **7750** and IS0 14001) by the year 2000.
- 25 percent reduction in energy consumption by the year 2000.
- 15 percent reduction in packaging materials by the year 2000.

Product division programs: aimed at improving products and the exchange of information

- EcoDesign, as an integral part of the product creation process.
- Communication strategy.
- External lobby.
- Internal network.
- Supplier requirements.

Besides the reduction of energy consumption and packaging materials, the implementation of the IS0 14001 standard and related items in the IS0 14000 series forms a major spearhead of the corporate environmental program. Philips is preparing all of its 250 plants in 60 countries for IS0 14000 certification by the year 2000 through a hands-on training program. The objective of this training program is to develop a list of what the factory is doing right, along with a list of what still has to be done for the plant to be certified. Philips Electronics's CEEO coordinates these activities.

Ultimately, at PD level the eight environmental objectives have to be implemented. Every division, including Philips Sound & Vision, has built up experience in the environmental field since the 1970s. In the 1970s and 1980s, the emphasis in the environmental policy of Philips Sound & Vision was on incremental improvements, especially in its production processes. The major driving forces behind this were legislation and regulation, and the associated rules concerning licensing. Since the early 199Os, the focus has widened to encompass improvements in the consumer electronics products themselves. An initial driving force for this was the corporate environmental policy formulated by Mr. Timmer. Another reason was the growing public pressure to find socially responsible ways of disposing of used consumer electronics goods. Additional factors were the (professional) customers' requirements with respect to the use of certain chemical substances and the short-term cost-effectiveness of some environmental improvements (e.g., through material saving, application of recycled material).

In recent years, Philips Sound & Vision has initiated numerous activities to improve its products from an environmental perspective. A manual on environment-oriented product development ("eco-design") has been produced for designers. The manual includes mandatory environmental requirements for design, and voluntary guidelines

to stimulate creativity for eco-design. For instance, a major project is being carried out to reduce the number of environmentally harmful substances in consumer electronics products. One example of this is the decision to stop using flame retardants in the plastic housing of televisions (which, in contrast to other brands; has been the case with Philips televisions since 1987). In addition, the manual contains guidelines concerning the best ways of designing consumer electronics products so that they can be reprocessed in environmentally sound ways at end-of-life. Training programs and workshops are organized to transfer environmental expertise to those responsible for product development. All these activities have taught the organization that environmental improvements can lead to a win-win situation, in which business opportunities can also be created.

Based on this learning process, Philips Sound & Vision is now turning attention to more far-reaching and complex solutions, aimed at radical redesign based on existing concepts and at product alternatives (level 2 and 3 improvements). In that context, it has developed the concept of the "green television," which incorporates all the accumulated environmental know-how of the moment. This concept will be used as a measurement for future generations of the product.

After gaining some experience with the design of these more far-reaching environmental product improvements, the company recognized the need to structure the way that decisions about strategic environmental product planning were prepared. No guidelines or rules of thumb existed for determining how to select promising environmental opportunities. The question arose of how the company could systematically elaborate its strategic environmental opportunities and decide which ones to take on board. Until recently, this had not been a prominent issue at Philips Sound & Vision.

Thus, originally the business strategy to be followed by Philips Sound & Vision was relatively simple: a defensive strategy in order to meet existing environmental regulation and covenants, or a cost-reduction strategy aimed at improving the environmental performance in a way that realized short-term cost savings. However, the strategy became more complex as Philips Sound & Vision began to introduce more far-reaching environmental improvements. The growing interest in this latter type of product improvements went hand in hand with the adoption of a third strategy. This latter strategy aimed at a more competitive market position through increasing its market share and improving its public image. Identifying promising environmental opportunities and selecting those options turned out to be much more complicated in this case. It required clear strategic choices with regard to the environmental issues that it wants to boast in the market. Not only Philips Sound & Vision but also most other companies had little experience with such a strategy.

The STRETCH Methodology

To generate and select green opportunities a methodology called Selection of Strategic Environmental Challenges (STRETCH) has been designed and tested at Philips Sound & Vision. The basic questions that needed to be answered were: What opportunities or threats does the environmental issue present for a company such as Philips, particularly for Sound & Vision? What technological options are available for dealing as adequately as possible with environmental problems? And finally, the most crucial question: *Which environmental opportunities should be selected to enhance the business and improve the environmental performance* of *its products?*

In order to address these questions, data are needed on the key drivers that will determine the future business strategy in general. For instance, in the case of Philips Sound & Vision the collection of data consisted of information about economic factors (i.e., future market perspectives of the consumer electronics sector in general and of the company itself) and the technological innovations to be expected. Moreover, some information was needed about cultural trends and the possible set of environmental issues at stake in the future. On the basis of this information, a limited number of plausible scenarios can be formulated relating to possible future product market strategies. These scenarios are used to help prioritize, select, and finally implement the most promising environmental challenges to be adopted by the company.

The STRETCH methodology consists of the following five activities:

Step 1: the identification of the crucial driving forces that will influence the business strategy in general;

Step 2: the design of a limited number of plausible scenarios that 1, leading to a list of potential product market strategies; the company can adopt on the basis of step

Step 3: the specification of potential environmental opportunities and threats for each scenario on the basis of a checklist of environmental design options;
Step 4: the selection of environmental challenges per product leading to a substantial improvement of its environmental performance (in the order of magnitude of a factor of 4);
Step 5: the implementation of the environmental challenges ultimately selected.

Step 1: Identification of crucial driving factors

The kind of data to be collected about the key drivers determining future business strategies in view of environmental issues largely depends on the industrial sector at stake. Within larger companies, a specific key group often works on strategy development and assists management in strategic decision making. These key people use various sources, techniques, and methods to acquire insight into the technological trends and the present and plausible future market position of the company in relation to its competitors. They are crucial sources of information and can provide relevant documents and oral information. Moreover, additional information and viewpoints should be collected through literature and interviews.
Information about future cultural trends can be acquired via specialized trend labs that systematically monitor changes in consumption patterns and cultural preferences. Key experts in assessing future societal trends can also be interviewed. For companies producing end products in particular, information about future cultural trends, together with focused marketing research per product, forms an important ingredient of their market strategy.

Step 2: Design of plausible scenarios

The information collected in step 1 is then to be interpreted in a time scale of one to five years (or beyond, depending on the particular strategy of the company). A useful instrument for doing this is the method of scenario analysis. Larger companies often analyze their future market perspectives with the help of sector scenarios. A scenario is not a prediction, but a systematic way of thinking effectively and creatively about the future. It is an instrument for designing views of plausible future situations in which decisions will work out. Sector scenarios generally consist of the following steps:

- Identify uncertainties in the sector (e.g., number of competitors, strategies of parties, new products, cost structures, demand level, and environmental pressure on society).
- Determine factors that cause these uncertainties (e.g., technological changes, users' needs, innovations, government policy, and competition].
- Formulate assumptions about the main causal factors.
- Compose a limited number of consistent scenarios.
- Describe the possible consequences of each scenario for the sector.
- Formulate the kinds of competitive advantages (e.g., operational risks, feasible profit margins, investment needs, and growth in turnover).
- Formulate possible consequences for competitive behavior (e.g., price and cost strategy, differentiation).

With the above procedure, companies can anticipate future threats and opportunities, taking into account their own weaknesses and strengths. Due to the many uncertainties involved in this process, the development of a limited number of plausible scenarios can help in selecting the ultimate business strategy. On the basis of these sector scenarios, companies are able to derive their own long-term strategic planning (including promising product market strategies).

Step 3: Specification of potential environmental opportunities

In this third phase, the crucial choice is made on the initial selection of promising environmental challenges. In order to make this selection, the product market strategies developed in step 2 should be related to potential environmental threats and opportunities.
The particular environmental issues which will be headline news in the coming five years, or even beyond that, cannot be predicted with great precision. The ECC of Philips Sound & Vision has therefore developed a general

checklist of environmental product design options that serves as a guideline for prioritization (see **Exhibit 1).** This checklist has been compiled on the basis of various sources.

This checklist of environmental design options can serve as a tool to assess the environmental challenges at stake when a company implements the product market strategies formulated in step 2. The central question to be answered is how to substantially improve the company's environmental performance and at the same time improve its competitive edge in the market.

To generate creative ideas brainstorming sessions can be a valuable instrument. These brainstorming sessions are preferably held first at PD level in order to gain a bird's eye view of promising environmental strategies at division level. To specify the most promising environmental design options at this level the support team should be organized from key persons from within the organization (for example, representatives of strategy development, product management, marketing, and the environmental department).

Exhibit 1. Checklist of Environmental Design Options

Minimization of production impact
- Minimization of waste, emissions, and energy use
- Respect for biodiversity

Minimization of product impact
- Reduction of toxic substances
- Minimization of materials consumption (e.g., through miniaturization, weight reduction, systems integration)
- Minimization of use of non-renewable resources
- Minimization of fossil energy consumption (e.g., through energy efficiency and durable energy use)

Efficient distribution and logistics
- Produce where you consume
- Direct distribution to consumer

Intensity of use
- Lease vs. sell
- Collective use

Durability of products
- Reuse
- Technical upgrading
- Longer lifetime
- Reparability
- Refurbishing
- Aging with quality

Recyclability of materials
- Reduction of materials diversity
- Materials cascading
- Design for disassembly
- Selected, safe disposal

Step 4 Selection of environmental challenges per product

In step 4, the preliminary choices of the most promising environmental design options made at division level should be discussed with the various Business Groups (BGs) or Business Units (BUS). In the end, each BG or BU needs to select its own priorities and further elaborate the most promising environmental challenges.

In principle, there are two ways to proceed at BG/BU level. The quickest way is to review the environmental design options initially selected at division level and pick out those options that are most relevant for that particular BG/BU. Next, focused brainstorming sessions can be organized to elaborate each option in great detail, together with relevant specialists. The results of these sessions can be translated into R&D and/or concrete product development plans.

The second, more time-consuming way, is to organize an intensive brainstorming session per product. In this case, one does not take the initial selection at division level as a starting point for further elaboration but just as an initial input for the brainstorming session at product level. During such a brainstorming session, which usually takes about two days, all environmental design options are taken into account one after the other. The result will

be a well-underpinned list of creative options to enhance the business through specific environmental challenges. Depending on the product at stake, specific representatives from the organization can be asked to attend the brainstorming session. These can be marketing people, product managers, and technical people, However, other stakeholders, key suppliers, or customers can also be involved in specific issues. After the brainstorming session, the most promising ideas need to be further investigated in the form of projects with the help of specific experts from the company. Small experiments can also be set up to test the economic viability of specific strategies.
In principle, the brainstorming sessions organized at BG/BU level should be prepared by collecting key data about the product and its market and technological perspectives and the environmental performance of the present product.
One of the first companies to try structuring brainstorming sessions aimed at eco-efficiency improvements by a factor of 4 is Dow. The way in which this company designed the brainstorming process has been an inspiring example in developing our own methodology at Philips Sound & Vision and is now being used at Philips also.

Step *5:* Implementation of those environmental challenges ultimately selected
On the basis of the step 4 results, management should decide on the environmental challenges to be implemented in the organization. The management should select those opportunities that seem promising both from a marketing/economic and an environmental perspective. After this selection, each strategy requires its own implementation trajectory (at Philips called "roadmap"), depending on the kind of improvements to be made.

Application of the STRETCH Methodology within Philips Sound & Vision
The STRETCH methodology described above has proven to be of practical use at Philips Sound & Vision. After collecting and integrating available data (steps 1 and 2 of the methodology) the ECC of Philips Sound & Vision identified a number of promising environmental strategies (step 3). To prioritize these strategies, the ECC organized brainstorming sessions with representatives of various key persons at Philips, namely representatives of strategy development at the Sound & Vision division, representatives of Philips Corporate Design and environmental experts from the Sound & Vision division.
This group of people then formulated a number of criteria to guide the process of prioritization. These criteria were:
1. Environmental improvements should preferably provide a business opportunity or competitive advantage.
2. Projects should have clear environmental relevance.
3. Environmental improvements should preferably be quantifiable.
4. Environmental problems directly related to health and safety issues require more attention.
5. Implementation should not be hampered because of difficulties in cooperation with third parties or because of lack of expertise within the company.

With the help of the criteria mentioned above, the brainstorming group made an initial selection of promising projects. This led to the selection of nine projects for further investigation. These projects are related to the following technological options:
- minimization of raw materials, toxic substances and energy consumption;
- further increase in material recycling;
- optimizing the life of the product (e.g., by recycling the product of components, technical upgrading);
- improving the efficiency of distribution of the product;
- finding alternative ways of performing the present function of the product.

The environmental coordinators of each of the three main BGs within the Sound & Vision division were asked to select projects that were considered relevant for their BG. Each BG selected five projects. Together, the BGs covered all nine projects. Within the framework of each project, brainstorming sessions were organized with relevant persons from the particular BG, including product managers, marketing people, and technical experts. Although the general approach of the ten projects was similar, the elaboration of each topic was tailor-made to each BG

and each project. Let us illustrate this point on the basis of the following three examples:

- The reduction in the energy intensity of Consumer Electronics products;
- The reduction of the material intensity of Consumer Electronics products;
- The development of potential strategies to enhance the durability of products.

With respect to the item "reduction in the energy intensity," an intensive brainstorming session was held in the BGs TV, Audio, and VCR in order to generate and select more far-reaching environmental improvements in the energy consumption during use and standby. As improvements could be made in various parts of the product (e.g., in the components or in the printed circuit board), experts from various backgrounds were present at these workshops. The options that these experts proposed are currently being elaborated in a technical, economic, and marketing sense.

Secondly, "the reduction of the material intensity of Consumer Electronics product" was also elaborated in a specific way. In order to generate options for the reduction of material intensity, close cooperation was established between Philips and one of its main suppliers of materials. Various brainstorming sessions were held to identify promising alternative materials that are lighter, but at the same time have the appropriate functionality for fulfilling the demands on the product. The results of these brainstorming sessions are currently being elaborated in R&D projects.

The project related to "the development of potential strategies to enhance the durability of products" was elaborated in a slightly different way. First, a summary of the potential options for optimizing the life of products was made on the basis of a literature survey. Next, the capability of Philips Sound & Vision in meeting these options as a way to achieve further optimization of the life of its products was assessed. At this stage, it was found important to gauge the view of the outside world on this matter. To this end, Philips Sound & Vision's ECC in The Netherlands organized a brainstorming session with external stakeholders that was attended by 15 representatives from environmental, consumer, and women's groups, from the Ministry of Housing, Physical Planning and the Environment, and the Ministry of Economic Affairs, from relevant research institutes and from Philips.

The participants at this session were asked which five (not more) activities they thought Philips Sound & Vision should give the highest priority in the context of the theme of "optimizing product life."

The reactions of the participants suggested a clear prioritization. Particular attention was given to the following topics:

- Making more robust constructions.
- Designing modular constructions.
- Selling the use of products/leasing.

These results were presented in brainstorming sessions with the BGs Audio and VCR. Establishing which additional methods stand a good chance of success in the future of Philips Sound & Vision is currently part of further internal consultation and investigation. Initial results show that products usually break down due to thermal problems (too high temperature) or defective components or joints. Only after more information has been gathered on the various advantages and disadvantages of improving the durability of the products will Philips take concrete action.

The three examples clearly show that it usually takes a number of brainstorming sessions and specific R&D initiatives before a final assessment is made of the most promising environmental opportunities to be implemented. Through these sessions and specific projects, learning experiences are built up that are used to reduce the present uncertainties about environmental opportunities and market perspectives. When the company has learned more about these more far-reaching environmental improvements, it becomes easier to integrate these endeavors into the regular product development process.

The Structural Embedding of Strategic Environmental Product Planning

The selection of promising environmental challenges, as described above, is one of the two main pillars of strategic environmental product planning. The other pillar concerns the structural embedding of this endeavor within the

organization. In practice, this is an even harder job than identifying and selecting strategic options. It requires a strategic way of thinking about environmental issues within the organization, especially at senior management level. In fact, it requires environmental issues to become an integral part of the strategy development and marketing of new products. Achieving this involves a process of cultural and organizational change that takes time.
Within Philips Sound & Vision, integration of this kind is also a new phenomenon. In the past, major attention was focused on incremental environmental improvements that were usually made at the operational level. Now that more far-reaching environmental improvements are at stake, the time scale involved has been extended one year to one to five years (and even beyond that). As a result, these improvements require decisions at strategic company level.
The implementation of this strategic approach can be successful only if the environmental aspects are incorporated into the process of product planning as a structural component. Companies usually structure this whole process, from generating to ultimately realizing new products, in a more or less similar fashion. During all phases of this so-called "product creation process" environmental aspects can play a role. Roughly speaking, the following five phases can be distinguished:
1. Generation of first ideas of the new product.
2. Design of drafts of the new product.
3. Proposal of the new product concept.
4. Design and engineering of the new product concept.
5. Development, manufacturing, evaluation of the new product.

At Philips Sound & Vision the product creation process is divided into two main phases: first, the strategy & planning (including "know-how" planning) phase and, next, the product realization process (from concept start to commercial release).
In the first phase, a product/marketing strategy is formulated, and the architecture and standard design planning is derived from this strategy. In the second phase, various quality controls and validation procedures are carried out by implementing numerous go/no-go decisions. Each step in the product realization process must conform to a set of standards and release criteria before the next step can be made. In this second phase, major changes in the product design cannot be implemented. Such decisions need to have been made in the first phase.
In the context of the structural embedding of STRETCH three major actions should be undertaken. The first action at Philips Sound & Vision was the integration of environmental goals into an early phase of the product creation process. Although it may seem simple to do, it requires enormous effort to promote this integration within the existing organization.
First of all, the written procedures already in place should be evaluated with regard to environmental aspects. Where necessary, these procedures should be reformulated in order to incorporate the environmental items to be taken into account. This requires cooperation between the various people responsible for such procedures. At Philips Sound & Vision various interviews were held to explore the way in which environmental aspects can be incorporated into the written procedures. As this division was in the process of restructuring the procedures of the product creation process in the context of the so-called "SPEED" project, the environmental aspects were included in this procedure. This led to the incorporation of environmental aspects in all phases of the product creation process.
After having incorporated environmental aspects into the written procedures, the next step is to deploy the environmental responsibilities. This process, currently taking place, is the most difficult part of the integration process. It requires people at various levels within the organization to take environmental aspects into account. This often involves substantial cultural changes to the way people think and act. Changes of this kind take time. A second action to be undertaken is the incorporation of the above procedure into the environmental management systems-ISO 14001 and related items in the ISO 14000 series. Until recently, the environmental management system BS 7750 had a common primary focus on procedures to reduce the emissions of individual plants through process improvements. The integration of environmental issues into product design strategies has received limited attention.
With the current replacement of BS 7750 by the international standard on environmental management systems-

IS0 14001 and related items in the IS0 14000 series-this situation will change. More than the BS 7750, the IS0 14000 series stresses the importance of product-oriented objectives and auditing tools and product-oriented support tools (e.g., lifecycle assessment). Therefore, Philips expects that the implementation of the IS0 14000 series will provide a good framework for environmental product improvements. However, adoption of the standard will not in itself guarantee optimal environmental outcomes.

At Philips, the CEEO is presently elaborating the IS0 14001 standard in such a way that the standard is well suited to the Philips' context. Within the organization a specific quality system already exists, called Philips Quality Assessment (PQASO). Within this particular system of PQA 90 the IS0 14001 standard will be included.

A final action to be undertaken in the context of the structural embedding of STRETCH concerns the attuning of the selected environmental challenges to the general marketing strategy of the company, In order to bring about these challenges, a fundamental change is required in the company's marketing strategy on the environment. The ompany needs to adopt an aggressive strategic attitude. This is quite different from following a defensive strategy tchat is designed to comply with all the relevant environmental legislation and regulations. A direct cost-reduction strategy that focuses mainly on measures that provide short-term solutions is strongly supportive but not the heart of the matter. A company that wants to introduce more far-reaching environmental measures derived from STRETCH must make strategic choices as to how the company wants to strengthen its market position by means of a better green profile than its competitors.

Philips Sound & Vision as well as most other companies have hardly gained practical experience with such an aggressive strategy. Exceptions in this respect have been market entrants with market-shaping strategies. They profile themselves from the start as environmentally responsible companies. Good examples of the latter (outside the area of consumer electronics) are companies such as Ben and Jerry's ice cream and the Body Shop. Most companies that have already built up a particular image and tradition have more difficulty in adopting an aggressive environmental strategy. Such companies cannot just change their deeply rooted image, culture, and knowledge overnight for the sake of the environment.

The Sound & Vision ECC has recently started to set up the activities necessary to develop an adapted marketing strategy within the framework of STRETCH. This environmental strategy aims for:

- average to good performances right across the board in the environmental field;
- ensuring sufficient compliance with environmental regulations (in the fields of products and process);
- where possible, yielding money directly from environmental activities;
- outlining a specific marketing strategy, both internal and external, for those environmental items with which Sound & Vision wishes to project a positive image, and converting this strategy into a real marketing and PR strategy in conjunction with the marketers and press officers.

Conclusions

Until now, no structured methodology existed for attuning environmental considerations to the business strategy of companies. The Philips Sound & Vision Environmental Competence Centre has developed a methodology for this purpose. This methodology is called STRETCH (Selection of Strategic Environmental Challenges). The objective of STRETCH is to incorporate environmental considerations into the business strategy and select strategic environmental challenges in an early phase of business development.

The application of STRETCH provides the possibility of meeting three main objectives:

First, focusing on long-term environmental product design strategies can elicit innovations that may enhance the competitive position of the company. Through the integration of eco-efficiency goals into product innovation in general, a company does not aim to beat the competitors purely on environmental grounds, but on its innovative product strategy in general. In this way, economy and ecology can go hand in hand.

By taking environmental aspects into account at an early stage of product development, more far-reaching improvements can be made in future consumer electronics products compared with the current range of products. The first strategic environmental efforts, like those taken by Philips Sound & Vision, are still more the exception than the rule. This approach, however, could provide a way fomard to substantial improvements in eco-efficiency.

Second, the environmental opportunities and threats to be expected in the future can be anticipated in an earlier

phase. Through this early warning system, an attempt can be made to diminish the negative consequences in an early stage and a response will not be required when it is actually too late. In this way actions are more proactive rather than defensive.

Thus, the company can even be one step ahead of all kinds of government demands and public pressure by redirecting product development in the context of sustainability in a more fundamental way. By proactively integrating environmental aspects into the earlier phases of the product creation process, external criticism can be avoided and the lead taken in environmental priority setting.

Third, as a result of more far-reaching environmental improvements even higher eco-efficiencies are expected to be reached than through incremental improvements. At this stage, the exact data on eco-efficiency gains to be realized within the nine strategic projects currently being carried out at Philips Sound & Vision cannot be provided; these will be collected during the execution of the projects.

On the basis of the STRETCH methodology, Philips Sound & Vision has prioritized nine projects for further investigation. Through the performance of these projects, learning experiences are built up that can reduce present uncertainties about the environmental opportunities and market perspectives. Once the company has learned more about the more far-reaching environmental improvements, it becomes easier to integrate these endeavors into the regular product creation process.

From initial experiences with the application of STRETCH within Philips Sound & Vision, we learned that environmental objectives can be attuned very well to the business strategy. We are convinced that the promotion of this method within the organization can lead to a win-win situation, in which business and environmental improvements can go hand in hand. Moreover, we learned that the implementation of environmental challenges is not only the task of product development departments but of the whole business.

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Rituals and habits, 4

Eh, eh, eh

One of the great things at Industrial Design Engineering is that the graduation is individual (see also Rituals and Habits, 3). Part of the exam is that the candidate has to give a presentation about his of her graduation project. It is an important part; if you have good results but you are not able to communicate them to the outside world, this is a serious problem later on in professional practice.

Forty-five minutes are allotted for the presentation. Finishing in less time is not encouraged, using more time could mean that you cannot express yourself in a clear and crisp manner. Rehearsing before can be done with friends and fellow students but not with mentors. At this stage of the graduation project their earlier help is now being judged.

A lot of prospective candidates make a good show of their presentation, some struggle. There is one thing which is very common amongst all the presentations: almost everyone says 'eh' with a frequency ranging from near to zero up to 3 times per minute. Experience shows, that the amount of eh's cannot be correlated with the strength of the presentation. What is relevant however is the frequency distribution. When candidates have not memorized (parts of) their speech or have difficulty in explaining an item, the 'eh' frequency goes up, sometimes upwards of 10 times/minute. Bursts of 'eh' or the absence of it are a powerful yardstick to make proper judgments on the quality of presentations.

Nice story, eh!

4.1.3 The unpredictable 'outcomes of going green'

Strategic Environmental Product Planning has been presented to the organization as 'Ecoefficiency', that is an activity serving both environment and economy. All business groups at that time (Audio, TV, Monitors and VCR (video cassette recorders) took the idea on board and in 1996-1997 there was huge activity in the field: brainstorm sessions, idea generation, priority setting, implementation etc. It turned out that 'Eco' is a tremendous catalyst for generating a wealth of ideas. Several of these had little to do with 'Eco' itself, showing that looking to products from an environmental perspective generates a much wider catalogue of improvement opportunities. This experience led to the proposition that "Eco is a new perspective to look at often old problems, often yielding results which go far beyond Eco". It was true and it is still true and in my opinion this is the best reason to provide a budget for environmental departments (provided that they play this catalyst role properly).

How 'STRETCH' worked out is documented in the following paper *"The Unpredictable Process Of Implementing Eco-efficiency Strategies"* for the three business groups (at BG Video Cassette Recorders). Things took a different turn after the advent of Digital Video Disk Players. Ecodesign investment went into the new DVD players rather than into the older VCRs. Of all the strong results reported here, there was one shocking outcome of these activities: no matter how 'Eco' creative you are, almost irrespective of your environmental know how, external factors which have little to do with the environment ultimately determine to a large extent the results of an 'Eco' drive.

When this was realized, this led to an important paradigm shift: for 'Eco' success the first thing to do is to actively manage internal and external business processes. A new buzzword was born: INTEGRATION. This was a watershed also in a different way; it was the moment when most of the EcoDesign approaches used in academia and other research institutions and proactive industry started to diverge (see chapter 2.1).

The Unpredictable Process Of Implementing Eco-efficiency Strategies

Jacqueline Cramer and Ab Stevels

1. The promising potential of eco-efficiency

A growing number of companies are aware of the need to take the environment seriously. They realise that the environment should not be seen as a threat, but as a challenge for business. Some scientists even argue that we are on the eve of an 'industrial transformation' that can lead to a sustainable development for society. These predictions are perhaps too optimistic. But undoubtedly, companies are currently making tremendous strides towards sustainable development.

The most important sustainable development trend within industry is the increasing attention being paid to eco-efficiency (DeSimone & Popoff, 1997). This concept of eco-efficiency was introduced by the World Business Council for Sustainable Development, a group of prominent companies. They define the concept as follows: "Eco-efficiency is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity." (WBSD, 1995)

So eco-efficiency means not only *ecological* efficiency, but also *economic* efficiency. It makes a direct connection between ambitious environmental targets and enhanced market opportunities. A number of companies, including Philips Electronics, Akzo Nobel, and Dow are making efforts to put the eco-efficiency approach into practice (Fussler, 1996; Cramer and Stevels, 1997; Cramer, 2000). Their experiences teach us that this approach fundamentally differs from the environmental management approach that is pursued by most companies. First of all, it involves a chain-oriented approach requiring more communication and co-operation between partners in the product chain (for instance, between suppliers and customers). The eco-efficiency approach is also much more strategic in nature than the more operational environmental management approach currently in place in most companies. More eco-efficient products should also be economically attractive as well as serve long term goals. Consequently, the environment becomes part of a company's strategic planning and requires a greater involvement of management in environmental policy.

Experiences gained so far with the eco-efficiency approach have shown that it is perfectly possible to create win-win situations. Eco-efficiency improvements can lead to cost reduction, strengthen the market position of existing products, extend the product range and create new markets, avert criticism from external stakeholders, and increase the possibility of the company's survival in the long term.

There are many examples of companies that grasp these market opportunities. For instance, automobile manufacturers are investing in research and development on fuel efficiency and vehicle recycling in order to strengthen their competitiveness and improve their environmental image. Societal pressure to reduce the environmental burden of vehicles has forced the industry to develop such innovative solutions. As a result, they are offering competitive advantages for eco-efficiency improvements.

In other cases, the eco-efficiency approach has led to substantial cost reductions. For example, Philips Medical Systems has realised a tremendous reduction in material consumption for one of its medical instruments, the MRI. This redesigned instrument weighs 35 tonnes less, resulting in a transport cost reduction of 50 per cent. Moreover, the product is easier to dismantle and recycle than the original instrument.

Another example is the carpet producer Interface. A total of 40 factories have saved about USD 60 million by reusing and reducing waste. The Canadian electricity company Ontario Hydro was also able to save USD 37 million through energy-efficiency improvements alone (Cramer, 1999).

A last important example is Xerox, a major producer of photocopiers. The company set a goal of using as few natural resources as possible, which meant focusing on reusing and recycling waste materials. Old copiers are now being "remanufactured" and their spare parts reused. In 1995, this strategy led to a cost savings of USD 12 million in the recycling program and USD 50 million in the spare parts recycling program (Elkington, 1997, p. 314).

These examples illustrate the promising potential of eco-efficiency.

However, it is not possible to determine in advance what marketing and strategy opportunities will ultimately present themselves. This will only become evident during the change process, since this involves innovations whose outcome is often unpredictable. The identification of promising eco-efficiency improvements is, therefore, more of a search process than a well-defined development path. This point will be illustrated below on the basis of the experience gained by Philips Consumer Electronics in strategic environmental product planning.

2. Strategic environmental product planning within Philips Consumer Electronics

Since the early 1990's, the environmental policy of the Philips Consumer Electronics division (PCE) has evolved from a purely process orientation towards a focus on consumer electronics products themselves. An initial driving force for this was the corporate environmental policy formulated by the former CEO, Mr Timmer. Another reason was the growing public pressure to find socially responsible ways of disposing of used consumer electronics goods. Additional factors were the demands made by professionals and consumers regarding the use of certain chemical substances and the short term cost-effectiveness of some environmental improvements (i.e., through material reduction, application of recycled material).

Since 1990, PCE has introduced a number of measures to improve its consumer electronics' products incrementally. For instance, a major project was carried out to reduce the number of environmentally harmful substances. Based on this experience, PCE turned its attention in 1995 to farther reaching, strategic environmental improvements aimed at product alternatives and a radical redesign based on existing concepts. To structure this strategic approach, a methodology was developed, called STRETCH, an acronym for *Selection of Strategic Environmental Challenges* (Cramer and Stevels, 1997).

STRETCH represents a similar view to the one expressed by Hamel and Prahalad in their book *Competing for the Future* (1994). Instead of looking defensively for the right 'fit' among its own business operations and between them and external environmental demands, a company must make room in its business strategy for 'stretched' objectives (Cramer, 1999). Therefore, the basic idea behind the STRETCH approach is that the selection of promising eco-efficiency improvements over the whole lifecycle should be attuned closely to the Business Groups' (potential) business strategy and to the future demands of external stakeholders, including those of its suppliers and customers. In order to ensure that the STRETCH approach becomes an integral part of the general business planning, it has to be embedded structurally in the organisation and attuned to related activities (i.e. ISO 14001).

The STRETCH approach was tested first at PCE and later at Akzo Nobel. It can be stated based on their learning experiences that the STRETCH approach consists of the following six steps:

Step 1: Survey the unit's (potential) product/market strategies and the most important driving forces determining business strategy in general.

Step 2: Monitor new developments and trends in the environmental debate and changes in influence exerted by external stakeholders.

Step 3: Identify potential eco-efficiency improvements that can be made in the product chain.

Step 4: In light of the previous steps, select eco-efficiency improvements leading to the development of promising market opportunities or preventing potential market threats, then formulate an action plan for short-term and long-term eco-efficiency improvements in the product chain.

Step 5: Embed the STRETCH approach in the organisation.

Step 6: Bring the results in line with related Business Group activities, i.e. ISO 14001 compliance, product stewardship, and product development.

The implementation of STRETCH started at PCE with the collection and integration of available data (steps 1, 2 and 3).

Subsequently, representatives of strategy development and environmental experts from the Consumer Electronics division and representatives of Philips Corporate Design made an initial selection of promising project themes. Nine project themes related to the following technological options were selected for further investigation:

- Minimising raw materials, toxic substances and energy consumption;
- Increasing further material recycling;
- Optimising product life (e.g. by recycling product components and by upgrading technically);
- Improving product distribution efficiency;
- Finding alternative ways of performing the present function of the product (either by applying more eco-efficiency physical principles or looking at more service-oriented systems).

These themes were discussed with representatives of the three main Business Groups (BG) of the Philips Consumer Electronics division: TV, Audio and Monitors. Each BG had to select four to five themes for further investigation. Within the framework of each BG, brainstorming sessions were organised with relevant persons from the particular BG, including product managers, marketing personnel and technical experts.
The brainstorming technique used was the one developed by Dow (Fussler, 1996). It centres on brainstorming sessions for teams of experts from different backgrounds aimed at generating promising eco-efficiency strategies. During each brainstorming session, ideas are generated that will reduce the environmental burden of the new product substantially and lead at the same time to promising market opportunities.
Separate brainstorming sessions were held on the particular themes selected by each of the three main BG's. On the basis of each session's results, BG representatives formulated priorities for the development of new, more eco-efficient products. Most of these priorities could not be implemented immediately, but needed to be further studied both from a technical and a business perspective. As will be shown below, it took sometimes two to three years after the brainstorming sessions began before their results were visible in the regular product planning process. It was impossible to predict which of the ideas generated during these sessions was implemented in the end. It appeared that the pace and success of the implementation process related mainly to the following five factors:
1. The organisation's culture (i.e. internal factors, such as management interest, environmental skills, cross-functional linkages, personnel motivation);
2. The business conditions (i.e. profitability, market share);
3. The degree of environmental influence exerted by external stakeholders, (customers, authorities);
4. The available room to manoeuvre regarding product housing and functionality in relation to combined environmental and economic gain;
5. The degree to which the environment can be used to gain a competitive edge.

The relevance of the five factors mentioned above could be assessed by each BG at the introduction of the eco-efficiency approach. However, this information was insufficient to formulate firm conclusions about the success or failure of some of the promising eco-efficiency improvements selected during the brainstorming sessions. For each case considered, the road towards implementing eco-efficiency improvements turned out to be a special journey with its own specific characteristics. As will be shown in the PCE cases (i.e. Monitors, Audio and TV), the results were quite unpredictable both in terms of achievement and time.

3. Catalysts for eco-efficiency improvements at the start of the brainstorming sessions
In order to clarify the potential responsiveness to eco-efficiency improvements within the BG's Monitors, Audio and TV, the authors have presented below an overview of the main catalysts for eco-efficiency improvements at the start of "STRETCH" brainstorming sessions in 1996-1997:

Table 1 Catalysts for eco-efficiency at the start of STRETCH brainstorming sessions (1996-1997)

		Monitors	Audio	TV
1	Internal factors (culture)			
	Management attention	Strong	Weak	Moderate
	Environmental skills	Fair	Fair	Good
	Cross-functional linkages	Good	To be improved	To be improved
	Eco-efficiency activities already in place?	Limited program	Small program	Extensive program
	Personnel motivation	Good	Good	Good
2	Business conditions			
	Profitability	Good high	Marginal low	Moderate
	Market share	Growing	Recovering	High
3	External influences			
	Customer pressure	Strong	Absent	Moderate
	Legislation	Weak	Absent	Strong
4	Room for manoeuvre			
	Product functionality	Good prospects for win-win	Moderate scope for win-win	A lot of improvements already realised
	Product alternatives	Alternative is different (LCD screen)	Different physical principle (wind up radio)	Physical principle (LCD screen)
5	Competitive edge			
	Competitive environmental benchmarking done?	Yes	No	Yes
	Is competition active?	Yes	No	Starting

It can be concluded from table 1 that the internal factors differ greatly in the three BG's. In the Monitors group, a member of the Management Team had made himself a 'defender of the environment' and was pushing hard for results, in particular for a combined customer and environmental benefit. Due to the high motivation of the employees involved, a good cross-functional linkage could be established and the existing backlog in environmental skills could be reduced. This led to an acceleration in eco-efficiency activities in a short period of time.

In 1996-1997, management's interest in eco-efficiency activities was weak in the Audio group. At that time major attention was being paid to the first results of a turnaround program. All efforts were being put into further implementation of the restructuring programs. The environment was 'alive' but had a low profile. However, after the business results had become healthier, effective product and program managers stepped in and achieved good results.

The TV group had already an extensive eco-efficiency program in place. As a result the group scored well in environmental benchmarking. However, this turned out to be more of a disadvantage than an advantage for further progress: apart from a strongly motivated environmental manager located in the development department, the TV group showed otherwise moderate interest, particularly the marketing department.

Furthermore, the three BGs' business situation was completely different in 1996. Monitors had developed a profitable business, enjoyed growing value and market share and had created a good investment position. On the other hand, Audio was still recovering from a slump in 1992-1995. Its restructuring process absorbed almost all the resources and attention of management. TV viewed the environment from a different perspective: due to the good environmental performance already in place this BG could differentiate itself in a market with stabilising volume and over-capacity.

As regards external influences, the Monitor group customers - the big computer companies - exerted strong, tangible pressure both for environmental improvement and lower retail prices; the main customers of Audio and TV are private households who only exert a diffuse pressure. An influential external pressure on TV was the European consumer test magazines that introduced an environmental section in their television evaluations. However, since Philips TV's scored well in these surveys, these tests did not engender further action.

In the field of legislation the debate about manufacturer responsibility and take-back obligations was very heated for TV, marginal for monitors ("the TV issue has not yet been solved, afterwards only it will be our turn") and non-existent for audio ("our products are much smaller and represent a low percentage of electronic waste").
Management's room to manoeuvre on this issue was determined to a large extent by the physical, chemical and electronic prerequisites for realising a certain functionality (pictures, sound, etc.). The environmental improvement potential is therefore dependent on the housing resulting from these factors. Products containing a cathode-ray tube (CRT) generally offer the best scope for eco-efficiency gains due to their relatively high energy consumption and weight. An important difference was that the TV group development department had already taken many initiatives and was even considering aiming to achieve an environmental breakthrough by initiating an environmentally friendly TV project.
Monitors was less advanced but as such the housing offered more potential. Liquid Crystal Display (LCD) screens are an alternative for CRTs and this technology will be environmentally friendlier at a later stage of development. Due to the fact that LCD screens are substantially easier to view, Monitors decided to push ahead with this technology. In TV application the prospect of such a 'flat screen' is attractive. However, for the time being brightness and contrast challenges combined with a high price are serious roadblocks to the introduction of the LCD screen as a consumer commodities on the mass market. Products were planned to be introduced slowly to the market and for high end (superior quality) products only.
For Audio, human-powered radio's were a viable alternative for portable products. In 1996, only the 'Bay Gen' human-powered radio was on the market but was seen by industry leaders as too heavy, unattractive and difficult to operate. The real message ('There are other ways to realise Audio functionality') which this product was sending to the market was not perceived as such by the Audio management . After a heated debate in the Environmental Team, the product manager involved decided not to follow up the human-power avenue for the time being.
Competitive benchmarking had been done in 1996-1997 for both TV and Monitors with completely opposite results. Most TVs scored well in environmental and efficiency performance tests against the competition. For Monitors, the competitive benchmarking results showed an urgent need for improvement. This was even more pressing when the competition started including environmental arguments in their sales pitches. (This was not the case for TV.) Audio started benchmarking two years after the eco-efficiency brainstorming sessions. At this time, a successful turnaround had been achieved and the eco-efficiency success of the other Consumer Electronics groups had been made public.

4. Eco-efficiency brainstorming sessions and their impact on product development

To generate ideas for eco-efficiency improvements, each BG management organised brainstorming sessions in 1996-1997. These sessions were prepared by the authors of this article, who were affiliated to the Environmental Competence Centre of Philips Consumer Electronics.

4.1. Monitors

The eco-efficiency brainstorming session for Monitors on the basis of STRETCH took place on 9 September 1997. The BG CEO's message at that time was that "all relevant items had to considered". The management had already approved the inclusion of an environmental paragraph in the BG strategy, and on the basis of this approval and other considerations, Monitors had decided to develop and market LCD-based monitors as well.
Other than this strategic information, data obtained through a thorough environmental benchmark on 17-inch monitors formed a solid basis for a creative brainstorming session. In total some 25 to 30 main environmentally friendly options were generated and ranked in the so-called Eco-design matrix. (See below.)

Green Options	Benefit				Feasibility	
	Environmental	Business	Customer	Societal	Technical	Financial
First option						
Second option						
Third option						

Figure 1 The Eco-design matrix

In this matrix, the columns were filled in from left to right. First of all, management checked whether the proposed environmentally friendly options actually contributed in a positive manner to the environmental performance of its product. A positive score was preferred for the other columns as well, which served primarily as a tool for ranking priority from a business and feasibility perspective. With the aid of the eco-design matrix, management selected 12 main options for further investigation, of which seven were incorporated in a new product concept approved in January, 1998. Due to the fact that the concurrent engineering started in the autumn of 1997, the product creation period was to be fairly short. In May 1998, the new product, the A580BQ Brilliance Monitor, was launched. It was a huge success due to its favourable product characteristics and its environmentally friendly characteristics, evident in the table below:

Table 2 Improvements in 17-inch monitor resulting from eco-efficiency brainstorming session (STRETCH).

Specification:	
- Scanning range:	8% increase
- Maximum resolution:	5% increase
- Brightness:	15% increase
Bill of materials (incl. CRT):	12% decrease
Component count:	32% decrease
Assembly time:	35% decrease
Energy consumption:	6% decrease
Material:	
- Weight of plastics:	18% decrease
- Weight metal:	42% decrease
Hazardous substances:	
- PCB total:	decrease from 8 to 6
- Component count:	32% decrease
Packaging weight:	10% decrease
Recyclability:	
- Screw total:	40% decrease

Based on the results in this table it can be concluded that an extremely good result has been achieved with the 17-inch monitor. Contributing to this success (in terms of table 1) were favourable business conditions, strong management support and the positive advantages that could be derived from the Eco-design matrix. These conclusions could only be drawn at the end of the implementation process.

4.2. Audio

The brainstorming sessions for Audio took place from 21 to 24 May 1996. The initiative for holding these sessions had been taken by the Environmental Competence Centre of Consumer Electronics. The Centre had detected a high eco-efficiency potential for audio products. The organisation itself was, however, rather indifferent about the idea. In contrast to Monitors, Audio decided from the very beginning to focus on three areas:

- Standby energy reduction for audio sets;
- Portable audio battery replacement with human power;
- Durability improvement (in particular for audio sets; defined in this meeting as the decrease in environmental load over the life cycle per hour of use).

The brainstorming sessions on the standby energy reduction yielded initially 20 reduction options, of which four were selected. Since the brainstorming session had a more voluntary character compared to Monitors, the results were not phrased as clear proposals to management. This resulted in serious delays in the standby energy reduction program. Environmental benchmarks in 1997 and 1998 indicated that Philips Audio's market position was slightly better than that of the competition. (See Stevels, 2000.) Nevertheless there was still substantial unrealised potential.

Similar conclusions were drawn in 1996 but then business conditions were more favourable than they had been. New product and program managers had effectively taken over and aimed to realise good business results. Moreover, the environmental 'technicalities' were better elaborated and put in clear management perspective: it could finally be shown that the substantial standby reductions were feasible and cost effective. In 1999, the FW870 Audio set was launched with very low energy consumption (0 W in the power save mode; 2 W in the passive standby mode). Moreover, other energy improvements were made with respect to on-mode energy consumption, weight and packaging reduction, etc. The resulting life cycle environmental load of this product is 15 per cent lower than the best competitor in its range. On a life cycle basis, the cost of ownership for the user is approximately USD 35 less than for the best competitor.

It can be concluded based on the standby power example above that apart from more favourable business conditions and motivated managers, technological progress, the definition of an appropriate business rationale, and a value proposition to the customer were crucial to realising the eco-efficiency potential.

In 1996 the ideas for human-powered portable products were examined in a predevelopment study by Philips Corporate Design. This study showed good prospects for audio products. However, housing was not demonstrated due to the lack of interest from Audio.

Almost simultaneously a human-powered radio named Bay Gen was launched. This radio was intended for the reception of information broadcasts in Third World countries where batteries and/or electricity are not available or too expensive. However, this product was soon marketed as an environmentally friendly product in the electronics mass market as well. Although the first product was attractive from the point of view of avoiding the hassles associated with battery use, it received negative reviews from professionals in the field. They talked about the unattractive design, the high weight due to the heavy metal spring storing the energy and the winding crank which did not look very durable, and expressed doubts about its environmental friendliness on a life cycle basis (Jansen & Stevels, 1998). This movement in the market combined with the restructuring of the audio business and the revamping of the product line put on hold the development of a human-powered product within Philips Audio.

However, since that time the human-powered radio has been intensively discussed within Audio. After the BG had gone through the turnaround process, the business prospects became more favourable and led to new initiatives. As a result, the decision was made in 1999 to develop a product for mass markets. In February 2000, the Philips AE1000 wind-up radio was launched with the following characteristics:

Table 3 Characteristics of newly developed Philips AE1000 wind-up radio.

	Philips AE 1000 (wind up)	Philips AE 2130 (conventional)	Competitors product	Bay Gen product latest version
Energy Consumption (W)	57	58	90	57
Product weight (g)	350	600	1500	900
Hazardous Substances	0	0	Contains Ni-Cd cell	Wiring contains CD (Cadmium)
Packaging	Cardboard only	Cardboard and 1 kind of plastic	Cardboard and 1 kind of plastic	Cardboard and 2 kinds of plastic
Life cycle load (Eco-indicator mPt)	20	40	25	49

It can be concluded from table 3 that the Philips human-powered portable audio product is competitive in environmental load with both conventional and other wind-up products. In the case of this human-powered product, the progress in product development have strongly influenced competitors' behaviour and internal issues.
As far as durability and possible durability strategies for audio products are concerned, it was concluded in 1996 that insufficient insight existed in these matters. Also due to the input from BG Audio it was decided at the division level to financially support a research project at the Design for Sustainability Lab at the Delft University of Technology. By then, definitions, conceptual models for the influence of product characteristics on replacements decisions and the impact of intensity of use had been published (Van Nes, Cramer and Stevels, 1999).
Recently a case study on audio product durability has been carried out (Smeels, Van Nes and Stevels, 2000). The study proposed conceptual designs that have a 60 to 75 per cent lower environmental load over a period of 15 years for the full audio functionality (including DVD), compared to traditional products with the same function.
In conclusion, the Audio case shows how unpredictable the eco-efficiency improvement process can be. At the start of the brainstorming sessions the potential was high, but the interest of management limited. In the course of time, the responsiveness of the BG increased due to the combination of factors as described above.

4.3. TV

The eco-efficiency brainstorming sessions for TV, initiated by the development department, took place on 2 February and 10 May 1996. An important catalyst for organising these sessions was the participation of one of the preferred plastic materials suppliers. In these brainstorms sessions, Fussler and James' approach was closely followed (Fussler and James, 1996). All fields of the eco-fitness compass were considered: raw materials, manufacturing, distribution, use and end of life. The following subjects were prioritised:

- Materials and manufacturing: future housing designs;
- Materials and manufacturing: alternatives for the current glass based CRT;
- Recyclability: 100% recyclable TV.

Thirty-eight ideas were generated In the field of future housing designs. In the first session, these were reduced to 24 and a further selection brought this number down to seven. The endeavour to find alternatives for the current glass-based CRT resulted in the proposal to investigate the feasibility of a plastic picture tube. For this project, 21 items to be researched were defined. For full recyclability there were initially 12 ideas.
By the summer of 1996, further progress on the eco-efficiency brainstorming sessions and other related efforts were strongly influenced by TV management, who decided to consolidate all eco-efficiency efforts into one effort: the 'Green TV' project. In this project the chemical, physical and electronic limitations had to be explored based on the existing concept of a glass CRT.
As a result of this decision, the proposals for future housing and for 100 per cent recyclability got a clear boost. However, the planned feasibility study on a plastic CRT was replaced by efforts to reduce the products' further energy consumption. The output of the eco-efficiency brainstorming sessions and the contributions from other sources (e.g. the TV development department) led to the huge success of the Green TV, having the following performance results:

Table 4 Achievements of 'Green TV' compared with standard TV (1996)

Energy consumption reduction	39%
Plastic weight reduction	32%
Hazardous substance reduction	100%
Recycled material	69% (of total weight)
Recycling potential	93%
Reduction of life cycle environmental load	30%
Reduction of cost price	5%

The strategic success of the Green TV was primarily that 'it could be done'. As such, it was one of the powerful impetuses for the Philips-wide "Eco Vision Program" (Stevels, 2000).
The technical success of the Green TV was that after 1996 many inventions and improvements to the Green TV concept have been introduced in conventional products, qualifying the best of them now as 'Green Flagships' - products with superior environmental performance.
However, the Green TV was never brought to the market due to the fact that the environment value chain had not been properly addressed (Ishii and Stevels, 2000). The reasons for this were:

- A lack of clear value propositions to the potential customer;
- An unclear product line-up positioning at that time;
- Insufficient involvement of suppliers;
- Insufficient attention to the consequences for production (investment, factory layout);
- Problems with logistics (e.g. availability of recycled material).

For the TV group, it can be concluded that the brainstorming sessions for implementing eco-efficiency strategies worked out in a different way than originally anticipated. Instead of leading to technology-oriented projects, the improvement options were merged into advanced product development activities. Moreover, the corporate strategy and program development were strongly affected by the outcomes of the brainstorming sessions and other related activities.

5. Conclusions

The examples from Philips Consumer Electronics presented in this article show that processes of implementing eco-efficiency strategies have resulted in a positive but unpredictable outcome.
In terms of achievements, internal factors ('culture') had a strong influence in all three cases. Particularly, management interest, decision-making and cross-functional capabilities were major determinants. This "Internal Value Chain" seemed in fact to be more important than the external one. Moreover, it can be concluded from this study that business conditions, external influences and the possibility to get a competitive edge influenced particularly the time scale on which eco-efficiency was realised. Room for manoeuvre on the issue of product functionality did not play a major role in the case studies. However, if the main thrust is to realise eco-efficiency through radical housing system changes this aspect may become very dominant.
In hindsight, four years after the eco-efficiency programs actually started at Philips Consumer Electronics, it can be concluded that although the paths taken have been different in each case, good results have been obtained. Finally, an assessment of the catalysts for eco-efficiency and an appropriate structuring of the potential environmental and economic benefits can contribute positively to the process of change. However, such activities cannot predict the real outcome of the eco-efficiency programs. In this respect, the implementation of the eco-efficiency approach will remain a real adventure.

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Cities, 4

Bilbao, a city of transformation

Bilbao is in the north of Spain, tucked away in an estuary of the Gulf of Biscay. It is one of the most important cities, or even the most important city, of the Basque Countries. It has a mix of the proud traditions of the Basques and the almost equally proud (but different) traditions of the immigrants from elsewhere in Spain.

It used to be a smokestack city. Iron ore and coal dominated the scene. Iron smelting and the production of products made from iron are still important today, but clearly declining. This also holds for the shipping activities. There are still daily direct flights to the Ruhrgebiet, the cradle of the iron and steel industry in Europe.

When I traveled to Bilbao, my prejudice told me that this could not be a very cheerful experience with its' derelict factories, social tensions, political tensions, and crumbling buildings in the inner cities I expected little.

This turned out not to be true, a lot of the steel industry had been turned into a recycling industry. Looking to their operations the conclusion I drew was regarding their leadership in technology. For example, direct smelting routes of metal rich electronic products was pioneered in the region. The Gaiker Research Institute near Bilbao is considered to be leading in plastics recycling as well.

In the city, slogans and graffiti on the walls looked to be old and were fading away. The new Guggenheim Museum with its remarkable architecture (and content) has been an anchor for urban renewal. Step by step dilapidated buildings are restored and old rubbish is moved away. Progress is impressive; a good balance between new and old will be found soon. For me the visit to Bilbao was much more than just a business trip.

Check your mindset and remember what can be seen in Bilbao. Refresh, develop new ideas and avenues of thought and get rid of the rusty ones in which you have believed so long!

City walk: Start at the head of the abandoned railway station, go R over the Arenal bridge and L to San Nicolas church go to the L at the backside, go R and walk Askao and La Cruz street , pass the two churches(on L and R) wind you way through the "seven streets" as you like, but make sure you end at the river front near Mercado de La Ribera. Cross the Park de San Anton and start here your river walk all the way to the Guggenheim Museum.

Favorite restaurant: Restaurante Bikadi, Calle Somera 21 (in the 'Seven Streets' area).

Country walk: Either go with the local Metro (red line, northern direction) to Algorta or Bidezabal, walk along the coast till you find the special geological formations and beyond.

Or: go by RENFE train to Durango, let you take by taxi up to the monastery and walk in the Urkiola National Park surrounding it (recommended in spring).

4.2 Integration into processes

4.2.1 Product Creation Processes

In the period between 1998 - 1999 there was an interesting situation concerning Applied EcoDesign. On one hand activities in this field brought environmental gains as well as cost reductions for the company engaging itself in this field (see also 4.2.2). On the other hand it had become clear that 'green' as such did not sell in the market. 'Green' benefits had to be linked to other items that are beneficial for the consumer (see also chapter 5.4.1)

Although awareness and positive response by the organization were getting better and better, real positive outcome of Eco-drives were by no means sure (see chapter 4.1.3). Moreover, when management in a group - which had taken 'Eco' on board - was changed, often the process of confidence building in EcoDesign had to start all over again. Also employees successfully dealing with 'Eco' were moving on to new jobs like everybody today. Through this process a lot of experience was lost.

In order to make the 'Eco' activities more effective, it is therefore necessary to closely integrate EcoDesign into business processes and the ways of working. At Philips Consumer Electronics this has been done by a simple 'add on model'. For each activity an 'environmental paragraph' has been added to existing procedures. In this way all the basic processes (like strategy, product creation, purchasing production, marketing and communication) became environmental. As an example such an add-on scheme is given below for Product Development.

Feedback / continuous improvement			
	→	Stage 1: Planning	Get facts, prioritize according to benefits and feasibility, align with company strategy, consider environmental aspects, life cycle thinking
	→	Stage 2: Conceptual design	Brainstorming, life cycle screening, consolidate into specification
	→	Stage 3: Detailed design	Applying design approaches
	→	Stage 4: Testing / Prototype	Evaluation of results against targets and specification
	→	Stage 5: Market launch	Release, communication plans
	←	Stage 6: Product review	Consider environmental aspects and effects

Figure 4.1 Generic model of integrating environmental aspects into the product development process

This diagram builds on the existing procedures and simply adds environmental activities to each step. The power of doing it this way is that it introduces EcoDesign as something 'natural'. Simultaneously the effect is that it takes away fear that the usual way of working would be changed or disturbed in some way or another by 'Eco'.

This type of approach has been worked out in much more detail. The publication below gives a full account of it.

Experience has shown that full integration of 'green' into processes has substantial benefits. This could have the danger that a focus on environmental issues could be lost simply through the multitude of tasks which have to be accomplished to be successful in business today. 'Eco' is still immature when compared with business items like quality for instance. Due to this immaturity a special Environmental department is needed to drive further integration internally and to absorb and translate the rapid developments in the outside world (science, regulation, consumer perception). For the same reason specific environmental roadmaps and specific environmental requirements in executive incentive schemes will be needed as well (see also chapter 4.3 and 4.4).

Application of EcoDesign in the Electronics Industry

Ab Stevels

1. Introduction

Environmental care in industry has been in existence for many decades. In the early sixties, the detrimental effects of emissions to air, water and soil was recognized at a global scale and since that time legislation, regulation and voluntary programs have been initiated to abate pollution.

For more than twenty years the main focus has been on production processes and hence on industry sectors involved in basic production (chemicals, materials like steel, paper etc). The environment was seen as part of industrial engineering; solutions to environmental problems were sought in "end of pipe" cleaning solutions through investment in installations.

The Brundtland report (1987, see ref. 1) called attention for the first time to the fact that products (the result of production processes) can also cause substantial environmental loads. Product embodiments sometimes use scarce resources and can contain environmentally relevant substances as well. Packaging, packaging waste and transport to the user can contribute considerably to the overall life cycle burden of products. For products using consumables like water, gas, electricity this holds in an even more outspoken way for the so called user phase. Finally, the end of life phase is relevant as well (recycling of discarded products, adverse environmental effects of landfill and incineration).

Due to the very nature of its products, environmental issues in the electronic industry started to get more attention in the early nineties. Improvement programs focused (and still do) on prevention, that is reducing environmental effects upfront by appropriate product specification and design. In this way product management and development groups got involved with the production departments. Due to the fact that products, once produced, can potentially move all over the world, environmental product issues have a global character in contrast to production/manufacturing issues, which are primarily local/national.

Authorities and consumer groups were the first to move after the awareness phase. In the early nineties in various countries around the world the first drafts of legislation on electronics products started to appear. Test magazines started to include environmental paragraphs in their tests reports.

The reaction of the industry was primarily cautious; compliance with legislation/regulation and preventing bad test scores ranked high on the agenda. Basically this represented a defensive attitude; in this stage (1992-1996) the environment was primarily seen as a cost rather than as an opportunity to enhance business.

Around 1995, the electronic industry started to realize that environmental and economic interests run parallel to a large extent:

- Resource reduction (energy use, materials, packaging) also means cost reduction.
- Reduction of disassembly times also means reduction of assembly times.
- Reuse of subassemblies, components and materials is cheaper than buying new ones.

This provided momentum for cost oriented environmental programs.

A new type of program that was customer oriented or proactive were started by several companies as of 1997-1998. The basic idea here its to increase market share through offering environmental benefits (which are communicated in terms of financial, immaterial and 'emotional' benefits as well) to the customer.

In 2 the general characteristics of the defensive, cost oriented and proactive approaches are discussed and elaborated on.

In 3 examples will be given of a typical defensive activity: setting up a basic environmental organization, mandatory rules and establishing chemical content of electronic products.

In 4 examples of cost oriented activities are addressed: Environmental Management Systems (ISO14001), energy reduction and packaging reduction.

In 5 examples of proactive activities are presented; an Eco Vision Program, environmental benchmarking and a strategy for environmental communication.

The examples given in 3, 4 and 5 are from the authors practice at Royal Philips Electronics, Product division Consumer Electronics. Activities there have developed starting from a defensive approach in 1992 towards cost oriented programs in later stages (from 1995 onwards) and the current proactive approaches have been added. In 6 the 'cultural' effects of the introduction of these programs is discussed, both in terms of successes as well as in terms of items further to be improved.
On the basis of these experiences a general model for integration of EcoDesign into business has been developed. This model has turned out to be widely applicable outside the electronic industry.

2. General characteristics of environmental approaches in the electronic industry.
The general picture of environmental approaches in the electronic industry are summarized in the table below.

Table 1 General characteristics of environmental approaches in the electronic industry.

Item	Defensive approach	Cost oriented approach	Proactive approach
Driver	Legislation/Regulation	Money/cost	Market/customer
Management	* Environmental declaration * Command and control	* Policy * Projects	* Vision * Integrated into the business
Main objectives	Comply	Improve with respect to previous generation	Be better than the competition
Organization	Formal structure	Delegated responsibility	Management of processes
Core processes	Manufacturing Suppliers (purchasing)	Product creation process	Chain management
Control	Afterwards	Built-in	Upfront
Activities	* Substances reduction * Standby energy reduction * Take back of discarded products * ISO14001 (partly)	* Material reduction * Energy reduction * Reduction of (dis)assembly time * ISO 14001 (partly)	*Designs with lower cost for user * 'Green' designs which are easier to operate or fun * Durable products * Products with emotional benefits ('green' image)
Supporting Tools	* Checklists * Chemical content tool * Environmental weight calculation	* Manual * Packaging reduction tool * Energy reduction tool * End of life cost analysis tool	* Greening your business handbook * Eco indicator software * Benchmark tool * STRETCH creativity tool
Training	How to comply	How to reduce	How to integrate with business
Communication to the outside world	Compliance beyond minimum	Environmentally friendly but not more expensive	Greener and other benefits combined
Language of communication	Environmental ('scientific green')	Reduction of resources	Perceived 'green'
Main benefits delivered	'Green' & societal benefit	'Green' & company benefit	'Green' and customer benefit

In practice individual companies in the electronic industry operate environmental affairs in a way which is a mix of the approaches shown above. The exact structure of the mix both depends on external and internal factors.
External factors include:

- Geography (regions, countries of the world where business is done)
- Product characteristics (environmental potential)
- Customer awareness
    - private customers
    - professional customers

- Position in the market (competition)
- Position in the supply chain (power, leverage)

Internal factors include:
- Business focus, ambition and ethics
- Management style
- Availability of skills

Due to the fact that integration of the environment into the (electronic) industry is also a cultural process, the three approaches are sequential. From this perspective the defensive approach is to be seen as a minimum approach to start with and to be done by all companies. Based on the experiences built up in this phase, further steps can be taken to introduce the cost related 'green' programs. For instance, a proactive approach can be developed.
Practice has shown that jumping directly into the proactive mode of operation fails in the market. When the defensive items are not appropriately addressed such programs are very vulnerable.
The drivers (item 1 in table 1) are strongly geography dependent; generally speaking legislation and customer awareness are best developed in Europe, liability and cost reduction are most important in the USA whereas resource reduction in highest on the agenda in Japan.
Management style strongly influences items 2-4 of table 1 (management & organizations): centralized organizations operating top-down can move swiftly in the defensive approach, decentralized ones with a bottom-up culture do well in proactive approaches. This is also due to the fact that for such an approach tailor made solutions, dependent on product characteristics, have to be developed.
Items 5 and 6 (processes and control) depend externally on the position of the company in the supply chain and internally on the business focus.
The activities (item 7) to be done have a strong relation with product characteristics and with the customers. Products of a complex nature, with substantial volume, weight and energy consumption, often have the highest potential for resource and cost reduction. Especially in professional markets such activities will be highly rated. Environmental tools for cost related activities (item 8) are the ones which are the most easy to develop and operate. The same holds for training (item 9).
In the field of environmental communication (item 10-12) there are clear distinctions. The electronic industry is perceived as high-tech and professional, therefore it is well-positioned to perform in compliance and in cost reduction. Especially in societies with a high income per capita (brand), image plays a tremendous role in these markets. Being seen as a "caring" company (through a proactive approach) is of primary importance in this field.

3. Examples of a defensive approach

3.1. The organization of environmental responsibility in a global electronic company

In order to make corporate environmental goals visible and deployable one of the members of the Group Management Committee, preferably the President and CEO should be responsible for environmental affairs.
By nominating a 'green' standard bearer it is clear that the company takes 'green' issues very seriously and wants to integrate them into all operations.
At a corporate level support to the chief environmental officer should be given by a Corporate Environmental Office/(CEO).
An appropriate headcount in the electronics industry is approximately one person per 5 billion USD of revenue.
Tasks of this CEO include:
- To develop the corporate policies, strategies, programs
- To handle external affairs (legislation, communication)
- To monitor progress of company programs.

A replica of the corporate structure should be made at division and business group levels:
At the division level a member of the Senior Management Team should be responsible for environment. Support at the division level is to be given through the Environmental Competence Center; the headcount of such an ECC should be in the order of magnitude of 1 person per 2 billion USD of revenue. Tasks of such an ECC are:

- Support of the division level environmental steering team.
- Making of division level programs, roadmap.
- Support of implementation at Business Groups.
- Ensuring availability of know-how and supporting tools.
- Training and audit.

At the Business Group level environmental matters should be handled by a member of the Management Team. Support is to be given by a Division level Environmental Manager (1 person per billion USD) through revenue and a line of business /plant Environmental Managers. Most of the people in the last category will be part-timers, located in the quality or health and safety departments.
The main tasks of the division level environmental managers are supporting implementation and reporting on progress.
The structure sketched above shows that in the electronic industry environment it is seen as a line responsibility. This very line responsibility means that integration of environmental issues in the normal operations is the only way to successfully operate in this field. This holds irrespective of whether the environmental strategy of the company is defensive or proactive. In this respect the environment will follow developments similar to what has happened with quality issues. It started as something separate, to be addressed by specialists, but it has now become fully integrated into the tasks of all employees.

3.2. Mandatory rules

In order to ensure a minimum of environmental care in all operations companies should have minimum mandatory rules. Application of these rules should be checked on product release and/or in manufacturing operations reviews.
For the electronic industry these mandatory rules include:

- Banned substances
  - brominated flame retardants of certain types
  - heavy metals (Cd, Hg,…..)
  - ozone depleting chemicals
  - organic solvents and liquids (PCB, PCT,..)
- Availability of environmental information:
  - energy consumption
  - environmentally relevant substances (see also 3.3.)
  - recyclability
- Packaging
  - material application
  - printing inks
- Marketing and labeling of products and/or product parts
- Customer information
  - for optimal environmental operation
  - disposal of discarded packaging and products
- Batteries
  - marketing
  - handling

The precise formulation of the mandatory rules vary from company to company; some of them stick to strictly fulfilling legal requirements and have regional policies if requirements differ. Others go beyond the minimum and have global mandatory environmental rules.

3.3. Chemical content of electronic products

Knowing the chemical content of electronic products is not only important to fulfill actual legal requirements. It will also be helpful in anticipating future developments. It is crucial to start elimination efforts well in advance of the passing of laws because finding alternatives will involve a lot of work.
Some substances will not be legislated in the future, for instance because a scientific basis for forbidding them is not available. However using such substances ('the suspects') could do harm to the brand image of the company.
The vehicle used by Philips Consumer Electronics to find out about chemical content is the so-called chemical content questionnaire (see annex 1). This questionnaire has been sent to all components and materials suppliers. This action included hundreds of suppliers all over the globe and some 20,000 code numbers.
Apart from the list, the supplier gets an accompanying letter explaining the procedure. It is essential to make clear that if in any category the supplied items exceed the threshold limits on the list, this means that PCE wants to start improvement actions with the supplier and does not want to terminate relationships.
On the contrary, it is stressed that
- We want to know the chemical content of our products.
- We want to improve our products in close cooperation with the supplier.

The answers given by the suppliers are processed by specialists of the Environmental Competence Centre. When information has been considered to be complete, the component/material concerned is given a so-called environmental indicator (E.I.).

E.I. = 9 Component/material contains no environmentally relevant substances.
Fully released

E.I. = 6 Component/material contains environmentally relevant substances, but no Philips banned substances. There are no good alternatives.
Temporarily released

E.I. = 1 Component/material contains environmentally relevant substances. There are good alternatives or component/material contains Philips banned substances.
In both cases: Rejected

The results of this environmental classification are communicated to the organization through:
- Updates of the Environmental Design Manual.
- A computer database to which all S&V/CE development groups are connected.

In the Product Creation Process (PCP) Environmental Performance is checked at the milestones. In so-called product cross sections the chemicals used in the product are described in terms of fully released, temporarily released and rejected components/materials. When rejects are still present the milestone cannot be passed!
A physical example of a chemical content project has been the work on the composition of printed wiring board in GFL-V2 (in 1997). This board has been used for several years in mid range TVs (21, 25 inch). Environmental indicators have been as follows:

Table 2 Chemical content of printed wiring board G.L. - V2

	Number in %	On weight basis (%)	Target % (number)	Target % (weight basis)
Total number of components 3637				
Chemical composition known	95	98	98	99.5
of which fully	64	87	80	92
Temporarily released	36	13	20	8
Released rejected		0.2	0.0	0.0
Total	**100%**	**100%**	**100%**	**100%**

After the determination of the E.I. it was concluded that the design of GFL-V2 still contained some rejected components. Moreover, the % of temporarily released components and materials was still pretty high (36% and 13% respectively). On the basis of this information the decision was taken to reduce the number of rejected code numbers to zero and to reduce the temporarily released ones to 20% (number wise) and 8% (on weight basis). This project was successfully executed before release in the beginning of 1998.

4 Examples of a cost oriented approach

4.1 The Environmental Opportunity program of Royal Philips Electronics

This program has been introduced in 1996 as a follow-up after a period in which defensive attitudes were dominant. The main items are given below:

Table 3 The environmental Opportunity Program of Royal Philips Electronics

Corporate part
1. All factories EMS certified (ISO14001 or EMAS)
2. 25% energy reduction in all operations
3. 15% packaging reduction in all operations

Product Division Part
Eco design according to business needs
4. Supplier requirements
5. Creation of internal, external network
6. Active participation in legislation, regulation discussion

In the program a clear distinction is made between the mandatory corporate part and the part that is at the discretion of the Product Divisions. In practice the corporate part was the dominant one, with energy saving and packaging reduction as the carriers for the ISO14001 program. As will be explained in 6.2, starting with the cost savings side of ISO14001 rather than with the more formal part offered many advantages in practice. In this way environmental management systems become a logical result from integrated practice oriented activities instead of a set of upfront stand-alone items.

4.2 Energy saving in manufacturing operations

Energy savings in manufacturing operations has been treated as the core platform on which the ISO14001 certification was to be obtained. This means that these projects have been organized in such a way that they fit in both "upstream" and "downstream" ISO14001 activities. This can be sketched as follows:

Table 4 Energy saving as core activity in ISO14001.

ISO14001 activity		
Vision, Policy	↑	
Legal and other requirements		
Objectives, target and programs		Upstream
Structure and responsibility		
Training, awareness		
Operation Plan, Do, Check, Actions	CORE Platform Energy saving	
Communication	↓	
Documentation		
Operational control		Downstream
Emergency preparedness		
Monitoring		
Records		

This table shows that on the basis of practical experiences in the factories, the ISO elements, as far as not yet present, are organized or built as structures. Experience has shown that this 'carrier' approach is very effective indeed.

In order to create the platform for energy saving actions a so called Energy Potential Scan (EPS) has been carried out in many Consumer Electronics factories. This EPS is in fact making a detailed and systematic inventory of all energy flows in the production system. Data collection sheets were organized in such a way that these could be used for both 'upstream' and 'downstream' activities.

A general observation has been that the very fact that comprehensive data are brought together in one concentrated form means that awareness, creativity and effectiveness in saving energy have been stimulated enormously.

The results of such an EPS is a list of prioritized options to save energy, both in terms of its environmental effect and in terms of payback time.

The items to be prioritized strongly depend on the location (need for air-conditioning/heating in winter), the type of products manufactured (assembly, processing), degree of automation, etc. So execution of locally, tailor made action plans is necessary.

On average for Royal Philips Electronics energy reduction programs have brought savings of USD $40 M/year with an average payback time of investments in two years.

4.3 Packaging reduction

The packaging of products has a multitude of functions. Apart from its protection function, it can also play a role in handling, communication of messages to the customer and creation of brand image. These items should be mapped out in detail before starting reduction actions. This should prevent that such "add on functions" of packaging disappear in the process.

A first step in packaging reduction is getting facts. In the Philips Consumer Electronics case these include the following basics:

- Integral environmental load and cost of packaging and transport
- Ratio's (see also 6.2)
    * packaging weight/product weight
    * packaging volume/product volume

- Environmental weight ratio. This is a number that takes into account material application, substances in packaging and recyclability.

These numbers (and subsequent simulations) are used to establish the main strategies for packaging reduction. These include:
• Material reduction (works out on integral load and weight ratio)
• Increase in amounts of recycled materials (affects environmental weight)
• Volume reduction (works out on integral load and volume ratio)
• Material replacement (affects environmental weight)
• Improving fragility (shock resistance) of the product or matching fragility better with the packaging concept. (works out on all categories).

For audio products the following figures for integral environmental load and costs have been established for products manufactured in Asia and sold in Europe.

Table 5 Integral environmental load and costs of transportation.

	% of integral environmental load	% of integral cost
Packaging material	48	42
Packaging operation	<1	3
Transport	45	43
Storage	1	12
End of Life	6	<1

This table shows that both for environmental load and costs the potential is approximately equal for material reduction and for volume reduction. Also the data in table 8 points in the same direction.
Fragility measurements showed that in fact the packaging was over dimensioned, especially in with respect to the EPS buffers. This means that in the execution the volume reduction strategy was preferred. Design avenues for material reduction were derived from the benchmark (see 6.2).
In total the effort yielded a reduction of environmental load and integral costs of 8%, of which 6% is to be attributed to volume reduction and 2% to weight reduction.

5. The proactive approach.

5.1 The Philips Eco Vision program (1998-2002)

The formulation of the Philips Eco Vision program as a proactive approach to environmental issues was a result of several paradigm shifts:

- Environment is business rather than a technicality.
- Environmental benefits as perceived by other stakeholders are key rather than scientific calculations of environmental gains.
- Best environmental care means to be measured in comparison with the competition.
- Understandable communication of environmental results is just as important as achieving the results themselves.

The current Eco Vision program is presented in Table 6:

Table 6 The Eco Vision program of Royal Philips Electronics.

Products (per Line of Business)
- 'green' focal areas in product communication
- 'Green Flagships' in 1998
- X% of products fully Eco designed in 1999
- Y% of products fully Eco designed in 2001
- 15% packaging reduction in 2000 (ref. 1994)
- Y > X to be determined by each division

Manufacturing (reference 1994)
- 35% waste reduction in 2002
- 25% water reduction in 2002
- Hazardous substances reduction in 2002
  - Category I 98%
  - Category II 50%
  - Category III 20%
- 25% energy efficiency in 2000 (stretch to 35% in 2002 to be decided upon)
- ISO 14001 on all manufacturing sites in 2000

The corner stone of the program is the communication of top achievements in 'green' to customers and other stakeholders, as embodied in 'Green Flagship' products. These achievements are to be realized through management of the cross functional processes around creation, production and marketing/sales of these products. In the creativity phase, environmental benchmarking (where do we stand with respect to the competition) is a key element, this is described further in 5.2. In 5.3 an example will be given of communication about 'Green Flagships'.

5.2. Environmental benchmarking

The relation of environmental benchmarking with EcoDesign is sketched in the figure below:

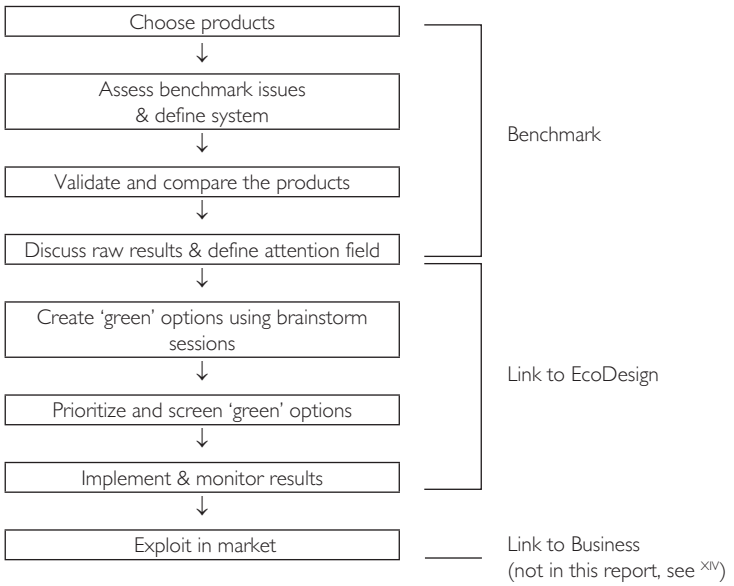


Figure 1 Relation of environmental benchmarking and EcoDesign

In order to do a proper benchmarking, the system boundaries should be well defined and the functionality of the products to be compared should be as identical as possible (see also ref. 2). Also a list of items to be benchmarked should be available; this list contains the items which will be used later on in communication with stakeholders. For this purpose, the Eco Vision program has defined five focal areas:

- Energy consumption
- Weight/material application
- Packaging and transport
- Substances in particular hazardous substances
- Recyclability

For electronic products benchmarking items have been divided into five groups as well, see the table below.

Table 7 Benchmark items

Energy	**Packaging**
Energy consumption 'off' mode	Packaging material weights
Standby mode	Packaging volume
Operational mode	Packaging weight/product weight
Energy consumption of subassemblies	Packaging volume/product volume
Energy consumption for user scenario's	End of Life costs of packaging
Battery life and costs	
Materials	**Substances**
Weights of plastic applications	Number of weight of suspect
Weights of metal applications	Components, subassemblies
Weights of subassemblies, speakers	**Recyclability**
Weights and surface area of printed wiring boards	(Calculated) disassembly times
Weights of cables and wiring	Estimated material recycling efficiencies
	Estimation of end of life cost
Life cycle calculations	
Environmental impact (Eco indicator) of the various life cycle phases	
Environmental impact (Eco indicator) of total life cycle for various user scenario's	

The example given below of products on the market in 1997 demonstrates that environmental benchmarking can be very powerful, both in terms of generating data and ideas for further improvements, but also for product positioning in the five focal areas. In the table below the main properties of traditional Audio Systems are compared. The four products selected have approximately the same functionality and features and consist of a tuner/amplifier, a double tape deck, a CD changer, and two loud speakers.

Table 8 Example of benchmarking results for Audio Systems.

Benchmarking items	Product of competitor 1	Product of competitor 2	Product of competitor 3	Product of competitor 4
Energy (W)				
Standby	2	11	8	12
Operation	21	22	30	23
Tuner	20/25	31/28	18/50	23/24
CD	25/27	25/28	31/60	26/34
Tape decks	23/24	22/27	31/43	25/34
Weight				
Parts total	4300	4100	4600	6200
Of which transformer	1800	1800	2100	2800
Sound system	6887	9988	5612	9453
Packaging				
Number of boxes	1	2	2	1
Weight total (g)	2895	2607	1804	3401
Packaging weight/ Product weight	0.17	0.14	0.12	0.15
Volume ratio box/ Product volume	2.06	1.89	2.02	2.56
Environmental weight ratio	0.91	0.95	0.98	1.11
Disassembly time (sec)				
Total	160	90	100	150
Of which due to screws	90	40	50	90
Life cycle score (mPT)	600	1200	1600	1300

The results of this table show that in spite of the fact that products of this type have been on the market now for more than ten years, there are substantial differences in almost all focal areas and categories. Apparently the companies active in this field have completely different design strategies, using them to meet environmental objectives is relatively new.

For Philips Consumer Electronics (Audio Group) the benchmark results mentioned above clearly showed the strategy for how to develop 'Green Flagship' products, that is bringing products to the market which have superior environmental performance with respect to the competition. This strategy included:

- Keep the lead in standby energy consumption.
- Increase the small lead in energy consumption in operational mode
- Stay among the best in weight issues.
- Reduce packaging weight and volume so that it becomes at least on par with competition.
- Drastically improve disassembly times

(Since energy consumption is a major contributor to the life cycle impact score, the lead in the score will be automatically kept).

5.3 Environmental communication

5.3.1 'Green' communication at Company level

'Green' communication at company level should particularly contribute to enhancing the brand image. "Putting more green" into the brand can be realized by:

• Leadership:
- Top management shows visible involvement in 'green'
- Communication of environmental vision
- Visible proactive attitude in trade associations
• Programs:
- Communication of corporate environmental programs (see 4.1 and 5.1)
- Communication of awards, ISO14001 certificates obtained etc.
- Having a supplier requirement program
- Communication of successes obtained through programs
• Making documentation available
Examples in the Philips Electronics case are:
- 'Green' product brochure
- (Public) Ecodesign guideline book "from necessity to opportunity"
- Environmental Annual report
- Internet 'green' homepage
• Sponsorship
Examples in the Philips Electronics case are:
- Sponsoring of chair in EcoDesign at Delft University of Technology
- Sponsoring of environmental conferences
- Sponsoring of cleaning up the Antarctics
• Hardware:
- 'Green Flagship' products (see 6.3.2)

5.3.2 'Green' communication at Product Division level

'Green' communication at Product Division level should be directed towards the methods and tools which are applied to ensure that the 'green' products brought to the market are really outstanding with respect to competition (or to conventional products).

In the case of Philips Consumer Electronics particular attention is paid to:

- Communication of the benchmarking method used (see also 6.7).
- Explaining what the life cycle principle means in terms of combining the five focal areas: energy, materials, packaging and transport, substances and recyclability.
- Explaining the Ecodesign procedure followed.
- Communicating what a 'Green Flagship' means and presenting these products.

5.3.3. 'Green' communication of specific products

This type of communication refers to scores in the focal areas. One example is provided here of the Audio System type nr. FW870C produced by Philips Consumer Electronics, data are given below. This is a product which was launched in September 1999. This product was developed on the basis of the benchmarking results presented in 6.2 and the resulting design strategy.

Table 9 'Green' communication focal areas.

Focal area	Unit of	Message
Energy	kWh/$	Over the life cycle of the product energy costs are $35 lower than for the best competitor
Weigh	Kg	The weight of the product is 15% lower than that of the best competitor (this saves resources)
Packaging	Kg	The packaging weight is now 5% lower than that of the best competitors (this saves resources)
Substances	Concentrations	N.A.
Recyclability	%	Now better than the competition
Life cycle performance	Eco-points %	This product has a life cycle impact score which is 35% lower than the average of competitors

6 Effect of environmental approaches on the organization

6.1 The defensive approach

Philips Consumer Electronics started with what was basically a defensive approach to environmental issues in 1992-1993. Basic elements of the environmental program were at that time:

- Formulation and deployment of an environmental declaration
- Setting up of an environmental organization (see 3.1)
- Formulation and monitoring of mandatory environmental (design) rules (see 3.2)
- Start of making an inventory of banned and environmentally relevant substances in materials and components (see 3.3).

The effect of organizing this defensive program in the organization is summarized in the table below.

Table 10 Effects of defensive approach

Good:	To be improved:
• Awareness created	* Perception as threat by organization
• Action taken, first mover	* Benefits for company doubted
• Environmental managers in place	* "This is technical"
• Collection for information	* Philips, what is in for me?
• Program further developed	

An immediate result of implementation of the program what that a strong environmental awareness was created. In spite of urgent cost cutting and restructuring efforts taking place at the time of introduction, 'green' earned a solid place on the business agenda.

Outside Philips CE was from the very beginning perceived as a caring company. "This is one of the first companies in the electronic industry to take real action." In particular this was achieved by sending letters to all of the suppliers about the chemical content program and by communicating this to the outside world, in particular to authorities in various countries.

A further advantage was in the systematic and the comprehensiveness of the approach. Through the presence of a network of full-time (in only few cases) and part-time (in most of the cases) environmental managers throughout the organization, all kinds of environmental information were gathered and improvement actions going beyond the mandatory program we started. In such a way, the basis for further development of 'green' activities was created.

All these positive effects could not prevent that pending legislation was seen as a threat; benefits for the company were doubted. Particularly because of the fact that the introduction of the program coincided with a major re-structuring proved to be a serious handicap. The content of the program with chemical content as the core meant that it was seen as something of a technical and highly specialized nature. This mentality had to be turned into a perception of 'green' and as a business item in later stages.

6.2 The cost oriented approach

The environmental opportunity program (1996) (see 4.1) substantially widened the scope of the environmental opportunities. Effects on the organization are given below:

Table 11 Effects of environmental opportunity programs

Good:	To be improved:
• Business groups systematically confronted with environmental concerns through EMS	* Sometimes bad experience with ISO9001, why should ISO 14001 be better?
• Clear cost saving through saving energy	* "It works in the factories, why not for products"?
• Clear cost saving through reducing packaging	* EcoDesign manual too static
• EcoDesign taking off, manual in place	* LCA turns out to be difficult, need for more practical approach
• Supplier requirements	* Business rationale, resistance from purchasing
• Internal and external network built	* EU/government inflexibility backfires internally

The obligation to put an operational Environmental Management System in place according to the internal ISO14001 standard confronted the Business Groups with a systematic way to deal with environment. Of particular significance was that an ISO standard is a global one and as such is much more appealing to a global business, like Consumer Electronics, than national or regional (draft) legislation.

By linking energy savings activities in manufacturing directly to ISO14001, through the introduction of appropriate organizational structures and reporting formats, the cost saving potential of ISO14001 could be made very visible.

A similar effect was reached through the packaging reduction programs. the programs got an environmental flavor through increasing the amount of recycled materials used and by eliminating, to a large extent, expanded polystyrene (which is perceived as an environmentally unfriendly material).

With the momentum created in this way EcoDesign in general received more attention. Also the presence of appropriate metrics and supporting tools contributed towards this end. Achieving a strong environmental image also worked out positively for Philips in terms of supplier relations. Requirements were accepted as an opportunity to learn and to improve rather than as a threat and source of cost increases.

The internal and external network were further strengthened by the Environmental Opportunity Program. Through its performance, authorities took proposals and initiatives seriously – although this did not always work out in final regulation. In spite of all the successes there were still items to improve:

- implementation problems (in spite of a practical approach through the savings
- side rather than addressing the more formal part first) with ISO 14001 occurred in situations where business units or factory locations had a mix of negative experiences with the ISO 9001 quality programs. Also, savings in factories (utilities!) turned out to be easier to achieve than in product design itself.

This was to a large extent due to the fact that the EcoDesign (Design for Environment) tools and manuals were formulated in environmental rather than business language so that it was sometimes difficult to get the message across and boost creativity. This was enhanced by the fact that in spite of all potential savings, a clear strategy to exploit savings both upstream (suppliers) and downstream (in the market) was not yet in place.

In the mindset of many employees, environment activities were positioned clearly in the technical domain and not

seen as a real business item. Therefore sometimes other (non-technical) internal stakeholders were resistant to the idea. This was enhanced by external events; in this period authorities still took a formal attitude towards the electronic industry, thinking in principles rather than solutions. Particularly in Europe this was perceived by industry as unjustified and unfair.

6.3 The proactive approach

The EcoVision program (1998) see 5.1 created a tremendous shift in the mindset of the organization. The fact that the President and CEO introduced Eco Vision personally contributed substantially to its success. Soon it turned out that an introduction of the first 'Green Flagship' products lead to increases in market share (+2%), price premiums (an average +3%) and a lower bill of materials (approx –5%). Therefore the outcome – also in the cultural sense – has been very positive as set forth below:

Table 12 Effects of the proactive approach.

Good:	To be improved:
• Vision, strategy, roadmaps in place	* Deployment to improve
• Environment integrated into business	* Need to keep it separate in the beginning of process
• Broad based actions – fantastic results	* A lot of strain on the support organization
• EcoDesign works well feasibility remain hard to fight	* Consolidation into concepts,
• 'Green' marketing put into practice	* Special strategy needed to circumvent prejudice

On a strategic level the environment was integrated into business, vision, strategy and roadmaps. This received further support by results obtained in practice (see above).

In fact Eco Vision's success strained the support organization; not all initiatives, requests and questions could be adequately handled in the beginning because of the volume of all the work involved.

It also turned out that in spite of all integration efforts in later stages, environment should be kept separate in the very beginning of the design process. In this stage 'green' creativity is a basic issue. Too many day to day business issues had a negative impact on out of box thinking and specifically for environmental thinking.

Special attention needs to be paid to deployment as well. In the beginning of the program the basic mindset of many employees was still that the environment is a threat rather than an opportunity for the organization. Only the communication strategy of joint benefits, environmental as well as others, is able to overcome this.

8. References

General references: Proceedings of the IEEE Conference on Electronics and Environment, held each year in May, somewhere in North America.

1. The Brundtland Commission, "Our common future", Report of the world commission on Environment and Development Oxford University Press, Oxford U.K., 1987.

2. A.J. Jansen and A.L.N. Stevels, the EPass Method, a Systematic approach for Environmental Product Assessment, Proc. CARE environment '98, p313-p320, Vienna, Nov. 1998.

Annex I

Philips Consumer Electronics List of Environmentally Relevant Substances

Component (family): Supplier:

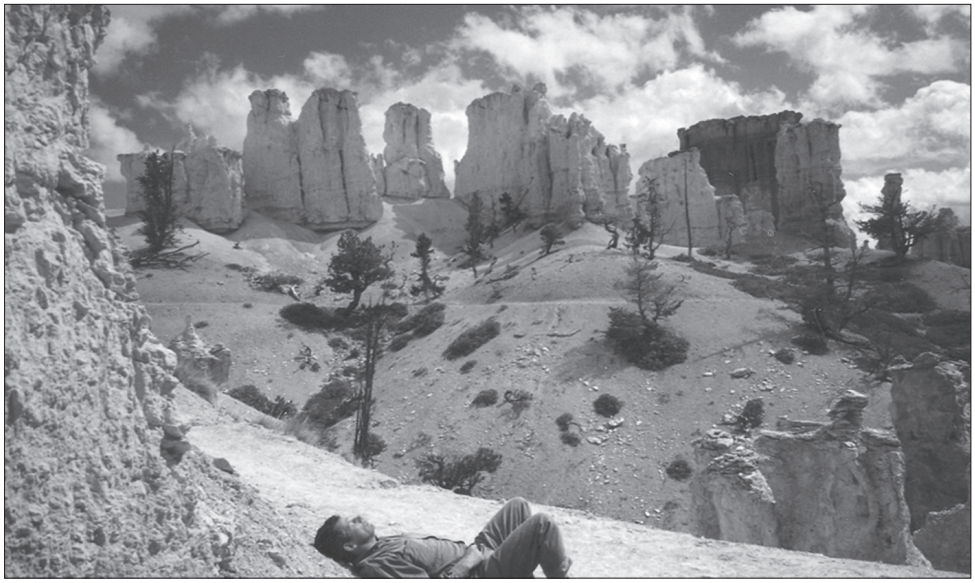
Supplier type number: Date:

Component weight (excl. packaging):

Compound	Threshold conc. ppm (mg/kg)	Tick off if actual conc. > threshold	Actual conc. ppm (mg/kg)
Antimony and –compounds	10		
Arsenic and – compounds	5		
Berylium and –compounds	10		
Cadmium and –compounds	5		
Chromium (hexavalent) compounds	10		
Cobalt and –compounds	25		
Lead and –compounds	100		
Mercury and –compounds	2		
Metal carbonyls	10		
Organic Tin compounds	10		
Selenium and –compounds	10		
Tellurium and –compounds	10		
Thallium and –compounds	10		
Asbestos (all types)	10		
Cyanides	10		
Benzene	1		
Phenol (monomer)	10		
Toluene	3		
Xylenes	5		
Polycyclic aromatic hydrocarbons	5		
CFC's and halones	0		
Acrylonitrile (monomer)	25		
DMA, (N, N)- dimethylacetamide	10		
NMA, (N)-methylacetamide	10		
DMF, (N,N)- dimethylformamide	10		
NMF, (N)-methylformamide	10		
Diethylamine	10		
Dimethylamine	10		
Nitrosamide	10		
Nitrosamine	10		
Ethylene glycol ethers and –acetates	10		
Phtalates (all)	25		
Formaldehyde (monomer)	40		
Hydrazine	10		
Picric acid	10		
PBBE, poly brominated biphenyl ethers	10		
PBB, poly brominated biphenyls	10		
PCB, poly chlorinated biphenyls	1		
PCT, poly chlorinated triphenyls	10		
Pentachlorophenol	10		
Dioxines	0		
Dibenzofurances	0		
Other halogenated aromatic hydrocarbons	20		
Epichlorohydrine (monomer)	10		
Vinylchloride (monomer)	1		
PVC and PVC blends	1000		
Other halogenated aliphatic hydrocarbons	10		

Pictures, 4

Bryce Canyon, UT, USA - Respect for Nature



4.2.2 How to make money with 'green'

Up until present day there has been a strong need to demonstrate that working on the environment brings in money for the organization involved with it. Often – even in proactive organizations – it is asked to demonstrate this in a bookkeepers way.

As such this cannot be done. However, there is a strong correlation between sound environmental activities and reducing costs for the company involved. For the electronics industry, I estimate the correlation coefficient to be 75%. The rest is either intangible (for instance image) or simply not profitable, or even represents a cost. This can either be the result of regulation (but then it is rather the cost of operation rather than of environment) or a matter of ethics and perceived licence to operate.

Whatever it is there is still a high demand to demonstrate the positive contribution of environmental activities to the bottom line.

For the audience of the Philips Global Environmental Conference, I wrote the following paper *"Five ways to be 'green' and profitable"*.

Of the five ways to make money with 'green', the EcoDesign and the 'Green' Supply Chain Management ones are very well known as approaches combining 'green' and profit. 'Green' marketing and communication is more tricky in this respect. Publicity emerging from companies can be counterproductive if the messages are formulated from a one sided 'green' perspective and other benefits for consumers are not mentioned (see also chapter 5.4).

A subject neglected in most environmental considerations is increasing the quality of the production and correspondingly reducing the amount of rejects. With the increased sophistication of many products, production processes get more complicated as well. After energy consumption in the use phase, the production phase ranks second in the environmental load over the complete lifecycle (see chapter s 3.1 and 3.2). Improving yields in production is therefore a high ranking environmental priority.

A striking example of this is the production of Liquid Crystal Displays (LCD screens). Theoretically, TV

sets with such screens would have a total environmental load which is 3-4 times lower than the traditional products with Cathode Ray Tube screens. However up until a few years ago LCD TVs had a load which was even higher than CRT based TVs. This was due to the very low yields in the production processes of the screens. By now, the yields have increased substantially and LCD TVs are clearly below CRT based TVs regarding their environmental loads. Better production yields are also one of the reason that prices of LCD TVs have also dropped.

The fifth opportunity mentioned in the article basically has to do with conservatism and risk avoiding behaviour in industry. The requirement to lower the time to market has enhanced this problem. In many electronic companies there is simply not enough time to rethink decisions taken in the past and to come up with new approaches. This would greatly help the environment and would avoid unnecessary cost as well!

In the article several examples are given where 'green basics' have a clear and positive outreach to completely different business aspects. This is because the environment is relatively new and "neutral". This is another reason to reconsider decisions made in the past. In such a process it is often discovered that the world has changed much more than just with the emergence of 'green'.

Five ways to be 'green' and profitable

Ab Stevels

Abstract

In this paper five ways to make money while being 'green' are described. These include a form of EcoDesign (Design for environment) in which company, customer and societal benefits are taken into account, a new way of dealing with suppliers, 'green' marketing and sales focusing on add-on benefits, increasing product quality through 'green' and paradigm shifts in creative thinking both for improved and alternative products. These concepts can be applied separately but when combined there are substantial ramifications of the results.

1. Introduction

In the last 10 years, environmental care in products has changed substantially in its approach.

- Upstream (supplier involvement) and downstream ('green' marketing and sales)
- To business level (strategy, roadmap) and support level (tools and tools development)
- To higher levels of sustainability (alternative functionality) and quality improvement (less rejects).

In a related development, environmental improvement ("creating green options") is now seeking to realize combined stakeholders benefit and is considering feasibility upfront. This is shown in the figure below:

Green Options	Benefit				Feasibility	
	Environmental	Business	Customer	Societal	Technical	Financial
First option						
Second option						
Third option						

Figure 1 The EcoDesign matrix.

From this figure it is clear that in order to be realized in practice, 'green' options should bring environmental benefit as a first priority, as well as company, customer and societal benefits. On top of that they should be feasible from a technical and financial point of view.

With this consideration environmental benefit is defined as a lower environmental load over the life cycle of the product or system concerned (see ref. 1). The other benefits can be classified as being material (money), immaterial (advantageous but difficult to express in monetary terms) and emotional. These items are described in more detail in the table below.

Table 1 The benefits matrix.

	Company	Customer	Society
Material	Cost reduction	Lower cost of ownership	Use of fewer resources
Immaterial	Simpler to produce, simpler to sell	Easier, convenience, more fun	Better compliance
Emotional	Better image	Feel good, quality of life, less fear	We make progress in green

In practice it turns out that there is a strong correlation between environmental benefits and other stakeholder benefits as specified above (at least in the electronic industry). This is creating the platform for the present paper which describes five ways to make money while being 'green'.
Paragraph 2 sketches the five ways and their interrelation; paragraphs 3-7 give more details.

2. Five ways to make money while being 'green' and their interrelation

The five ways to make money while being 'green' and their interrelation are given in the figure below:

Figure 2 Five ways to make money while being 'green'.

This figure shows that the five ways include:

- EcoDesign (design for Environment)
- Greening the supply chain
- 'Green' marketing and sales
- Increased quality through the 'green' perspective
- Introducing paradigm shifts; looking at functionality instead of embodiments.

These items are interrelated through enabling relationships; this means apart from having financial merit they will also enable improvements in the other departments. This is the reason that the five ways are positioned on a circle: improvements in one field create the basis for progress in other fields etc. Some examples are given which will be elucidated in paragraphs 3-7:

- EcoDesign will enable 'green' marketing and sales and increase production quality
- Suppliers' performance will enable better EcoDesign and 'green' marketing and sales
- Enhanced sales through green will stimulate EcoDesign and further functionality thinking
- Design for production quality leads to lower supply cost
- Paradigm shifts will open new lines of business lower supply cost.

There is a clear link between the five ways to make money of fig. 2 and the benefits matrix of table 1. This correlation is shown in the table below:

Table 2 Link between ways to make money and material and immaterial benefits

Way	Cost reduction	Immaterial / Emotion
Eco design	Resource reduction	Lower Life Cycle impact compliance
Suppliers	Supply cost	Enable EcoDesign
Green marketing & sales	Sell more	Caring, fun, nice to have
Quality	Less rejects	Easy, simple
Paradigm shift Functionality	Higher margins	Lower Life Cycle Impact

This table shows that being 'green' in the various approaches works out positively in different ways. However resource reduction, lower supply cost, more sales, less rejects and higher margins are all positive in monetary terms!

3. Making money through EcoDesign (Design for Environment)

In order to make EcoDesign operational in industrial organizations it is useful to split the field up into five focal area's (see ref. 2):

- Energy consumption
- Material application
- Packaging and transport
- Chemical content
- End-of-life / recyclability

Each of these area's has its own cost saving potential as evidenced by the following table.

Table 3 Environmental and cost benefits per EcoDesign focal area.

Focal area	EcoDesign action	Environmental benefit	Cost effect for producer	Cost effect for user
Energy	Use of more powerful IC's, miniaturization	Less energy used	Lower bill of materials	Lower electricity bill
Material	Less material	Less resources	Lower bill of materials	Lower price of product
	Material substitution	Less environmental load	?	?
	Use of recycled material	Closing the loop	Lower bill of materials	Lower price
Packaging & Transport	Less packaging materials	Less resources Less waste	Lower cost	Lower price of product
	Less packaging volume	Lower transport energy	Lower cost	?
Chemical Content	Mono material	Better recyclability	Volume discount	Lower price of product
	Elimination of flame retardants	Better recyclability	Lower bill of materials	Lower price of product
End-of-life, Recyclability	Design for disassembly	Higher recycling yield	Lower assembly cost	Lower end-of-life cost

From this table it is evident that a variety of activities can be envisaged to produce combined environmental and financial improvements. In order to structure this wealth of opportunity two issues should be considered in particular:

- Setting up an appropriate procedure for EcoDesign
- Setting priorities. A procedure for EcoDesign is given in Fig. 2 (taken from ref.).

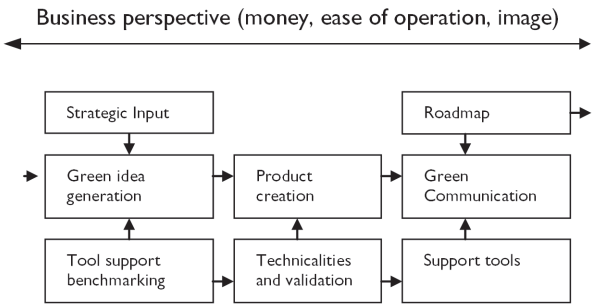


Figure 3 Flow chart for EcoDesign from a business perspective.

The basic idea behind this flow chart is to manage the processes in three ways:

- Strategic, managerial processes (roadmap)
- Execution of processes (ideas, creation, exploitation)
- Supporting processes

Particular significance is to be attributed to the processes at the very beginning of the whole procedure, that is idea generation supported by benchmarking and strategic input. In this stage positioning with respect to the environmental performance of competitors gives strong direction for what is to be achieved in later steps of EcoDesign. Apart from being the basis for ideas, benchmarking also provides "learning for free", flagging up improvements and solutions which competitors have already put into practice.
Table 4 gives statistics from 18 product benchmarks performed at Philips Consumer Electronics (PCE). In each case products are compared with 2 or 3 competitors, so with average performance PCE would be best in 25% or 33% of the cases. In practice the score is:

Table 4 Benchmarking score of 18 Philips Consumer Electronics products.

Benchmarking at Philips Consumer Electronics	
18 products compared with 2 or 3 competitors	
	Philips is best
Energy consumption	54%
Weight	56%
Packaging	44%
Chemical content	33%
Recyclability	57%

This table indicates that the performance of PCE products is clearly above average.
However, the table also shows that looking per focal area 8-12 products still can be brought up to competition levels – which is performance which has been proven in practice and is beyond any doubt regarding feasibility (see fig. 1). There is however more than just following the best competitors. In many cases, the analysis of benchmark results leads to ideas which when implented clearly go beyond best performanceof the competitors. Combining these has proven to lead, in practice, to substantial cost reductions in the product portfolio (if also table 3).

4. Making money through addressing suppliers

Currently the role of suppliers in ensuring good environmental performance has been generally recognized. Both inquiries about evidence for complying with legislation/ regulation and about implementation of Environmental Management System like on basis of ISO 14001 received an established position in Supply Chain Management.
It must be noted however that such an approach is basically 'top-down' and of a fairly defensive nature. Organizational and compliance costs resulting from single mindedly pushing through the items addressed above could lead to price increases rather than price decreases.
In this paragraph two avenues of action are proposed which will assist suppliers in bringing down prices while increasing environmental performance:

- The Environmental Quality Concept (EQC).
- The design for the supply chain concept (DSC).

The Environmental Quality Concept has been pioneered by Nagel (see ref. 3). It basically consists of a benchmark of suppliers in a similar product category. Inputs (energy, basic material, auxiliary material, water, packaging) and outputs (products, emission to air, water, solid waste) are analyzed quantitatively on the basis of a questionnaire. On the basis of the outcome quality indicators (I) are calculated for each input or output stream. (Normalized per unit of product delivered to the customer). I have the general form.

I = K* [Product stream out / Stream of consideration (in/out)]

In this equation K is an 'environmental quality constant' for the item considered. The quality indicators I can be consolidated into one "overall" quality indicator by adding all the I's per item in a weighted fashion. The weighting can take place in two ways:
Either based on * the "degree of perfection" of the different environmental items to be addressed in the category.

Or * The relative importance of the environmental items to be addressed in the category.
Or * The economic (monetary) importance of the environmental items to be addressed in the category.

The outcome of such calculations is a score I per category. Practice has shown that (note the similarity with product benchmarking in 3), no supplier scores 'best' consistently in all categories.
On the basis of such scores a customer can assist individual suppliers to define the meaningful avenues to improve. Since all environmental items involved are directly associated with cost items as well, a cost reduction potential can be defined:

Price reduction (Pr) = Pr standard + (1-E) Pr

With E being the environmental performance as calculated with the formulae of ref. 3.

The Design for the Supply Chain Concept entails that the customer involves suppliers in making designs with the particular aim to lower the environmental load and costs to the supplier. Basically this involves similar process management as was described in §3 for EcoDesign, however with the difference that this is applied upstream rather than downstream. The paradigm shift (see also §7) in this is that supplier and customer investigate jointly how a certain functionality can be realized best rather than forcing a given embodiment down the supplier's throat. As specialists in their field suppliers can make substantial contributions to enable producers to lower the environmental load over the life cycle of the product. This is particularly apparent in the electronic industry where up to 70-80% of the bill of materials (and of energy consumption of the future users) is related to suppliers. Impressive results of such 'enabling design' by suppliers are for instance:

- Lowering energy consumption of TV's and increasing playing (use) time of portable products by making available dedicated ('smart', 'green') IC's.
- Decreasing the amounts of plastic needed for housings by applying gas assisted molding and by using recycled materials.
- Designing full cardboard packaging for consumer electronics products with weights below 10 kg.

5. Making money by 'green' marketing and sales

Basically this strategy comes down to selling more products (preferably with higher margins). Because they are 'green', at first sight, this strategy seems to be an abortive one since it is generally recognized that 'green' as such does not sell. As will be pointed out below, this statement is right. However, this should lead to eliminating the 'as such' (that is taking 'green' marketing out of its isolation) rather than refraining on developing 'green' products.
An analysis of consumer attitudes (see ref. 4) has shown that worldwide – fairly irrespective of the country concerned – for only 20 – 30% of the population the environment is really important in buying decisions. For another 40 – 50% of the population 'green' is nice to have whereas for 20 – 30% of the people 'green' is unimportant or even negative. These figures make clear that in order to cater to a majority (70 – 80%) of the public, particularly the 'nice to have' category, has to be drawn into the camp of interested buyers. This is done by the environment AND… strategy through linking environmental benefits with other benefits as specified in table I (see customer column). Such a link between environmental and other benefits is shown in a schematic form in the table below:

Table 5 Link between environmental and other benefits for the five focal areas in 'green'.

Item	Environmental effect	Benefits	% of buyers attracted
Energy reduction	Less emissions	Material = lower cost	80
Material reduction	Less resources	Immaterial = simply, easy	75
Packaging/ Transport	Less resources, less emissions	Immaterial = convenient	75
Substances reduction	Less emissions	Emotional = less fear	60
Durability/ Recyclability	Less resources	Emotional = quality, feel good	75

This table shows that for all 'green' focal areas (see §3) large proportions - up to 80% for energy reduction - of the buyers are interested.
It is to be realized however that in current markets brand image – in this case environmental brand image – is just as important or may be even more important than technical 'green' achievements.
Areas in which 'green' can contribute to brand image include:

Leadership:

- Top management shows, visible involvement in 'green'
- Pro active in industry associations
- Participation in international activities like the World Business Council on Sustainable Development
- Having a Corporate Environmental Vision, Policy and Roadmap.

Programs:

- Corporate programs like Philips' (Eco Vision).
- ISO 14001 certification
- Supplier requirements

Documentation:

- Environmental (annual) reports
- Brochures like the Philips' "Greening your Business"
- Scorecards/reviews
- Internet
- Press release/free publicity/technical, scientific articles

Sponsorship:

- Environmental research and teaching chairs at Universities/institutions
- Environmental related events (like EGG)
- Nature conservation groups.

Focus on company 'green' achievements and brand image turned out to be more instrumental to increasing sales than applying for Eco labels. In the table below the differences between a company run 'green' communication program (in this case the Philips Eco Vision program) and general Eco label programs is outlined.

Table 6 Comparison of effect of Philips Eco Vision communication program and Eco labeling.

Identity	Unique for Philips	One of many companies having Ecolabel
Scope	Global	Local, National, Regional
Nature	Technical, image	Political
Procedure & to obtain	Own control	Dependent on thirds
Language	Five focal area's (easy to understand)	Environmental (difficult to understand)
Accountability	Life Cycle Calculation	?
Transparency to customer	Big	Small

This table shows that the big gain from having a company specific program is the transparency provided to the customer both in terms of brand identity and language used.

6. Making money by increasing product quality, reducing rejects.

The three basic factors to product quality are depicted in fig. 4.

Figure 4 Basic factors determining product quality, reject level.

This figure is well known from considerations how to improve product quality. It is the basis for applying methods like as six sigma and Poke Yoke. Basically three items are addressed: supplier quality, human errors and design complexity. Two of them (supplier quality and design complexity) have a clear link with Ecodesign. Reversely, starting from the 'green' perspective can therefore have a positive effect on reducing reject levels:

- Design for the supply chain (see also 4) will increase supplier quality and therefore reduce the risk of high reject levels.
- Reducing design complexity for instance by resource reduction and modular design (see 3) will simplify assembly processes. Generally speaking this reduces the amount of errors in production. Specifically, design for disassembly will contribute towards this end.

Both items are examples of fields in which environmental thinking leads to improvements outside the very environmental territory. How reducing design complexity / design for the supply chain influences the number of rejects is shown by the Hinkley correlation (see ref. 5):

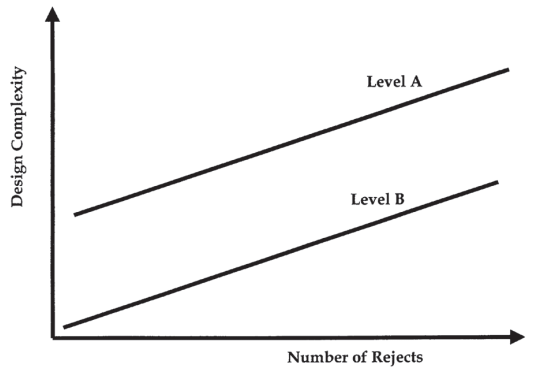


Figure 5 The Hinkley correlation

This diagram shows that for a certain level of supplier competence and skills in a production factory there is a linear relationship between design complexity and number of rejects. The diagram also shows that design complexity needs to be reduced when production is moved from a high level industrial environment to a lower level. The penalty for not doing so is a higher amount of rejects.

7. Making money by applying paradigm shifts

The meaning of the word paradigm is 'believing' that things should be as they are. A paradigm shift is therefore a change of mindset. As regards products 'green' thinking is stimulating such paradigm shifts because the environmental approach questions 'why are embodiments of products as they are' and are there ways and means to provide the same functionality in a more environmentally friendly way. This contrasts with the traditional approach in which first priority always has been to produce the chosen embodiments through more and more efficient production. The classic example is the packaging of electronics products. For more than 50 years the paradigm was that the box should consist of cardboard and the buffers of expanded polystyrene. In that period, optimization of the concept has been worked on continuously and in the nineties it was believed that further progress had become impossible.

When the environmental approach addressed these items the following questions came up:

- What is the maximum % of recycled cardboard that the boxes, given the climate conditions during transport and storage, can have?
- What is more important: reduction of volume, environmental load of transportation or reduction of packaging weight (environmental load of materials).
- Can the buffer function of EPS also be realized by applying low impact materials like cardboard or molded fiber?
- Can the shock resistance of the product be increased so that less packaging is needed.

Looking in this way at this classic packaging issue brought impressive environmental gains and cost savings at Philips Consumer Electronics.

- The recycled content of cardboard has consistently increased to 60% worldwide.
- For TVs worldwide and for other consumer electronics products exported to a different part of the world, volume reduction is more important than weight reduction, both from the ecological and the economic perspective.
- In products with weight below approx. 10 kg. EPS can be replaced by other materials.
- The shock resistance approach works out well particularly for certain categories of audio products.

Paradigm shifts also play an important role in conceptual changes (next to the "improvement" approach as demonstrated above). Examples are:

- Apply different physical principles:
  - Human powered radio versus battery operated radio
  - Monitor with Liquid Crystal Display Screen instead of Cathode Ray Tube.
- Life cycle optimization
  - Create modular functionality, e.g. for Audio sets, so that only parts of the set have to be replaced with development of user requirements and technology developments.
- Services: capability of electronic products to download from the internet (music, film, information)

In all these cases environmental gains and economic benefits for producers and users go (or will go) hand in hand.

8. Current implementation of the five ways to make money while being 'green'

The following chart features a review of best practices for implementation of the principles to make money while being 'green' yields the following picture:

Table 7 Review of best practices of implementation of the "five ways".

Perspective / Item	Awareness	Organization of processes	Business perspective	Customer perspective	Societal perspective	Overall result
EcoDesign	+++	+	++	0	+	++
Suppliers Questionnaires	+	+	0	0	+	0/+
Suppliers performance	0	0	0	0	0	0
Green marketing and sales	++	+	+	0	0	0
Quality/reject	0	0	0	0	0	0
Paradigm shifts	++	+	+	0	0	+

This picture shows that the overall implementation of the five principles is still weak; only EcoDesign is consistently addressed well, although organization of the processes and customer perspective are still weak. On the other hand supplier involvement does not surpass the questionnaire level and considerable economic potential has not yet been addressed. Using the environmental perspective to tackle quality and reject issues is virtually absent. 'Green' marketing, sales and forms of paradigm shift are well recognized as opportunities but are still weak at the execution level. Overall the customer perspective is still an unknown territory in environmental thinking. There is a need for drastic improvements here because customer care should be the basis for market driven environmental improvement. The business perspective and societal perspectives are weak too: this is an indication that the "environment" is an item, which is developing too much in isolation. Also in the organization of process there is still big improvement potential: it seems that technicalities are still dominating the management of 'green'.

9. Conclusion

This paper has shown that environmental approaches have tremendous potential not only for the environment as such but also for companies, consumers and society as a whole. Its significance is therefore going far beyond its original domain.

In order to realize all these benefits in practice, integration of the environment into business (product creation but also supply chain management production) 'green' marketing is an essential ingredient. Apart from widening the concept to include supplier performance and quality / reject this is the basic step to be taken in the years to come.

For EcoDesign this includes a shift from supply to demand driven activities which means that business should look at what sensible things can be done proactively in the environmental domain rather than waiting for things to be driven by external developments. For suppliers the big challenge is to come from a defensive approach to proactive chain management in which performance plays a big role. 'Green' marketing and sales will have to overcome the prejudices, which currently exist in this field.

An environmental perspective is also useful to come to real quality products and to reduce rejects. The first steps still have to be made and results can be expected not earlier than five years from now.

Paradigm shifts still have limited foothold mainly because they are revolutionizing the way companies are traditionally operating. This is however the field where the biggest environmental lessons and societal gain can be made. Currently there is a strong push in this sector, particularly on the basis of technology driven product service combinations. The examples given in this paper show however that also in the field of 'old-economy' products, using paradigm shifts as a management approach can be very fruitful.

Overall it is concluded that there are at least five ways forward in 'green'. All run in the same direction which combines environmental and economical gain. We are still at the beginning of these avenues. Five to ten years from now it will turn out that this will be a long but rewarding trip.

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Highlights of the year, 1997

Environmental benchmarking

The idea to develop an environmental benchmarking method came from Delft.

At that time my newly established chair had been positioned in the Design Engineering group and not in the Design for Sustainability group. The reason remains a mystery, most likely it is a kind of university dialectic which is difficult to explain to relative outsiders.

Anyway, one of the good things about Design Engineering was, and is, its desire to build on physical principles and its passion for metrics. This is helpful in an environmental world where talking about design paradigms, holistic principles and socially responsible design (whatever that may mean) continues to dominate.

Together with Arjen Jansen the 'EPass' method was developed. This is a systematic approach for the measurement of the environmental properties of products (see also chapter 6.3.1)

Its two elements are:

**Measurement of physical parameters in the five focal areas:*

1. *Energy consumption in various modes of operation and of products and subassemblies (in watts)*
2. *Material application (on the basis of material type and subassembly function (kg)*
3. *Packaging and transport (weight, volume)*
4. *Chemical content (indirectly through weight of electronics and of cable and wiring in kg)*
5. *Recyclability (disassembly time (sec.) and efficiency (%)*

**Measure on a relative scale: compare current products with those of previous generations but particularly with products of other brands.*

At Delft EPass had been successful so the method was ready to be tested at Philips Consumer Electronics. This approach however was initially rejected; prejudice against 'green' was still widespread. Finally, the Business Unit Monitors in Taiwan were prepared to do a test. The credibility that had been built up by the disassembly analysis (see chapter 7.3) was of great help in giving the E-Pass the benefit of the doubt. Student Rolf Namjeski was sent to Taiwan and his benchmarking work became an instant success. It was demonstrated that both in environmental design (and in overall design) Philips monitors were far behind those of Sony and Samsung. Rolf's report became the basis for brainstorms that resulted in the total revamp of monitor design (see chapter 6.3). The new products, the Philips 'Brilliance' monitors were 'green', had better performance than the competition and sold well.

This meant that the other Business Groups became interested too. In 1999 Environmental Benchmarking became mandatory for all groups of the CE Division. Even today it is the cornerstone of the environmental part of the Corporate Philips Sustainability Program.

4.3 Product Environmental Care Systems

In the year 2000 the integration of environment into business - according to the experiences and ideas described in the chapter 4.1 and 4.2 - had been completed at Philips Consumer Electronics. Activities for developing a planning and performance measurement tool to and providing visibility for that tool in company operations had been started (see also chapter 4.4).
It was still necessary to position the approach with respect to external developments. These included:

- The ISO14001 standards. Several authors claimed the standards needed to more explicitly address product development.
- The ISO14062 report, which was an attempt to fill the perceived gap for product development in the ISO 14001 standards.
- IPP (Integrated Product Policy). This was a European Union effort intended to promote Life Cycle Thinking and EcoDesign. In a later stage EEE and EuP were placed under this IPP banner. Both EEE (see below) and its successor EuP (see chapter 9.2.2) focused more explicitly on EcoDesign of electronic products.
- EEE, an initiative of the Directorate General Industry of the European Union, that intended to establish 'harmonized' standards for essential (Eco) requirements of electronic products.
- Eco-labels. The idea behind this is that when products satisfy Eco-requirements, they sell 'automatically' (this is highly doubtful, see chapter 5.4). Eco-labels were therefore thought to be strong drivers for EcoDesign.

A common denominator of all these systems is that there is a lot of emphasis on environmental issues. Balance with traditional business interests is almost absent, which meant implementation in all cases was pretty cumbersome. In spite of this, these systems got a lot of publicity. Inside Philips the question was raised "why do we needed a special system?"
As a result I had to make several presentations to explain why our system was better suited for business than the others, which were pushed externally. Basically the argument is that the Philips System combines the best of all worlds. This means that all the elements present can be found in one or more of the EcoDesign/Product Environmental Care Systems described above. On top of that, there is more emphasis on organizational and business issues. In fact, the Philips system is rather more complete than less eco.
In light of all kinds of discussions going on at that time, it was also decided to communicate this idea at conferences and seminars. An example of such a paper is given on the next page. In this paper *"Product Environmental Care, A Praxis – Based System Uniting ISO 14001, ISO 14062, IPP, EEE And Ecolabel Elements"*, it is concluded that the Philips system is in fact a combination of elements existing approaches, such as those mentioned above.
In a later development EuP has become the successor of EEE (see chapter 9.2.2) and has become a part of IPP. It contains a lot of enhancements. EuP puts the necessity of an environmental product life cycle analysis in pole position. Physical parameters are allowed in such an analysis, although impact analysis is still preferred. Moreover, EuP stated that environmental improvements needed to be balanced against economical, technical and social issues, which is in fact calling for business and societal integration. These basic items are important steps forward. Simultaneously, the EuP approaches still have several important practical drawbacks which are discussed in 9.2.2 as well. It is however my firm opinion that the current Philips Product Environmental Care system is a very practical way to serve the intent of EuP in an excellent way.

Product Environmental Care, A Praxis – Based System Uniting ISO 14001, ISO 14062, IPP, EEE And Ecolabel Elements

Ab Stevels

Abstract

Approaches addressing Environmental Care in products have been assessed according to requirements which were derived on the basis of practical experiences when implementing EcoDesign / Design for Environment (DfE) in the electronic industry. Systems examined include ISO standard 14001, ISO technical report (draft) 14062, the European EEE and IPP approaches and Ecolabels. None of the approaches as such fulfill all requirements in a satisfactory way. However, if elements with the best scores are combined into one system a very good basis for further tool development is created.

I. Introduction

EcoDesign / Design for Environment (DfE) has been addressed in the last ten years by a multitude of institutions either with an academic, standardization or governmental background. Academics have been focusing on design methodology and assessment (Life Cycle Analysis). Standardization has been looking to management systems such as ISO 14001 and EMAS. Public institutions (EPA, Directorates Environment of the European Union) have developed instruments like Energy Star, Ecolabels of various kinds as well as legislation developed. In the last category countries of the European Union are very active in fields such as packaging recycling, take back and recycling of electronics (WEEE) and cars, substances (the so called RoHS proposal) and so-called Environmental conformity initiative (EEE).

In spite of all these initiatives, EcoDesign / DfE has achieved only a limited foothold in industry. Proactive companies have shown excellent performance in this field – showing that when organized well EcoDesign / DfE really pays and enhances the business (see also II). However, on average the approach in industry has been fairly defensive so far. In the opinion of the author this unfortunate situation is due to the lack of integration between environment and business. Wanting to do good for the environment and focusing on the designer as the person who has to deliver, bypasses the realities of the business value chain and overemphasizes the technical part of the EcoDesign / DfE concept.

On the other hand there is a widespread misconception within industrial organizations, and by customers, that environmental activities cost money so that market forces cannot deliver more sustainability. This perception, which is fed by experiences in the process industry for more than 30 years, means that initiatives by academics and governments are sometimes contested by industry or at least placed low on the business agenda.

In this paper it will be shown on the basis of practical experiences that EcoDesign / DfE can provide substantial strengths for business. Its ramifications go far beyond environmental performance exclusively. When expanded and embedded in Environmental Care Systems it can be considered to be a new business management approach (II). Environmental Care Systems need to be organized. In III it is explored which issues need to be addressed. These issues include: Awareness, "Why" (should it be done), "What" (strategy, organization, programs and requirements) and "How" (idea generation, execution, validation and exploitation of the result).

As a matter of fact Product Environmental Care system should fit into usual business requirements to leave room for market forces, integrate with the business value chain and provides terms of reference to measure performance.

In IV it is explored to what extent current Environmental approaches fit into the cutline of III. This includes:

- The ISO 14001 standard for Environmental Management Systems.
- The (draft) ISO 14062 report (version December 2000) on guidelines for integrating environmental aspects into product development.
- The (draft) Integrated Product Policy document of the European Union, version January 2001.
- The (draft) Environment conformity of Electronic and Electrical goods regulation of the European Union (version November 2000).
- Ecolabels of various kinds (average).

In V it will be concluded that none of the approaches cover all items in a satisfactory way (Structure, Business, Design principles) for a comprehensive Product Environmental Care System. However, if elements with the best scores are combined into one system a very strong tool can be developed. The ISO Technical Report 14062 as it stands now scores relatively well. Since it is still in a draft form it is expected that it will be improved further. In future it will form a strong basis for the development of Product Environmental Care Systems.

II. The strengths of EcoDesign / Design for Environment to be incorporated in a Product Environmental Care (PEC) system

DfE / EcoDesign is based on a number of principles which have significance for the environmental field as such but in practice have been shown to go far beyond that. Based on these principles substantial cost reductions have been achieved, products turned out to be simpler to manufacture and the image of the producer has been improved. In these cases there has also been lower cost of ownership, and more satisfaction for the customer. The five EcoDesign principles are:

1. Prevention. Do more with less.

Two examples of the application of this principle are:

- Flame retardants in TV sets. By rearranging the position of the electronics within the set and lower energy consumption, the problems of internal "self heat" of electronics products can be mitigated. Several companies in Europe, including Philips, were so successful in this that all flame retardants used in the housing could be eliminated. As a matter of fact, the standards for fire safety were still satisfied by a wide margin. while satisfying with a wide margin the safety standards.
- CFC issues. The requirements of eliminating all CFC use has led many companies to a reexamination of cleaning practices. In the Netherlands and in Sweden this has led to a situation where in approximately 40% of the cases cleaning could be completely eliminated. By preventing contamination earlier in the process, water-based cleaning could be easily applied in 40% of the cases (also because for the first time the content of the requirement to be clean was clearly defined) and in only 20% of the cases substantial research for alternatives had to be done.

2. Functionality thinking. Look first at the function of the envisaged design instead of embodiments. Examples of this approach are:

- Replacing Expanded Poly Styrene (EPS) buffers used in packaging by cardboard buffers. EPS has been used for many decades. It is applied as the obvious solution to make packed products shock resistant. The environmental perspective suggested, as a possible design strategy, the use of lower impact materials which led to a reexamination on a functionality basis. It was concluded that cardboard buffers can be used in packaging of electronic products with a weight of less than 10 kg.
- In monitors, a metal "cage" was used in the past to ensure shielding of electromagnetic radiation from the electronics. Simultaneously this cage was used as a mechanical support in the construction. Due to the lower energy consumption of the electronics, the shielding function can be fulfilled by using less material. However to realize this environmental and cost improvement, product architecture, in particular the mechanical support functions had to be redone.

3. Life Cycle thinking: Check whether design improvements in one of the five focal areas (energy, material packaging and transport, chemical content, recyclability) really brings a positive environmental effect on a life cycle basis.

- Design effects for improving TV packaging were redirected when it turned out that the integral environmental load of packaging and transport were 70% volume related and only 30% material related. The focus became reducing volume rather than reducing packaging weight.
- High recycling percentages can more easily be achieved by applying metal rather than plastic in products. However in the department of material application the environmental load of metals is higher than that of plastics. On a net basis improved recycling cannot compensate for that.

4. Chain management. Upstream (suppliers) and downstream (recyclers) activities can contribute substantially to lowering the environmental load.

- By making and executing a common roadmap with their IC suppliers, consumer electronics companies have been able to lower the energy consumption of the standby function substantially. Energy consumption in the operational mode has also been decreased.
- Recyclers have requested not to attach cables /wires to a product's housing so that recyclability is higher. This has inspired many to pay much more attention to cable /wire configurations, resulting in less material use as well.

5. Paradigm shifts. Question: Why are things as they are?

- Investigation of the limited application of energy saving lamps in living rooms (replacing with incandescent lamps) led to new business directions to support this development:
  a) develop energy saving lamps with a better color rendition.
  b) extend the energy saving lamp, product line-up in the low Watt range.
  c) introduce lamp shades taking into account the slightly different form of the energy saving lamps.
  d) produce checklists through which users can determine for themselves where the application of energy saving lamps is beneficial from an environmental and economic perspective.
- Further penetration of portable products is hampered by their battery power. These batteries are a source of discomfort and are considered to be environmentally unfriendly. This means that the application of solar cells, fuel cells (methanol) and human powered products are now considered. A first result of this is the availability of human powered radios, which are a huge commercial success.

All these examples show first of all that the application of the EcoDesign / DfE principles can bring advantages during all phases of the lifecycle (production, packaging and transport, use and end of life) and on all major items contributing to environmental impact (energy consumption, materials application, substances and chemicals and recycling).

A second very important item is that the benefits are not restricted to the environmental field exclusively, but are combined with those for other stakeholders, according to table 1.

The benefits matrix in table 1 is on one hand the key for the selection and prioritization of 'green' design possibilities. On the other hand it is the key to successful 'green' marketing strategies; only when environmental benefits can be combined with other benefits (or vice versa), will 'green' products sell well (see ref. 1).

In the examples given above there is another element which is inherently linked to EcoDesign / DfE: cross functionality. In all cases combinations of disciplines play a crucial role, for instance designers and purchasers, production and production engineering, logistics and packaging designers, electronics engineering and purchasing, mechanical engineering and product managers etc. Organizing such crossfunctional processes to bring primarily environmental improvements pays dividends in a number of other fields. This is giving EcoDesign / DfE significance far beyond its own field.

Table 1 The benefits matrix

Stakeholder / Type of benefit	Company	Consumer	Societal
Material	Costs reduction	Lower cost of ownership	Less imports
Immaterial	Easier to produce Easier to sell	Easy, convenience, fun	Better compliance with 'green' policies
Emotional	Enhancement of image	Feel good, quality of life	"We make progress in green"

III. Requirements for Product Environmental Care (PEC) systems

Requirements of PEC systems can be split in three parts:

1) The five EcoDesign principles, as set forth in II, should be addressed.
2) The processes ensuring cross functionality and prioritization, according to the benefit matrix, should be organized.
3) The conditions for successful integration into a business should be fulfilled.

In this section items 2 and 3 will be examined. The basis for formulating the requirements are studies on the implementation of EcoDesign / DfE in the Netherlands. These include:

- Integration of EcoDesign into the business (ref. 2).
- Application of EcoDesign in the electronics industry (ref. 3).

These studies propose a detailed systematic approach for making product environmental care happen in business. Particular attention is to be paid to drivers why to do it, to separation of idea generation and validation and to benchmark to set terms of references.

- Environmental Value Chain Analysis: A tool for product definition in EcoDesign. Here the necessity of aligning internal and external value chains is addressed (ref. 4).
- The unpredictable process of implementing Ecoefficiency strategies (ref. 5).

In this study conditions for success which can be derived from cases studies are formulated. These conditions include; management of the internal value chain, responding to external drivers favorable to business conditions, product characteristics which allow room to maneuver and the potential to gain competitive advantage.

- Product oriented Environmental management systems (ref. 6).

This work emphasizes management support, the necessity to have clear strategies and the importance of information systems.

Organizing the elements on these studies requirements on PEC systems can be described in the following way:

Starting EcoDesign / DfE processes should begin by creating awareness. People in an organization should realize that there is an opportunity out there and that it can be done, for instance by showing that e.g. competitors did it already. A next step is examining relevant external and internal drivers. External drivers can be customer requirements and legislation / regulation. Internal drivers are, for instance, cost reduction and a better image. Analysis of such drivers already provides a first direction and first priorities for the activities. This is very relevant because for each activity in a company – including 'green' – limited budgets, capacities and time frames are available.

Using these limited resources properly is the goal of the next chapter to be addressed, the 'what' items:

* strategies: What goals are to be set.
* organization: What responsibilities are to be defined.
* programs: Definition of scope and items to be realized.
* requirements: Translation of strategies, programs into specifications for individual products.

Last but not least the 'how' items are to be considered. These items are closest to traditional EcoDesign / DfE, however there are some remarkable differences:

- Idea generation: Develop ideas on the basis of facts acquired from suppliers or through environmental benchmarking (see ref. 7). When these are tested according to the benefits matrix, see fig. 1, the ideas can be prioritized and fed into product specifications (note that this is a process different from applying upfront LCA – addressing of non environmental items in this phase is ensuring business integration!).
- Execution: Apply technical EcoDesign / DfE principles to the prioritized targets.
- Validation: Validate the result on the basis of environmental common sense (reduction of W, kg, see, % etc.), factor methods or abbreviated or full Life Cycle Analysis.
- Exploitation in the market: 'Green' marketing and sales on the basis of the benefits matrix (see fig. 1) according to the principles outlined in ref. 1.

By operating in the way that has been studied above the conditions for successful business integration and operating in the market with 'green' items are fulfilled. What needs to be added to this is defining terms of reference. Most traditional validation methods work on an absolute floating scale which has no significance for internal and external stakeholders and is as such difficult to communicate. Such terms of reference can be:

- Products of a previous generation (focus on "internal improvements").
- Products / comparable functionalities of competitors (focus on "external" improvement).

IV. Rating of current systems addressing Product Environmental Care

In this chapter five systems addressing product Environmental Care in one way or another are rated according to the criteria and requirements developed in II and III. These include:

- The ISO 14001 standard for environmental management systems.
- The draft ISO 14062 report (version Dec. 2000) on guidelines for integrating environmental aspects into product development.
- The draft Integrated Product Policy (IPP) document of the European Union, version January 2001.
- The draft Environment conformity of Electronic and Electrical goods regulation of the European Union (version Nov. 2000).
- Ecolabels of various kinds (average).

First, the EcoDesign / DfE items are examined. Results are summarized in table 2:

Table 2 EcoDesign / DfE principles in current systems considering Environmental Care

Item/Approach / Principle	ISO 14001	ISO 14062 Version Dec. 2000	IPP Version Dec. 2001	EEE Version Nov. 2000	Ecolabels
Prevention	0	+	0	++	0
Functionality thinking	0	+	0	0	+
Life cycle thinking	0	++	+	+	+
Chain management	0	0	0	0	0
Paradigm shifts	0	+	0	0	0

+++ = addressed very well ++ = addressed well + = addressed 0 = not addressed

First conclusion from table 2 is that with the exception of chain management the EcoDesign / DfE principles are all addressed. Since ISO 14001 is primarily a management system it is natural that it does not score in this table. In ISO 14062 there is clearly room for further improvement. IPP, which is chiefly about policy instruments to foster EcoDesign / DfE clearly needs to be beefed up which also holds for EEE. Ecolabels specifically consider products with similar functionality brought to the market rather than business processes. Many chain management activities and design paradigm shifts are not rated at all. However prevention, functionality thinking and life cycle thinking should be enhanced.

In table 3 the PEC requirements of current systems considering Environmental Care are assessed.

Table 3 PEC requirements in current systems considering Environmental Care

Item / Approach	ISO 14001	ISO 14062 Version Dec. 2000	IPP Version Jan 2001	EEE Version Nov. 2000	Ecolabels
Awareness	+++	+	+	+	+
Why to do it	0	+	0	+	+
"What"					
Strategy	0	+	0	+	0
Organization	+++	+	0	0	0
Programs	+	0	+	0	+
Requirements	0	+	0	+	++
"How"					
Idea generation	0	0	0	+	+
Execution					
Validation	0	++	0	0	0
Exploitation of result	0	++	++	++	+
	0	+	0	+	++

+++ = addressed very well ++ = addressed well + = addressed 0 = not addressed

Due to the fact that ISO 14001 is a well established global system its awareness power is maximum. The other systems can only score higher by increasing their appeal or by giving up their regional or national character (Eco-labels). The "why" items (the drivers) get surprisingly little attention, which also holds for strategy. There is a clear need to further stress these items.

In terms of organization ISO 14001 scores very well both through the required structure and the plan-do-check-act approach. The European IPP and EEE are too focused on the design process as such (see "how") whereas the "whats" are addressed to a lesser extent in the current drafts.

For programs and requirements the current status is pretty poor as well. Structured approaches are not widespread and there seems to be too much confidence in "designers staring out of the window wanting to do something good for the environment".

In the field of "how" the table shows that there should be more attention paid to systematic idea generation and prioritization. ISO 14062 scores particularly well for execution. Attention for validation is high although the scores in this department are not at their maximum. This is because generally speaking those LCA approaches that are promoted are difficult to carry out in an industry.

For exploitation of results only Ecolabels get an "addressed well" score – this could be further enhanced by linking 'green' with other benefits (see fig. 1). The business items are reviewed in table 4.

Table 4 Business items related to current Environmental Care systems

Item / Approach	ISO 14001	ISO 14062 Version Dec. 2000	IPP Version Jan. 2001	EEE Version Nov. 2000	Ecolabels
Leaving room for market forces	0	+	+	+	+
Integration with business	+	++	0	+	0
Defining terms of reference	++	0	0	+	+++

+++ = addressed very well ++ = addressed well + = addressed 0 = not addressed

In this category the item "leaving room for market forces" is a difficult one. On the one hand it is generally recognized that better environmental performance should be rewarded. On the other hand there is a lot of leveling of the playing field observed in practice: ISO 14001 has lost its character as a qualifier. Labels and conformity marks will most likely go the same way. From this perspective ISO 14062 and IPP have the best potential.

IPP and Ecolabels so far link up primarily with business process as occur in practice. ISO 14001 has in this respect a limited appeal due to its formal character. ISO 14062 scores well because it focuses on product creation processes. In the department: defining terms of references general scores are poor with exception of ISO 14001. This is related to the fact that EcoDesign / DfE has started addressing absolute items like "environmental load" rather than the improvement idea.

V. Synthesis

In spite of the fact that quite some criticism is possible on the present systems addressing Product Environmental Care, there is also a lot of good news:

- Three of the five systems are still in their draft stage (ISO 14062, EEE and IPP). It is expected that further discussions among the stakeholders will result in improvements of these approaches, resulting in higher scores in the tables 2, 3, and 4.
- Although there are gaps in each of the systems considered, a combination of the best scores for each element could result in one comprehensive system for Product Environmental Care.

The Design for Sustainability group of Delft University in the Netherlands will further develop such systems on the basis of the best combination and test these in industrial practice. Key elements in the system to be developed will:

- Assist in defining the key 'green' (design) avenue and setting their priorities
- Assist in building strategies, programs and requirements.
- Assist in fostering creativity / idea generation and defining terms of reference for validation.
- Assist in defining key processes and their alignment, including overall 'green' performance scores.

It will ensure that other stakeholder benefits will be considered jointly in this Delft Product Environmental Care systems. This will empower the PEC to be developed when tested at the business level. Results of such tests will be helpful to enhance standardization and public policies in this field.

VI. Conclusion

EcoDesign / DfE principles can be a strong basis for enhancing business. When introduced in the form of Product Environmental Care systems the benefits of this concept can be systematically exploited. Current standards (ISO 14001, ISO 14062), policy approaches (EEE, IPP) and Ecolabeling schemes individually fulfill only part of the requirements to be set (from a practical perspective) in a satisfactory way. However, if elements of all these approaches are combined through a 'best score' approach, a very good basis for further development is created.

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Personalities, 5

Leendert Cornelis ('Leen') Dronkers Sr. (1885-1955): Creation and nature

Leen Dronkers is my grandfather (and the father of my mother, see Personalities 6). From him I learned a love for nature and respect for Creation. He was born in a little village in the southwest of the Netherlands (Nisse, Zeeland, see also Pictures, 14). As the son of the local baker he had limited possibilities for development. Social mobility was uncommon in those days. One of the few ways to achieve this was to become a schoolteacher. That was what he became and what he really was, with all his heart and soul.

I was his favourite grandson and when my grandparents moved to Eindhoven to live close to their children and grandchildren I went every Wednesday and Saturday afternoon to see him. I got taught how to grow herbs and plants in the garden, how to pick apples and other useful things, or we went out of town (nature was still close to the place where we lived). He could tell endless and interesting stories about trees, wild plants, mushrooms and butterflies (both still abundant). He knew the names of all the species. If I found a plant that he did not know the name of I got paid ten cents. I almost earned some money with what turned out to be 'witte rapunzel' (Phyteuma spicatum). This was because he was very surprised that is was growing in the Eindhoven region and not because he did not know the name of the species.

Opa (the Dutch name for grandfather) was also a Calvinist with strong patriotic feelings. He thought that it was very well possible that one of the ten lost tribes of Israel had turned up in Zeeland. He was proud of the Republic of the Seven United Provinces (from 1677 – 1795, the glory days of the Netherlands). His sense of duty was even stronger: "Work till you have finished it". "There is always more to learn". "If you can walk for ten kilometres do not compromise for five". He was not optimistic about society but nevertheless he always wanted to look forward: "From the past you can learn little".

When Opa Dronkers died, I was almost 11 years old, the impact on my life was enormous and it still is.

The ' Dronkers' Walk: go to Nisse (Zeeland), 6 km south of Goes. Start at the village square, go past the Dutch Reformed Church on the Zuidweg, cross the N666 and go R (Palmboomseweg), go R (Koedijk), go L, go R than first L (Zwaaksedijk), go R (Vreelandsedijk), go L, go R (Nieuw Vreelandsedijk) and direct L. Go straight ahead and in the end R. Go straight to Kruipuitse Dijk, go R (Oudelandsedijk) and first R. At the end of the road R (cyclists path), direct L (Ambachtsherendijk), and R (Brilletjesdijk). Go L (Valdijk), go L and directly L again.

After that go R and R again (footpath Paardekerkhofwegeling) , go L Akerweg and L to Nisse.

4.4 Managing the Environment and Business today: planning and performance measurement.

4.4.1 Introduction

Interest in what companies are really doing in 'Eco' products was further stimulated with the start of the research project of PhD candidate Oriol ('Uri') Pascual. Coming from Barcelona he was immersed in the Delft mentality and style, but soon added flavor to DfS with his Catalan/Spanish style. The first part of his work (the second part is focusing on EcoValue, see chapter 2.3) has been dealing with 3 research questions:

- What do electronic companies publish on Applied EcoDesign?
- How far the implementation and performance measurements of EcoDesign in electronic companies have progressed?
- For companies having mature EcoDesign activities, what is the style of their operations?

The approach to finding answers to these questions has been mainly empirical. As was pointed out in chapter 2.1, little has been published about this subject. There is still active debate about all the findings we have had - and still have. However, the main issues are very clear and should be interpreted in a comprehensive way. The complete results will be published in Uri's thesis to be published mid 2008.

In the paragraphs below three publications are presented with information referring to the research questions presented above. The information for these results was obtained through literature reviews, checking websites and other cooperate information and through interviews.

Tidbits, 5

From Human Power to Consumer Power

Portable devices represent convenience, however their batteries are seen as being a nuisance. This is not only from an environmental point of view but particularly from a user perspective (you always run out of power at the wrong moment) as well as a cost perspective (batteries are relatively expensive). Human powered products could offer an alternative for these inconveniences. Literature however offers little guidance about where human power can be applied with success. Therefore, at Industrial Design Engineering in Delft, such products have been studied intensively. In the course of several years, some 20 graduation projects have been carried out on the subject. One PhD dissertation summarizing it all, and putting it into a broader ergonomic and physical framework, is still underway (see chapter 4.6).

There are a lot of physical principles to choose from however to generate the power, both by active movements (finger, thumb, hand, arm, foot, leg) or passive ones (chest, heat emission, airflow). In physical language there rotation, translation and are all available. In fact there is an embarrassing amount of choices. Several projects had difficulties in matching the energy generation principle and the functionality required.

Not for student Eelco S however. His approach for designing a human powered remote control was a very pragmatic one. In the spirit of Delft's engineering tradition - take big steps and try to get home quickly - he established 13 principles for generating energy. The principles ranged from 'wind-up' to 'break-up' and he explained the principles to users and asked them what they would like most. The selection of the six preferred principles included the wind-up, the pull, the roller, the push button, the trackball and "shake-it". A further selection was made by applying other design criteria like reliability and price. At the end of this exercise only three concepts survived: the wind-up, the roller and the "shake-it". The next step was to build real prototypes and have them tested by users. Eelco observed each meticulously and drew the following conclusions. Shake-it drops out. Roller seems best but has some problems with usability. The end result was the design of a TV remote control that was powered through a combination of the wind-up and roller principles.

The lessons learned for the designer from this project was do not be arrogant and do not think that you know better than anyone else. For the engineer the lessons were let practice show the way and do not try to calculate everything upfront. For the design engineer it was let the users feel, touch and speak.

So what happened with the design and the well resolved prototype? It landed on the desk of a product manager in Singapore who concluded - without any real arguments - that it was a nice product but that there was a market for it. Not invented here? Lack of entrepreneurship? Mediocrity? Fear? Risk avoiding Philips? Who knows?

Anyway, the 'Consumer Power', which proved to be so helpful in the design phase was not reciprocated by 'Marketing Power'. I still believe however that one day human powered products will be a hit!

4.4.2 What subjects are addressed in Applied EcoDesign activities by industry?

This publication shows that industry pays a lot of attention to 'end-of-life' and recycling issues and relatively little attention to energy reduction issues. This is in spite of the fact that life cycle considerations show – irrespective of the analysis tools used – that 50-90% of the life cycle impact of electronic products is due to energy consumption. This phenomenon is analysed further in the paper *"Electronics Ecodesign Research Empirically Studied"* below.

Electronics Ecodesign Research Empirically Studied

Oriol Pascual; Casper Boks; Ab Stevels

Abstract

An extensive literature analysis has been carried out, encompassing over 850 papers published at ecodesign community conferences. Using a classification framework based on academic and industrial processes of fact-finding, analysis, implementation, and exploitation of ecodesign knowledge and adjacent topics, insight has been generated as to the distribution of research attention across these topics. This information has been used to discuss propositions related to under- and overemphasis of research topics.

1. Background

In the past decade, ecodesign research has been focusing largely on what could be addressed as technicalities. What has been accomplished and what presently exists is a wealth of idea, tools, methods, pilot studies, information, and knowledge about the integration of environmental aspect into product design. These technicalities mainly refer to environmental impact data, technological improvements, material substitution, ecodesign tool development and a variety of other elements. However, it can also be observed that '...even in countries where method development, education and dissemination are reasonably mature, actual environmental product design still scores relatively low in the maturity profiles [1].

A small number of recent publications [2-9] have addressed this discrepancy. In these papers, causes have been identified such as an excessive focus on complex tools and methods (also when not needed), lack of life-cycle thinking caused by organisational complexities, insufficient cooperation by actors (in terms of communication, exchange of experience and mutual cross-fertilisation), gaps between supporters and executers, a lack of industrial context, a lack of clear target groups, lack of stakeholder inclusion, an overestimation of manoeuvring room in industry, a lack of testing tools and an overall lack of simplicity.

Some of these findings have been accumulated from company interviews and other sources of industrial experiences. Some also reflect the opinions and 'gut feelings' of those involved in ecodesign for a substantial amount of time. In any case, these findings address the fact that there is a certain gap, or discrepancy, between the bulk of ecodesign-related research (either by academia or industry itself) and that what is needed by the industry to actually implement research findings.

2. Goal of the paper

For the purpose of this paper the above observations from literature have been summarized in a number of propositions given below.

- Proposition 1: In research focusing on ecodesign issues for the electronics industry, there is an excessive focus on complex tool and method development (e.g. after Mathieux et al., 2003).
- Proposition 2: In research focusing on ecodesign issues for the electronics industry, there is an excessive focus on end-of-life issues.
- Proposition 3: In research focusing on ecodesign issues for the electronics industry, there is a lack of examples of successful ecodesign that will stimulate a wider application throughout the industry.
- Proposition 4: In research focusing on ecodesign issues for the electronics industry, there is lack of research attention for the complete industrial stakeholder chain when designing solutions for ecodesign implementation (e.g. Mathieux et al., 2003, Cramer and Stevels, 2001).

As indicated, these propositions are derived from statements in literature that are or are not substantiated by empirical evidence. The goal of the present paper is to find additional empirical evidence to either attack or defend these propositions, other than by the results of a single study or by someone's experience or 'gut feeling'. It is believed that this will contribute to a better foundation for opinions that seem to emerge in the ecodesign community lately. It is no coincidence that this paper is prepared at a time when on various levels there are signs that (successful) attempts are being made to overcome the above indicated discrepancy by specifically addressing the problem areas listed here. For academia this means for example addressing implementation issues and doing

practical surveys rather than conducting stereotypical ivory tower research.
The emergence of these relatively new topics in the ecodesign community is by some, in particular those with an engineering attitude and/or background, addressed as the *soft side of ecodesign,* referring to a variety of sociological, psychological and perhaps intangible factors that research should address as well. Surprisingly (or perhaps not), those with a designer attitude and/or background are more inclined to refer to these issues as the *'hard' side of ecodesign,* referring to the hard reality of business life, deadlines, budgets, and sceptical or smirkish attitudes towards environmental issues. This is yet another discrepancy, caused by a difference in backgrounds and attitude between engineers and designers, and it may very well illustrate the task that indeed lies ahead; namely the synchronisation of content, form, context and time when communicating ecodesign [9].

3. Research method

In order to do so an extensive literature analysis has been carried out, encompassing about 850 conference papers that addressed ecodesign issues for the electronics industry in the 1998-2002 period. In all of Ecodesign literature, literature surveys are frequently devoted to the identification of the state-of-the-art of technological progress, implementation schedules, legislative processes, etcetera. However, literature analysis in a more bibliometric fashion is seldom seen. However, it can be shown that such an overview, done regardless of topic but rather encompassing all of ecodesign, can be insightful for a number of reasons. One of example of this type of research is found in [10], where a literature survey was done on order to determine in what type of scientific publication media the topic of (Applied) Ecodesign is most alive.
For the present study, most of the Ecodesign literature published in the 1998-2002 period has been classified using a detailed classification scheme in which all main and other ecodesign research topics are covered. In Figure 1, the classification scheme is graphically shown. An important feature of the classification scheme is the division in the industrial and academic background of authors of publications. Both parts of the classification scheme reflect the process of fact-finding, analysis, implementation and subsequent operationalization and exploitation of ecodesign knowledge, such as for example found in [11]. The classification scheme depicted in Table 1 reflects the main categories in which publications have been divided. Subdivisions (up to five levels) have been made for each of the 15 categories as well, resulting in over 100 categories. As an example, below the subcategories for topic category 5: Technicalities and Validation is given. Similar subcategories were created for all 15 topics.

Table 1 Division into subcategories

5 Technicalities and Validation			
5.1	LCA in general	5.2.2.3	Product recycling
5.1.1	LCA tools	5.2.2.4	Modularization (upgradeable products)
5.1.1.1	Abridged approaches	5.2.3	Legislative issues
5.1.1.2	Method comparisons	5.2.3.1	Labelling
5.1.2	LCA Databases	5.2.3.2	Draft legislation review
5.1.3	LCA Software	5.2.4	Remanufacturing/refurbishing
5.2	End-of-life issues	5.2.5	Reuse
5.2.1	Disassembly issues	5.2.5.1	Product reuse
5.2.1.1	Theoretical analysis	5.2.5.2	Component reuse
5.2.1.2	Practical evaluation	5.2.6	Logistics/take back
5.2.2	Material recycling issues	5.2.7	EOL Management
5.2.2.1	Material recycling process	5.3	Usage stage/Energy issues
5.2.2	Chemical/toxicity issues	5.3.1	Alternative energy sources
5.2.2.2.1	Glass recycling	5.4	Material Content
5.2.2.2.2	Plastics issues	5.4.1	Halogen-free/Flame retardants
5.2.2.2.4	General PWB issues	5.4.2	Lead-free solder

4. Justification of chosen literature base

It has been chosen to focus on literature published in conference proceedings only. Reasons for this are twofold. Firstly, especially in the field of ecodesign proceedings are a main platform for publishing research results. In [10] it was shown, based on a sample of 3000 references of which over 500 were journal publications, that 29% of these references were published in proceedings, constituting the largest category, with references to journals making up 21% and books 16%. This supports the argument that by including in the present analysis a number of relevant journal articles - which are pretty scattered over a number of journals mostly not specifically addressing ecodesign - the relative distribution of topics will not significantly change. Secondly, it is in the nature of science that often research results are presented in proceedings before they are refined and published in journal articles or book chapters. Including the latter in the analysis could then even imply double counting certain research efforts, something which is preferably avoided (although it could be in argument in favor of weighing research efforts according to their importance).

The sample of literature has involved proceedings from the European CARE Innovation conferences in 1998 and 2002, Electronics Goes Green conference in 2000, and Electronics Goes Green conference in 2000, the American IEEE International Symposia on Electronics & the Environment 1999-2002, the Japanese Ecodesign conferences in 1999 and 2001. These conferences have been chosen as they are commonly accepted to be the main platforms for the community of researchers involved with ecodesign for the electronics industry. Papers presented at these conferences that were clearly outside the scope of ecodesign of electronics products have been omitted from the sample.

5. Empirical results

It was found that 36.4% of all papers originated from academia (i.e. the principal author had a university affiliation), whereas 57.4% originated from industry. Furthermore, 6.2% of all papers were classified as case studies that involved academic as well as industrial research partners. The empirical results from the literature survey are displayed in Table 2. In these tables, the percentages are given of all scanned literature, divided over the topical categories given in Table 1.

A factual interpretation of the results presented in Table 2 provides the following observations:

- Considering **industrial contributions**, the majority of the papers (60.5%) is devoted to technicalities and validation. Within this category, 3.9% is devoted to (alternative) energy issues, 2.3% to LCA issues, and 54.3% to end-of-life issues. The majority of this percentage is devoted to material recycling issues (30.1%), including such topics as lead-free solder (9.7%), specific process issues (7.1%), and halogen-free issues (6.8%).
- With 13.5% the category 'environmental management and integration' constitutes the second biggest part of the industrial literature. In this category, papers addressing supply chain issues (3.5%), and papers addressing the issue of combining economic and environmental considerations (without a tool context) (4.8%) constitute the biggest subcategories.
- Furthermore, it appears that the further away topics are from design and manufacturing, the less attention they get. This seems to hold for the strategic issues, green idea generations, and green communication topics.
- Considering **academic contributions**, the majority of the papers (68.8%) is devoted to operationalization of knowledge and theory. Within this category, 6.5% is devoted to LCA issues, 3.3% to supply and environmental chain issues, 3.5% to various business perspectives, and 38.5% to end-of-life issues. A further subdivision of this latter category shows 12.0% of these papers devoted to material recycling issues, 10.0% to specific disassembly issues, and 6,1% devoted to remanufacturing and reuse. The remainder is divided between smaller topics like EOL management and EOL logistics.
- The identification of societal phenomena and external factors receives with 8.8% relatively limited attention. Out of this percentage, 6.4% was devoted to legislative issues, with the remaining 2.4% devoted to other societal issues. An interpretation of this could be that in the subdiscipline of ecodesign, research is based on findings and paradigms that are either originating from other (environmental) disciplines, or are originating from the time period before 1998. Apparently, legislative developments are considered an exception to this as they receive a lot of attention within ecodesign literature and up to now.

Table 2 Division of research attention across topics

	Perc. per subsample (ac./ind.)	Perc. of all scanned literature
Industrial Contribution		
1. Strategic input	2.9%	1.1%
2. Roadmapping	5.1%	1.9%
3. Green idea generation	1.0%	0.4%
4. Tool support and benchmarking	7.4%	2.7%
5. Product creation	7.4%	2.7%
6. Technicalities and validation	60.5%	22.0%
7. Green communication	2.3%	0.8%
8. Environmental Management & Integration	13.5%	4.9%
Subtotal industrial contributions	*100%*	
Academia Contribution		
9. Identification of societal phenomena/ external factors	8.8%	5.0%
10. Gap identification and analysis	1.8%	1.0%
11. Survey of existing knowledge	3.9%	2.2%
12. Operationalization of theory and knowledge (tools & methods)	68.8%	39.5%
13. Theory development, real-life abstraction	13.0%	7.5%
14. Information transfer for educational purposes	3.7%	2.1%
Subtotal academic contributions	*100%*	
15. Case studies		6.2%
Total amount of papers		**100%**

6. Empirical evidence for the propositions

In this section it will be investigated to what extent the empirical data presented in section 5 does or does not support the propositions presented in section 2.

It would be most useful when for this purpose a frame of reference would be available that could be used for validating whether a certain amount of research attention for a certain research topic is for example 'too much' or 'too little'. Such a base line could for example look like

- 'when a topic Y receives more than x times as much attention in comparison to topic Z, it receives relatively too much attention'; or
- 'when a topic Y receives more than xx% or less than xx% attention, it receives too much or too little attention'.

However, several reasons exists why it has been chosen not to operate such a base line, the main one being that setting boundary percentages would be arbitrary as no consensus exists on what topics should receive more attention than others. This choice brings about that the discussions on the verification of the proposition is done on an ad-hoc basis, based on what the authors consider as fair arguments.

6.1 Proposition 1

Proposition 1 proposes that there is an excessive focus on complex tool and method development in recent literature.
From the result it can be observed that papers, written by industry and devoted to technicalities and validation, constitute 22% of all papers. At the same time, papers devoted to operationalization of theory and knowledge constitute 39.5% of all papers. This means that over 60% of all papers to some extent focus on capturing knowledge and information into tools and methods with the intent of being utilized by industry. Without a baseline it is difficult to discuss whether this is an excessively large percentage or not.
Taking a closer look at the data it becomes clear that many papers focus on specific issues (see for an example again Table 1). When filtering out papers that specifically address (complex) tool development - according to the authors of the present paper - we arrive at the count presented in Table 3.

Table 3 All categories focusing on tool development

Category (incl. subcategories)	Name	Paper count
3.4	General DFE tool prototypes	15
5.1.1	LCA tools	5
5.2.1.1.	Disassembly issues - Technical Analysis	4
12.1.1	LCA tools	17
12.1.3	LCA software	10
12.5.1.1	Disassembly issues - Technical Analysis	14
12.5.7	General EOL tool prototypes	8
13.3	General DFE tool prototypes	31
	Total papers	**104 (12.2%)**

Again, without a frame of reference it is difficult to state whether 12.2% of all papers is or is not an 'excessive' amount of attention for tool development. But if we consider that methods and tools are intended to facilitate product development of ecodesigned products and we use as baseline case studies and examples of ecodesigned products found on this review (6.82%), it gives the impression that the effort on methods and tools it is not translated on a relevant amount of ecodesigned products, as it was supposed to be. (I.e. 54% of the electronic and communication companies at Global Fortune 500 that claim to use ecodesign on their PDP, demonstrate it by showing examples [12]).

6.2 Proposition 2

Proposition 2 proposes that there is an excessive focus on end-of-life issues. In the categorization, categories 5.2 (for industrial papers) and 12.5 (for academic papers) were especially devoted to end-of-life issues. The paper count for these categories has been 169 (54.3% of all industrial papers) and 189 (38.5% of all academic papers), respectively. This means that 41.9% of all papers in the sample have been specifically devoted to end-of-life issues. It should be noted that in this count, papers devoted to WEEE legislation as a strategic issue or as a societal phenomenon (in total 17 papers) are not included.
As with the previous proposition, without a frame of reference it is impossible to classify this figure as being 'excessive' or not. When however compared to papers addressing other life-cycle stages, for instance papers addressing energy issues, it can be observed that in this latter category a mere 23 papers were classified, 2.7% of all papers.

This at the least supports the argument that there is very little attention for the usage phase, especially considering the environmental impact for this stage, which for consumer electronics is 50-80%. However, this is just a scientific perspective of what is important from an environmental point of view. There are several other perspectives of 'what is green' as well, including a customer and a governmental perspective. From these perspectives, end-of-life scores often much higher on the priority ladder, because of political and emotional reasons.

6.3 Proposition 3

Proposition 3 proposes that there is a lack of examples of successful ecodesign that will stimulate its dissemination throughout the electronics industry. This proposition is supported by the fact that what seems to be a relatively small number of papers is devoted to case studies (6.2%). A closer look to this result shows that of this amount of papers, roughly one third was devoted to LCA studies, and the remaining two-thirds were examples or pilot studies of eco-designed products.

It remains a question however to what extent these examples provide insights for less experienced companies on how to do ecodesign, and to assess the learning effect. To some extent, the presented case-studies can be considered window-dressing, where only the end result is promoted without attention for the underlying processes and what could have been learned from that. Therefore it is suggested that there even successful ecodesigned products are poorly communicated.

6.4 Proposition 4

Proposition 4 proposes that there is lack of industrial context when designing solutions for embedding ecodesign in industry. Papers that do have attention for the industrial perspective have been categorized in various subcategories. For example, academic subcategory 12.7 (2.0% of all papers) is devoted to papers discussing the alignment of economical and environmental perspectives (12.7.1) and the aligning of ecodesign with traditional business perspectives (12.7.2). Also, industrial subcategories 8.3 and 8.4 (2.0 % of all papers) have a similar topic. So, in fact there is attention for this industrial context in relation to specific ecodesign topics although not in large numbers. This shows "environmental apartheid".

Papers specifically devoted to discussing supply chain issues (23 papers; 2.7%) or environmental value chain issues (9 papers, 1.1%) have also been categorized in specific categories in categories 8 and 12. Topics relating to 'green communication' and 'green marketing' result in a total count of 19 papers (2.2% of all papers).

According to whatever baseline one might choose, it is clear that these topics receive little attention in literature. The question whether this is a 'bad situation' or not is a much harder to answer. 'Mitigating circumstances' would apply when the discussion on how to put ecodesign processes in industrial context would take place in adjacent scientific disciplines such as business and economic sciences; although the present study does not address this, it can be observed that this is only partly true. Product oriented environmental management is a discipline that is indeed studied in management sciences, but it can be motivated that without engineering and design perspectives, practical applicability will be limited. And if indeed this multidisciplinary approach is taken, papers of this nature could be expected to be published in the proceedings that have been analyzed in this study.

7. Conclusions

The present paper is intended to empirically test some propositions found in ecodesign literature and to bring food for thought and discussion about what could or should be ecodesign's main future developments.

The main conclusions from the present study are:

- Most of the developments in ecodesign appear to be based on paradigms that already exist for many years. Issues that have a high legislative and/or emotional priority appear to dominate the choice of research topics - something which cannot always be justified from a scientific point of view (i.e. end of life vs. energy consumption).
- Ecodesign discipline was developed and launched by academia some fifteen years ago, nowadays it seems that based on quantitative argument (with 57.4% of the papers written by industry) that industry (at least, in the electronic industry) is taking the lead of its evolution.

- Generally, it can be said that most of the attention is put on technicalities and validation, while the alignment of ecodesign with business operations is still rating low. It is suggested that ecodesign's potential may achieve its maximum expression when its cross-functional characteristic is fully explored. Therefore, alignment of ecodesign with business operations needs more attention.
- Examples of ecodesigned products that successfully perform on the market are available in literature in very limited numbers. Apparently, it is still difficult to empirically demonstrate that embedding ecodesign in business operations lead to improvements and competitive advantage, as has been claimed by academia.
- Research on energy consumption of products receive little attention, when it is a dominating factor on the environmental impact at product life cycle and it will become a future issue due to international agreements (Kyoto).
- It seems that the current main driver for adopting ecodesign at organizations is Environmental legislation (latest EU developments). Other aspects as consumer demands (marketing studies) receive little or no attention.

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Rituals and habits, 5

The Gang Dinner

PhD Students love to go conferences abroad. It is an adventure. You can get in touch with experts, the travel is paid for and a private holiday can be connected to the trip. International experience before starting professional life is very important in my opinion. Moreover, the student should realize that the Netherlands is not the center of the world (and Delft is not its intellectual capital). On a European scale, the Netherlands is a small country, on a world scale it is a peanut. Delft University is pretty famous, but not the top in global rankings. Culture and style, in which technical and environmental issues are dealt with, is vastly different among countries and in regions of the world and it is important for students to experience this early on.

Yes, I have generously supported the PhD students in their traveling. I have only one condition: contribute to the event in the form of a paper and make a presentation which is able to catch the attention of the audience.

Saying "yes" to such challenges has grueling consequences: in the first instance the paper has to be written by the student him or herself and the presentation has to be rehearsed (see Personalities, 1). As a co-author, I only give comments with the aim to improve; in the end the students have to do it their way. Many years ago, I used to write comments with a red ballpoint; this had a negative psychological effect – it was perceived that a lot was wrong. When I made comments in blue, better results were achieved.

This is not the end of the story. When students present, several people are listening, making notes, for instance on the frequency of the presenters use of "eh" (see Rituals and Habits, 4). They hate you for doing it and at the same time they appreciate it!

Finally there is the reward. When all the Delft speakers at a conference are done, a Delft Gang Dinner is organized at night. Friends from other universities can be invited, also one 'lonely boy or girl' at the conference who is completely unrelated to the Gang is always invited as well. There is a lot of eloquence, a lot of fun, but the night is too short.

See you next year at the Delft Gang Dinner table!

4.4.3 Maturity of implementation of Applied EcoDesign in electronic companies

Between the years 1990-1995 the first electronic companies took Applied EcoDesign on board Some ten years later (in 2003) only 30% of the 37 companies considered have become reasonably mature in the field. This observation is substantiated in the paper *"Measuring Implementation and Performance of ecodesign in the Electronics Sector"* on the next page.

On the other hand 26% continued to show virtually no interest at all. Today (2007) the situation has slightly improved but the general impression is that proactive Applied EcoDesign in the electronics industry still has a long way to go.

Measuring Implementation and Performance of ecodesign in the Electronics Sector

Oriol Pascual; Ab Stevels; Casper Boks

Abstract

From the beginning of the ecodesign discipline it is been claimed by academia that its adoption on industrial contexts leads to improvement of competitive advantage by the organizations adopting it. At the same time, it seems that after more than ten years of ecodesign developments, the discipline is not as spread as it was expected and the benefits of it still unclear. This paper empirically explores which are the rates of ecodesign implementation in the electronics sector and whishes to define the different strategies adopted by the organizations when doing it.

1. Background

Applied ecodesign adopted on day-by-day basis by companies brings, according to experts [1] [8], strategic/economic benefits (reduction of production costs, competitiveness, and improvement of image) while reducing environmental impact.

Currently many large organizations spend time, economic resources and knowledge creation on applied ecodesign and launch products to the market that perform environmentally better than previous models or products of competitors, while retaining their functionality. Nevertheless, after more than ten years of developments by academia and industrial organizations, literature and expertise [1], [2], [3] suggest that ecodesign is not as spread as could be expected. Therefore clear that a gap exists between academic/theoretical developments (and claimed benefits) and ecodesign applicability.

A study is carried out at Delft University of Technology, in which a mid-term goal is to benchmark organizations according to their ecodesign performance in order to understand who is successful applying the ecodesign discipline. The final goal is to define conditions of success for ecodesign in business contexts. Here, "successful in ecodesign" is defined as being able to produce an ecodesigned product -to deliver a certain function- and to be successful in the market at the same time.

The aim of the paper is twofold: to present an initial study which measures the rate of ecodesign implementation in large organizations, and to discuss the different strategies used when applying ecodesign.

2. Approach

To understand the size of the defined gap, i.e. between academic/theoretical developments and ecodesign applicability, it is crucial to analyze what the current levels of performance of applied ecodesign are. Assume a situation where a company simply uses common sense to develop products that have a lower environmental load than its competitors, and compare it to a situation where similar results are achieved using various ecodesign guidelines, tools, and methodologies. The question is whether both companies have the same level of applied ecodesign. As in literature this issue is not dealt with, it is suggested that more insight here is needed in order to understand the current situation of this discipline at a business level. Hence, the present study uses a methodological approach based on practical examples to get novel insight of the current situation of ecodesign at large industrial organizations.

3. Methodology

To facilitate the study, it is needed to define scope and size of industrial organizations:

The electronics and communications industry is selected due to its perceived expertise in the ecodesign discipline and the emerging legislative requirements for the industry. It is decided to choose "large manufacturing organizations". "Large" can be defined by the number of employees working on an organization, revenues generated, stock value, etc. In this case the authors decided to select the world's top organizations by revenues (Global Fortune 500, time period: 2002).

The companies studied were those included in the industry sectors as organized in the Global Fortune 500:

- Electronics & electrical equipment
- Computers & office equipment
- Semiconductors & electronic equipment
- Network & communications equipment

Environmental reports (either in print or via official websites) of all companies present in the above categories in the Global Fortune 500 were studied in detail. For each environmental report, we analyzed the level of ecodesign implementation and determine whether:
a) An organization claims in its environmental report that it uses ecodesign in their product development process (PDP),
b) Evidence is presented of doing so (examples of ecodesigned products),
c) Managerial elements of the ecodesign process are mentioned (such as programs, goals, and roadmaps).

a) Claiming to use ecodesign: studying the Environmental Report and Corporate web sites of the studied organizations, it was determined whether the use of the ecodesign discipline was mentioned using terms as ecodesign, Design for the Environment, and Design for X.

b) Examples of ecodesigned products: it was determined whether examples of ecodesigned products were provided in the environmental reports of all the studied companies. The original intention of the authors was to empirically measure rates of ecodesigned products launched to the market, but it is been found that organizations do not clearly specify when a product has been ecodesigned (therefore it is not possible to know the rate of electronic ecodesigned products launched to the market), but some companies do show examples. It is assumed that if an organization is proactive on the ecodesign discipline and develops ecodesigned products that perform better than previous models or that competitor, they will state so, or at the least they will give an example.

c) Set up of managerial targets: it was determined whether one or more indicators for measuring presence of managerial elements of ecodesign were given, by means of established targets. A differentiation related to ecodesign of products is made between quantitative, e.g. "our target is to reduce 15% energy consumption of our products by 2005" and qualitative targets, e.g. "we'll improve energy efficiency". Targets may refer to a certain amount of ecodesigned products or to the product itself (reduce energy consumption, stand-by).

4. Results

Table 1 gives the results according to these three aspects:

Table 1 Overview of results

Element	Number
Total companies studied	37
1. Companies that claim to use ecodesign	28
2. Companies showing examples	20
3. Companies publishing targets	19

Based on the three scores, it was found that six different profiles exist among the companies studied, see Table 2.

Table 2 Summary of empirical results

Group	Claiming Use Ecodesign	Publishing Examples	Setting-up Quantitative Targets	Setting-up Qualitative Targets	RESULTS
1	×	×	×		30%
2	×	×		×	18%
3	×	×			6%
4	×			×	6%
5	×	-	-	-	14%
6	-	-	-	-	26%

For each of the profiles the characteristics are indicated. Moreover, a list of companies is provided[1].

Group 1- Companies that CLAIM to use ecodesign in their PDP, SHOW EXAMPLES of ecodesigned products and SET-UP QUANTITATIVE TARGETS related to ecodesign of products. They represent 30% of the electronics and communications companies in the Fortune 500.

Companies under this cluster:

IBM
Sony
Matsushita
NEC
Sharp
Ricoh
Fujitsu
Mitsubishi
Philips
Canon
Sumitomo

Group 2- Companies that CLAIM to use ecodesign in their PDP, SHOW EXAMPLES and SET UP QUALITATIVE TARGETS related to ecodesigned products. They represent 18% of the electronics and communications companies in the Fortune 500.

Companies under this cluster:

Siemens
Hitachi
Motorola
Intel
ABB
Ericsson

Group 3- Companies that CLAIM to use ecodesign in their PDP, SHOW EXAMPLES of ecodesigned products do NOT PUBLISH/CLAIM to SET UP TARGETS (of any kind). They represent 6% of the electronics and communications companies in the Fortune 500.

Companies under this cluster:

Hewlett Packard
Toshiba

Group 4- Companies that CLAIM to use ecodesign in their PDP, but do NOT PUBLISH EXAMPLES, and SET UP QUALITATIVE TARGETS. They represent 6% of the electronics and communications companies in the Fortune 500.

Companies under this cluster:

Nokia
Dell Computers

1 ***Disclaimer:*** *the information presented in this study has been gathered from official web sites and environmental and/or sustainability reports from the selected companies. If a company is being proactive on the ecodesign discipline and this is not reflected on this study, it may be due to a lack of information on their web sites or in their environmental and/or sustainability reports. At this stage of the present investigation, no other verifying research has been done.*

Group 5- Companies that CLAIM to use ecodesign in their PDP, do NOT PUBLISH EXAMPLES, or SET UP TARGETS. They represent 14% of the electronics and communications companies in the Fortune 500.

Companies under this cluster:

Compaq Computer (HP company)	Nortel Networks
Lucent Technologies	Sun Microsystems
Cisco Systems	

Group 6- Companies that do NOT PUBLISH/CLAIM to use ecodesign. They represent 26% of the electronics and communications companies in the Fortune 500.

Companies under this cluster:

Tyco International	Emerson Electric
Samsung	Onex
LG Electronics	Flextronics Int.
Sanyo	Whirlpool

5. Discussion

5.1 Defining "ecodesign"

Due to the diversification of terminology found on the environmental reports of the studied organizations, and the variety of strategies linked to this terminology, questions rise about what is understood as ecodesign.

Literature offers many definitions of "ecodesign" [4], [5], [6]. Most of these definitions (if not all) have been developed by academia, and the general aim can be summarized in the definition formulated by Brezet & van Hemel: "ecodesign is understood a design process that ecological aspects are integrated into the conventional product design process [4]. Apart from this widely recognized definition, the International Standard Organization (ISO) offers a similar definition of the term on the ISO 14062 ("integrating environmental aspects into product design and developments").

Both definitions are too vague to allow a classification of organizations, even knowing which managerial process is behind an ecodesigned product, as it is intended in this paper. Therefore, this study intends to establish a novel system to classify the distinct organizations. Any kind of ecodesign "level" or "stage" fits under these generic definitions. The application of a clean technology in the Product Development Process, e.g. lead-free soldering, can be considered an element of "ecodesign", and at the same time an organization that sets up a program to reduce their environmental load, that benchmarks its products in order to develop new ones with lower environmental load every time, or that uses specific tools with that objective, fits as well under this concept. However, there are clear differences between both organization types, i.e. the scope of activities is different, the effort applied is not equal, and the integration with other business activities is distinct.

It is interesting to understand which drivers lead to these organizations to adopt ecodesign. A differentiation can be made between organizations adopting ecodesign as a proactive approach towards environmental aspects and organizations adopting it due to external pressures (i.e. legislative issues).

Under this situation, and due to the lack of a specific definition accepted and standardized, it is difficult to classify organizations according to the managerial aspects behind an ecodesigned product. Thus, the lack of a standard definition of ecodesign leads to a wide range of interpretations of whether and to what extent a company is involved in ecodesign. Consequently, without this common understanding of what ecodesign is, most of the organizations name their ecodesign process in different ways, for instance misunderstanding and confusion by stakeholders.

Interestingly, from the study presented here, some conclusions regarding what ecodesign is can be drawn. All companies studied use the term "ecodesign", or any of its possible synonyms, referring exclusively to products. However, in the case of Sony, a broadening of the concept is visible. The company talks about "Environmentally Conscious Products & Services", escaping from the classical technical view and adopting managerial aspects towards services (delivery of functions without ownership of a product).

Most the studied companies that claim to use ecodesign on their PDP demonstrate it by showing examples of ecodesigned products. Nevertheless, most of the times the examples presented do not give detailed information about its characteristics.

Terms referring to ecodesign (found on reports) include:
Environmentally Conscious Product Design
Environmentally Compatible Product Design
Environmentally Conscious Products & Services
Design Energy Efficiency
Environmentally Conscious Products
Green Products

Figure 1 Variety of terms used to refer to ecodesign

5.2 Showing Examples

54% of the studied organizations show examples of ecodesigned products in their public communication media. Examples include products that are been totally re-design from a previous model to a new concept, products were new materials with lower environmental impact it is being used, products in which new technologies are being used at process level, and products that without being re-design are considered "green" due to new take-back systems on the market that allow their collection and recycling/energy recovery, etc. Of interest for this paper is to realize which is the rate of ecodesigned products that a certain organization is launching to the market. Another relevant aspect would be to know which is the rate or number of products labelled as "green" for the manufacturers. This kind of information has not been found in any of the environmental reports of the studied organizations.

Further steps of research may focus on how performance of ecodesigned products is shown and which methodology it is been used in order to measure it. This fact leads to the question if costumers are requesting "green" products to EOM or are interested on performance and benefits perceived from ecodesigned products.

When showing examples of ecodesigned products and giving information about them, it seems clear that ecodesign may be found at different levels of integration at the different organizations. This aspect can also be linked to setting up of targets.

5.3 Managerial aspects

According to the results obtained in this study, propose two levels of ecodesign implementation or maturity:

1- Ecodesign Rules Level: under this cluster we find the most known aspects and elements of ecodesign, manuals, tools, methods and training programs to understand what ecodesign means. Pilot projects are carried out by organizations to analyze whether the discipline "really works" and understand the advantages that it may have. Most of the organizations fall into this category.

2- Ecodesign Management & Integration Level: this level accomplishes the use of the discipline on daily basis. Personnel knowing about ecodesign, uses the tools (software), and environmental programs are set up. Subsequently, quantitative or qualitative ones targets are defined and we may consider that ecodesign is no longer a separate discipline from the organization, but rather integrated on daily activities.

With the compiled data, the authors whish to qualitatively define strategies used by companies regarding applied ecodesign. This classification is not absolute and the aim is not to rate organizations as "good ecodesign performers" or "bad ecodesign performers" we propose the first steps to set up a framework that may help to understand better the role of ecodesign at organizations and therefore, fulfil the gap between academic promises of the ecodesign discipline and real implementation (up to which extent applying the ecodesign discipline helps to gain competitive advantage).

Based on the three chosen variables (claim to use ecodesign, showing examples, and setting up targets), a description of companies' efforts on the ecodesign discipline can be drawn:

Group 1- Relatively mature organizations (30%)

Companies previously referred as being on *Ecodesign Management & Integration level* of ecodesign's implementation. Organizations falling into this category are known to be first movers on ecodesign implementation, usually working hand by hand with academia, developing methodologies and tools to facilitate implementation and test-

ing academic developments on real business operations, and they can do it because own resources (economic, personnel, knowledge, and time).

All the organizations under this cluster claim to use ecodesign on their product development process, they demonstrate to do it by showing examples of ecodesigned products launched to the market and a managerial system is in place that helps them to define their environmental strategy (where it is possible to find quantitative targets related to ecodesign of products).

They demonstrate that ecodesign becomes integral part of the overall environmental/company's strategy exploiting its cross-functional characteristic when setting up qualitative targets.

Diversity seem to be found in this category according to the drivers that lead to apply ecodesign (comply with legislation or being proactive). This profile should be studied in more detail in order to define conditions for success.

Group 2- On their way to maturity (18%)

Companies under this cluster claim to use ecodesign on their PDP and show some examples of ecodesigned products. When observing their compromise on the managerial area, targets and goals are set-up on qualitative basis. This gives an indication that the organization is proactive on the ecodesign field, and that it is relevant on the overall strategy of the organization (due to the fact that goals are set-up on the environmental management system/program).

Nevertheless, the nature of the qualitative targets gives indication of the intentions of the organization, without compromising themselves to achieve a quantitative goal.

Group 3- First movements (6%)

Here we find companies that claim to use ecodesign on their PDP and they show examples of ecodesigned products. At the same time, there are not evidences of self-compromising themselves to a continual improvement of their product's environmental performance, neither to increase the rate of ecodesigned products.

It seems that ecodesign is not included on the overall strategy of the organization, due to a lack of targets and goals related to ecodesign of products.

It is suggested that and organization that show examples of ecodesigned products, but do not publish targets, may be experimenting with the discipline and do not feel secure about the benefits that the discipline may bring to themselves.

Group 4- Starters with good intent (6%)

Organizations under this cluster claim to use ecodesign and include the discipline on the overall company strategy by setting up qualitative targets. In this case, no examples have been found that demonstrate what has been claimed on their environmental report.

It can be interpreted that the organization is starting with the discipline (ecodesign's rules level), there is not enough expertise on the organization to launch or demonstrate that they applied the discipline (therefore they do not show examples) and as starting point (good intent) they define qualitative targets.

Group 5- Basically publicity driven (14%)

Organizations under this cluster claim to practice ecodesign during their PDP, do not publish any example of ecodesigned product, neither set-up targets on their managerial system. Therefore it is doubtful that the organization spends resources on this area. It is suggested that organizations under this cluster use ecodesign as a marketing driver.

The advantage for organizations under this cluster is to use environment as a marketing strategy in order to appeal costumer's sensitivity towards issues like environment (everyone likes environment-green!).

Group 6- Not published/not interested (26%)

According to the measurements done in this study, most of the large OEM lay down under this cluster. The fact that such amount of organizations (26%) falls into this category, supports the idea presented in literature that Applied Ecodesign is still on an immature stage of implementation.

Furthermore, literature suggests that the lasts organizations to move towards environmental management will fail on accomplishing legal and costumer demands, and therefore will not be competitive. But it has to be shown in practice if this will be materialized, and this strongly depends on enforcement policies on different countries.

6. Future directions

It is stated by the authors that there seems to be a gap between what academia and theory developers claim as direct benefits for the company due to implementation of ecodesign at the product development process and the real benefits perceived by management. To understand the size of the gap, measurements are needed.

Is of interest of the authors to focus on understanding the diversification of maturity of organizations under the first cluster (relatively mature organizations), how this organizations measure performance of their ecodesigned products and which are the drivers that lead them to adopt the discipline. A maturity grid is under development at the Applied Ecodesign group of Design for Sustainability Program (TUDelft).

The authors focus its measurements on three elements: ecodesign at process level, ecodesign at product level and business benefits related to ecodesign activities.

About process: it is suggested that maturity of ecodesign implementation is reached when the manufacturer influences all the life cycle of a product due to ecodesign. Raw materials extracted in an environmentally sound way, supplier involvement, manufacturing, user phase and at the end-of-life of the product. That means that ecodesign broadens its context and overpass the technical dimension and gains relevance as managerial element, dealing with its goal: reduce environmental load per monetary unit at every stage of the life cycle. Therefore, measurement of ecodesign influence on the life cycle is discussed, as well as which role ecodesign adopts at the organizations, just as a marketing strategy or it adopts a cross-*functional dimension.*

About products: it may be that at process scale, all the classical elements of ecodesign implementation (procedures, training, tools, etc.) are in place, but not reflected at the final product, or that a company without any element in place of the ecodesign process is producing high rates of products that have a lower environmental load that competitors or previous models. The aim of this section is to make clear which rate of ecodesigned products are placed in the market by the electronics industry.

About business: according to academia and pilot projects [1], [8], ecodesign implementation improves competitiveness, reduces costs, avoids regulatory fines, improves image and market share. The aim in this section is to measure which business improvements can be directly link to ecodesign.

7. Conclusions

- A variety of attitudes can be found on the business world regarding ecodesign.
- Tangible benefits of applying the ecodesign discipline are not yet clear
- There is a lack of a clear-specific definition for the term ecodesign, this hampers the judgment of what it is published on the environmental reports
- Standard definition of ecodesign and a standard definition of maturity grid may help to discriminate more sharply within the categories which have been defined in this paper
- A general lack of published ecoperformance results makes difficult for the consumer to base their decisions on the right criteria

8. References

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Cities, 5

Brussels, two faces, or even three?

Brussels used to be the capital of the 17 provinces forming 'the Lower Lands' till 1584. Then the north (the Republic of the Seven Provinces) separated: subsequent wars continued the split between north and south. The south oriented itself towards the continent under Spanish and Austrian rule, the north looked overseas. Calvinists dominated the north, Roman-Catholics the south.

Mentalities grew apart and it was quite logical that the attempts to unite again after Napoleonic times failed. Now the south had to wrestle independence from the north. The new state, with Brussels as its capital was conceived as a Unitarian one but had two cultures: Wallon (French speaking) and Flemish (Dutch speaking). It took the Flemish almost a hundred years to get equal status for their language. In the meantime Brussels turned slowly from a predominantly Dutch speaking city into a French speaking city.

Nowadays Belgium is a federal kingdom with 3 regions (Vlaanderen, Wallonië, Bruxelles/Brussel) of which 2 consider Brussels as their regional capital. There are 3 cultures (including a German speaking one in the east of the country) and all of them come together in Brussels, where the federal government is.

How do you feel in Brussels as a person with a Dutch passport? At the 'Grote Markt' in Brussels there is that feel of communality in early history but there is also a clear perception of the differences found today. Belgians generally seem more successfully combine the pleasant things of life and capitalism. Maybe this is because they have been invaded and occupied so many times. For this reason they also seem to embrace Europe more easily than the Dutch who have this strong feeling of wanting to be independent and of wanting to do a better job than somebody else (or at least are perceiving themselves as doing so).

Brussels is also the capital of the European Union and in that respect it has two or even more faces. One face is the necessity to accommodate European rules and lift national barriers, which are an unfortunate legacy of the past. On the other hand there is lack of decision-power, inability to deliver straightforward policies. There is always horse-trading among Member States, the complicated and sometimes weird compromises can cost the European taxpayers billions.

In the environmental field all of this seems to be even more pronounced.

Brussels has one face looking to history and one to the future – and that can be seen wherever you go. The European Union is still chiefly busy, very busy, with its past. What may have been wise policies in the last century are unwise today. Subsidizing agriculture, which is operating at costs far above world prices and trying to keep industries alive that cannot compete, are loosing propositions. Fostering quality infrastructures and stimulating activities with real added value could make Europe a winner. Too little of that is being delivered today.

Implementing environmental policies based on principles of the nineties of last century will result in disasters in the realities of today (see chapter 9).

Brussels is slowly turning a positive face, for Europe it is not too late to follow.

City walk : Start at the Central Station, go through the Ravenstein exit, Horta Street, Cross the Kingstreet, pass through the Park of Brussels, follow Beliard Street, go somewhere R and L to Beliard street, go Right at Aarlen street, pass under the European buildings, go Left on Wiertz street, go R to Leopolds park, cross the park to Waverse Steenweg, go R and follow the road to Naamse Poort, go L and cross the ring at Louise Place to the town centre, go to the Justice Palace, go R to Regent street, walk through Grote Zavel (R), go straight Rollebeek/Alexis street, go R to Stoofstraat and end at Grote Markt.

Favorite restaurant: De Koning van Spanje, Grote Markt.

Country walk: Go with tramway no. 44 to Tervuren and walk any distance you like in the Colonial Park – if it rains, visit the museum.

4.4.4 Integrated Process Management; the Soft Side of EcoDesign

Further developments in dealing with 'eco' at the companies considered in 4.4.3 include the arising of different styles of operation, of different levels of integration in processes and of various ways in which the "Soft side of EcoDesign" is being considered.

The different styles, ranging from EcoDesign primarily for competitive advantage to EcoDesign primarily for legal compliance have been described in chapter 2.1

Integrating Ecodesign into the processes is aiming particularly at organizing for success and for reaping benefits and has little to do with the more technical aspects.

The same holds for considering the "Soft Side of EcoDesign"; this terminology has been introduced by Casper Boks. This is about considering all kind of contextual aspects in which EcoDesign activities are taking place like the internal and external value chains. Also a lot of communication issues can be put under this notion.

In many companies today, these process management and "soft side" activities are dominating. Addressing the technicalities has got a lower priority. This observation made that at the "Electronics Goes Green Conference in Berlin in 2004 in the paper below with the provoking title *"EcoDesign in Industry is not an Environmental Issue"* has been presented. It shocked part of the audience but is has been an eye-opener for some participants as well.

Ecodesign in industry is not an environmental issue

Oriol Pascual, Ab Stevels

Abstract

The existing paradigm for ecodesign research remains to focus on technical and physical issues. Design and technology receive most of the attention, especially in the community that attends electronics oriented conferences like the IEEE/ISEE, Ecodesign, CARE Innovation, and Electronics Goes Green. At these conferences, a more managerial focus towards integrating ecodesign considerations in the electronics industry is generally limited to discussions about environmental management systems, ISO standards, and of course EU legislation like EuP, WEEE and RoHS, leaving on a side the wider stakeholder benefits issue and value chain problems.

This paper highlights the observation that ecodesign activities at large electronic manufacturing organizations have little to do with environmental considerations. The rationale behind ecodesign is of a self-protective nature.

1 Introduction

The aim of ecodesign practice is to reduce the environmental load of products "from cradle to grave" (i.e. from raw material extraction and purchased components, design and manufacture, to distribution, use and end-of-life). Life-cycle thinking is the scientific principle behind this practice.

Environmental management related to ecodesign is a twofold dimension:

- *Environmental dimension:* related to technicalities like physical units, materials, energy, efficiency, environmental load, and environmental validation.
- *Managerial dimension:* related to business aspects of the discipline like goals & targets, EMS, legislative requirements, and value chain management issues.

The *environmental dimension* of ecodesign has been widely explored by academia and practitioners. In the past decade, ecodesign research has been focusing largely on what could be addressed as technicalities. What has been accomplished and what presently exists is a wealth of idea, tools, methods, pilot studies, information, and knowledge about the integration of environmental aspect into product design.

In a study carried at Delft University of Technology [1], an extensive literature analysis was carried out, encompassing over 850 papers published at electronics ecodesign community conferences. Using a classification frame-

work based on academic and industrial processes of fact finding, analysis, implementation, and exploitation of ecodesign knowledge and adjacent topics, insight has been generated as to the distribution of research attention across these topics.

The study shows that over 60% of contributions at leading ecodesign conferences address technical issues (i.e. LCA, materials, recycling, lead-free soldering, etc.). It also shows a lack of priority setting supported by scientific evidences; energy in electronic products represents 40-80% of total environmental load, meanwhile a rough 2% of the papers address the issue.

The *managerial dimension* does not receive much attention. It represents roughly a 10% of the contributions (i.e. alignment of ecodesign with traditional business perspectives, supply chain, EMS, green marketing, etc.).

Among others, the study concludes that alignment of ecodesign with business operations is still rating low. It is suggested that potential of ecodesign may achieve its maximum expression when its cross-functional characteristic is fully explored. More attention is needed on the alignment of ecodesign with business operations.

In practice, the managerial dimension is about drivers (externalities) and organizing for success (internalities). Organizing for success is about money (how to optimize investments and get reward from it), information (how to get the right information for decision making purposes; prioritization) and intangibles like emotions and feelings. That is known as the value chain.

Companies design for functionality and aim to optimise the value of products at the shop. To do so, optimization of the value chain management is significant. Ecodesign is in practice beyond the superseding functionality issue. Managing properly the value chain (internal and external) is a question of dealing with opportunities and self-protection. Opportunities relate to issues like competitiveness, reorganization of business (paradigm sift), and improved image. On the self-protective side; compliance, legitimacy and market requirements issues are present.

This paper focuses on drivers for engaging ecodesign on business contexts, explores both perspectives and discusses the misconnection between listed drivers and environmental considerations. Special attention is paid on the so called self-protective perspective. Here, self-protective perspective refers to avoidance or control of negative effects of environmental activities on the organization (i.e. legislative issues, costumer perception, and market demand issues). In literature, the self-protective perspective of green is merely stressed. The goal if this paper is to demonstrate the existing misconnection between drivers and environmental considerations.

2 Research method

Information presented in this paper originates from authors' experience on applied ecodesign field. Academic developments are combined with industrial practices and observations.

The outcome from a recent project carried at DUT is used. The aim of the project is to collect specific information (from three organizational levels; corporate, members of environmental support departments, and business units) on ecodesign operationalization from the electronics and electrical equipment categories of Global Fortune 500. In addition, a previous study from DUT [2], in which we were able to map maturity levels at electronics industry, ranging from complete integration to lack of attention to the issue, is used. Moreover, empirical observations from more than ten years of ecodesign introduction at Philips Electronics are deeply analyzed.

The electronics industry is selected due to its perceived expertise in the ecodesign discipline and the emerging legislative requirements for the industry.

3 Observations

An ideal process of product ecodesign (or re-design) takes into account environment during the entire life cycle, since its primary objective is to reduce cumulative negative impacts of products. Roughly, the process involves; product selection, analysis of environmental load from a lifecycle perspective, identification of improvement options, re-design, and product realization. The result is a product with lower environmental load that its predecessor; a more efficient product.

In practice, an organization claiming to perform ecodesign activities is not necessarily familiar with the whole process, neither with lifecycle thinking. Experience shows that the set up of a take back system by an organization, or a technological evolution, is considered as ecodesign. Consequently, the result is not necessarily a product that

performs better from an environmental perspective. Therefore, there is need to set up environmental priorities for action.

A survey carried in 2002 by Dutch consultancy firm KPMG [3] points risk reduction, among others, as a driver for companies to engage sustainable actions and reporting. This called the attention of the authors, who as part of a study [4] identified drivers at large manufacturing electronic organizations for engaging ecodesign activities with current business practices. A self-protective perspective was found in all of them.

Since lifecycle thinking is not the core element of ecodesign activities in most organizations, it is suggested that priorities are not set on environmental basis but on a variety of other purposes;

1- Compliance issues
2- Potential competitiveness
3- Legitimacy
4- Imitative behavior
5- Market requirements

Discussion follows on misconnection of listed issues with environmental aspects.

3.1 Compliance issues

Environmental considerations related to products rate high on current legislative requirements. Take-back systems and ban of hazardous substances in Europe, energy efficiency and end-of-life programs in United States, and labeling schemes in Japan, are on top of the agenda of electronics sector managers. Companies are global actors: manufacturing of products in country A, shipped and/or used in country B, and finally disposed in C. Therefore, regional legislation becomes relevant for global companies.

The effects of mentioned regulatory initiatives rarely play a key role stimulating ecodesign activities among electronics industry. In the case of recycling initiatives, ecodesign is of minor relevance after issues like creation of economies of scale and treatment technologies [5]. For the rest, the goal of managers is to keep compliance costs under control and as low as possible.

Avoidance of threats due to a lack of institutional initiatives response seems to be the rationale behind this attitude. Early adopters make cognitive changes [6] and may gain competitive advantage.

3.2 Potential competitiveness

Some authors (Elkington, Porter, Bonifant) base environmental management benefits on win-win strategies were both the environment and the bottom line get positive results. Following that claim, proactive organizations decided to invest resources on environmental management activities expecting to gain competitive advantage, defined as "potential for ecological responsiveness to improve long-term profitability" [7].

A dimension of tangible competitive advantage is determined by identifying, measuring, accumulating, analyzing, preparing, interpreting and communicating financial an non-financial information used by management to plan, evaluate and control the environmental aspects of an organization [8]. This practice is known as environmental accounting. In countries like Japan and US, national governments launched environmental accounting guidelines. As a result, first sights of information disclosure in companies' environmental reports can be found. Checking environmental reports [9] it is found that information presented is immature and refers mostly to investments, lacking examples of economic effects.

From a business perspective, tangible economic benefits of ecodesign are difficult to be demonstrated. The main reason relates to the fact that cost reduction applies to selected fields like packaging, transport, and disassembly activities. Gaining competitive advantage is also about doing a bit better than competition. Once higher level than competitors is achieved there is not incentive to improve further.

The environmental pro-activeness is not just a question of market opportunities but managing environmental related threats and avoiding negative consequences. Managing properly the value chain (internally and externally) is a relevant area to explore potential competitiveness.

A less tangible dimension of competitive advantage gain relates to legitimacy.

3.3 Legitimacy

Effects of negative environmental related information or lack of companies' environmental performance disclosure is perceived by organizations as a threat to business operations. Different cases of organizations that failed complying with regulations and/or disclosing environmental related information are frequently mentioned in conversations with industry (i.e. the case of a Japanese electronics manufacturer that had hard times due to negative publicity related to hazardous content on its product's wire, or a Japanese car manufacturer that also had negative reactions from stakeholders due to the company's position of non-disclosure of environmental information). Legitimation refers to the desire of a firm to improve the appropriateness of its actions within an established set of regulations, norms, values, or beliefs [10]. Implications of such attitudes are perceived as negative for the business, and lessons are learned from them.

Legitimacy is strictly related to image of the corporation and reflects on products launched to the market. Image of an organization plays even a more relevant role in purchasing decisions than in (environmental) performance of products. A study done at DUT shows that image counts for more than 50% of the product perception by consumers.

Legitimacy is also enhanced by imitating successful competitors.

3.4 Imitative behaviour

Imitation of other companies' attitudes from the same sector is a common practice among industry. In several occasions authors noticed that organizations perform certain environmental activities because "competition is also doing it!". Bansal and Roth [7] mention that "firms operating in close proximity are usually subject to the same regulations and social norms; they often operate with similar standards in a social cohesive environment".

It is also true that a lot can be learned from competitors' facts. A company, successfully embedding ecodesign into business, is more credible that studies and recommendations from university environmentalist. A practical example is the reduction of energy consumption on TV at 1Watt in stand-by mode. Without a proper study, it is not know if reducing energy consumption to 1 Watt is the perfect balance between environmental aspects and investment required. But currently, every company is doing it, so you do it.

Examples of imitative behavior are usually related to the use of certain methods, participation in institutional activities/ proposals and, green claims in public communications. Authors experienced that Asian organizations are more mimetic than European and American.

A mimetic approach aims to reduce risks of being a front runner or lacking behind common industry practices.

3.5 Market requirements

In business operations where final consumers are product users, a market pull for environmentally efficient products has not been identified. Some surveys [11] reflect willingness by consumers to purchase "green" products. These are socially desirable answers. Green as such does not sell and in general this argument is used as an excuse to avoid extra efforts on the environmental arena. This situation can be efficiently improved by linking green to other benefits of what a demand exist.

However, price, functionality, and service are top in purchasing decisions [12].

Furthermore, in a study carried at DUT [13] within large electronic manufacturing organizations it was found that a lack of demand is considered the main obstacle for successfully bringing ecodesign products to the market.

In the case of business-to-business operations, environmental performance of products is relevant and usually a criteria for selecting suppliers. The reason is of a legislative nature; regulation like the European Directive on the ban of hazardous substances (RoHS) originates an increase of control on the supply chain ensuring that environmental requirements are fulfilled at all levels. It is for that reason that most large electronic manufacturing organizations require to their suppliers to demonstrate a certain degree of environmental commitment and proper environmental management. Middle management and business units' personnel of some organizations visited by DUT mentioned to stop commercial activities with suppliers that could not demonstrate fulfilment of company's requirements in environmental aspects.

On the demand side, public procurement is gaining momentum as market pull for environmentally efficient

products. Certain administrations from all over the world are starting green procurement programs; a market for environmentally efficient products is created. In 2001, the European Commission estimated that public authorities in Europe spent some € 1,000 billion on goods, works and services. This includes, for example, 2,8 million computers and monitors purchased each year by public authorities in the European Union [14]. A common strategy for green procurement has been established at EU. In US, an environmental criterion is used by the Environmental Protection Agency to sign contracts with suppliers. Recently, Dell Computers became official EPA computer supplier due to the implementation on a take-back system by the company.
Opportunities can be created in a demanding market by expanding creativity on new business areas and undertaking paradigm shifts. Organizations lacking awareness of the current market demands put into risk potential alliances and contracts with strategic partners.

4 Discussion

In previous sections it has been shown the presence of a self-protective approach as a driving factor for large electronic organizations when deciding to engage ecodesign activities in current business practices.
Analysing drivers is as important as paying attention to technicalities, but ecodesign in industrial contexts is also about:

- *Technical issues;* how to do ecodesign from a technical perspective.
- *Integrated process management;* how to organize ecodesign for success.
- *Manage the value chain;* how to get benefits from the efforts done.
- *Soft side of ecodesign;* how to communicate properly on a two-way communication and cooperation, rather than a top-down approach. [15]

From a business perspective, the dimensions of green include; scientific green (technicalities), costumer green (perception and feelings), and governmental green (legal requirements) [11].
Threats for the organization are present in all three dimensions. Moreover, in the ecodesign community, a lack of attention on how to manage them efficiently is lacking.
On previous sections, the relevance of issues like compliance, legitimacy, market demand and competitiveness in relation to with ecodesign has been shown. All factors are present on the value chain and have little to do with an environmental dimension. We propose to broad the ecodesign dimension and not rely merely on technicalities for success (ecodesign does not happen just with technicalities). Success in the ecodesign area consists also on:

- *Prioritization;* too much attention on emissions and little on materials (resources). The same applies for recycling versus energy.
- *Link environmental and economic considerations;* eco-efficiency concept as a decision making tool based on the bottom-line.
- *Environmental value chain management;* managing stakeholder value internally and externally.

In general, attention is needed on how to systematically manage properly the environmental value chain in the process of designing environmentally efficient products. It is not a question of how to ecodesign a product (technical aspects), or how to engage environmental thinking in business activities (environmental management practices), but how to be in control of threats and opportunities associated to the whole lifecycle of a product. These issues need attention and will be covered in future publications [16]

5 Conclusions

Based on the evidences presented in this paper, it can be concluded that ecodesign is more that technicalities and drivers play a minor role when engaging ecodesign in business contexts. In addition, the managerial dimension of ecodesign is not receiving the required attention.
As literature states [17], a lack of alignment between ecodesign and existing business activities exists. Further research in value chain management would help this alignment process. Therefore Delft University of Technology is drawing an initial model that will be the basis of future research.

6 Literature

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Pictures, 5

China, an Ecodesign Adventure on the Great Wall

4.5 Product lifetime and life time extension

4.5.1 Life cycle optimization

One of the central dogmas of traditional EcoDesign is product lifetime extension. Keeping products in the hands of their 'first owner' is thought to be 'green' because the materials (and components) remain in the 'techno sphere' longer so that the depletion of resources (the 'ecosphere') is at least postponed.
Traditionally, several design strategies are recommended to achieve this:

- 'Upgradeability' (the possibility to add more functions to keep up with increasing requirements).
- Attractive design (so that products are not thrown away because users do not like them anymore).
- Easy repairs when products have broken down.

Priorities in these options can be set by finding out for previous product generations; how many products were discarded by their first owner because of technical breakdown, how many are discarded because they are 'not liked anymore' after a given period of time and for which products upgradeability is needed. Subsequently the prioritized strategy can be determined

It should be noted that a lot of electronic products today have much better environmental characteristics than in the past. This is achieved through high levels of function integration. Such kinds of design hamper good repairability, upgradeability and to some extent achieving an attractive design. Moreover, most electronic products today degrade as a result of 'wear and tear' (of electronic components and subassembly), rather than break down outright because of mechanical failure.
These reasons also suggest that modular construction – frequently recommended to enhance reuse and recycling – is often not a good idea. The functionality of many electronic products deteriorates slowly as a function of time. This cannot simply be remediated by reuse design strategies .
There is however, for electronic products, an even more overriding issue: energy consumption. This represents 50-90% of the total environmental load over the product's life cycle. For a TV this represents 80% of the total load for user scenarios with 3 hour viewing time and 15 hrs standby. When viewing is one hour a day it is still 60%. When it is 6 hours a day (hopefully it is better to say in this case with the TV 6 hours on) it increases to 90%.
This means that from an ecological perspective, as well as life time extension perspective, energy consumption – not material consumption – should be the primary design driver. Due to technological developments the energy consumption of TVs drops as a function of time. This is partly undone through the addition of more and more features but on balance there is a clear net decrease. It was estimated on the basis of actual data that from an ecological perspective it makes sense to replace a TV after 8-10 years of use. In such situations, trying to extend lifetimes can even be considered to be anti-environmental.
In order to establish whether life time extension can really contribute to 'green', it is necessary to know how much the energy of the product concerned has dropped from subsequent product generations. Simultaneously it should be assessed how much environmental load is avoided through life time extension.
Such considerations led to the concept of 'ecological payback' times. Here the work of Nicole van Nes comes into play. She was a PhD student at Delft and later at Erasmus University in Rotterdam. She started more detailed and conceptual work on the pay back concept (see also chapter 4.5.2).
In chapter 2 of her thesis Nicole gives detailed mathematical formulae for the ecological effects of product transition. These formulae were not tested by case studies so the concept of 'ecological payback' for life time extension stayed unfortunately in the domain of qualitative considerations.

Highlights of the year, 1998

Recycling

From the very beginning of the environmental activities at Philips Consumer Electronics (PCE) a lot of attention has been paid to recycling efforts (design rules, cost models, etc., see chapter 7) and recyclability of materials (products, plastics, glass). PCE was also an important player, on behalf of industry, in discussions with the Dutch Environmental Ministry about the Dutch Electronics Recycling Law. In 1998 this law was agreed upon and recycling operations started on January 1, 1999.

Inside Philips we had numerous discussions about the proposed laws and about the system to be organized. Initially Philips, like all other electronics companies, were opposed to such a law. Soon after Philips became the first company in the electronics industry to realize that take-back and recycling were fads promoted by environmentalists and ministries. However, these calls represented a much broader societal interest that required a positive response. Management decided to strongly support the take-back and recycling pilot in the Netherlands in 1997. This decision was followed up with more realistic legislation (see chapter 8.3).

As regards the recycling system, a so called 'let the competition go to hell' scenario was developed initially. Philips had a high market share in the Netherlands, had in-house recycling facilities and last but not least its products were designed in such a way that the recycling cost of Philips products was lower than that of the competition. Therefore the obvious conclusion was, in the tradition of the idea of Individual Producer Responsibility, go for a Philips-only system. However, soon this idea began to crack (see also chapter 8.1).

- *In the past the market share of Philips CE in the Netherlands was even higher, so recycling cost per piece would be lower, but total cost would be high compared to newcomers to the market.*
- *It was decided by the Board of Management that the Philips recycling operations were to be divested; no in-house advantages anymore.*
- *A projection of cost for the future showed that recycling costs would drop. However, even with the best Ecodesign it would stay far from cost neutral for glass (TV's, monitors) and plastic dominated products (the structural deficit, see chapter 8.3.1).*
- *Logistics costs were projected to be high, contrary to earlier expectations, (up to 50% of total cost) adding to the structural deficit.*
- *It was also calculated that economy of scale pays (see chapter 8.2).*
- *If take-back had to be introduced elsewhere stand-alone systems would be disadvantageous in countries where Philips CE had a low market share.*

Conclusion: whatever systems is chosen, Philips always needs fees to be paid by the consumer due to the structural cost deficit .

The next issue became: how can we ensure we get the fees? This discussion was brought to a quick end by a ruling made by the Dutch Environmental Ministry. Fees can only become mandatory for a product category if producers representing a market share of more than 75% support the idea.

In practice this means that the only way to get fees is to set up recycling systems jointly with your competitors. This is the basic reason why Philips CE stepped into the so called 'collective systems'. CE does not like collectivism but in this case it cannot afford to go alone.

So it happened!

4.5.2 Discarding behavior of first users

In the studies of Nicole van Nes it was realized from the very beginning that the discarding behavior of first users is in fact decisive regarding the presence of opportunities which can be qualified as 'green'. In her work studying the discarding behavior of first users therefore received priority. First a conceptual model for discarding was developed which was published in the article below.
The model in this publication was quantified later by extensive empirical research. For a wide variety of household appliances, consumer electronics and IT equipment the motives for discarding were tracked down via questionnaires. Motives can be clustered into four groups :

- wear and tear (physical functionality) dominated, on average 30% of consumers.
- utility (economic and immaterial functionality) dominated, on average 15% of consumers
- expression (immaterial and emotional functionality) dominated, on average 20% of consumers
- new desires (combination of all functionalities) dominated, on average 35% of consumers.

In her dissertation it is concluded that there are opportunities for influencing the discarding behavior of consumers through design, particularly for cases where 'expression' and new desires are the chief reason for discard. The old design rules for life time extension are too simplistic, but there is ample evidence that it is worthwhile in the functionality analysis (see chapter 2.2) to consider how the ecological lifetime optimization of products can be achieved best. The paper below *"A Practical Approach to the Ecological Lifetime Optimization of Electronic Products"* is a first analysis in tis respect.

A Practical Approach to the Ecological Lifetime Optimization of Electronic Products
Nicole van Nes, Jacqueline Cramer and Ab Stevels

Abstract

In order to be able to answer the question of whether to 'extend or shorten the product lifetime', one must first analyze the gap between the ecologically optimum lifetime and the current usage time. The ecologically optimum lifetime is defined as 'the time until replacement is considered ecologically sound' and is determined by two factors: the reduction in the efficiency of the product itself due to use and the improvement in the efficiency of new products in the market.
When trying to find a way to close the gap, it is helpful to distinguish between the different dimensions of the product that can become obsolete. This information forms the basis for the development of directions for redesign.

1. Introduction

Every new product that is developed and produced has an impact on the environment. Natural resources (energy, materials & water) need to be extracted and the production, use & disposal all have an impact on the environment. There are several eco-design strategies that can be followed in order to reduce the environmental burden (Van Hemel, 1998). One of these is 'product lifetime optimization'.
Ecological lifetime optimization is a matter of finding the best moment for replacement from an ecological perspective, and subsequently influencing the moment of replacement in favor of this point in time. In so doing, it is important to realize that it is not only the technical state of the product that influences the replacement decision. Nontechnical aspects also have a role to play, as proved by the research carried out by Blonk (1993). It is often suggested that aspects such as esthetics and features are important in the replacement decision (Hinte, 1997; Creusen, 1998).
At present little is known about the range of different factors that influence the product lifetime. As a result, there is a lack of 'guidelines' to support designers in the development of products with an optimum product lifetime, in both ecological and economic terms.
This paper aims to elaborate on the relevance of lifetime extension and to explore the possibilities for such guide-

lines, particularly for electronic products. The first paragraph discusses how one can determine the ecologically optimum lifetime in comparison with the current usage time. The second paragraph explores which factors influence the product lifetime. Finally, indications are given of how the gap can be closed between the current usage time and the ecologically optimum lifetime of a particular product.

2. Extend or shorten the lifetime?

Generally speaking, the positive environmental effects of designing longer-lasting products lie primarily in the area of reduction in the use of raw materials and (toxic) waste by decreasing the number of replacements. However, lifetime extension of products does not always represent an environmental improvement. The washing machine and the refrigerator are well-known examples. This leads to the question of when it is ecologically sound to extend or shorten the product lifetime (Cramer, 1996).

This question is particularly relevant for those products that 'consume' something and generate an environmental effect during use, such as the consumption of energy, paper, chemicals, water, etc. In such cases it is possible that the environmental investment in the production, distribution and disposal of the replacement product is earned back by a higher environmental efficiency during use. These products can be characterized either by:

1. A significant reduction in the efficiency of the product itself due to use, or by
2. A significant improvement in the efficiency of new products (with the same function) in the market.

These two factors are independent and can be put together in a two-by-two matrix as shown in figure 1.

	NO reduction *in the efficiency of the product itself*	***Reduction*** *in the efficiency of the product itself*
*Replacement by **identical** product*	- Category I - Lifetime extension always constitutes an environment benefit	- Category II - Calculate whether replacement is environmentally sound
*Replacement by new **more efficient** product*	- Category III - Calculate whether replacement is environmentally sound	- Category IV - Calculate whether replacement is environmentally sound

Figure 1 Ecological Lifetime Optimization Matrix (ELOM)

For products belonging to category I, lifetime extension is always of benefit to the environment. For products belonging to category II, III and IV the environmentally sound moment for replacement can be calculated on the basis of the use of the environmental pay-back time. The environmental pay-back time (T) is the time it takes to earn back the environmental investment in the replacement product (P) by the improvement of the environmental efficiency during use (ΔE). This can be expressed in a formula as: $T = P / \Delta E$ or $P = \Delta E * T$. The replacement is considered to be environmentally sound when the expected usage time of the replacement product is greater than the environmental pay-back time.

Ecological pay-back time:
$T = P / \Delta E$

- P – the environmental impact of the replacement product, including production, distribution and disposal.
- ΔE – the improvement in efficiency created by the replacement
- T – the environmental pay-back time

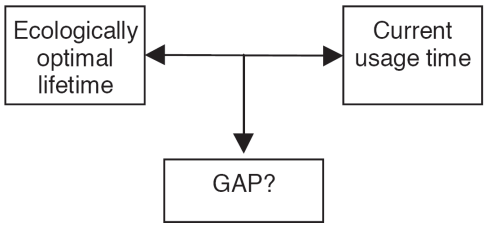

Figure 2. The gap between the ecologically optimal lifetime and the current usage time

The model described in this section can help us to find the best moment of replacement from an ecological perspective. In practice, there is usually a gap between the current usage time and this ecologically optimum lifetime. This is visualized in figure 2.

3. Understanding the gap

In order to bring the current usage time closer to the ecologically more desirable lifetime we need to understand whether and how to influence the current product lifetime. We are in particular interested in the question how the product lifetime can be influenced by the product design. In order to come to grip with the problem a conceptual model is developed by Van Nes e.o. (1998) based on a literature review and expert interviews.

This model focuses in particular on product-related aspects that influence the replacement decision. The model (figure 3) distinguishes several dimensions of a product that cause dissatisfaction, or in other words that can lead to obsolescence. The first factor, technical obsolescence, relates to changes in the product itself as a result of usage. The other factors relate mainly to changes in the market, with the effect that current products are perceived to have become obsolete.

The different types of obsolescence that can be distinguished include:

1. Technical obsolescence: the product itself is worn out and no longer functions properly. E.g. hard disc of computer crashes.
2. Economic obsolescence: new products in the market are more economic in terms of cost, they have a lower cost of ownership. E.g. energy-saving lamp.
3. Ecological obsolescence: new products in the market have a less harmful impact on the environment E.g. refrigerator, energy-saving lamp. Ecological obsolescence and economic obsolescence often go hand in hand, although this is not necessarily the case.
4. Esthetic obsolescence: new products in the market have a nicer look or a more fashionable design in the perception of the consumer E.g. coffee-maker in style of 70's in kitchen in style of 90's.
5. 'Feature' obsolescence: new products have come onto the market that offer more or better features E.g. faster computer, cd-rom drive, high density TV).
6. Psychological obsolescence: a new product has greater emotional value (e.g. present/gift or inheritance) or the present product has a negative emotional value.

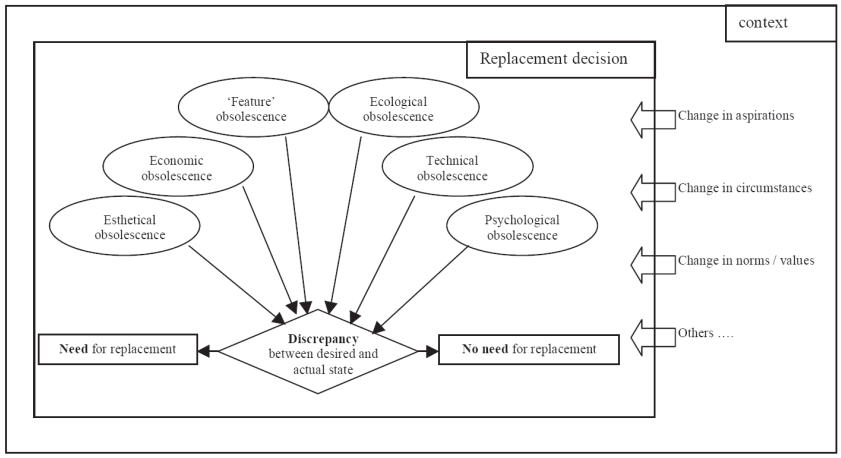

Figure 3 - Conceptual model of the influence of product characteristics on the replacement decision

The above model shows the set of factors that can potentially cause dissatisfaction. A single factor can cause dissatisfaction, but the dissatisfaction can also be caused by a combination of different factors. The different factors can also strengthen or counterbalance each other.

The weight that is given to each of these factors varies per product. For example, for a coffee-maker the visual state is considered to be important, whilst for a vacuum cleaner it is mainly the technical state and for a computer it is the functionality. The weight given to the different factors also depends on the user. A 'techno freak' may regard an audio system as obsolete, whilst the 'no-nonsense consumer' perceives the same audio system as satisfactory.

The factors within the model are product-related factors that influence the replacement decision. However, the deliberation within the model is influenced by the context.

For example: moving to a new house influences the desired state of a great many products, and as a result discrepancy with the actual state arises. Other examples of circumstances that influence the deliberation within the model are, for example, the neighbor purchasing a new car, having children or a rise in income. There is therefore a context around the model that contains the non product related factors that influence the replacement decision.

4. Directions for improvement – how to close the gap?

Once we have understood the reason for dissatisfaction it only takes a small step to formulate design directions to extend product lifetime. In order to do so, one must anticipate this on dissatisfaction by adapting the product to the relevant aspects. Design directions can be drawn up to make only the obsolete part repairable or upgradable, and replacement parts can be offered instead of replacement of the whole product. Design directions to be considered are:

1. Technical obsolescence → e.g. improve repairability, self repair by consumer
2. Economic obsolescence → e.g. replace printed circuit board with a more efficient one
3. Ecological obsolescence → e.g. replace printed circuit board / engine with a more efficient one
4. Esthetic obsolescence → e.g. replace the front or the housing
5. 'Feature' obsolescence → e.g. add new features through software or hardware (modular design)

The business concept behind this approach is to sell a reduced quantity of materials, offer the same added value for the consumer and make greater profit. This requires a change in paradigm within business from 'selling boxes to selling a function'. In spite of the current tendency towards faster replacement cycles, this approach has a lot of business and consumer benefits. The benefits to be achieved include:

- improving product quality,
- increasing consumer satisfaction,

- brand loyalty,
- postponement of the moment of dissatisfaction with the product,
- stronger bonding with consumer,
- opportunity to move from hardware to service with a higher profit margin.

5. Continuation

The ecological lifetime method as presented in this paper is now being tested on audio products and lighting products. The experience gained will be used to further refine the approach. More cases will be selected to enable the general applicability of this method to be evaluated.

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Tidbits, 6

Info about women is on the Internet

Around the year 2000, we did quite a bit of work on 'green' marketing (see chapter 5.4). It turned out, amongst a lot of other things, that generally speaking women are much more environmentally conscious than men, particularly between the ages of 18 and 40. Simultaneously it was observed that the percentage of female buyers purchasing consumer electronic products was rapidly increasing. Today buying cars, whisk(e)y and gin are the last strongholds 'for men only'.

Finding out how to link 'green' marketing and gender seemed to be therefore a great graduation project. To my surprise only male students turned out to be interested. Eelco H. ultimately took on the subject. The initial problem was to gather loads of detailed information? Asking fellow students is not good enough and doing random interviews takes too much time for a six month project. Eelco H. was a smart guy however, and he managed to convince the marketing people to post a (temporary) pop-up on the Philips CE product website. He was able to ask his questions there. The results were stunning:

- *In a short period of time there were almost 1,000 reactions, 91% women, 9% men.*
- *40 % of the respondents were single.*
- *Of the women with a partner, 50% made consumer electronics purchasing decisions together, 20% did it alone, and 30% left it to their partner.*
- *In a ranking of 25 products shown on the net, 'green' products (it was not specified which products were 'green') scored low for attractiveness. The main comment was 'they look so lousy'.*

The last conclusion is a real killer! The physical functionality of the 'green' products is OK, the economical functionality seems to be OK however, the emotional functionality turned out to be seriously neglected: 'green' was associated with misery, not with quality. The lesson for product realization is not 'go for the absolute minimum in environmental load'. Instead, make sacrifices to design a product which is attractive for potential buyers while being greener than standard products.

Several business groups took this lesson on board with surprisingly positive results. Eelco, thank you very much!

4.5.3 A market for services to extend lifetime?

In the studies about discarding behaviour at Philips Consumer Electronics a shortcut has been taken. Based on the 7 archetypes of environmental behaviour of consumers (see chapter 5.4.1) and the traditional consumer behaviour characteristics, as used by PCE, correlation matrices between the two were plotted. These included a general correlation matrix (table 3 of the publication below) and a specific one showing replacement behaviour of a TV set's first user (table 4). The aim was to find out which consumer group would be interested in services aimed at postponing replacement. Secondly, when a positive result was obtained to tailor design strategies for future products towards these strategies.
The results of this study are given in the paper *"Service to extend the life of TV sets"* below. Conclusions suggest that there is, even in affluent societies, some 50% of first users who have interest in services to extend product lifetime. However, the ecological and economic payback of lifetime extension efforts is, at least for TVs, very limited. As a result the 'service project' has been abandoned.

Service to extend the life of TV sets

Ab Stevels and Michel Boekee

Abstract

Based on an in depth user research, two upgrading scenario's for TV's which are currently discarded by first owners have been identified. Due to the fact that energy consumption is dominant in the environmental load over the total life cycle, the environmental and economical gains are limited for the current models, that is 22% and 5% respectively when lifetime through the upgrading service is extended by 50%. Future models should allow easier replacement of Printed Wiring Boards so that an upgrade service offers more value for producers, customers and society.

1. Introduction

It is widely assumed that, in our affluent society, a lot TV sets that are replaced by the first owner still function more or less properly. This is due to the fact that apart from irreparable breakdowns, repair is thought to be too costly in comparison perceived (rest) value or to be too inconvenient or too much a hassle.
Apart from that increased functionality ambition of the user is another chief reason to discard products (see also refs. 1 and 2)
In this paper it is explored what services or design approaches could prevent 'premature' discarding. This strategy is ranking the highest in the environmental preference for end of life strategies which is as follows:

Table 1 Environmental ranking of end-of-life strategies.

I Strategy	Environmental Rank
Prevent replacement	1
Product reuse	2
Product repair	3
Product remanufacture	4
Subassembly/component reuse	5
Recycle (with disassembly)	6
Recycle (without disassembly)	7
Incineration with energy - recovery	8
Disposal	9

In ref. 3, it has been calculated on basis of Eco-indicator 95 (see ref. 4) that although in absolute terms the ranking of strategies 2-9 in the correct one, for TV's in relative terms the difference between the strategies 2-6 is small, a few percent difference only. This is due to the fact that the environmental effects of energy consumption in the user phase are dominant (approx. 80% of the total load) and in the sector materials the environmental load of

mining and producing materials (the 'kilograms') is much higher than bringing form and function into these materials. It is also shown in ref. 3 that due to developments in technology which make that – at equal functionality- the energy consumption of TV sets goes down under circumstances the ranking of the preferred strategies could be reversed so that for instance recycling of materials of old TV's is from an environmental perspective is better than keeping them in use.

From these considerations it is concluded that the best chance to improve to prevent discarding at the first user is to offer as service functionality upgrades which simultaneously enables to lower overall energy consumption of the TV.

In order to explore this opportunity a pragmatic research approach is followed. First actual consumer discarding behaviour is studied in detail. On basis of this target groups are identified for which the availability of the service as described above is in principle an interesting value proposition. Next the design possibilities to enable TV upgrading are identified and rated according to user benefit, company benefit and feasibility. The preferred option is subsequently rated according to their environmental and value potential.

2. Consumer categories

In our research the Philips Consumer Target Segmentation method has been used to identify buyer/user groups in the consumer electronics market. Each buyer group has different priorities and criteria and it is expected that this also will apply when describing buyer behaviour.

Six buyer/user groups have been identified.

The overall characteristics of table 2 turned out to be strongly correlated with the archetypes of environmental behaviour as described earlier (ref. 5). In the correlation matrix below, crosses indicate the interrelationship.

Table 2 Buyer/user characteristics

Group name	% of total	Remarks
Home aesthetics	13	Design and ease of use are important, average education and age, females dominate
Enthusiasts	16	Latest technology/features are important, averages education, younger age, males dominate
Techno-connoisseurs	20	Knowledgeable, require high quality, above average education, younger age, males dominate
Rationalists	13	No outspoken priorities, average education/demography
Prudents	20	Want value for money, average demography
Uncertain	18	Price and ease of use are important, below average education, elder age dominates

Table 3 Correlation between general buyer/user characteristics and environmental attitudes about consumer electronics (see also ref. 5).

General Characteristics / Environmental Characteristics		Home Aesthetics 13%	Enthusiast 16%	Techno-connoisseurs 20%	Uncertain 18%	Prudents 20%	Rationalists 13%
15% Green engaged	++		×				×
15% Optimists	+					×	×
13% Disoriented	+				×	×	
15% Too complicated	0			×	×		
15% Pessimists	0		×			×	
10% Growth optimists	-	×		×			
17% Enjoy life	--	×	×				
Environmental attitude of buyer/user group		--	-	-	+	+	++

With two exceptions all crosses in table 3 are located on the diagonal running from bottom left to top right.

3. The replacement behaviour of first users of TV sets

In table 4 below data about replacement behaviour of first users of TV sets are given

Table 4 Replacement behaviour of first users of TV sets

Consumer segment		Life time at replacement (years)	Discarding due to low functionality (%)	Discarding due to irreparability (%)	Viewing time/ day (hrs)
Home Aesthetic	13%	9	50	50	3.6
Enthusiast	16%	8	67	33	2.3
Techno-connaisseur	20%	9	46	54	2.4
Prudent	20%	11	34	64	4.4
Uncertain	13%	11	31	69	4.6
Rational	18%	10	46	54	3.7

This table allows some remarkable conclusions:
In the group with generally negative environment attitudes (Home Aesthetics, Enthusiasts, Techno-connoisseurs, the HAET's) products are replaced earlier (average 8.7 years) than for the environmentally positives PUR's (Prudents, Uncertains, Rationalists), the average being 10.6 years. This correlates with the fact that more TV's are still functioning at the PUR's (37%).
Surprisingly the table allows also the conclusion that user groups with a positive environmental attitude have their TV's switched for longer hours (average 4.2 hours/day).
It is concluded from table 4 that design -allowing postponement of replacement at the first user should primarily cater to the Home Aesthetics/Enthusiasts/Techno-connoisseurs target group. Items as good styling, new technology/features and quality are more important than for instance energy consumption (although from an environmental perspective the opposite is true).

4. Design strategies to postpone replacement

Although 3 is already giving some general indications about the design strategies to be followed to postpone replacement, an in depth and detailed analysis of all strategies has been pursued to get better clues what tot do in practice to make the service offered to the market really successful.
Following items will be explored:

1. Do the design strategies fit with the target group (Home Aesthetics, Enthusiasts, Techno-connoisseurs)
1a. Appeal to needs
1b. Deliver benefits
1c. Costs of upgrades

2. Do the (design) strategies fit with the competence and business interests of the producer
2a. Does the design strategy fit with the current business strategy and is the technical know how/market access available.
2b. Financial consequences. How does the design strategy link out a sales, profitability and market position.

3. Are the strategies really green that is:
Will the strategy lead to a longer lifetime before replacement and will the strategy lead to a lower environmental load per hour of viewing.

The results of this assessment are summarised in the table below. On the left hand side the 'durability' strategies are mentioned – entries in the various columns are indicated qualitatively.

Table 5 Evaluation of design strategies to postpone replacement

Issue / Strategy	1a need	1b benefit	1c cost to user	2a strategy fit	2b financials for producer	3 green?
Functional upgrading	++	++	-	0	+	++
Tailor made functionality	+	++	--	-	0	+
Styling upgrade	++	+	0	+	+	0
Tailor made styling	+	+	--	-	0	++
Timeless design	+	0	-	+	0	0
Emotional bonding	+	+	0	+	+	--

In the considerations, a central issue has been that the energy consumption in the user phase is much more important in the environmental load over the life cycle than the materialisation. The design strategy chosen should fulfil the needs and benefiting the target groups in more general but also include the possibility to lower energy consumption in line with latest technology available. This condition makes that all strategies related to styling and function integration are getting low scores, irrespective whether they fit to the producer interests.
In fact in this way only two strategies can be selected: functional upgrading and tailor made functionalities. Due to the costs both for the user and the producer the final choice becomes a functional upgrading design strategy – also in this strategy a clear condition is that the user van earn back the additional cost of the upgrade by the lower electricity use in the phase after postponement of replacement.

5. Design for functional upgrading

The functional requirement for upgrading were identified as follows:

- Digital video receiver
- New services which require identification of user
- Web browser/ E-mail
- Dolby surround processing
- Reviewed interface

These should be combined with styling requirements:

- Variable styling (front)
- No separate additional boxes
- Upgrade must preferably be suited to be installed by the consumer

It was found that these functional requirements could be met in two ways:
I Replacement upgrading. This is the most radical method because several printed circuit boards need to be replaced. The advantage is that a new Small Signal Panel/tuner module can be installed which will be more power-efficient due to miniaturisation and integration of functions (technical developments). Also the power supply can become (when replaced) relatively more efficient due to better matching with the new electronics.
II Additional upgrading. This basically means that extra modules can be plugged into the existing electrical chassis. Such scart card extension system already exists; problem will be however that the interface with the upgrading system will need to be compatible for al long time. This is unlikely to occur - in view of all the technical developments taking place.
For the style upgrading several proposals were worked out based on either adding a new front or replacing the complete encasing. Just replacing the front with a slot to enter a 'smart card' is to be preferred due to lower environmental impact.

6. Environmental & economical validation of the design proposals

In the environmental validation several scenarios have been considered. Starting from the expectation that by the chosen upgrading strategy life is from 8.5 years to 12.7 years (50% increase) it has been calculated that:

The replacement upgrading brings an improvement of (an average – dependent on user scenario's) 22% of the environmental impact per hour of functionality (=TV on). This 22% is the net result of:

- Lower environmental impact per year of the overall materialisation/production
- Higher environmental impact due to the environmental investment in new small signal panels etc. (which gave to be written of in 4 years)
- Lower energy consumption in the last four years due to introduction of new energy saving technologies.

The additional upgrading brings an improvement of only 5%. This is the result of:

- Lower environmental impact per year of the overall materialisation
- Higher environmental impact due to the 'environmental investment' of modules added which is as such small compared to the pcb investment in case of the small signal panels in the replacement scenario's
- Increase in power consumption due to the additional functions
- The changing in style (new front or even complete new encasing) has relatively little negative impact (1-5% depending on the choice).

In the economical validation the total costs for the consumer consisting of initial purchasing costs of the basic set cost of the upgrades (priced with margins allowing the producer to take-in absolute terms-the same overall profit as in the situation without postponement of replacement), costs of power consumption and the costs of the upgrading service (installation).

In this approach the initial costs (basic sets and the upgrades) will be higher compared to the situation without postponement. However the total cost of ownership turned out to be lower in the upgrade scenario's:

- for the replacement upgrading the advantage is 6%
- for the additional upgrading the advantage is 5 %

In fact the scores for both upgrading scenarios are more or less equal. This is because the lower investment costs of the additional upgrading scenario are offset by higher power consumption costs.

7. Conclusions

This study has shown that it is possible by carefully studying consumer behaviour to develop upgrading concepts for TV sets that lead to an increased lifetime. At the current state of technology the environmental impact of TV watching van be reduced up to 20-25% per unit of time. The total cost of ownership can be reduced up to 5% / year. Since for TV sets energy consumption is dominating in the life cycle impact, increase of life time (which basically involves a better use of the materialisation) through upgrading scenario's as the ones proposed here results in relatively modest environmental and economical gains. Future efforts should be concentrated in products where the ratio of:

$$\frac{\text{Environmental load of materialisation /production}}{\text{Total environmental load over the life cycle}}$$

is low.

When in future TV concepts are developed which are more suitable for upgrading (basically this means bringing down the relative by contribution to the total environmental load) than the existing types, this will increase the benefits for the environment and the consumer of an upgrading service approach.

Companies doing so well will be perceived by the consumer as a leader in environmental care and as a manufacturer of top quality products.

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Personalities, 6

Suzanna Bastiana ('Suze') Dronkers (1913-1991) - Curiosity and language

She is my mother. All of her life she stimulated in me all kinds of curiosities and interest in languages.

I was brought up in an atmosphere of respect for science and high esteem for universities. Broad knowledge was highly rated and knowing seemingly useless facts was highly appreciated. As a boy in elementary school, I was already reading the daily newspaper, de Nieuwe Rotterdamsche Courant (enlightened conservative at that time), in great detail and spent many hours reading the Winkler Prins Encyclopedia. The only popular magazine in our home was Donald Duck. Still today I do not understand why my parents immediately subscribed to it when it was edited in Dutch (1952). It was supposed to be utterly popular and not for 'intellectual families'.

Of course my sisters and I were sent to the 'gymnasium'. In Eindhoven there was not a 'real one' but instead it was integrated into an ordinary highschool. You had to study ancient Latin and Greek for up to ten hours a week. This is not as useless as it seems; it sharpens your mind and creates a solid basis for picking up languages quickly. Last but not least it keeps relatively intelligent children busy as well.

Ma had a degree in classical languages herself and was an archeologist by profession. The war, outdated employment laws (kept alive by the Christian parties, in particular the catholic ones) and a crippling tax system (introduced by the socialists) caused her to abstain from taking a paid job. Without being a feminist she fought for women's equality through committees, but without regret she stayed home. I felt happy at home, not at school.

Heartless teachers dominated in the schools. Moreover, the quality of the municipal schools was low in the south of the country.

My mother always had high ambitions for me, but she understood the job changes in my professional life better than my father; maybe it was due to the same restlessness and inclination to experiment she had as well.

She was proud when I told her that I took books of the Antiques on my business trips, like Xenophon and Homer. Many years later it was revealed that I read Dutch translations rather than the originals written in Greek. My mother was upset and emphatically gave me advice to go back to the real sources. Real civilization can only be found there!

My mother died one year before I started in my job at the Environmental Competence Centre. She would have seen that as a great move for me and would have asked me a thousand questions about what I was doing and how I was progressing...

The 'Suze Dronkers walk': Drive (there is no public transport there) to either Valkenswaard or Leende, both south of Eindhoven. Halfway between these villages there is the entry of "Boswachterij Leende". Start from the car park with the Loofhout walk (green leaf walk) but switch at the appropriate moment to the Heide walk (heather walk). Include Laagveld and the Hasselsvennen in your route. Make it up to Grote Heide or if you want to proceed even further go to the Achelse Kluis and go back by the path of your choice.

4.5.4 Influencing the replacement behaviour of consumers

When analysing the marginal results of the study above, the conclusion is – in retrospect – that much more attention should be paid to the combination of environment and cost. Repair/upgrading generally involves high costs due to the labour cost involved, and to a lesser extent the cost of materials. These costs have to be earned back by energy savings. Electricity is still relatively cheap, therefore sufficient economic payback is often problematic.

For environmental payback the opposite holds true. Electricity has a high environmental load compared to its costs. Materials score average in this respect, and components below average whereas labour is the lowest environmental impact/ cost ratio

For a TV this works out so that energy in the use phase constitutes 80% of the environmental load over the life cycle but only some 35% of the life cycle cost (for 3 hrs/day in 'on' mode). For one hour/day the cost is reduced to roughly 15% of the life cycle cost. Even for 'heavy use', energy cost barely exceeds 50% of total cost.

Through repair/upgrading energy savings can be achieved. The ecological payback time of repair/upgrading is much shorter than the economic one. This difference between ecological payback and monetary payback means that essentially repair and upgrade services face an uphill battle.

For products to be replaced by services, which involve more transportation, the same conclusion applies. Also 'dematerialization' is not a generic strategy. When it involves more energy consumption it fails. On the contrary – against traditional 'Eco' beliefs -materialization strategies can be very successful. The best example is replacement of incandescent lamps by energy saving lamps. The last ones have a very high environmental payback (although lots of material is used) and still an acceptable environmental payback.

High-speed trains are another interesting case. When flight transportation is replaced by high-speed trains, there is a short ecological payback (even when all the materials to build tracks are taken into account); whether there is an economic payback is highly doubtful.

Applying such considerations to consumer electronics products leads to interesting conclusions as well. Changing for instance from Cathode Ray Tube based TVs to Liquid Crystal Display ones has a high ecological payback (LCD TVs production facilities today have economies of scale comparable to CRT TVs) and has no economic payback, since the current price difference cannot be earned back by the lower energy consumption of the LCDs.

Criteria other than economic influence replacement. Immaterial and emotional functionalities play an important role (see chapter 2.2). Apparently these work for LCD TVs; today CRT TVs are in rapid decline.

In the case of LCD TVs (and of plasma TVs for which the same holds with respect to CRT TVs), the fundamental driver for environmental gain is the physics used to realize the functionality. Design supports in the immaterial and emotional dimensions of functionality, see chapter 2.2. This is needed to overcome economic issues such as high prices. It looks as though it is a modest role but it is an essential one!

In Delft we are deliberately more radical in 'green' design. Such radical designs are meant to be a challenge and provide stimulus for the design of products which have to adapt themselves to the market. Radical design is perfectly suited to gaining all kinds of new insights. Going back to reality after this kind of learning leads to better results than starting in an adaptive mood straightaway. This is the approach of the Applied EcoDesign group and in my opinion that approach that must be taken.

The paper on the next page *"Influencing Product Lifetime through Product Design"* presents a design proposal for an electronic product, which can be carried along throughout someone's whole life and is 'green' for that reason. It is sufficiently integrated enough to allow environmental and economic savings and modular enough to allow the required functionality changes

The general reaction to this design proposal was very positive. Even the most anti-environmental diehards among the product managers had to admit that a lot has been solved at the product level. Now the next level has to be addressed; the strategic level. Which company dares to invest massively in such approaches?

Influencing Product Lifetime through Product Design

Erik Smeels; Ab Stevels

Abstract

The lifetime of the current generation of audio systems is far away from its ecological optimum. Replacing a product for a better, nicer or just more cosmetically pleasing one is the order of the day. The question this paper addresses is whether optimising the lifetime of audio systems is an interesting concept to gain environmental and business benefit. The paper concludes that in the case of audio systems lifetime optimisation can be used to bring about innovative new ideas that at the same time reduce environmental impact substantially.

1. Introduction

Research shows that 60 percent of all audio systems still function when first users want to dispose of them. This means that many audio products are discarded for other reasons than technical malfunctioning alone. Moreover, those products that have a technical malfunction (like a broken switch) cannot easily or economically be repaired. And when on top of that a new technological feature is being added to new audio systems (like MP-3), the only option is to replace the whole product with a newer one. In other words the current generation of audio systems is not designed to be repaired or to be upgraded. This suggests that upgradability of audio systems may offer opportunities from both an environmental and a business perspective. These opportunities are explored further in this paper.

2. Design for longevity

Optimisation of the lifetime of a product considers bringing the moment of replacement of a product closer to the ecological sound moment of replacement and thereby taking customer and company benefits into account [van Nes, 1998].

Design for longevity involves designing a new product that has the ability to change over time. The product has to be made adaptable to changing technological possibilities and changing user preferences. In this report a new concept audio system, the Sound 2000, is presented that has the ability to change over time, thereby postponing the moment of replacement.

3. Design approach

As stated earlier a new product concept has been designed with an expected prolonged lifetime. The introduction of which could lead to a new consumption pattern that offers opportunities from both a business and environmental perspective.

Before a design solution can be developed to optimise the lifetime of audio systems, understanding what influences the moment of replacement is essential. In general, the moment of replacement of a product is determined by product-related and user-related factors. The product-related factors are those factors that define the change in performance of a product, whereas the user-related factors relate to the way the user changes over time. Both changes in performance and changes in user needs and expectations can lead to obsolescence of a product. During the lifetime of a product the performances start to diminish. Six different types of product performances that a product offers to the user can be distinguished:

1. technical performance
2. financial performance
3. ergonomic performance
4. aesthetical performance
5. technological performance
6. ecological performance

The two underlying design strategies that enable product lifetime optimisation are:

1. design for upgradability
2. design for emotional product attachment

Each strategy is individually described in more detail below, as well as in relation to its application on audio systems.

3.1. Design for upgradability

Upgradability can be defined as the ability to add extra functionality to a product during the life of that product. The difficulty with design for upgradability is that future developments are usually unknown, simply because they have not yet been developed. Design for upgradability thus involves assessing future developments. Trends must be analysed on all six product performance areas in order to be able to design a product that in the end can be upgraded rather than being discarded.

When designing for upgradability it is important to assess the relative importance of product performances for the specific product. The relative importance indicates which product characteristics have to be made upgradable. In the case of audio systems the most important types of product performances are the technological and the aesthetical performance [Blonk, 1993].

3.2. Design for emotional product attachment

Emotional product attachment can be defined as the extent to which people are emotionally related to a certain product. In relation to the lifetime of products it is interesting to know how product attachment affects the length of time a possession is kept. Attachment processes cannot be directly influenced by product design. Whether or not people develop strong feelings of attachment largely depends on accidental circumstances. It is however possible to design unique products that trigger feelings of attachment.

4. Design proposal

The objective for the new product concept was to design a new audio system that triggers feelings of attachment and is adaptable to changed user needs and new technologies.

To be able to assess the benefits of the new product concept, a reference product is needed. For this paper the Philips FW-870 audio system is chosen as a reference product.

How design for ugradability and design for emotional product attachment is applied in the design of the new product concept is described below.

4.1. Design for Upgradability

For an upgradable product architecture a division has been made between fast-changing technology and slow-changing technology (see figure 1).

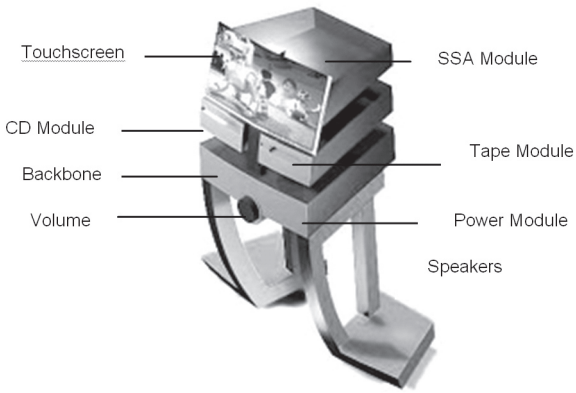

Figure 1 The Sound 2000

The slow-changing technology (transformer, the tuner board and the amplifier, together with the main printed circuit boards) is also referred to as the power module. The fast-changing technology is individually packed in technological modules that can be attached to a vertical backbone. Power- and signal distribution to and from the power module will be provided by the backbone. At the time the product is launched, it will contain a single CD-module and a single Tape module.

The new product concept can be upgraded with new technological features that become available, through replacement and additional upgrades. Replacement upgrades are upgrades that replace existing modules, whereas additional upgrades are added to a product without replacing an existing module.

An example of a replacement upgrade is the CD-recorder. Trend analysis shows that it is to be expected that the CD-recorder will, in time, replace the recording function of the tape module. DVD players are also capable of playing normal audio CDs; as a result the CD-module can be replaced by a DVD-module.

When the technological performance changes as a result of the addition of new (not yet developed) modules, the control options of the hifi system must change as well. The new product concept is controlled through buttons on the touchscreen. The user is able to alter the buttons and the background of the touchscreen to meet his or her personal preferences. Consequently, when new technological modules have been added, the control buttons can be adapted to these new technologies.

Software upgrades also provide an interesting opportunity from both a business and an environmental perspective. Software upgrading facilitates a reduced time-to-market of new functionalities. Extra, not yet developed features can be added later. From an environmental point of view, software upgrades are also preferable, due to the low environmental impact of the upgrade itself. The environmental impact of software upgrades is negligible compared to the impact of hardware upgrades. In the case of hifi systems two types of software upgrades can be imaginable, music [MP 3] and technological upgrades. A technological software upgrade that could, for example, be added to the new product concept in future is speechcontrol. This kind of control requires mainly software to function. The software can be downloaded from the internet. The conditions of success for this type of upgrade are secure payment through the internet and the finalisation of copyright issues. Software updating should be as easy as running a new application on your home PC.

4.2 Design for Emotional Product Attachment

As stated earlier attachment processes cannot directly be influenced by product design. The new product concept has two characteristics that trigger feelings of attachments. The first characteristic is the option to change the position of the speakers, which has a substantial influence on the overall appearance of the product. Each individual can thus change the appearance of the product to meet his /her personal preferences. This way people can personalise their own hifi system (figure 2).

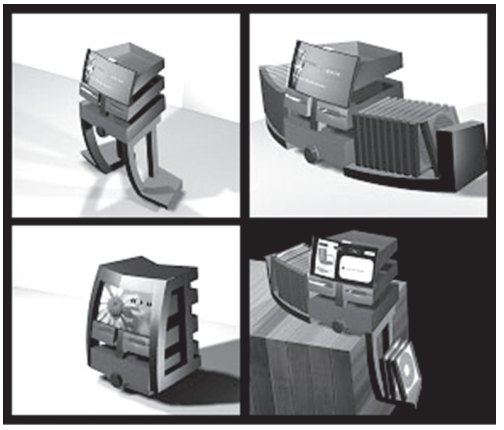

Figure 2 Possible speaker positions

In addition, users are able to personalise their product through influencing the design of the touchscreen. They are able to create their own display, define their own buttons, according to personal preferences.

5. Environmental benefit

The environmental impact of the new product concept, and consequently the environmental benefit in comparison to existing products, cannot simply be determined by performing an LCA on both products. The total environmental impact depends on how many times the user has upgraded the product. The type of technological upgrade chosen also influences the total environmental impact. It is therefore important to make an assessment of various upgrade scenarios. The possible upgrades are visualised in figure 3.

Scenario 1	Upgrade with DVD
Scenario 2	Upgrade with DVD and CD-Recorder
Scenario 3	Upgrade with DVD and CD-Recorder and Solid State Audio
Scenario 4	Upgrade with CD-Recorder
Scenario 5	Upgrade with CD-Recorder and Solid State Audio
Scenario 6	Upgrade with Solid State Audio

Figure 3 Upgrading scenarios

The maximum and the minimum environmental benefit that can be achieved by the new product concept depend on both the upgrade scenario and the environmental impact of the upgrade modules [DVD, CD-R and Solid State Audio].
In order to be able to come to clear conclusions involving the environmental benefit, several assumptions have to be made. These assumptions are outlined below.

5.1. Initial lifetime of the reference product

In this case an average initial lifetime of 7 years is chosen. A functional unit of 7 years is often used when calculating an LCA made of hifi mini systems [Ram and Looren de Jong, 1999].

5.2. Energy usage

It has been calculated that that replacement of hifi systems for more energy efficient ones is not preferred from an ecological point of view [Smeels, 2000]. Therefore the environmental impact as a result of the energy usage during the lifetime of the product is assumed equal for both the reference product and the new product concept.

5.3. Impact compared to reference product

As the environmental benefit in this project results from the optimisation of the initial lifetime of products, no extra attention has been paid to decrease the environmental impact of the product itself. Therefore the environmental impact of the new product concept is assumed to be equal to the impact of the reference product.
Figures 4 and 5 outline the environmental benefit of the new product concept according to a simulation. In these figures two consumption patterns are simulated. Consumption patterns reflect the way in which customers acquire new or extra functionality. In the case of the current generation audio systems people are only able to acquire new or extra functionality by replacing one product with another. The new product concept however provides the customer with the ability to upgrade the technological performance and to change the appearance of the product. In order to get a clear impression of the environmental benefit, only two scenarios will be presented; the best case scenario representing the highest environmental benefit [fig 4] and the worst case scenario representing the lowest environmental benefit [fig 5].

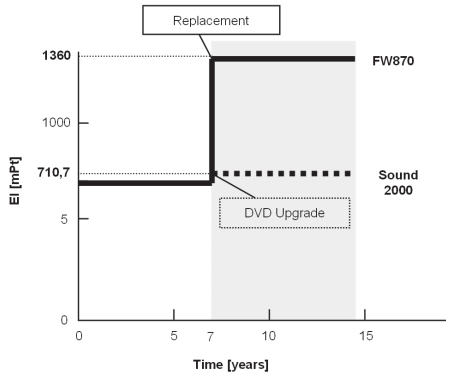

Figure 4 Best Case Scenario

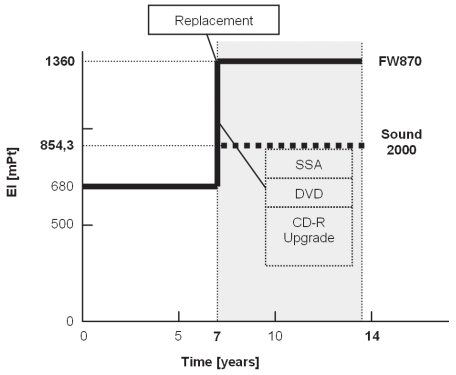

Figure 5 Worst Case Scenario

From the scenarios displayed above it can be concluded that upgrading a product in order to acquire extra functionality instead of replacing the entire product will reduce environmental impact by 95 percent if the product is upgraded one time (best case), to 70 percent if the product is upgraded three times (worst case).

5.4. Long-term perspective

As mentioned before, the introduction of the new product concept will change the consumption pattern of consumers. People will upgrade their products instead of replacing them. The change in consumption pattern results in a slowdown of the throughput of energy and materials. For this project, the different consumption patterns are characterised by the material- and energy throughput. This throughput can be judged by calculating the environmental impact as a function of time as a result of the current and the new consumption pattern. In the equation below the term 'material and energy throughput' has been defined.

Material- and energy throughput = EI (until replacement) [mPt] / Initial lifetime [years]

EI (until replacement) = The total environmental impact of a product before it is replaced [including environmental impact as a result of upgrades and repairs]

In the calculation below the material- and energy throughput has been calculated for the current consumption pattern (based on the reference product).

Material- and energy throughput = 680 mPt / 7 years
= 97, 14 mPt / y

Figures 6 and 7 reflect the effect postponement of the moment of replacement has on the material- and energy throughput for respectively the best case scenario (if the product is upgrade only once) and the worst case scenario (if the product is upgraded three times). The throughput is listed for the new consumption pattern (varying from one-year lifetime extension to seven years). The proportional slowdown compared to the current throughput is displayed.

Lifetime extension	Absolute	Proportional slowdown
1 year	106 mPt/y	-9 %
2 years	94 mPt/y	3 %
3 years	85 mPt/y	12 %
4 years	77 mPt/y	21 %
5 years	71 mPt/y	27 %
6 years	65 mPt/y	33 %
7 years	61 mPt/y	37 %

Figure 6 Best Case Scenario

Lifetime extension	Absolute	Proportional slowdown
1 year	89 mPt/y	8 %
2 years	79 mPt/y	19 %
3 years	71 mPt/y	27 %
4 years	65 mPt/y	33 %
5 years	59 mPt/y	40 %
6 years	55 mPt/y	43 %
7 years	51 mPt/y	48 %

Figure 7 Worst Case Scenario

As can be concluded from the figures above the proportional slowdown of material- and energy throughput, compared to the current generation of audio systems, varies from 48 percent [seven years of lifetime extension, one upgrade], to 3 percent [after two years of lifetime extension, three upgrades].

6. Business benefit

The business concept behind the approach of upgrading is to sell a reduced quantity of materials, offer the same added value for the customer and make more profit. Producers can sell upgrades (hardware and software) with the same profit margins as the current hifi systems. If upgrading purchases will be done more frequently than replacement purchases, overall profitability will increase.

In the current situation consumer only contact retailers for replacement purchases. With the introduction of the new product concept however, these contact moments will increase with the number of upgrades. This closer contact gives companies more insight in the behaviour of its customers and are able to continuously monitor their satisfaction. This provides companies with a tool to establish a sound brand image and to strengthen their position in the market.

In highly saturated markets, such as the audio market, producers are always looking for new markets (market development strategy) or are developing innovative new product offers (product development strategy). The proposed design concept is a good example of the latter strategy.

7. Conclusion

The consumption pattern (upgrading instead of replacing products) resulting from the introduction of the new product concept, provides companies with the opportunity to sell extra functionality with reduced environmental impact. However, the total environmental benefit of the proposed product concept is closely linked to the need people have for new technological features and a change in product appearance. Regarding the long-term perspective it can be concluded that the material- and energy throughput will start slowing down after some time if

the moment of replacement is postponed by upgrading the product. The proportional slowdown compared to a reference audio system varies from 48 per cent to 3 per cent.
If the introduction of the proposed product concept will be picked up in the market it can lead to a new consumption pattern with a reduced environmental impact, On top of that it also provides important advantages for the manufacturer. In the highly saturated market of audio systems the new product concept can be used as a differentiating product. Moreover, through increased upgrading purchases the producer has closer contact with its customers. This way the company can get more insight in consumer behaviour.

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Rituals and habits, 6

The Garden Session

There are three good reasons to have garden sessions with PhD students. The first one is an obvious one. During most of our professional life we have to sit in mostly dull, occasionally functional but always overheated offices. This is terrible and after forty years I still have not adjusted to it. Fresh air is a relief.
'Die Luft der Freiheit weht' is the motto of Stanford University. This means 'the air of freedom is drifting' and there is deep truth in it. Even if the air outside is cold or hot the essential thing is that it moves. This is never found inside buildings and even if there is moving air, it is unpleasant.
A second reason to have garden sessions is the possibility to shut off electronic communication and use much more in-depth communication. Cell-phones, email, and the internet all increase the intensity of information and most of all speed. Simultaneously it makes work a lot more superficial. No time to think, no time to write, the next item is already waiting, without every previous announcement your mind has to switch again. Electronics make it almost impossible to concentrate and to work for several hours on one specific item.
The third reason for the garden sessions is to provide a personal touch which includes: discussions with students in an informal atmosphere, having a drink and a meal together, fun.
Garden sessions typically take place in summer. Either it is (under a big sunshade) on the lawn or on a covered terrace when it rains. All forms of electronics are prohibited; the maximum allowed is paper and pencil.
Typical subjects addressed are the tentative organization of their dissertations (chapters and content), balancing of methodic and empiric approaches, but most of all creative thinking about any issue of the PhD.
The PhD student has to take the initiative. I am a challenger and sparring partner only, who also continuously checks on the consistency of arguments and the soundness of their reasoning. The session goes on for hours and hours, mostly with great results.
It is intensive, it digs deeply and it is addresses the essentials of PhD research.
A great experience!

4.6 Human powered products

4.6.1 Portable Radios

People love portable products; they can be used wherever you go. They allow you to be independent of the electricity grid and the nasty wires which have to be plugged in all the time! This freedom means that even batteries are accepted although they are hated almost equally. You always run out of batteries at the wrong time; even 'rechargeables' have a similar problem. It is necessary to have batteries changed appropriately – those bloody springs, they get loose all the time. When it rains batteries can get wet which leads to car door opener failure and other disasters out in the wild (see Personalities, 2).

Batteries cost little - at least for most equipment users - but are perceived to deliver little in comparison to their cost. In developing countries it is a different story; the relative cost is high for many users in those regions of the world. Many of these users own portables out of necessity (information, education) and not for leisure.

On top of all this arrived environmental awareness, in the nineties of last century. Batteries and battery production turned out to consume a relatively high amount of resources; they contain potentially toxic substances and sometimes outright hazardous substances as well.

This awareness has been an important driver for consideration of human powered products. Generating energy by yourself is an attractive idea for many people: 'Zap yourself fit', it must be fun!

The first foray into the field came from Trevor Baylis, a British inventor. His 'Bay Gen Freeplay' radio was presented to the industry but it found no support. This was because of the clumsy nature of the product (it had a big metal spring, which had to be wound), that and its 'terrible' exterior design. Not a particularly trendy product for a new generation, to say it mildly.

Industry's rejection showed that it did not grasp the underlying message. This message was: human power is an opportunity to create a product line combining 'green', high-tech, fun and utility. It has market potential for a wide range of potential customers, from rich to poor, all over the world.

Of course the energy generation mechanism of Baylis's product had to be drastically improved or changed; from winding to - for instance - pushing or pulling. The electronics themselves could be much more effective in drastically improving the ratio between play time and winding time. Most importantly the product needed to look more attractive and associate good environmental design with quality lifestyle.

In contrast to industry at Delft University we were excited about human powered products. Arjen Jansen picked up the issue and he has since become the 'Guru' in this field. Many students have completed their graduation projects under his guidance. He has done some relevant research in the field. Guru's do not publish PhD dissertations however I still hope that it will happen; it will be a treasure trove for designers.

When moving into this field the first issue addressed was the academic question: are human powered products really as 'green' as they are claimed to be? The products need more material in manufacturing than traditional radios. Can this additional environmental load be 'earned back' through less impact during use? The answer to this question is a clear yes (see the paper on the next page *"Renewable energy in portable radios, an environmental benchmarking study"*), which would be an even stronger yes in the case that the load associated with battery waste could be assessed more accurately than was possible at that time.

Calculations, as presented in the following article, created a platform to lobby at Philips Consumer Electronics for producing human powered radios. In 1999 the AE 1000 product finally (it took three years to convince the management) hit the market. The product functioned well, in particular because the energy generating mechanism was made more elegant. The mechanism was difficult to produce in large numbers however (an example that supply chains issues had insufficiently been addressed in the early design stage, see chapter 2.2), which lead to delays and thus to the irritation of dealers. In terms of free publicity and 'green' image the AE 1000 was a great success. It sent a clear and positive signal to the outside world about the environmental intent of Philips Consumer Electronics. From a commercial perspective it was a different story. Most of the sales organizations took the product on board (not all of them did so) but were not investing enough in distribution. As a result their availability in shops was limited. People reading or hearing about the radio in the media, wanted to buy it but could not find it.

Moreover, the immaterial and emotional value of the product (see chapter 2.2) was not recognized to its fullest extent. The product was priced at average margins. A higher margin would have been possible if the apparent benefits for the consumer had been properly valued. Evidence that higher prices could be commanded in the market was found by store checks done by Delft students. Philips marketing people did not believe these results however.
Nevertheless almost 500,000 of the products were sold.
The human powered radio AE 1000 experience produced valuable lessons regarding the public reception of the product. Being 'green' is not good enough. Even if there is market acceptance, there is need to invest in distribution. The complete internal value chain (including production and marketing/sales) has to stand behind the product whole heartedly, any hesitation will be punished by the market. Most of all the reward must be reaped to the fullest extent. If a product has clear value, dare to ask a price in accordance with that value!
The AE 1000 did not have a successor at Philips in spite of the many attempts of the environmental departments who pushed for it. Proposals for human powered MP3 players, human powered cell phones or integrated MP3/cellphones (a human powered iPhone) were all turned down. Missed opportunities!

Renewable energy in portable radios, an environmental benchmarking study
Ab Stevels and Arjen J. Jansen M.Sc.

In this paper the results are presented of a environmental benchmarking study of 4 portable radios, 2 of these radios are powered by an alternative system, the others are powered by batteries. The study shows that there is considerable room for the improvement of both electronics and (human powered) alternative energy systems. It also shows an interesting environmental trade off between the use of batteries and alternative energy sources.
The analysis of these four radios is a first result in a research project at DUT on the subject of 'human powered energy systems in consumer products'. Ongoing research on this subject will focus on the analysis of physical constraints of the human body, new systems for converting human power into electricity, possibilities for the application of these systems in consumer products and assessment of the environmental consequences.

Introduction
At the Department of Engineering Design of the Faculty of Industrial Design Engineering, research within the Technical Product Analysis group (TPA) concentrates on the technical analysis of products, particularly addressing the environmental aspects of product design.

Figure 1 The analysed radios

Methods

The radios were "environmentally benchmarked" using the TPA method and by determining the EcoIndicator 95 value [Goedkoop 95], using EcoIndicator 95 classification factors [Goedkoop 95]. The SIMAPRO software version 3.1 [Pré consultants 95] was used for calculating the Life Cycle Analyses (LCA). The TPA method is set-up at the Faculty of Industrial Design Engineering in order to obtain a combination of LCA and various other product analysis tools. It focuses on a practical approach in gathering and analysing data of products with a similar or comparable functionality. A draft version of the TPA manual, in which the TPA method is described, will be available from the authors at the end of 1997.

Description of the analysed radios

The **BayGen Freeplay** is produced in South Africa. The radio is designed to be used in remote areas where batteries are hard to get or very expensive. The BayGen received world wide attention because of its alternative energy system, invented by Trevor Baylis. Although the radio was not primarily designed as such, it is seen as a "green" alternative by West-European consumers and specific environmental organisations [Benjamin 96], [Belgiovane 95]. In the analysis we focused on the "green" perception of this radio.

The BayGen Freeplay is charged manually by winding a constant-torque spring. The spring can be wound up to a maximum of 60 revolutions, average charging/winding time is 40 seconds. The required input torque is 1.66 Nm, total required input labour is 628 Joule. The output drum of the spring delivers a constant torque to a gearwheel transmission, which is coupled by a small driving belt to a dynamo (Mabuchi RF 500TB). Total gearing ratio *i* is 1:904 (dynamo speed is approx. 1800 rev/min). A fully wound-up spring allows the radio to play for 30 minutes. By dividing the output at the dynamo of 162 Joule (90 mW x 1800 sec) with the input of 628 Joule, an efficiency of 26% for the total energy system is found.

The **Dynamo & Solar** radio is produced in China. It has a versatile energy system, it can be powered by batteries (2 penlights) or by a build in NiCd battery (2 Varta V280R cells, capacity 280 mAh). The build-in NiCd battery can be charged by a solar panel (amorphous Si, 25 cm2), by net-current or by a hand-powered dynamo. When winding the handle at maximum speed, the NiCd batteries are charged with 100 mA. Winding the handle at a sustainable speed, it takes about 11 hours (at 25 mA) to charge the build-in battery. The solar panel is able to charge the batteries with 0-5 mA (cloudy day) to a maximum of 48 mA (bright sunshine).

Both the **Grundig Boy 55** and the **Philips AE 1595** are small portable radios powered by batteries only (2 Penlights, AA/R6). These radios served as the benchmark for the analysis because they have a functionality similar to the BayGen and the D&S radio (AM/FM, portable, no use of net-current). The Grundig and Philips radios are produced in China.

Table 1 Power consumption, weight and stored energy

	Power consumption at 70 dB(A) [mW]	Weight of the energy system [gram]	Stored amount of electrical energy [Joule]	Energy/Weight factor [Joule/gram]
BayGen Freeplay	90	1670	162	0,09
Dynamo & Solar	32	68,8	2670	38
Grundig	58	37,0 (= 2 ZnCl batteries size AA)	10500	284
Philips	33			

Assumptions and data for LCA

The LCA is based on the assumption that the radios will be used in the Netherlands. Containers are used to ship the radios from country of origin to Rotterdam harbour (at 0.44 mPt/tonkm). Inland transportation of the radios in the country of origin and from Rotterdam harbour is not considered. End-of-life (EOL) data are based on the assumption that the radios will be treated as household waste. However, these EOL data do not include the electronics of the radio. Because the availability of data for the environmental assessment of electronics is limited, the data used in this paper for PCB's is supplied by the Philips CFT EcoDesign group. A value of 1350 mPt/m^2 was used for the production of PCB's.

The environmental impact of the use of the radios is compared by defining the following "functional unit":
1 hour radio at 70 dB(A) a day during a five year period. (5 x 365 = 1825 hours). This five year period is based upon estimated life time for the radios.
The battery consumption of the radios was measured by playing the radios until the batteries were exhausted. In the case of the Dynamo & Solar radio, the alternative energy system has not been used. Power consumption (see Table 1) was measured in order to compare the measured and calculated life time of the batteries. Only small differences (<10%) were found between the life time test and the calculated values. The number of batteries used in the five year life cycle is an extrapolation of the average of tested and calculated battery lifetime; the Grundig radio uses 62 batteries in 5 year, both Philips and D&S use 32 batteries in 5 year.
Studies show that the environmental impact of batteries mainly depends on EOL scenarios. In this report, the EcoIndicator 95 value for the production of batteries (0,44 mPt/battery, ZnCl, AAtype) is generated by the Philips CFT EcoDesign group. Full-recycling has been chosen as EOL scenario, assuming 1,6 mPt as EcoIndicator value for EOL (source: Philips CFT).

LCA results

In figure 2, the results of the SIMAPRO analysis on production are presented. The high BayGen score is due to its large and heavy energy system (3,7 mPt due to steel spring) and resulting large and heavy housing, compared to the other radios (also see fig. 1). The difference between D&S, Grundig and Philips are mainly due to a larger PCB and the energy system of the Dynamo & Solar radio (2 mPt estimated for the production of the solar panel, 1 mPt estimated for the production of the NiCd battery).

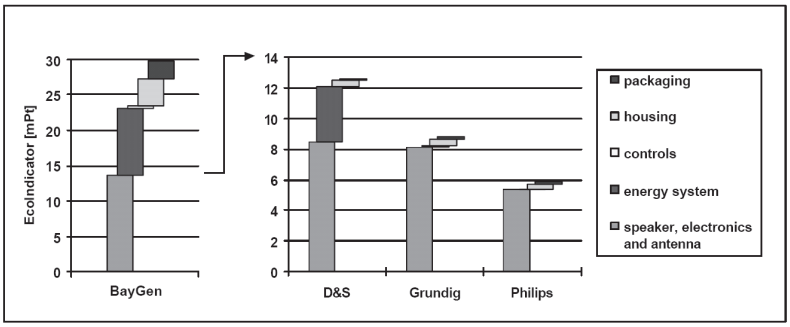

Figure 2 EcoIndicator 95 values for production. Notice that the y-axis scale has a different range for the BayGen (0-30) versus the D&S, Grundig, and Philips radios (0-14).

The EcoIndicator values for the total life cycle of the four radios have been calculated using SIMAPRO. The transport value for BayGen is high, due to its size and weight. EOL value for D&S is assumed 1 mPt for solar panel and 2 mPt for NiCd battery. EOL values for Grundig and Philips are too low to be visible in the graph.

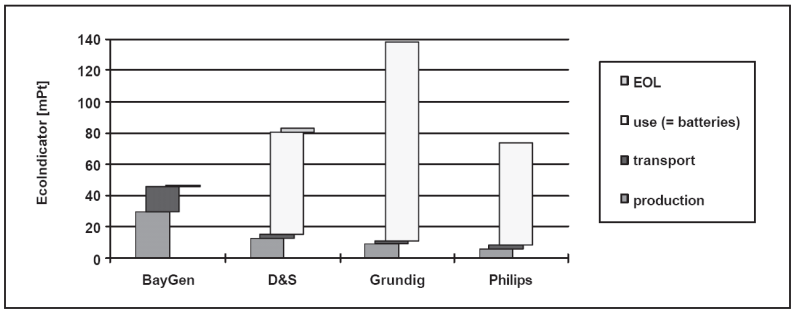

Figure 3 EcoIndicator 95 value for total life cycle of radios

The next step is adding the EcoIndicator values for Production, Transport, and EOL for each radio. Add to these totals the EcoIndicator values for the equivalent use of Batteries each year. The result is shown in the graph in Figure 4.

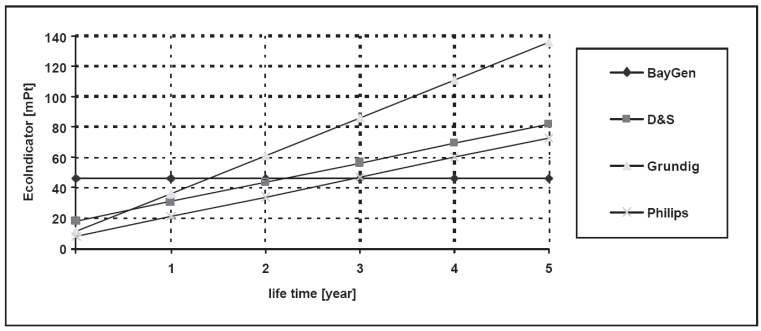

Figure 4 EcoIndicator 95 value during life time (starting point at 0-year consists of the sum of production, transport and EOL values)

Conclusions

The technical product analysis shows there is considerable room for the improvement of the design of radios with alternative energy sources;

- The NiCd battery inside the Dynamo & Solar radio can not be taken (unless soldered) out before discarding the radio. This means that the battery will end up at a landfill or will be incinerated. Recently, products containing non-removable batteries have been prohibited in the Netherlands [Dutch Government 95].
- Improvement potential for the BayGen Freeplay consists of reduction of the size and weight of the housing, upgrade of the electronics and better packaging (no PS foam). In this way reducing the EcoIndicator value for production with approx. 8 to 10 mPt. Reduction of the weight of the radio will also affect the EcoIndicator value for transport.
- In case the environmental load of products is dominated by the use of batteries, reduction of the power consumption has to be the first green option (also see table 1).

When consumers consider products with energy systems other than batteries, they often conclude that only the absence of these batteries makes the products "greener". This conclusion is not necessarily correct. Renewable energy systems based on Human Power may be an alternative for batteries in some products, but the environmental trade-off has to be watched carefully.

The conclusions of this benchmarking study mainly depend on the chosen EOL scenario for batteries (in this case full-recycling). Further studies should chart the effects of different EOL scenarios.

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Cities, 6

Delft, in the name of her Majesty the Queen

Delft is a middle-sized, typical Dutch city, which shows that it dates back to the Middle Ages. It is also the town of the House of Orange. Prince William I started the 80-year war of independence from here. He also was assassinated here and buried in the 'New Church', which actually dates from the 14th century. After him, all members of the Royal House have been buried here as well.

For me however, Delft is the town of the University of Technology, THE UNIVERSITY.

This is because its contributions to society are based on a combination of technical know-how, science and a mental attitude - the Delft Engineering Mindset. 'University democracy' which came into existence in the Netherlands in the seventies of last century could not jeopardize it and the Delft Mindset is very much alive today. I am really proud to represent its traditions.

The sociology of the seventies did a lot of other damage to universities in the Netherlands and Delft especially has been slow in recovering from it. Even today there is denial that science is basically a meritocracy. Whether you like it or not, that is the way is works. It has to be accepted, the penalty for not doing so is mediocrity.

At Philips Consumer Electronics, I barely survived the drastic and brutal restructuring of the early nineties (see Highlights of the year, 1993). The company with this family flavor and its often inconsistent management almost went broke in the early nineties. This unleashed forces under which some people were simply pulverized or crushed. Almost everybody working for the company got at least a few or more bruises, including me. It was a necessary bloodshed.

Delft was the avenue to a new future. I grasped the opportunity to become a part-time professor in Applied Ecodesign and I got appointed on December 1, 2005.

In the old days - when a professorship was still an office - you were appointed by the Queen with the order to be 'active in you professional area'. Not anymore. Things are now supposed to be more rational, even at a university.

Not for me. I experienced my professorship as highly emotional. At elementary school we learned a song: 'Het is plicht dat iedere jongen voor de onafhankelijkheid van zijn geliefde vaderland zijn beste krachten wijdt' ('It is the duty of every man/boy for the independence of his beloved country that he dedicates the best of his abilities for that'). Although this sounds weird, it represents my emotion in Delft.

It is weird because in this song girls do not exist. Yes, for many Dutch including myself independency is more important than power or wealth, 'beloved' is a supposition at best and at the time of writing of the song there was no awareness of the European Community or mankind as a whole. But most of all it states that you have to work to the best of your abilities. That for me is Delft, and Delft University. Although I have republican inclinations I support this idea, in the name of Her Majesty the Queen. To the best of my abilities!

City walk: Start at the railway station, cross the square and walk into the very narrow street at the opposite side (Barbarasteeg). Go L on Oude Delft till the Old Church. Go R (Oude Kerkstraat) and L (Hypolytusbuurt) and R (Voldersgracht). Go R (Vrouwenregt) and directly R (Kerkstraat). Cross the Grote Markt in a diagonal way to Jacob Gerritstraat, go L, Burgwal, Beestenmarkt, Boterhuisstraat, Go Oosteinde, through the Oostpoort L across the Groene Brug, go R and L and arrive at the Julianabaan.

Keep R, go into the Mijnbouwstraat and R (Michiel de Ruyterweg). Go L below the bridge (do not cross) follow the Kanaalweg. Cross the bridge, go through the tunnel and go over the bridge L and again L to Giststraat. Go R (Lange Geer), L over the bridge Breestraat and back through the Barbarasteeg.

Favorite restaurant: de Kleine Griek, Oude Delft. (has in summer a boat in the canal which acts as a restaurant)

'Country walk': Take tram 1 and ride it all the way to Scheveningen. Go to the beach and walk either north as far as you like (and back) or south and board tram 11 to Hollands Spoor railway station where you can go back to Delft by tram 1 (or by train).

4.6.2.Human power and user centered design

Where Philips kept on hesitating, Delft moved on. A fine piece of work was the design of a human powered remote control. Apart form its environmental and technical success, it moved the spotlight towards another theme: 'user centered design'. Like 'green' this is part of immaterial and emotional value (see chapter 2.2) which makes a product more valuable in the market. As the article below demonstrates, user centered design can be combined in a very natural way with 'green'.

User Centred Ecodesign: Experiences from the Design of a Human-Powered Remote Control

E. Smit, Prof. A.L.N. Stevels, Dr. C Sherwin

Abstract

This paper presents early results from research into the design of Human-powered Remote Control product. This is a collaborative project between the Environmental Competence Centre, Philips Consumer Electronics, Philips Environmental Services at CFT, Philips Electronics and undertaken as a graduate project at the Design for Sustainability group, TUDelft. Previous research has indicated the feasibility of Human-powered technology for small electronic product applications. There are a number of Human-powered products and technologies emerging now on the market. However there are a number of technological, user input options and ways to generate energy that would dramatically alter the product design and interface. Little research has previously considered these more user centred human-powered technology questions, or these more market-related issues in EcoDesign more generally. For examples, what kind of energy generation is acceptable for a particular human-powered devices and how much effort are consumer prepared to input? This paper presents early results from a research project aimed to explore these issues, and also shows a way in which EcoDesign research and methodologies can and should move more from their roots into greener technologies, processes and materials towards market, consumer and user-related issues.

1. Introduction

This paper describes early research findings and the methodology from a graduate student project at the Design for Sustainability program, TU Delft and undertaken as a collaboration with the Environmental Competence Centre, Philips Consumer Electronics and Philips Environmental Services at CFT, Philips Electronics. To begin, an introduction will provide some background information on the project, on human power and on the conception and motivation for the project.

1.1. What is human power?

Human powered energy systems or human power for short, refers to energy generated with the human body. A human powered energy system describes the entire system that makes it possible to transfer the energy of the human body into usable energy for a product. An important distinction for human powered energy systems is the storage of energy, which makes it possible to use this energy instantly or at a later time. This distinguishes them from products such as staplers or bikes, might also be referred to as 'human powered'.

Probably the best-known example of a human powered product is the human powered radio (Figure 1).

Figure 1 The Freeplay radio

At first the human powered radio was developed by the Freeplay Company for remote areas where electricity or batteries are not available. Encouraged by the good results other companies have since introduced human powered radios – see above.

1.2. Reasons for this project

The last years have seen vast quantities of handheld electronic devices flood the market. Many use batteries as a power source because this is an easy, small and relative high energy density way of powering the product. The main disadvantage of batteries is that they contain a limited amount of energy; meaning they have to be replaced or charged every now and then. The second disadvantage is from an environmental point of view; the batteries have to be collected as chemical waste. When we look for a solution to these problems human power is a possibility. The human body can serve as an inexhaustible, 'green' (environmentally friendly) power source for some of these handheld devices.

Previous research has shown that a remote control is a product for which human power can be a good alternative power source [1] [2] (For more information on human power see: www.humanpower.tudelft.nl). Calculations have shown that introducing human power into a remote control can save up to 0.5 mPt per product [4]. This means that if the human powered remote control would penetrate 10% of the market a profit of 50 Pt per year could be reached [3].

While there are several technical details to be 'ironed out' before human powered technology becomes completely viable, what is increasingly clear is that the key problems are not technological at all. In fact the key obstacles to the uptake of human powered products are cultural – in that perceptions of human powered technology and products conjure up images of returning to the 'dark-ages', of lack of progress or of 'hardship culture'. So, is it possible to make human powered technology attractive and acceptable to users? And following this, which combinations of energy generation and product design and interface are accepted by which consumers?

1.3. Project description

Building on previous research into human-powered products at Philips Electronics, resulting in the Philips AE1000 human-powered radio, the goal of this project was to design a human powered remote control that is aligned with customer needs and expectations. Because of the innovative character of the product, and quite specific uses of remote controls it is important to know what the customer wants from this, otherwise it will never be accepted. In attempting to answer these complex research and design questions, the project draws on both issues of traditional EcoDesign as well as from areas more usually from the marketing domain.

2. Designing from the Environment - Ecodesign

EcoDesign is a relatively new design phenomenon of some 10 or at most 20 years old.

Whilst its details are still emerging, we do know perhaps two key concepts about its theory and practice. For the theory side – there are more than one ways to approach designing for the environment, with Brezet [5] describing a 3-step approach of:

- Product improvement: existing products (material or technology) are improved and impacts are reduced.
- Functional innovation: the function or service (cars=mobility) is delivered in new, innovative ways (from letter to email). New concepts result.
- Systems innovation: the system (not the product) is optimised across traditional business and sector boundaries (transport system not cars). New business results.

Practice and companies tend to be at stage 1, product improvement or EcoDesign [6]. This is largely based on incremental improvements to existing products and is most often based on Life Cycle thinking or Life Cycle Analysis.

What EcoDesign and LCA, etc., can do is highlight a products main impacts. What it cannot do is answer much more complex questions about user behaviour or consumer acceptance of certain technologies. In short, EcoDesign methods are not sufficiently adequate for the problems of human-powered technology and products. If you really want to know about the acceptability of human powered technology, why not just ask consumers?

3. User Centred Design

As mentioned in section 1.2 it is important to know what the user expectations and needs are when designing a product. If a product is designed without this knowledge there is a possibility that the product will never be accepted and its introduction will be a disaster. Getting familiarized with the user expectations and needs is especially essential for innovative products that are never before used by customers. In such a case the designer cannot fall back on their experience with designing similar products, so other information sources are required.

Information can be collected in a number of ways and most of these methods can be summarized as 'user centred design'. Central questions in user centred design are:

- What does the user want?
- Why does the user want this?
- What does the user expect?

3.1. User-research methods

There is a lot literature on user centred design that it is not possible to introduce in this paper. (For more information see references Presence [7], and Empathic Design tool [8]) The decision on what method to use is mostly based on what results the designers want. Some examples of well-known methods are discussed below with the possible results.

- Usability testing: Testing usability involves observing and questioning sample users as they use past or planned products in typical daily situations. Typical results for this method are data on acceptability, adjustability, ease of use and dimensional compatibility. [9]
- Scenarios: Constructing stories can help design teams project forward to design concepts from an understanding of people's present experience. They help prevent professionals making assumptions based on their own, limited experience. [7]
- Questionnaire: These are broadly focused, quantitative surveys of people's attitudes and behaviours asked through a number of different media to find general opinions at a point in time. Surveys are most often used for mass interest events, like elections. [8]

3.2. Use of model

A lot of the user centred design methods use some sort of model of the product to explain to the user what the product is about. These help visually and materially describe the usage and appearance to the user. Again there

are a number of possibilities on what sort of design model to use. Rooden [10] concludes that each modelling effort may yield equally useful information for usage-centred design.

3.3. Targeting specific group

Because people are diverse it is almost impossible to design a product for all. Products designed for all are most of the time products full of compromises meaning the product does not attract anyone. A solution to these problems is market segmentation.

Kotler [11] describes market segmentation as:

"dividing the market into different groups of buyers with different wishes, characters or behaviours who might need different products or marketing mixes". (Translated from Dutch text)

Kotler [11] also describes three advantages of market segmentation:

- A company can market more efficiently by focusing their products or services, channels and communication on those customers who can then be served best.
- A company can market more efficiently by adjusting the prices and programs to the needs of the carefully defined segments
- A company has less competition, if less competitors focus on a specific segment.

Almost all the larger companies already have market segmentation tools available. The data in these tools is specific for the products, markets and the geographic location of the company. Philips has developed its own market segmentation tool in cooperation with RISC International [12]. In this tool the market is segmented into five specific focus groups – which can be quite unique and different. The tool gives extensive details of the values, beliefs, lifestyles, purchasing patterns, product and visual preferences for each of these groups. It is intended for use in new products, concept and marketing development to ensure that new business matches the expectancies of an increasingly diverse, but demanding group of consumers. This tool also describes the focus groups Philips wants to target and which not. In providing extensive data on users and market segmentations, these market segmentation tools can be invaluable for design.

Somewhere between EcoDesign (in this case human powered technology), user centred design and market segmentation methods lies the key to this research task and to designing acceptable and desirable human powered energy products. We call this 'user centred EcoDesign'.

4. Human Powered Remote Control Concept

A good way to explore this issue of user centred EcoDesign is via the methodology used in this human-powered remote control project. At first the research questions will be introduced, followed by the method, the type of models and the user groups – which brings together all the 3 design spheres described above.

4.1. Research questions

There are a number of ways to generate and input human powered energy (turn handle, push button, spin wheel, etc) for a remote control system and a number of ways to embody that within the product design and architecture. This project aimed to provide insight into which human powered energy generation methods were most relevant and attractive to certain users. Specific research questions were:

1. How do people interact with the human powered remote control with the emphasis on problems with usability?
2. Which human powered remote control concepts do the users accept and for what reason?
3. Are the input forces accepted? The amount of energy generated by the consumer depends on a few parameters one of these is the input force of the interaction.
4. Do specific user groups better accept some concepts than others?

5. The Methodology

The project would be completed over 9 months and result in a concept proposal for a human-powered remote control that would match and be acceptable to certain users needs. The following project stages were defined:

1. Define energy generation/input concepts
2. Design concepts and build models to embody the energy generations
3. Test with users and identify user groups
4. Conduct interviews
5. Analyse data and select best concepts from results
6. Refine and further develop concepts from results.
7. Test again with users
8. Select best concept and develop into concept proposal

As the research is on going, this paper reports on progress to date – chiefly stages 1-6.

5.1. Defining the energy generation and input

The first stage was to brainstorm on the possibilities of human powered energy generations for a remote control system. These refined and amalgamated into 13 key concepts, which were then recreated as models for the following user tests.

5.2. The design models

As discussed in section 3.2 Rooden [10] has researched design models and set-up guidelines for designing models for user tests. Two conclusions were:

1. **Show changes in appearance during the interaction:** Information about manipulation is difficult to verbalise. When the manipulation is an important part of the interaction, full-scaled models should be considered. For this reason full-scaled models were used in the human powered remote control project (Figure 2).
2. **Stimulate manipulation:** The interaction is made more lifelike if the changes are made visible (most important for drawings). For this reason all the energy input interactions of the concepts were possible to manipulate.

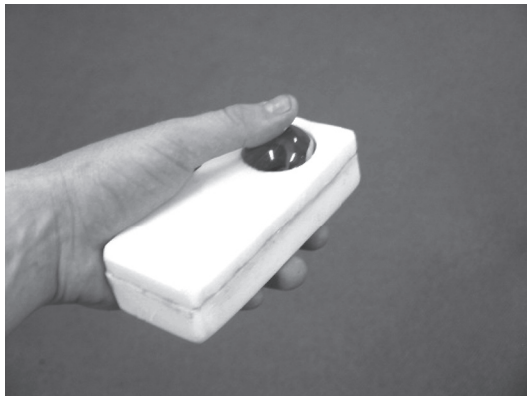

Figure 2 Design model of a concept

5.3. Testing with users

The first part of the user test was aimed at finding out to what user group the participant belonged. For this part the Philips allocation tool – part of the Philips market segmentation tool (RISC [12]) was used.

5.4. User groups

As mentioned in section 3.3, Philips has developed its own marketing tool especially for audio and video equipment. This was used in the human powered remote control concept. During the user test the participants were allocated into one of the focus groups. These results were used for further analyses later and to target specific groups.

5.5. Conducting the interviews

Next the human powered energy generation models were introduced to users via a series of 30 minute (approx.) interviews. Various products were shown to make the participants aware of the possibilities of human power. After this all the models were shown to the participants and the users could hold and manipulate the models. For all of the models a few questions were asked:

- What is your general opinion for each concept? (What do you think? How would you use this? Etc.)
- What is you opinion on the input force? (To hard? Etc.)
- Do you want an alternative input force? (Would you like more or less input power if you consider the effect on the usage time, this is interesting to know for further development of the concepts)

At the end the participants were asked to divide the design models in three groups; wanted, neutral or not wanted. This way it was possible to determine which models were accepted.
All tests were taped on a digital video camera to make it possible to analyse the tests at a later stage. The user test were held in different locations, this to minimize travel time for the participants. The setup of the room was the same in all locations. A corner of a table was used for the interview (Figure 3.).
On the short side of the table the participant took place and on the long side the interviewer. The camera filmed this corner of the table. This way the entire "working area" of the participant was taped.

Figure 3 User test location

This user test is a combination of different user centred design methods. A problem with new products can be that participants of the user test think that it is not possible to make such a product. As a result of this they don not take the test serious and the data will not be useful. A solution to this problem can be educating your participants; show them that it is possible to design such a product.
Asking your participants to suggest changes (in this project the input force) is a form of co-design. Participants get the possibility to change the product to their own opinion. This data can be used to improve the concepts.
This part is analysed by using video ethnography; all test are taped on digital video and the tapes are analysed at a later stage. The results of these methods are data on acceptability, adjustability, ease of use and dimensional compatibility. [9]
The human powered remote control project used a meta-method, where the user centred methods are combined into one - making it possible to combine methods until you can find the results wanted for the project.

6. Results

The data gathered in the human powered remote control concept was analysed in a few ways – all with the purpose of concluding on certain concepts and further developing those most promising (the current project status at time of writing). The opinions of the participants on which concepts were accepted and rejected were processed into a table. This table showed which concepts were accepted (+), neutral (0) and rejected (-) by all the participants (table 1).

In combination with the data from the segmentation tool it was possible to crosscheck and determine which concepts the Philips target user groups accepted individually and which concepts combinations of Philips target user groups liked.

Table 1 Sample of the results table

PP	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6
Participant 1	+	-	+	-	+	+
Participant 2	-	-	+	0	0	0
Participant 3	+	0	+	+	-	+
Total yes	2	0	3	1	1	2
Total Neutral	0	1	0	1	1	1
Total No	1	2	0	1	1	0

All the videotapes were analysed and summarised into tables also. These tables showed data on problems, suggestions and remarks of the participants. Some concepts had small problems and comments meant these could be easily refined and improved. Other concepts were just not good enough.

When this data was combined with the other two tables it was possible to determine which concepts were accepted and which were rejected. From the thirteen concepts that entered the user test six were accepted. These concepts will be further developed in the next months. Topics to be discussed will be the environmental impact of the concepts, manufacturing, existing patents, costs, etc. The best three concepts will be developed into semi-working models, which will be used in another user test. The result of this project will be a human powered remote control that is:

- Accepted by the user
- More environmental friendly.
- Fits in the Philips product line and target audience.

7. Conclusions

It is always difficult to design a new product and make sure the user accepts it. Designing will always be a speculative task, decisions will have to be made not only on scientific data but also on the designers experience and knowledge. This level of difficulty is increased with a relatively young design discipline such as EcoDesign, and the difficulty is doubled when dealing with 'new' technology and concept applications such as human power energy generation. This paper shows that 'user centred EcoDesign' can be a solution and can offer a series of suitable methods.

For Philips, this project offers a promising new product application for a technology that it can and should invest more in for the future. It also offers new, more visible ways to articulate the company's 'green' credentials and promote the sustainability of the Philips brand via the most powerful way to do that – the product.

There are further implications for EcoDesign. This project moves EcoDesign theory and practice from its comfortable roots in materials science and technology, towards a more marketing, user and consumer-related arena. When you do this, traditional EcoDesign methods and models are less appropriate and new methods, approaches and models are necessary - for example, can LCA ever tell us anything about users? Indeed, these issues of behaviour, acceptance and desirability can rarely be found in EcoDesign literature. In another way, the methodology used here brings EcoDesign more into the 21st century – where products are not 'sold' on their technical specifications, but on immaterial qualities such as brand, styling or appearance. In this new arena, the questions are less so

what is technically possible and more so what is socially acceptable and culturally desirable. More than anything else – these are questions for designers generally, and for 'user centred EcoDesign' specifically.

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Pictures, 6

Delft, Disassembly Session

4.6.3 The significance of human powered products

A lot of experiences with human powered products were consolidated in the paper below. The applications shown here indicate the wide range of energy generating mechanisms which can be applied. The variety of functionalities for which human power can play a role is apparent as well.
It is concluded in this article that human powered products have a special significance in Applied EcoDesign. Their psychological significance gives the consumer a feeling of empowerment and freedom. Their environmental contribution is their ability to reduce the consumption of batteries and, to a lesser extent, energy saving. But most of all human powered products are the token of a mindset. Grasp the opportunities and have fun!

Human Power, a Sustainable Option for Electronics

A.J. Jansen, A.L.N. Stevels

Abstract

The decreasing power requirements of consumer electronics combined with an increasing environmental mindedness of consumers and the increasing use of portable electronic products has set the opportunities for human power as a viable alternative to batteries. No use of batteries means an environmental benefit as well as a consumer benefit. It will lead to new product concepts offering real portable products that can be used anytime and anywhere.

I. Introduction

The research into human powered energy systems is one of the PhD projects within the DfS (design for sustainability) research program at the sub-faculty of Industrial Design Engineering at DUT, it started in 1997 and is due to be finalised in the year 2000. The main research question is: For what products and how can human power be a viable alternative to batteries in portable consumer products? The research will explore into ergonomic, mechatronic and environmental issues of human powered energy systems in consumer products.
It is taken as an example because its functionality has not really changed in all these years. The limit in power consumption will be determined by the amount of energy used by the mechanical parts of the Walkman®.

II. Relevant developments

In the last years we can see an increasing amount of handheld electronic devices (GPS, cellular phones, palmtop computers), increasing mobility, and need for communication and information. Also the percentage of products fully based on electronics is rising. For obvious reasons, the majority of these portable products is powered by (rechargeable) batteries; batteries are small, light and have a relative high energy density. The number of batteries, sold throughout the world is steadily growing. In 1996, in the Netherlands only, 1 10 million primary batteries have been sold (a 3400 miles chain, twice the distance between Boston and Denver!).
One other relevant development is the decreasing power consumption of portable consumer electronics. An example is given in fig. 1, it shows the decreasing power consumption during play mode of different types Sony Walkman® during 16 years [1].

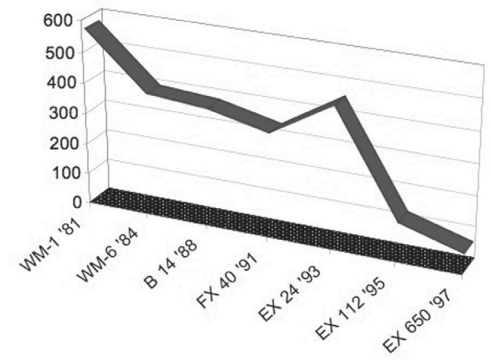

Figure 1 Power consumption Walkman® during play mode

III. Why replace batteries by human power?

Besides their plus points (small, high energy density, freely available, standardised), batteries also have disadvantages. The first one is given by the fact that primary batteries contain a restricted amount of energy resulting in a limited life time. So, they have to be replaced regularly (a fact of life is that this always happens when you need the product most). Also without using the product, batteries slowly discharge. Replacing batteries means discomfort for the consumer (costs, inconvenience).

The second disadvantage is from an environmental point of view. Empty batteries have to be discarded in an environmental sound way; they have to be returned to the shop or collected as chemical waist. In 1996 in the Netherlands (having a battery take back system), only 54% of the batteries was returned in one way or another [2]! In many countries the collection system for empty batteries is not as organised and therefore many batteries will end up at the land fill or be scattered in the environment.

IV. Human power

As shown in table 1, the human body acts as an energy producer in different ways.

Table 1 Energy production by the human body

Energy source	Forms of energy			
	Mechan	Electric	Thermal	Chemical
Muscles (active)	×			
Movement (pass.)	×			
Skin potential		×		
Perspiration				×
Body heat			×	

In the human power project we concentrate on the active use of the muscles. The amount of energy obtained from the human body depends on which body segments are used, the physical and mental condition the user and the design of the interface between the user and the generator. For short term tasks (up to 2 minutes) a number of specific measurements [TUD] is presented below.

Table 2 Measurements of required human power for various tasks

Description of task	Required human power
Pushing button with thumb (as with ballpoint)	0,3 Watt
Squeeze hand generator (Alladin power, Fig. 3)	6 Watt
Turn handle on BayGen Freeplay radio	21 Watt
Ride bike at 25 km/h	100 Watt

Data from literature in most cases focuses on the maximum force applied by users. We estimated the human power potential by using the maximum force exerted by an average male user in-between 20 and 30 years of age. The generated power for very short periods is given in Table 3.[3].

Table 3 Estimations for maximum power

Description of movement	Maximum human power
Push (16 N x 40 mm)	0,64 Watt
Squeeze (400 N x 30 mm)	12 Watt
Rotate crank or handle (30 N x radius 100 mm x 1,5 x 2π)	28 Watt

In a recently started ergonomical research project we will chart the potential of the human body as an energy generator, related to perceived comfort.

V. Power consumption of portable consumer electronics

At DUT a number of recent measurements of the power consumption of portable consumer electronics have been collected, it is presented in the next table.

The power consumption represents the average power consumption during use. A first comparison between the figures from table 2 and 4 already shows the possibilities for human power. This will be described in the next paragraph.

Table 4 Measurements of power consumption

Product	Power consumption
Small portable FM radio [4]	30 mWatt
Walkman (play mode) [1]	60 mWatt
TV remote	100 mWatt
Cell phone (talk /stand-by) [5]	2 W / 35mWatt
Electric torch (flashlight)	4 Watt
Video 8 (no LCD screen) [6]	6 Watt
Laptop computer Tecra 8000	10 Watt
TV (53/67/wide screen) [6]	50 / 74 / 111 Watt

VI. Human powered products

Combining the data from the previous two paragraphs will result in a number of opportunities for human powered products, as presented in Fig. 2. We assumed a 40% efficiency for the human powered energy system.

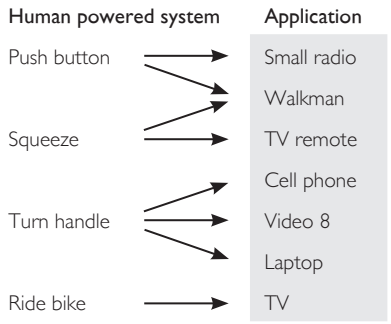

Figure 2 Opportunities for human powered products

The combinations presented in Fig. 2 will give a direction for projects in the near future. In these projects, the concept of human power will replace power systems of existing products, but also lead to totally new product concepts, combining an improved environmental profile and convenience for the consumer.
A good example is the design of a car remote control using alternative power. This project is now conducted at Volvo Car Company near Goteborg in Sweden. The mean reasons for Volvo to investigate the possibilities of human power are environmental concern and the current discomfort of batteries experienced by the user. The new remote control will feature an improved quality and environmental profile during its life cycle.
The analysis of existing human powered products learned there still is room for improvement. From the analysis of the BayGen radio, we found an overall efficiency of 26% for the human powered energy system and a high environmental impact of the human powered energy system in the production phase of the life cycle. Compared to radios powered with primary batteries, the average environmental 'return on investment time' of the human powered energy system was over 2 years [4].

Figure 3 Aladdin power by Nissho engineering Co.

One of the human powered products, now available on the market is the Aladdin power (Fig 3). When squeezing at 90 Hz, the output power will be approximately 1,6 Watt, sufficient for some cellular phones.

Figure 4 Interactive storyteller and bedside projector, Philips Design and Olivetti Italy

The interactive storyteller and bedside projector are results from the combined Philips and Olivetti project called Vision of the Future. One of the ideas was that children should have just as much pleasure winding up their toys as when they are watching the projected images.

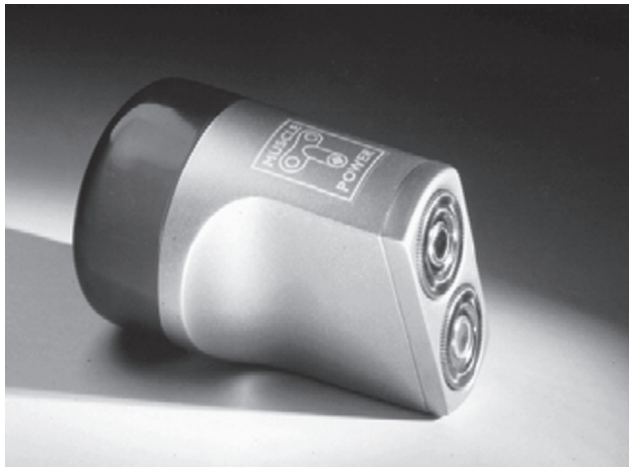

Figure 5 Wind-up shaver by MOY concept and design

VII. Discussion

Human power offers a range of opportunities as presented in Fig. 2, in this figure the main directions for the application of human power were identified. These directions will be explored in projects by Delft University of Technology in corporation with industry, as in the mentioned Volvo project.

From the analysis of existing products we conclude that human power also provides challenges to industry; improve on energy conversion techniques in order to achieve a higher efficiency and find ways to produce human powered energy system with less pollution.

Green marketing will have to emphasise the environmental advantages of human powered energy systems. Designers will have to take away existing prejudices against human powered products by strengthening the fun factor in these products.

"Human power is green, it's fun and it can be done".

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Highlights of the year, 1999

Stanford, the Value Chain

I had been working for several years with Catherine Rose, a PhD candidate at Stanford University. Her subject was to make a model through which the most suitable end-of-life strategy for products can be derived (see chapter 7.2).

This cooperation developed into a visiting professorship at Stanford in the fall of 1999. The agreement was that I would do a training course on Ecodesign, support Catherine and work with the crew from the Manufacturing Modeling Lab (MML). Philips Electronics, agreed to the plan, provided that I do some work for them during this period. Additionally they required that I use the holidays I had accumulated over the years for this visiting professorship. Delft University (for which the employment formula was that I was made 'available by Philips to them' for two days in the week) opposed the visiting professorship. I had organized it in such a way that all my obligations at Delft could be fulfilled as well. After fruitless discussions with the Dean I simply went to California, expecting the worst. Nothing happened, apparently it had all been theatre.

Stanford was inspiring and it was fun. A major insight for me turned out to be the value chain concept. We quickly applied it to environmental issues (see chapter 5.1). Apart from the 'green' TV case the concept also proved valuable in analyzing take-back and recycling systems (see chapter 8.1) and thus became effective for negotiating take back agendas with other actors.

The most interesting result was however, obtained by applying the value chain concept to Catherine's work. So far this had been something very technical. The optimum strategy was supposed to be related to a combination of product characteristics, product life and to speed technology development. It turned out that in many cases the recommended strategy was not implemented in practice, which was very puzzling. With this problem still outstanding the PhD work could be brought to a logical conclusion. Including value chain considerations provided a way out. For cases where there is a misfit between recommendation and implementation, there is at least one player in the chain which does not benefit (or even suffers) from following up on the best strategy. In such circumstances improving the technicalities will be of little help; active value chain management has to solve the problem.

Final conclusion: for doing the best job for the environment, technicalities are a necessary but insufficient condition for success.

After this breakthrough, Catherine could finalize her work. She came to Delft to write her dissertation and some other publications on the subject.

Her successful defense was held on October 25th, 2000!

4.7 Environment and Sustainability

In the new millennium, environmental activities were placed within a much wider perspective. Environment and EcoDesign became only one of the dimensions of sustainability. Social responsibility and economic responsibility became important sustainability themes as well. This is summarized in the following scheme:

Table 4.1 The 3 Dimensions of sustainability

Economic Dimension	Commitment to customers: employees, shareholders, suppliers, business, partners
	Business integrity: honesty, transparency, fairness
Environmental Dimension	Products: Reduction of energy, weight, packaging, substances, increase recyclability
	Production: Reduction of energy, water, auxiliary materials
Social Dimension	Listening to stakeholders: politics, consumer groups, generic public, labor unions, universities
	Employees: employment/careers diversity and inclusion (gender, regional origin of executives)

This figure shows that the content of the environmental dimension remains unchanged; it is about products (EcoDesign) and production (processes). The dimension of economic responsibility includes 'commitment' (to all stakeholders) and 'integrity'. The social dimension is represented by 'listening' (taking into account views from stakeholders) and 'care for employees'.
My involvement in sustainability kept its focus on the environmental issues. Therefore my adventures in the wider sustainability field were very limited, so in this book little is to be told about it. The best reference to find out more about sustainability in general at Philips is: www.philips.com/sustainability.
For sustainability planning and performance measurement I have been involved in an indirect way; I had developed the methods to do so for the environmental part and these had already been implemented in the organization. After a period of short research and some experiments it turned out that exactly the same approach could be applied in the economic and the social dimension ('mutatis mutandis' of course).
Since methods for planning and performance measurements inside companies are proprietary, little information about the methods applied for sustainability can be communicated here.
In the short paper on the next page *"Managing Sustainability in Electronic Companies"*, the general principles are described including environmental dimension only.

Managing Sustainability in Electronic Companies
Ab Stevels and Casper Boks

Abstract

In this paper a systematic approach to manage sustainability in electronics companies is described. The systematics for the environmental part have already been fully developed; it is shown that health and safety aspects and social issues can be simply introduced in the same schemes. The corner stone for operationalization are roadmaps which are partly based on corporate programs and targets but also are partly tailored to specific business circumstances and product characteristics of individual Business Creation Units. Progress in roadmap realization is measured by an Environmental Key Performance Indicator (EKPI). With help of an example it will be demonstrated how EKPI helps to integrate Environment in a business concept and how it contributes to improving performance.

1. Introduction

In the last years the meaning of the word "Sustainability" has substantially widened. Being focused on environmental issues as emissions, resources and potential toxicity, a couple of years ago, it now includes health and safety issues and social issues as well.

Managing sustainability in Electronic Companies has therefore to be put into a much wider context. An integrated approach can be structured as follows:

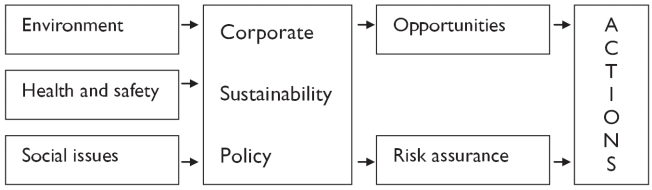

Figure 1 Integrated approach of Sustainability.

This figure shows that health and safety and social issues can be basically addressed in the same way as has been done so far for environmental issues. This also holds for integration of sustainability in its new meaning in the business as a whole. To do so, important lessons can be learnt from what happened to environment and Eco Design in the electronic industry in the last ten years.

Primarily environment and EcoDesign were seen as technical issues which made that as regards implementation engineers in the factories (for production) and designers in product development (for products) were seen as the key.

It was realized in proactive companies that this is by far not good enough to make it really happen and that close attention should be paid to:

- Creating awareness
- Analysis of enablers and drivers of green (the "why this")
- Formulating strategies, organization/definition of responsibilities, defining programs, roadmaps and formulating requirements (the "what items")
- Detailing and embedding the execution: systematic idea generation, specifications and targets, environmental validation and exploitation in the market (the "how items").

By now this comprehensive approach has been formulated in for instance the ISO 14062 report, based on ideas a.o. formulated in ref. 1.

When addressing health and safety and social issues much time can be gained when bringing them to high maturity and assurance levels by leapfrogging the developments which took place in the environmental field and go for a comprehensive approach directly. This will be helpful to bring all three sustainability items into socalled Business Excellence models which are currently applied in industry to gain and audit progress and to create a basis for incentive schemes for senior managers.

Such models look as follows:

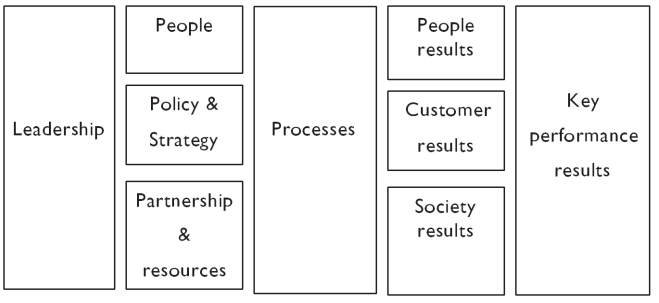

Figure 2 A Business Excellence model.

In the business excellence model presented above, sustainability is to be located in the box society results. In order to score well here, it has to be addressed in left hand boxes like leadership, people, policy & strategy and partnership/resources and be well integrated into all management processes.
In proactive electronic companies like Philips, Sony and others sofar the environmental issue has been fully developed to a mature part of the business excellence approach. How this looks like and what results have been scored will be discussed in this paper, particularly based on the experiences of the author in his capacity as Senior Advisor at the Environmental Competence Centre of Philips Consumer Electronics.
It is to be noted that the model for managing environment (and to be extended to sustainability) presented here represents the result of a development which started as bottom-up approach in the form of execution of technical projects. Subsequently awareness has been created, the first "what" items have been added (strategy, organization), than execution has been deepened, drivers and enablers have been identified and finally programs, roadmaps and requirements have been defined. In this paper particularly to last-named two items attention will be paid to.

2. Environment as part of vision, policy and strategy

Environment can be easily integrated into a companies vision and strategy by hooking up to the usual procedures for this purpose and simply adding "environmental paragraphs" (or extending to "Sustainable paragraphs") to current analyses. This is defined in the picture below.

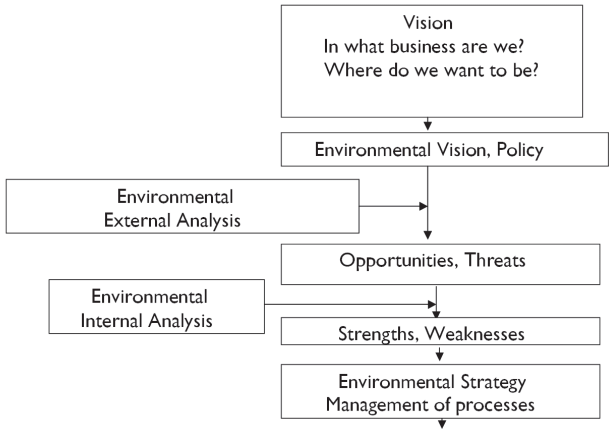

Figure 3 Environment as part of vision and strategy

An example of an environmental vision is given in the box below.

Example of Environmental Vision
Philips shall be the leading eco-efficient company in lighting and electronics industry
Background
Good for the environment (more sustainable)
Company value (enhances brand image)
Customer benefit
Pro-active to the society (it can be done)

Box 1 Example of Environmental Vision

The basic principles for implementation and execution can be formulated in an Environmental Principal as for instance in the box below.

Example of Environmental Principles
Sustainable development – finding optical balance between ecological impact and environmental growth Prevention is better than cure – from raw materials to manufacturing, to use and disposal Cooperation – with governmental and non governmental organizations.

Box 2 Example of Environmental Principles

The operationalization can be given further 'hand and feet' by adding an implementation policy, see box below.

Example of Implementation Policy
Set technically and economically viable objectives to optimize environmental performance Products should be evaluated as regards their total life cycle creating a basis for more efficient use of materials, including packaging, reducing energy consumption, reducing or eliminating potentially toxic substances and improving recycling and disposal Manufacturing should address consumption of utilities and auxiliary materials and business to air and water and the reduction of waste Establishment and maintenance of environmental management systems and of audits of these systems Compliance with all laws, regulations and voluntary agreements. Communication of policies and performance to various audiences and publishing of results in environmental reports. Education and training of employees in the environmental field.

Box 3 Example of Implementation Policy

3. Environmental Roadmaps, general items

Roadmaps basically describe where a company is currently situated as regards a certain issue and describes how progress should develop for instance 5 years time. From this perspective it contains issues, owners (the persons responsible to move the subject forward) and targets, for instance formulated on a year to year basis.
Positioning of companies in the environmental field should preferably done on a relative scale (for instance with respect to competition).
A procedure to do so is for, are described in refs 2 and 3; key element is that performance is described in tangible physical units well recognized throughout the organization (W, kg, sec, %, ..) instead of environmental language (ecodindicators, lifecycle prophiles) and that environmental issues are addressed which are in the scope of influence of the company ('internal' versus holistic perspective). This technical analysis should be combined with a thorough analysis of development taking place in the outside world. These include:

- Awareness, interests of the customers (private, OEM's)
- Development of labeling schemes
- Legal/regulatory requirements
- Development in management systems, environmental tools, environmental services / consultants, recyclers) and auditing.
- Developments in technology en in the Information society
- Strategies of competition

Roadmaps can be written on various levels. In practice it is useful to make a distinction between:

- Corporate roadmaps (chiefly strategy and program oriented)
- Product Division roadmaps (chiefly business oriented)
- Business Unit roadmaps (oriented chiefly towards products, manufacturing and deployment)

Practical experience has learnt that for operational purposes it is useful to organize the roadmap items into three parts: the defensive (compliance) related ones, the cost driven (reduction) items and the proactive actions (aiming

at gaining market share on the basis of green). Similarly strategy items organizational items, technical items and items related to green marketing and communication should be clearly distinguished.

4. Environmental Roadmaps, content

On basis of the principles for environmental management (2) and for roadmaps in general (3) it is now possible to formulate the specific context of the roadmap chapters.

Chapter 1 is about strategy, specifically about the availability and implementation of policies, programs and roadmaps and their updates. Particularly regular strength and weakness analysis and performance measurement (see 5) is to be addressed as well.

Chapter 2 is the business chapter. There is the planning of "green" products (significantly better than the competition), availability of evidence for "green performance", scores in the field of cost reduction and evidence of legal compliance is relevant.

Chapter 3 is the product chapter. Here tangible improvement targets are formulated in for instance a focal area approach:

- Energy consumption
- Materials application
- Packaging and transport
- Environmentally relevant substances
- Durability, recycling

Chapter 4 is the manufacturing chapter. The two parts are here: reduction of consumption (of energy, water, solvents, auxiliary materials), reduction of emissions (to air and water) and waste.

Chapter 5 is specifically about programs. This can include items ranging from generic programs like the introduction of ISO 14001 management systems to specific ones (approaches for green marketing and communication) or targeted ones (like for reduction of manufacturing, office energy or for packaging reduction)

A different form of a program is the consolidation of roadmaps of lower discussions or BU levels into a corporate program (example: the Philips EcoVision program)

Chapter 6 is about organization and deployment. This includes status of responsibilities, hiring of skills and budget performance of environmental activities. Included in this chapter are also internal communication and training issues.

5. An Environmental Key Performance Indicator

Progress in key performance realization can be measured with help of an Environmental Key Performance Indicator. At Philips Consumer Electronics EKPI is defined as follows:

EKPI (%) = $\sum A_i$ * score per item.

In this formula A_i is the weight of importance of roadmap item i. The sum of all A's totals to 100%.

The score per item can be:
Either 1 = OK = "green"
Or 0,5 = more or less fulfilled = yellow"
Or 0 = not fulfilled = "red"

Values for A_i are to be set dependent on product characteristics (relative importance of the different focal area's and of manufacturing), the status of environment in the business (starting/mature, behaviour of competition, customer interest, etc.) and on legislation/regulations. By tailoring in this way to environmental impact profiles and to needs, a maximum relevance of the EKPI is ensured. The calculated percentages (on a 0-100% scale) allow to set overall targets allowing flexibility to the business concerned in how to improve the score.

The mapping of the score items in green, yellow and red allows to identify in one glance where the weak spots are located and to go for focused action. Initially the EKPI of the various business units inside Philips Consumer Electronics showed a big diversity in scores, see the table below where a anonymized sample of results are presented.

Table 1 Environmental key performance indicator scores of various groups at Philips CE

Score	Projected score Target		
	Beginning 2001	End of 2002	1/1/2004
Group 1	56	75	80
Group 2	32	62	75
Group 3	37	51	70
Group 4	55	69	80
Group 5	76	75	75
Average	51	66	76

At the start of EKPI in the beginning of 2001 scores in the Division were ranging between 30% and 70% (average 51%). In 2 years time – by making the issue visible and by targeted actions – the spread has narrowed from 44 to 24% while the average has moved up to 66%. A further increase of the score to score 75% is expected by 1/1/2004.

For correct implementation it is to be realized that roadmap targets are moving targets. In fact therefore EKPI shows how well the set targets are followed. The example above shows that in 2001 some groups were still not to full grips of the comprehensive target system, will be pretty well in control by the end of 2002 and will be capable to follow-up on the ambitious targets in the year to come. This performance is the result of active management by Environmental Steering Committees at Business Creation Units and Product Division level through the well known Plan-Do-Check-Act circle.

6. Conclusion

Leading Electronic companies and Philips Consumer Electronics in particular, have in the last years done substantial effort to come to comprehensive and consistent environmental systems which are integrated in overall business models. Following items have been crucial in achieving success:

- Positioning of Sustainability in the box "society results" of an overall business model
- Developing of a vision, of principles and an implementation policy.
- Availability of deployed roadmaps (based on benchmarks) giving clear targets and owners
- Availability of a weighted Key Performance Indicator allowing proper management of outstanding issues.

The concept described above can be easily put into a wider sustainability approach which includes Health and Safety and Social issues. Consolidating the current scattered initiatives into similar systematics as developed for environment and expanding them full which will be an important task in the years to come.

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Tidbits, 7

Is there environmental justice in the world?

Very early on in the Nineties Philips Consumer Electronics managed to eliminate flame retardants from the housings of TVs and other electronic products.

This was realized through 'design for thermal balance', that is, by avoiding "hot spots" inside products. In this way elimination of the retardants was achieved while staying well inside the requirements for product safety.

We were praised for such initiatives from NGOs like Greenpeace and Friends of the Earth because traditional flame retardant plastics contain substances like brominated organics and antimony. Both of these substances rank very high on lists of potentially toxic materials or even outright hazardous materials.

The elimination of flame retardants also added to the recyclability of the products; so called monomaterial plastics without additives recycle well.

However, happiness did not last long. TVs without flame retardants were suggested to be more unsafe than those with retardants. Statistics emerged that asserted that the self ignition of TVs in Europe was more frequent than in the USA, and there were even twisted environmental calculations suggesting that TVs with flame retardants were worse for the environment. Then there was the film showing that a burning candle placed on top of a TV without a candlestick can easily set it afire, if there were no flame retardants in the housing. Suddenly letters started to arrive at Philips asking questions about the issue. It all gave the impression of a well orchestrated campaign against Philips. Our products also made it to the front page of the most popular daily newspaper in the Netherlands: Japanese products have more fire safety. The CEO of the company called us and asked, what are you bloody environmentalists doing? Product managers got nervous – emails began flowing in and out. The NGOs kept silent, apparently there were no points to be scored for them anymore.

We had to give in. Flame retardants were reintroduced, but not of the bromine/antimony type. It had to be acknowledged that perceived safety prevails over the environment in peoples minds. Publicity effectively hit that nerve and the environment suffered as a result.

Where is environmental justice in this world?

Facts and Figures, 3

Ph.D. Students

Working with Ph.D. students is for me the best part of the tasks which a professor is supposed to do. Exploring new territory, discussing conjectures, trying to keep logic in reasoning, the joy of discovery, the hard work in writing, being sparring partners, the expected and unexpected creativity, ... it is all there. It has been a deep sense of fulfillment and I owe all these young folks a lot.

I had four full time Ph.D.'s at Delft University :

**Casper Boks, Ph.D. on April 15, 2002*

**Jaco Huisman, Ph.D. on June 20, 2003*

**Oriol Pascual, Ph.D. in 2008*

**Renee Wever, Ph.D. in 2009*

One Ph.D. student did her thesis in cooperation with Prof Jacqueline Cramer of Erasmus University (Rotterdam): Nicole van Nes got her degree on June 6, 2003.

There have been two "external" Ph.D. students as well. This means that they combine a regular job with Ph.D. research. This is tough, but they managed to do it and did it with glory. Respectfully to be mentioned are:

**Menno Nagel, Ph.D. on September 18, 2001*

**Otmar Deubzer, Ph.D. on January 30, 2007*

Catherine Rose got her Ph.D. at Stanford University in the USA; together with Prof Kos Ishii I was her supervisor. On October 25, 2000 she did a succesfull defense of her thesis.

Through their research all these folks have been contributing substantially to this book and I would like to thank them for that. Evenmore, I would like to thank them for their trust, patience, endurance and most of all friendship.

What I like to do very much as well is being a member of the Ph.D. committee of candidates of colleagues. This means that there is a short time only to get acquainted with their research subject. This should allow to make contributions to the evaluation report but also to ask questions which lead to interesting discussion at the defense of the thesis itself.

This is great sports! Thank you Troels Kjeldmann and Claus Pedersen (TU Denmark), Bernadete Castro and Ewoud Verhoef (TU Delft), JiwHan Kim (Erasmus University, Rotterdam), Hanna Leena Pesonen (University of Jyväskylä, Finland), Trond Lamvik, Rolf Bohne and Ottar Michelsen (NTNU, Trondheim, Norway) and Mark Martin and Sören Petersen (Stanford University, USA) to have me invited to be on your committee!