Chapter 6: Ecodesign Tools

6.1 What is 'Green'?

6.1.1 'Scientific green', 'green' perceptions and 'government green'

In 1993, I started my environmental job on the basis of common sense. My assignment was to look at what was going on in the environmental world of electronic products and to make a first action agenda for Philips Consumer Electronics on the basis of these observations. A surprising first discovery was that stakeholders had different perceptions about the idea of 'green'.

For instance, at that time a large part of the buying public had a strong negative attitude towards plastics in general and in particular PVC was seen with considerable suspicion. These materials were seen as not being 'natural' and suspected of containing hazardous additives. PVC was singled out in particular because of its chlorine content. Greenpeace's opinion that 'chlorine chemistry is bad' was widely accepted by the consumers. It was much more widely accepted than the contrasting viewpoint of the chemical industry, which tried to argue on the basis of science that plastics were 'innocent' or at least fulfilling all kinds of functions in an ecoefficient way.

'Green perceptions' versus 'scientific green'. The electronics industry was caught in the middle of such debates. What to do? Be rational and stick to the use of plastics ('scientific green') or follow the ideas of a majority of the customers and go back to increased usage of metals ('customer green'). The first balancing act for Consumer Electronics was born. Attempts to reduce the use of PVC as much as possible were attempted. Some overzealous purchasers sent letters to suppliers that PVC was 'hazardous'. This forced lawyers of the PVC industry to become active: Philips is not just a company, it is an institution and as an institution the opinion that PVC is hazardous is not a 'private opinion' anymore.

Prove your statement or you will be taken to court. Consumer Electronics had to withdraw, from then on we called substances like PVC 'environmentally relevant' which is true for sure.

In the same period it turned out that there is also 'government green'. It is the priority which is given by a country's governments to the environmental issues to be tackled.

In the Netherlands, for instance traditionally there was (and continues to be) high priority placed on heavy metals control – this is closely related to the abundance of water in the country. The fact that several big rivers in Europe flow through the Netherlands after having passed through other countries (and having picked up pollution there) is adding to this concern.

In Switzerland, abatement SO_2 and NO_x generated by traffic and electricity production ranks high on the public agenda. Trees high up in the mountains die because of high concentrations of such gases.

Such priorities are 'natural' but mean that industry is confronted with a broad variety of regulations in different countries. Environment is a difficult issue to deal with when it comes to creating single markets and level playing fields!

Cities, 8

Hong Kong, a place to be!

Hong Kong is well organized so that you can move easily around as an individual. Simultaneously, it has this charming lack of total perfection which would make you feel unhappy. It is modern and wealthy with high rise buildings, four lane roads, lots of cars and a lot of well dressed people. In between however, there are all kinds of little things pointing to a different past. It was British; the trams, the walking trails and the pubs are still there. It is Chinese, you can eat everywhere and have fun everywhere. It is Chinese in its knack for trade and its ability to adapt to its new role in the region: from the gateway to China to orchestrating added value achievements in the regional economy.

And there is water. Stare at night from Tsim Sha Shui to the illuminated buildings at Victoria islands. Relax and organize your thoughts after a busy day. Go with a ferry to one of the outlying islands and recharge your energy.

I love to be in Hong Kong. In the period of technology transfer and joint ventures in China (1990-1994) travel was through Hong Kong. I was nervous when going to China, and exhausted when coming back. Hong Kong was to prepare and to wind down.

When starting my work in the field of environment I thought I would never be back in Hong Kong again. It did however work out in a different way. My first successes in the implementation of 'Eco' were in Taiwan but soon after in Hong Kong as well. The Business Group Audio had its head office there and operated several factories in nearby China. Activities included packaging-reduction on the basis of the environmental weight tool (still the best!) chemical content discussions, and formulating environmental requirements for subcontractors. After a lot of internal discussion the human powered radio was also developed. It sold well on the market.

I still can find the way to the Audio facilities which were in Kun Yip Street with my eyes closed. The sound of the closing doors of the MTR (metro) is so typical that it cannot be forgotten.

After 1999 somebody else took over the Business Group contact. I missed Hong Kong. New opportunities to meet came with the implementation of the European Environmental Directives for the Electronics Industry. Asian Companies are puzzled by it. Hong Kong Industry took the lead to get a grip on the matter. After retirement from Philips, I gave several seminars on WEEE, RoHS and EuP implementation (see chapter 9). I also supported an EcoDesign project with Hong Kong Polytechnic University and members of the Federation of Hong Kong Industries. It is still fun, I still love it, Hong Kong, a place to be!

City walk: Start in Central, on central square. Take the train in a western direction, get out at Western Market, go up (Morrison Street), go Right, Wing Lok street, go Left and directly Left, Bonham Street, go Right (Possession street), Left to Hollywood Road, proceed along the road till the mid level escalators, go down, get out at Stanley Street (Right), Left to Pottinger street, Right back to Central (check out Li Yaun Street, East and West.

Or: start in Central, on Central Square. Take the train into an eastern direction, destination Happy Valley. Get out at the terminus, walk up the street, Left to the Jewish Cemetery and go back, walk west of the Race Course along the Hindu and Parsee cemeteries. Enter HK-Cemetery, cross it, go out at the back side and take bus nr. 15 to the Peak. Make the circular walk here (Lugard Road & Harlech Road) and go back by the Peak Tram or walk Lugard Road and down (Hotton Road) and go back to Central with bus 13.

Favorite restaurant & pub: Kangaroo pub, East Chatham Road 37, Tsim Sha Shui and Deutscher Biergarten, Hanoi street, Tsim Sha Shui.

Country walk: Start at East Tsim Sha Shui Railway Station (KCR). Take the train to Tai Po Market. Take a taxi to the entrance of Tai Po Kan Nature Reservation. Make one of the walks indicated here. Recommended: the brown walk (2,5 hours).

6.1.2 What is 'green', what is really environmentally beneficial?

In the exploration about 'What is green?' it soon turned out that on the environmental side itself there are several dimensions. These relate to time horizon and to 'for real' or just 'risky' concerns.

- Short term ones: emissions to air, water
- Long term ones: resource depletion
- Potential toxicity: this is basically a risk, the toxic potential can materialize under circumstances or not.

Therefore from a real environmental perspective the answer to the question 'What is green?' is not obvious, nor it is univocal either.
The final answer to the question 'What is green (really)?' is therefore dependent on subjective judgments regarding what is most important even when assessed purely on environmental dimensions.
This is depicted schematically in the diagram below:

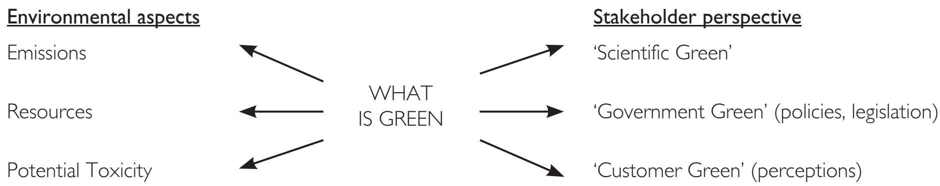


Figure 6.1 Aspects of 'What is green?'

The environmental aspects include emissions, resource aspects and potential toxicity aspects. For all three, descriptive models exist; the most well known is Lifecycle Assessment (LCA), which concentrates chiefly on emissions. For electronic products a typical Life Cycle Analysis based on single scores according to the Dutch Eco-indicator '95 method, would read as follows in Table 6.1:

Table 6.1 Life Cycle Analysis according to the Dutch Eco-indicator '95 method

Life Cycle Item	Life Cycle impact (% of total)
Energy consumption	40-98%
Materials and parts	20-60%
Packaging and Transport	2-12%
End-of-Life / Recycling	-3 - -15%
Substances, potential toxicity	N.A.

In LCA however, stakeholder opinions (see 6.1.1) are not addressed. This suggests that doing an LCA alone to underpin environmental decisions, can be misleading and even counterproductive. The European environmental Directives for the Electronics Industry (see chapter 9.2) have in their wording a strong inclination to rely on life cycle analysis (written with small letters this refers to the approach and not to the methodology, which is written in capitals).
As shown above great care should be taken when applying results of such analysis without checking a holistic environmental perspective (including resource and potential toxicity analysis) and stakeholders analysis. In view of this it is recommended to instead use the wording 'life cycle thinking' or 'lifecycle and stakeholder perspective' to avoid confusion.
Resource aspects can in principle be incorporated in an LCA (for instance by including future extra emissions which will arise due to mining of resources with low concentrations) but this opens up a new debate and adds to uncertainty about what depletion rates should be taken into account.

Even potential toxicity can be incorporated as well but here the debate will be how risk of emissions is to be incorporated on top of actual emissions in the future and to what extent 'natural' absorption levels have to be deducted.
It is concluded therefore that real comprehensive models are far away and that it is best to consider the three separate dimensions of 'green'.
In a lot of EcoDesign issues this solution is sufficient although not perfect. However, there are important policy issues for which the three dimensions pose inherent dilemmas. In such cases there is no escape from the necessity to make a judgment about real priorities.
A few aspects related to existing societal debates in Europe are listed below:

Table 6.2 Examples of Environmental dilemma's

Environmental dimension / Issue	Emissions	Resources	Potential Toxicity
Using natural gas instead of coal to generate energy	+ (less CO_2)	- (high energy resource sacrificed)	+ (no fly ash)
Replacing metal by plastics	+ (less energy needed for production)	- (recycling becomes a problem)	- (additives in plastic)
Lead-free solder	- (more energy needed for process)	- (use more source resources)	+ (lead eliminated)
Use of flame retardants	- (less production energy)	+ (less material needed)	- (more potential toxicity)

The dilemmas shown in this table can be described as follows:
- Fulfilling the Kyoto requirements for CO2 reduction (these are a case in point, but will not be discussed here further) will put pressure on the use of more high quality resources which in fact should be used for applications with a higher added value than just electricity generation.
- Replacing plastics to better fulfill the European substance (RoHS) and recycling (WEEE) Directives will result in more emissions in the production phase.
- Lead-free solder applications reduce the amount of potential toxic substances but it is their positive impact is doubtful from an overall environmental perspective, particularly when it is considered that a constituent like silver in lead-free alternatives is produced as a by-product from lead mining. Also, increased demand as a result of the lead free for tin could pose a resources problem.
- Eliminating flame-retardants will result in the use of more primary materials and thus in the use of more production energy.

So far, the drafts of the European Policies and Directives have been one sided in the sense that they concentrate on a single environmental dimension. RoHS has the potential toxicity perspective, WEEE the resource perspective. Both EuP and IPP claim a holistic perspective, but are in practice strongly emission/LCA oriented in their environmental analysis approach. Although in both cases recommendations and design rules also address the two other dimensions, no balancing mechanisms are proposed. The way in which this could be done is discussed in chapter 6.5.

Pictures, 8

Graduation at Delft University

6.1.3 What is 'green' and the application of EcoDesign tools.
As explained in 6.1.1 the stakeholder perspective basically has three dimensions: a scientific one, a governmental one and a customer one. Each of these contributes to the outcome of the debate regarding, 'which environmental issues need to be prioritized'.
'Scientific green' is best represented by LCA based EcoDesign tools (although this is a methodology rather than a science, in the end a subjective recycling step has to be taken to allow produce conclusions). For resources a variety of depletion models exist for which there is no consensus in the form of standards such as there is with ISO 14000 standards.
Potential toxicity models start to appear but here consensus is even further away.
In practice, 'Scientific Green' approaches will therefore prioritize emission related environmental issues.
'Governmental Green' strongly depends on a variety of factors like population density, availability of energy sources, geographical position (near the sea, mountains), availability of landfill sites and/of incineration capacity and the status of the economy. Such circumstances determine the priority of items on the agenda.
'Green' perceptions of the general public are strongly linked to emotions. Environmental issues related to Health and Safety (therefore potential toxicity) score particularly high. Resources are long-term and score low, emissions generally score medium. Perceptions also relate to events, for instance when energy taxes are raised, energy issues score high. When incidents involving toxicity/food safety occur, toxic dispersion steps are advocated. When shortages of fuels or materials occur, the resource aspect takes over.
In view of what has been said above, it is concluded that it is unlikely that the stakeholders' debate will result in the setting of clear 'fundamental' environmental priorities. This is badly needed however to align environmental policies and directives and to allow stability in time, so that investments in technology and product design can be appropriately prioritized.
The situation as depicted above leads to a complex situation for practitioners. Several questions emerge: what has priority, where to go, which 'green' purpose to serve best and what tools will support best the EcoDesign process aiming at the chosen 'green' ambition?
In 1997 the figure below was made to facilitate discussions about tool choice and tool development:

Table 6.3 Relevance of tools for the various types of 'green'.

Green Perspective	Scientific green			Government green	Green perceptions
Method	Production	User	End-of-Life		
Common sense	+	+	+	+	+
Environmental Weight, chp. 6.2.2	+	--	++	++	++
Ecoindicator, chp. 6.2.1	++	++	+	--	--
Chemical Content, chp. 3.4	+	--	++	++	++
End-of-Life Evaluation, chp. 7.1	+	--	++	+	--

The Common sense approach covers all aspects but has a low level of sophistication. Philips Consumer Electronics decided to test the Delft EPass method (see chapter 6.3.1). In fact this is a common sense performance measurement. It can also be seen as a life cycle inventory, which is not transformed into impact categories, as is occurring with the LCA.

The Environmental Weight (see chapter 6.2.2) method was already applied successfully in EcoDesign practice. Although not complete (energy is not considered), it yielded interesting and relevant clues for improvement.

The Ecoindicator tool (one- score LCA) was still under development. Although covering only 'scientific green' and excluding 'government green' and 'green' perception, a considerable amount of money was invested in developing the method and the data bank necessary to operate such systems. This was done because it was realized that in the future scientific validation of designs would be necessary for stakeholders dialogues.

The chemical content system (see chapter 3.4) was already in place and had been set up from the very beginning in such a way that it served not only 'government green' (compliance with legislation) but also dealt with the 'green' perceptions of customers and end-of-life issues.

End-of-life evaluation of designs (see chapter 7.1) had already scored its first successes before 1997. PCE decided to proceed with further tool development at the Philips Centre for Manufacturing Technology, but also to sponsor more fundamental work at Delft University. Finally, this led to the ecoefficiency tool described in chapter 7.5.

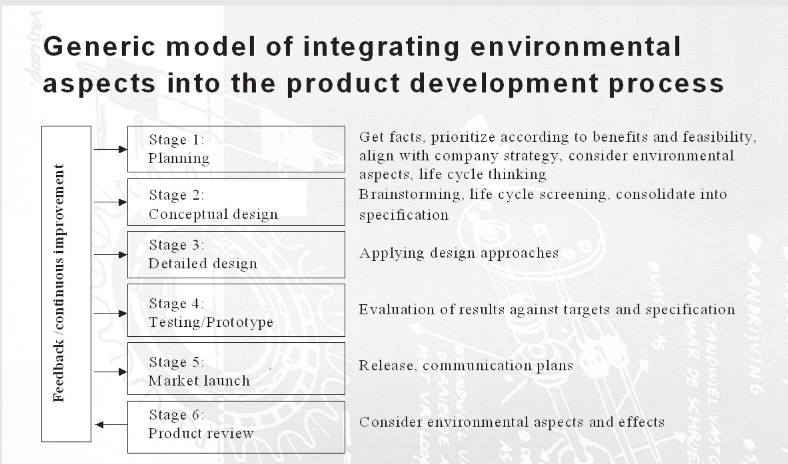
Highlights of the year, 2001

EcoDesign revisited, ISO 14062

After 8 years in Applied EcoDesign, many developments have taken place: from design rules to manuals, from defensive to proactive, from (self chosen?) apartheid to business integration, from environmental analysis to benchmarking in physical parameters. Simultaneously, it can be observed that industry and academia have grown more and more apart in EcoDesign (see chapter 2.2).

In 2001 a committee from the International Standardization Organization was given the assignment to prepare a report on the integration of EcoDesign into product development. Product design had not been well represented in ISO14001, the general standard for environmental management in industry. This was deliberate. Some representatives had posed the threat to vote against this standard if products were clearly addressed – so as a compromise products were left out.

However later, the subject was raised again. Some countries wanted a separate standard for products. Again there was opposition. Again there was a compromise: make a technical report, not a standard.
The Netherlands initially did not want to be represented because their original position had been that products should be in ISO14001, so it voted against ISO TR14062. How stubborn the Dutch can be: to take nothing rather than at least something if your views have not been fully acknowledged.
Anyway, I was invited to present at a seminar of the ISO TR14062 committee about applications of EcoDesign in industry. My presentation worked out, as a complete surprise. How could this be?
The answer is simple: through reduction in overhead costs, the budgets of standardization departments in industry has been reduced over time. Particularly for new subjects like environment, industry representation in the standardization committees has become poorer and poorer. Representatives of universities and research institutes supported by governments are gradually are taking over.
This development enhances the scientific character of the standards but lowers their practicality. A good example of this is the ISO standard ISO 14042. It has a high degree of sophistication but the net result of this standard has been that it has decreased interest in the use of LCA in industry.
The indirect effect of the seminar presentation was that I was invited to participate in the committee. With a 5 to 4 vote in the national committee I even became the official Dutch representative. The work was intense and took a lot of energy. As one of the few people with an industry background the most important thing was to communicate what was really going on in industry with regards to EcoDesign. It was also a fight against what I considered to be outdated and theoretical approaches. In my perception, the committee's work was not intended to be a beauty contest for which EcoDesign tool or method was the best one. It was about stimulating industry to put more 'green' into their product. A breakthrough came when the following item was produced; it is about the 'processes' when introducing EcoDesign, not about the tools to enable it:



Agreement about this generic integration model was quickly achieved. The method and tool discussion was ended by producing a number of tools/methods for each action or process. All of these were listed in the report. In this way the requirement of 'non-prescriptiveness' was fulfilled as well. Practitioners can make their own choice and really test whether an approach or tool was valuable and whether it had moved to where it belongs: practice.
ISO 14062 was saved and it became much more than just a flexible guideline allowing all kinds of levels of sophistication. It became a strong and helpful document!

6.2 Factor methods and Lifecycle Analysis

6.2.1 Factor methods, environmental weight

The environmental weight method was set up in an effort to link lifecycle stages (production, end-of-life), address impending legislation ('government green') and 'green' perceptions of customers (see 6.1). At the time environmental weight was implemented, abbreviated LCA and Ecoindicator methods were still under development. In contrast to academia, there was serious doubt in industry about whether these methodologies could support applied EcoDesign processes.

Using a stand-alone energy analysis alongside environmental weighting was thought to be a good alternative for the LCA of complex systems such as electronic products, because energy dominates in the use phase. In my opinion this is still a good idea today, especially as a method to better support EcoDesign in small and medium sized enterprises.

Bert Sondern, the environmental manager of the Business Group TV was the inventor of the Environmental Weight method used at Philips Consumer Electronics. Its scope is formed by three focal areas: material application, chemical content and end-of-life (recycling). For packaging materials a similar 'Environmental Packaging Weight' can be established.

The information needed to operate the system consists of:

- The weight of the (main) materials and components applied
- Their chemical content release status (see chapter 3.4)
- Information about marking of materials (for recycling)

In the design evaluation the weight of a material or component is transformed into an 'environmental weight' by multiplying using 'factors'. Factors lower than 1 represent environmental improvements with respect to the application of a monomaterial or component (for instance application of recycled material the multiplication factor is .5). Extra environmental loads with respect to the standard result in the use of factors bigger than 1, see the table below:

Table 6.4 Summary of weight factors in the Environmental Weight method.

Environmental weight factor to be applied	
< 1.0	major environmental improvement
1.0	monomaterial
1.0-2.0	factors for various types of surface treatment
3.0	temporarily released components
4.0	release status unknown
5.0	no marking (plastic parts)
10.0	rejected components

More than one factor may have to be applied to any one material. For instance a recycled plastic, which has been lacquered but not marked will get three multiplication factors. After application of the factors to all materials and components (above a certain weight, for instance 1g) the total Environmental Weight of the product can be calculated. An example of this is shown in the following figure:

Environmental Weight Calculation Sheet HOUSING							DATE: 30-jul-97
Code #	Material type	Env. Status y/t/r*	Marked yes/no	Actual weight (g)	Multiplication factors	Env. Weight (g)	Remarks
Back Cover	Styron 5168	Yes	Yes	2736	0.83	2270	Not painted, sticker
Cabinet	Styron 5168	Yes	Yes	2630	1.33	3132	Water paint, inserttsm, tampo
Bott. Plate	Styron XZ94030	Yes	Yes	800	3	2400	Temp. Rel plastic
L S Front PP	EPF 30R	TEMP	Yes	150	1.21	181	Cloth, other palstic
Contr Door	Lexan 121R	Yes	No	45	0.83	37	Other plastic, not painted
Woof Cover	ABS	Yes	Yes	125	1.65	206	Other plastic, paint
LS Grilles	Zinced Steel	Yes	/	230	2.25	517	Zinced, painted
Front Plate	Remex NR200	Yes	Yes	150	0.83	125	Recycled, water plaint

Total actual weight	6866	Release status	8874
Total environmental weight	8874		
Tio environmental weight	1.29		
Release criterion	1.35		

* y=released, t=temp. released, r=rejected

Figure 6.2 Example of an Environmental Weight calculation

After calculation of the Environmental Weight (EW), the ratio between EW and the actual (physical) weight (AW) can be determined. This ratio EW/AW has turned out to be very useful for design management. The fact that the calculation is transparent makes it easy to identify the big contributions to a score and to generate ideas for improvement. Working out the scores turned out to be fun for most practitioners. The numbers can be played with and the effect on the score is directly visible. At the CE business units experiments were also done with setting targets for the ratio to be realized after redesign. This had a mixed result – even when targets were fixed at the right level (ambitious, but not too ambitious = unrealistic).

In some cultures (Anglo-Saxon, most continental European) setting targets stimulates creativity although the game element is somewhat stifled. In other cultures (Asian, some continental European) a target is felt to be more of a threat and is therefore counterproductive for creativity.

Environmental Weight has been very successful between the period 1995-1999. After that it has been gradually replaced by environmental benchmarking (see chapter 6.3). This method is more complete (includes a wider range of items including energy) but separates the balancing of ‘scientific’, ‘government’ and ‘customer green’ from the ‘green’ idea generation itself. This is done when the ‘green’ options generated are evaluated through the EcoDesign Matrix. In EW this is included directly in the calculation.

For this reason, I believe that Environmental Weight still has value. Its essential significance is that it balances environmental issues that are seemingly incompatible. In the end this is what society will have to do: balance energy issues (in the EU predominantly EuP), resources issues (in the EU chiefly WEEE) and ‘(potential) toxicity’ issues (in the EU RoHS). Requirements in these three fields will become conflicting, particularly if they become more and more ambitious. Therefore, society will have to determine mutual priorities for the three dimensions. Since science will fail to give a basis for this, the weighting scheme applied explicitly or implicitly will be a subjective one. The Environmental Weight principle (a factor method) can be of help here to demonstrate in a simple way the effect of making a set of choices. This is worked out further in chapter 6.5.

Tidbits, 9

Is the Law the law?

It was a distracting trip, but it was necessary. Going two days from Trondheim, where we had such a good time (see cities, 14), back to the Netherlands.

The agenda of this trip was a very mixed one:

a graduation student in Delft was in trouble and needed to be helped out.

There was a presentation at Philips about the issue of what standardization could bring for progress on environmental issues within the company (not a lot in my opinion – I would be an unwelcome messenger because most attendees would have a different opinion). There was also a discussion planned about the focus of the Philips' Sustainability Strategy. I was in favor of placing energy savings inside and outside the company as priority number one. The general tendency among senior managers was, however, to favor more socially oriented projects like the so-called Bottom of the Pyramid activities. I would do a sales pitch for my ideas but was most likely to lose.

And then there was the real challenge; the challenge to speak at the celebration of the 5th anniversary of the Dutch Take Back and Recycle Scheme NVMP. Friend and enemy agreed that its performance has been better than anticipated – that was the good news. Underneath the surface, however, there was smoldering discontent: NVMP had been a pretty shaky, typical Dutch compromise. There was a chance that the old differences of opinion between industry and the government could flare up again. I had not been neutral in this debate and had backed most of the industry positions, so I could guess that the Ministry of Environment would not be amused upfront.

The Secretary of State for Environment was the speaker after me in the program, so it would be a very interesting afternoon.

I started my presentation deliberately with a provocative title: 'Is promoting Ecoefficiency (relating environment and money) criminal or is it environmental heroism?' It explained that products can have a high recycling efficiency on a weight basis (MRE) but a low efficiency on an environmental basis and vice versa (high environmental gain, low MRE). There are products with a high MRE at a low cost or a high MRE at a high cost as well. So, there is lots of work to do on NVMP operations, but also for the Ministry in rule making. In particular public policies on recycling should pay more attention to input of the recycling systems (collection), for the level of reapplication of the resulting secondary materials (output) of the recycling systems and the eco-performance of recyclers (both the ecological and the economic performance, not just cost alone). As a final message it was added that the Netherlands should promote its relatively good system more effectively in the EU (see also chapter 8.3).

And what did the Secretary of State say? He repeated the old ideas about recycling of electronics. About Individual Producer Responsibility, Polluter Pay Principle, the importance to reward EcoDesign, about design for disassembly and necessity of the modular construction of products. All of the Eco-beliefs of 1995 were included. Already around the turn of the century it had already been identified that completely different issues like achieving economy of scale, investing in high-tech treatment technology and high level reapplication of secondary materials were the real critical success factors for ecoefficient recycling systems. Apparently his speech was written by the traditionalists in the Ministry which had not caught up with latest developments. The body language of the Secretary of State showed that he himself felt in one way or another that there was something wrong with his speech. Also in the conference hall a kind of uneasy atmosphere seemed to build up among the audience. The Secretary of State did not have the improvisational talent to modify his speech while talking, he continued "to play the old gramophone record."

The gap between the two speeches could not have been wider. At the reception afterwards, the Secretary of State came to me and said: "Professor, I understood your messages very well and will do something with it!" He earned my respect - nevertheless I will never vote for the political party he represents.

6.2.2 Application of Life Cycle Analysis

In the nineties of the last century the status of the Life Cycle Method (LCA) has been a subject of continuous debate both at the Design for Sustainability Lab at Delft University and at Philips Consumer Electronics (PCE). On one hand, LCA and the methods derived from it (mostly simplified methods) were most commonly recommended by academia and consultants. On the other hand it was realized that LCA chiefly reflects 'scientific green', partly reflects 'government green' and does not reflect 'green' perceptions, for instance 'customer green' (see chapter 6.1).

Common sense and benchmarking methods (see chapter 6.3) allow for better results in this respect, as well as the 'Environmental Weight' method that was already applied at PCE which turned out to be successful as well (see chapter 6.2.1). Both benchmarking and Environmental Weight had the significant advantage that environment and business were linked.

In this respect Life Cycle Analysis and also one-score LCA methods are one sided, focus is on the environment and in particular on the emissions dimension. Concepts to link life cycle loads and prices paid by consumers (the Ecovalue concept, chapter 2.3) could add a lot to the societal relevance of LCA. Unfortunately the Ecovalue concept was virtually unknown at the time the crucial discussion described above took place. Research to link environmental load with costs in that period was focused on Life Cycle cost and linking Eco-impacts with remediation costs as well as on 'virtual Eco-cost' models.

In 1999, it was time to take stock of the situation and to position LCA methods in the EcoDesign practice as implemented inside Philips Consumer Electronics. It was necessary to find out how LCA based methodologies could contribute to the formulation of action agendas, policy and strategy making and how it could be used as a 'communication tool'.

A study done by the Design for Sustainability Group with the title *"Application of LCA in eco-design: a critical review"* concluded that LCA based methods were not really suitable to drive these issues in business.

In fact it was one of the first times, that it was highlighted that a gap between the industrial and academic approaches of Applied EcoDesign was starting to develop (see also chapter 2.1).

Inside PCE , LCA (through Eco-indicator '95 and later Eco-indicator '99) achieved the status of a tool for validation only. The tool used to fasten Eco-creativity and link it to the business became Environmental Benchmarking together with the EcoDesign matrix (see chapter 6.3) Environmental Weight (chapter 6.2.2) was gradually phased out.

Application of LCA in eco-design: a critical review

Ab Stevels, Han Brezet and Jeroen Rombouts

Eco-design has now become a business issue in various sectors. To enable eco-design requires a wider range of tools, most of which re in their early stages of development. Life Cycle Analysis (LCA) has emerged as a key tool. The article is based on Delft University of Technology's (DUT) experience of working with industry on eco-design projects using LCA. DUT's experiences are highlighted illustrating the strengths and weaknesses of LCA and the growing gap between industry needs and academic research in this area.

Introduction

Within the Delft University of Technology's (DUT) Design for Sustainability (DfS) programme, at the Sub-faculty of Industrial Design Engineering more than a hundred industrial eco-design case studies have been undertaken between 1993 - 1998, through graduates, PhD students and staff.

DUT's eco-design approach advocates several types of Life Cycle Analysis (LCA). This refers both to the selection of 'attention fields' and the creativity phase (finding green options) as well as to the environmental validation of design improvement recommendations.

Research has highlighted that consideration of *both* the technicalities of eco-design and the management of eco-design processes are crucial for success or failure. This relates to both the front end (idea generation and concept development) and to exploitation of the results in the marketplace. In all these processes the availability of appropriate manuals and tools plays an essential role. DUT's contribution to these include:

- PROMISE, a promising approach to sustainable production and consumption (Brezet and von Hemel, 1997)
- EPAss, a manual for environmental benchmarking (Jansen and Stevels, 1998)

Tools include:

- LEADS, Lifecycle Expert Analysis of Design Strategies(Rombouts,1998)
- IDEMAT, a material and process database for product developers containing mechanical, physical, financial and environmental data
- EcoQuest, a supplier ecodesign self-audit tool (Brink, Diehl and Stevels, 1998)
- STRETCH, a methodology for advanced environmental product development (Cramer and Stevels, 1998).

The LCA methodology has a pivotal position in the ecodesign process and tool applications at present. Particularly, in the selection of 'attention fields' and in the validation stage, the use of LCA is essential for environment-oriented product development. To a lesser extent this also holds for the creativity phase itself.

In this article, the DfS Programme's experiences of the use of LCA in industry-based eco-design projects are evaluated. This has led to the identification of both limitations and opportunities for LCA and directions for action and further research.

The following seven aspects related to LCA will be discussed in this article:

- LCA from the problem solving perspective
- methodological issues
- data issues
- LCA from the business perspective
- LCA as a stakeholder communications tool
- standardisation
- future of LCA.

LCA from the problemsolving perspective

- LCA is a very effective tool for the selection of product-related environmental impacts that need to be prevented or reduced. It is also useful in validating green design options when a mix of energy and, material application and process related aspects play a role. In a wide range of linear problems, good solutions can be found with a high level of sophistication and practicality.

- LCA is less effective in situations where toxic/ hazardous substances are involved (embedded toxicity with time dependent release) (Tukker, 1998). Its use in tackling recycling issues is also fairly cumbersome due to assumptions that have to be made to satisfy system boundary requirements. A main problem with LCA is that it is primarily based on an inventory of flows as at a moment in time ('in-out') and not on a balance sheet principle. As a consequence, taking the future into account is problematic, particularly for resource use ('environmental investment').
- In terms of environmental validation and prioritisation of green design options and product performance, current LCA approaches generally provide satisfactory information, provided that the analysis is made organisation-internal and on a relative base (Stevels, 1999). There is also evidence that a single figure LCA score like the Eco-Indicator '95 performs well in this respect. The obvious advantage of indicators and abbreviated LCAs is their need for limited expertise, time and money, which makes it a very practical solution for internal product comparisons despite all the criticism from the scientific point of view. Tools that can be used are EcoScan, SimaPro (see References) and others. Dueto a lack of a standardisation LCA is not yet appropriate for external comparison or absolute calculations.
- LCA is not suitable for generating green design options, because ideas generated by LCA often go beyond the influence of designers. This is due to the lack of separation between internal (eg. Product properties) and external (eg. electricity generation and waste treatment) issues in LCA applications (Stevels, 1999). As a consequence, linking the eco-design concept with the creation of sustainable, new 'business' coalitions (joint ventures with suppliers, recyclers, users etc.) and markets cannot be done through LCA. Therefore this link, which ultimately defines the overall net environmental benefit of 'ecodesigned ' product-market combinations, needs to be based on additional models and tools, like 'scenario making' (simulation of future user perspectives and preferences), environmental accounting (assessing the environmental and financial-economic benefits of eco-design concepts) and innovation management theories. Good results have been generated by benchmarking followed by supplier contacts (Brink, Diehl and Stevels, 1998) and green brainstorms (Cramer and Stevels, 1997). This generally leads to options within the designer's sphere of influence. In addition, the societal green context can be determined by using, for example, the Eco-Indicator 95.

Methodological issues

Currently worldwide efforts are being undertaken to enhance LCA methodology. It is the authors' opinion that some basic problems with LCA will remain which cannot be fundamentally solved (like time dependence, system boundary and momentary bases). The rating of impact categories, as one of the steps in LCA procedure, is and will remain a subjective issue, as long as environmental sciences are only ableto provide a very complex impact model.

With the progress currently being made all these issues can be solved, but the application by non-expert users (like policy making bodies and industry) will become too complicated and too costly. For LCA to progress, this will be a fundamental issue eg. how to balance a maximum of scientific truth with a maximum of user friendliness while keeping cost and capacity involved within reasonable boundaries.

A further problem with the methodology is that LCA works reasonably well on the product level, however on the level of service systems, analysis is very problematic. In developing product-service combinations, like carsharing services in neighbourhoods or at work, consideration of the infrastructure available (roads, parking lots) is an essential precondition for success. Other variables are also important, for example, the number of supportive products within the service (number, type of cars), the service co-ordination centre (space, use, energy) and the number and activities of employees involved. In selecting the products (cars), LCA can help us, but for making infrastructure choices standard LCA procedures are not or are less appropriate (only with a lot of artificial modifications). In addition, the effects of human labour should be included, which at this moment is usually omitted. When more fundamental system changes are discussed the exclusion of capital goods or infrastructure changes from the analysis makes discussion problematic (Goedkoop, 1999). To gain large improvements in sustainability there needs to be a move to more innovative solutions on a higher level than the product level. To improve eco-efficiency by a factor 20, which is often quoted as a sustainable level, an impact reduction of 95% needs to gained

which will be impossible by just improving our present day products (Brezet, 1997).
There is a big opportunity for universities and research institutions to develop new methodologies, which can operate meaningfully on the system level.

Data issues

Both data accuracy and data accessibility (databases) are both issues currently posing dilemmas. On the one hand there is a clear need for higher accuracy and reliability of data, but this will drive up the cost of data collection tremendously and only in a few cases will LCA practitioners be able to afford such a high standard. Data collection for LCA goes to the heart of business and enterprises, and many proprietary items will have to be discussed, especially when a high level of accuracy and reliability is required. In Europe many of the parties involved in LCA are willing to cooperate; however the condition is that the data acquired will only be used in private/proprietary relationships and will not be made public. A key question is: what is the best choice for the time being? and what is the best compromise?

LCA from the business perspective

There has been an evolution n thinking by business about environmental methodologies like LCA.
Leading industries have moved from a defensive to proactive position, from necessity to opportunity, and from the standalone to full integration into the business.
The academic community (including the LCA community) has generally been (and still is) slow in following this shift of thinking. Therefore we are now confronted with a gap between the proactive industry approach and academic approach. See also Figures 1 and 2 (Stevels, 1999).

Industry			
	step1 start with creative approach to environmental issues you can influence (benchmark, brainstorm)	**step2** validate and prioritise according to LCA	**step3** check prioritised options against company, customer and society benefits
	step4 check feasibility (physical, financial)	**step5** implement in programme	
Academia			
	step1 do LCA analysis, holistic approach	**step2** select internal and external improvement options	**step3** start stakeholder discussion
	step4 come to solutions	**step5** implement in programme	

Figure 1 Industry and academic approaches: issues which can be influenced

The proactive industry approach is actor based with an emphasis on effective implementation (with ownership). LCA has a useful but not a dominating role. The academic approach generally is holistic (with no specific ownership) and is centered around LCA. With respect to business there is generally a self chosen ‘green apartheid’ or specialisation within companies which seriously hampers practical implementation. This gap is deeply concerning and DUT is focussing part of the DfS programme on closing it.

LCA as a stakeholder communication tool

- In all parts of the world (even in the most environmentally conscious countries) environment as such is an appealing factor to a minority (25 % or less) of the potential customers. A majority (75 % or more) of potential customers however are attracted by a combination of an environmental benefit and other benefits (like money, fun/ease/ comfort or other positive emotions). For successful marketing and sales of eco-designed products the creation of a mix of the above consumer variables and values is an essential step. This also establishes the direction that environmental communications needs to develop. Environmental policy tools like ecolabelling should be replaced by a segmented approach, communicating an attractive mix of users' values, for instance:
  - lower energy: good for the environment and good for your 'wallet'
  - less packaging: fewer resources, easier, less hassle with waste
  - more recycling: waste reduction, fewer resources, feels good'
  - less hazardous: good for the environment, no fear any more
  - less material: fewer resources, cheaper, etc.

It has been argued that the lack of buying of eco-labelled products by the general public is due to a lack of scientific thoroughness and as a result LCA based eco-labels have been proposed.
The authors believe the contrary: the general public is calling for simplification rather than for sophistication and wants to be communicated to in terms of a world they live in.
When communicating to professionals the approach should be different. Professionals which are intermediates between policymakers and manufacturers (journalists, environmental experts of consumer organisations, etc.) generally appreciate environmental issues in terms of LCA. As such this category is likely to be well disposed to receive more specific information.
This picture changes at the moment the target group for communication consists of the environmental specialists (for personal interest). In this context, LCA is likely to get a sympathetic reception but the methodology applied and data accuracy will be critically reviewed. In general it will be argued that the actors have not sufficient thoroughness in their approach and apply over simplifications. From their perspective this always remains true whatever action a company takes.

Standardisation

Before touching upon the issue of standardisation in the field of LCA, we will go back to the origin and nucleus of standardisation. This is an industry interest because standardisation makes it easy to compete on a global level playing field. Therefore initially, industrial representatives took a strong interest in standardisation issues and were - for instance - strongly represented in the International Standards Organisation (ISO) committees.
In the present wave of cost cutting and 'lean and mean' approaches, industrial participation in standardisation authorities has declined. Their position has been taken over gradually by institutional (often government sponsored) and academic representatives. This has resulted in a shift in character of the ISO standards (the ISO 14.000 series): standards have become more comprehensive, have a highly scientific context, but their applicability is diminishing.
This is leading to a strong criticism from industry of the LCA standards under development. As a result, industry is considering initiatives to develop a separate (sub)standard which is more workable/applicable in practice (Lehni, 1998).
From the governmental side there is also criticism. Ideally an LCA based legitimacy of environmental policies would be a good basis for policy. However even in countries where this has been seriously attempted (eg. The Netherlands) this point has not been reached. Apart from the politics - including environmental politics - there are strong emotional and social components. Both components are part of real life and as such are legitimate but they also are very difficult to reconcile within a rigid LCA approach.
Altogether the future of LCA standardisation and related items is unsure, there will be either a single set of standards, which will be difficult to apply, or two sets with a continuous debate about the shape and significance of them. Neither of these two scenarios is attractive.

Example

An example given in the table below (Figure 2) shows the shortcomings of LCA/Ecoindicator. This example refers to the development of the Green 'Brilliance' monitor at Philips Electronics Monitor Division located in Chungli, Taiwan. This project was undertaken by DUT and Philips Consumer Electronics (PCE) Environmental Competence Center (ECC) in Eindhoven, the Netherlands.

This table (Figure 2) shows the complete environmental design process with all the LCA issues cited in this article playing a role. The column 'remediation' indicates that the weaknesses of current LCA/Eco-Indicator can only be partially compensated for other ways and means.

Stage	LCA issues/problems	Remediation
Idea generation		
Collect data (benchmark, suppliers)	Toxics, scope, methodology	Separate assessment of hazardous substances and 'end of life'/recycling
Brainstorm	Methodology	None
Concept consolidation, execution of eco-design		
Address focal areas: - Energy - Materials - Packaging - Hazardous substances - 'End of life'/recycling	Not applicable, use common sense	Not applicable
Address lifecycle perspective	Toxics, scope, data	Separate assessment of hazardous substances and 'end of life'/recycling
Exploitation of results		
Validation of results	Methodology, scope	None
Communications, marketing	Business perspective, private customers, scientific community, standardization	Very partly, communicate in bases of common sense (='unscientific')

Figure 2 LCA issues in the eco-design process.

Future of LCA

As things stand now, the future for the application of LCA in industry looks fairly bleak. The basic reason for this being is that LCA is a 'mix', that is a mix of scientific and practical elements, a mix of present and future, a mix of tangible and intangible issues. As things stand now this will be very difficult to sort out based on a consensus between stakeholders at a global level.

What should companies do now? Two approaches are recommended:

- Develop 'environmental accounting' (which in the authors' opinion is the fundamental reason for LCA) identical to accounting systems in the financial world. It can be done and a tremendous benefit would be the comparability in treatment of ecological and economic issues - as it is the authors' belief that ecology and economy are highly correlated (approximately 75%). Within the DUT DfS pro-gramme part of the research effort is focusing on this issue (Vegtlander, 1998) (Gielen, 1999).
- Create a 'living space' for different levels of sophistication of LCA (as a validation method). This will prevent endless discussions between practical, fundamental and politically oriented practitioners, as described in the study on the adjustment of LCA methodology of Bras (Bras-Klapwijk, 1999).

The authors' experience indicates that there is one effective solution to the many problems that seem to be associated with LCA (and also for instance ecodesign) - that is: experience of 'practice will show the way'. The DUT

DfS programme will research industry's experiences with LCA, and will model them into computer-aided tools (like described by Rombouts, 1998; Brink, Diehl and Stevels, 1998; and others) for both large industries and SMEs and will thus play its role in the development of a more sustainable future.

References

Brezet, J.C. & C. van Hemel, 'Ecodesign, a promising approach to sustainable production and consumption', UNEP IE, Paris, 1997. ISBN 92-807-1631-X

Jansen, A.J. & A.L.N. Stevels, The EPAss method, a systematic approach in environmental product assessment, Proc. CARE Innovation '98, Vienna, 1998.

Rombouts, J.P., 'LEADS-II, A Knowledge-based System for Ranking DfE-Options', Proc. Internat. Symposium on Electronics and the Environment May 1998, IEEE, Piscataway, 1998.

Brink, S, J.C. Diehl & A.L.N. Stevels, 'Eco-Quest, an Ecodesign Self Audit Tool for Suppliers of the Electronics Industry', Proc. Internat. Symposium on Electronics and the Environment May 1998, IEEE, Piscataway, 1998.

Cramer, J. & A.L.N. Stevels, 'Milieumanagement: van 'fit' naar 'stretch', Journal of Environmental Quality Management, Fall 1997.

Tukker, Arnold, 'Frames in the Toxicity Controversy, Based on the Dutch chlorine debate and the Swedish PVC debate', Tilburg University, Tilburg, 1998.

Stevels, A.L.N., 'Eco-efficient design, the Philips experience', Proc. EcoDesign'99: 1st Internat. Symposium on Environmentally Conscious Design and Inverse Manufactruing, Tokyo, 1999.

Goedkoop, M.J., et al., 'Product Service Systems, Ecological & Economical Basics', the Netherlands, March 1999.

Brezet, J.C., industry and environment Product development and the environment, volume 20 No. 1-2, 'Dynamics in ecodesign practice', United Nations Environmental Programme, Paris, June 1997.

Lehni, Dr. Markus, 'WBCSD Project on Eco-Efficiency metrics & reporting, State-of-Play Report', WBCSD, Geneva, 1998.

Vegtlander, J.G., 'Designing products for the future, Taking into account the 'virtual' eco-costs of a product in a sustainable society',

Internal document (public) of DfS-program, Delft University of Technology, 1998.

Gielen, D.J., 'Materialising dematerialisation, Integrated energy and materials systems engineering for greenhouse gas emission migation, Doctoral dissertation, DUT DfS program, Delft, 1999 [13]

Bras-Klapwijk, R.M., 'Adjusting Life Cycle Assessment for use in public Policy Discourse', Doctoral dissertation, DUT, Delft, 1999

Personalities, 9

Hans-Jörg ('Torsten') Griese: civil values and curiosity

In 1995, at the Environment & Electronics Conference in Edinburgh, a person speaking English with a strong German accent approached me to become a board member of his Institute, the Institute for Zuverlässigheit (Reliability) and Mikrointegration (IZM) in Berlin. Its special focus would be environmental issues. The guy turned out to be Hans-Jörg (Torsten for friends) Griese, head of the environmental department.

I answered that I would like to visit IZM first so that I could get a better idea of what my responsibilities would include. Soon after that, I was in Berlin, my first time after the "Wende". IZM turned out to be a positive surprise – a combination of solid traditional German style science and technology and the strong drive to move forward into new territories, including the environment.

IZM was also an amalgamation of an East German (Humboldt) and West German (Fraunhofer) Institutes with all the problems associated with that. If you have grown apart for 40 years, coming together in a short period of time is difficult.

At night we had a group dinner at a good restaurant and it was wonderful – it was as though all of us had already known each other for many years. There was a lot of communality, although IZM is very German and I am very Dutch.

Torsten is the personification of this communality. We both grew up after the war period, we both learned never to throw away food, to close the door (save energy), to be modest in your requirements (common sense), to be ethical in your work and to believe that reason will win in the end. These were all civil values, which were engrained both in the heads and minds of citizens. This climate still helps to deal with a lot of societal phenomena today. Being proud of what is normal, declaring special what is standard, asking a lot of money for what is your duty and responsibility, all represent the craziness of today, which has little to do with 'bürgerliche Anständigkeit'.

I would never want to go back to the fifties. That period is history. With all its goodies, it was dull, petty, 'klein karriert' (why do Germans have these nice words you cannot translate?), gloomy, and full of political threat from the East.

Students revolted against this type of society in the sixties, which was rightly so. In the end so called 'alternative thinking' brought more damage than benefit and still today considerable 'repair work' needs to be done.

What do Torsten and I share most? We share curiosity, a desire to learn new things, care for the future, the dream to create (a little) a better world, 'Sehnsucht in die Ferne' (longing for what is far away), travel, Iceland, China, the Baltic sea countries and the 'Boddenlandschaft' (a region in the north of Germany at the Baltic Sea coast). Finally, we share a commitment to hard work, working to the best of your abilities, having fun and memories of completing the Great Spur walk on the Great Wall of China (see Cities, 2).

Yes, I became a board member. IZM remains intriguing. Berlin continues to be emotional (Cities, 3). Torsten and I became friends, including Angelika and Annet. The environmental group at IZM earned a special place in my heart.

The 'Griese' Walk: Go with the S-bahn (S7 or S1) to Nicolaussee, walk along Schlachtensee, Krumme Lanke, Fenngraben, Langesloch, Grunewaldersee, Hundekehlesee to S-Bahnhof Grunewald. If you still have courage to proceed on the other side of the Avas avenue, follow the Schildhornweg, climb the Teufelsberg, go north, and return through the Teufelseestrasse to S-Bahnhof Heerstrasse.

6.3 Environmental Benchmarking

6.3.1 The EPAss method

The origin of Environmental Benchmarking is at Delft University for obvious reasons. As a University of Technology, Delft has a strong engineering tradition. Engineers want to measure upfront to do a better engineering job and to measure performance at the end to show that results are according to specifications. Making calculations is not good enough, it must be shown through measurements that it is alright.
Applied EcoDesign is an engineering activity as well; therefore it fits extremely well in this Delft tradition. From very early on, activities at Delft were aimed at creating a systematic approach for environmental product assessment. To make this easier the product life cycle was deconstructed and reorganized into five fields to which physical and chemical parameters could be more easily attached. These five fields are:

Energy (1)

Embodiment → material application (2)
Embodiment → packaging & transport (3)
Embodiment → chemical content (4)

End-of-Life (5)

[In a later stage this would grow out to the five focal area's approach at Philips.]

Students carried out several projects in order to see whether environmental product attributes could be measured in terms of simple metrics. Subsequently it was investigated whether such measurements could be used as a basis for EcoDesign creativity.
In this way a wealth of data was generated. On the basis of this data vacuum cleaners, coffeemakers and audio equipment were redesigned. The measurement procedures and their 'translation' into design approaches were consolidated into one benchmark procedure which was given the name EPAss (Environmental Product Assessment.
The EPAss method is explained in the article on next page. It has the title: *The EPAss method, a systematic approach in environmental product assessment.*

The EPAss method, a systematic approach in environmental product assessment

A.J. Jansen and A.L.N. Stevels

Abstract

This paper presents the EPAss method, a systematic approach in environmental product assessment. It consists of 6 comprehensible steps and provides design engineers with a clear method to assess consumer products on various environmental aspects. The method aims at identifying environmental redesign opportunities, the so called "green options". The EPAss method has been applied to various electronic products and has produced very good results, both from the academic and the business perspective.

1. Introduction

In the past years there has been a changing focus in environmental awareness. In a rapid pace the 'end-of-pipe' thinking has been redirected towards the earlier stages of the product lifecycle. It is realised now that environmental responsibility starts with the product design stage and we can see a rising number of methods directed towards environmental improvement of product (re)design. The Environmental Product Assessment method

(EPAss) originates from the Subfaculty of Industrial Design Engineering (IDE) at Delft University of Technology (DUT). The EPAss method offers a framework for the analysis of existing products and provides opportunities for the definition of (re)design options. The EPAss method aims both at academics and business professionals in the field of bench marking competitor analysis or environmental analysis. Due to the same approach for and the use of the functional unit, the
EPAss method offers a easy link to the Eco-scan Life Cycle Assessment (LCA)software package (Turtle Bay, 1998). The EPAss method has been documented in the EPAss manual. It contains the six steps of the EPAss method divided in a number of clearly described actions. At the end of each analysis step the manual contains a description of the so called 'short track' (overview of main items) and a check list.

2. Overview of the EPAss method

The EPAss method is divided into six steps (Fig. 1), which will be explained in the next paragraphs. The core of the method consists of the 3-e fact sheets. In these sheets, data concerning energy, embodiment and end-of-life are presented. The sequence of the analysis steps is empirically determined in earlier analysis sessions at DUT. Due to the nature of the method, some overlap will occur between various steps.

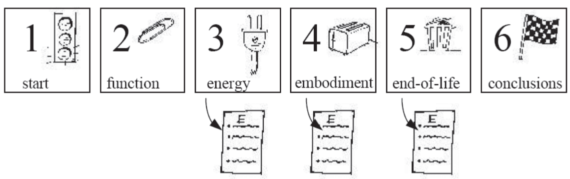


Figure 1 The six steps of the EPAss method

2.1. Start (step 1)

The starting position of the EPAss session should be defined clearly by knowing all available information on the product and its use. This information will also provide a starting point when defining the functional unit in step two. It is essential to be aware of the goal, the expected results and whether there should be any emphasis on specific aspects of the EPAss session. Besides these aspects, attention is paid to the acquisition of the product (packaging, price, documentation, manuals, remote control, accessories like batteries, grease, etc.)

2.2. Function (step 2)

In the second step of the EPAss session, the product is analysed on its functional aspects, the emphasis is on the definition of "the service provided by the product". A well defined description of the analysed function is of key-importance in the correct (environmental) assessment of products. The EPAss method uses four approaches to perform this task:

· the definition of the product-system and system borders,
· the input/output diagram,
· the functional unit and
· the life cycle of the product.

All four conceptions contribute in there own specific way to clarifying the functional aspects of the product. They will be discussed briefly in the next four paragraphs and will be illustrated by using examples from the EPAss session on fruitjuicers.

Analysing the product-system and it borders is one way of defining the scope of one specific EPAss session. The borders of the product-system are defined by the number of process levels and the scope of the process tree. Beside these main issues, product-system borders are also determined by time and space. Will we look at the product now or in the future? Will we look at the product in a global scope, or do we focus geographically? See fig. 2. In this example, the product system is defined as the combination of fruitjuicer, knife, cutting plate, oranges, electricity, water and the user. Outside the system border we can see the power plant, the waste water treatment, etc.

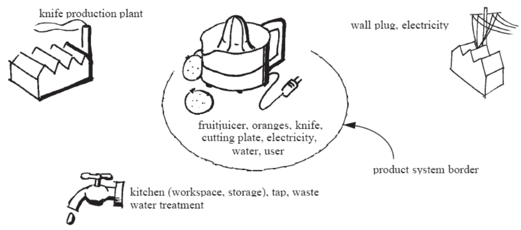


Figure 2 Example of product-system description of an electric fruit juicer

The product life cycle describes 'all the stages of the life of a product'. A standard life cycle is defined by the following steps; production (extraction of raw materials, purchase of components and sub-assemblies and production/assembly of the product itself), distribution (packaging, transport, handling, ..), use (purchase, installation, use, maintenance, repair,.....) and end-of-life (re-use, recycling, incineration, landfill,........). The system boundaries of the life cycle can be varied in three dimensions: length; in time ('cradle to grave' approach or just use-phase), wide; in number of related processes or product life cycles taken into account and depth (number of sub-assembly levels).

Life cycle and product system borders are closely related. The description of the life cycle helps in defining the (borders of the) product-system and the other way around; the definition of the product-system (and its borders) helps in defining the number of related processes to be taken into account. In the case of the fruit juicer; the kitchen knife to cut the oranges *does* belong to the product system, (Fig. 2) but its production (an additional life cycle) is *not* taken into account when describing the life cycle of the fruitjuicer.

In the input-output diagram, the product is seen as a black box, interacting with its environment (Fig. 3). The total input needed to reach the required output can be divided into: material, energy and data (information). The product is described as the (physical) embodiment of the chosen functionality. The total output has to be divided into: required output (required by the user of the product, which also can be defined as: the service provided by the product) and unwanted output, not pursued by the user but inevitable when using the product and sometimes offering unexpected (re)design opportunities.

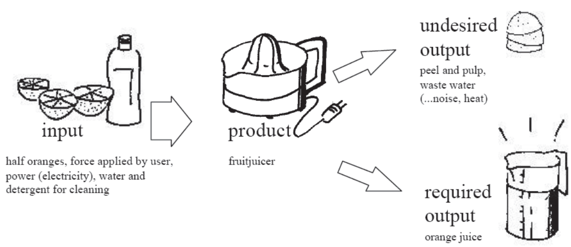


Figure 3 Example of input-output diagram fruit-juicer

One of the definitions of a product is based on the perceived benefit(s) of the product to the user(s). A product should provide a service or utility to the user(s), it is the reason for its existence. A service or utility, however, can be provided in many ways (Tab. 1). This offers the opportunity for environmental product assessment to com-

pare the environmental consequences of products and services and vice versa (Wenzel, 1997). Quantifying the magnitude 'service' gives the 'functional unit'. This quantification is necessary in order to make different products and services comparable. The functional unit acts thus as a fixed reference point for analyses and assessments. The functional unit also offers the possibility to take different life spans into account.
A functional unit should include both: a qualitative description of the service delivered by the product (also defining the quality level of the required service) and a quantitative specification of the duration of the service and the amount of products used, based on the expected life span of the product (Wenzel, 1997). Keeping this in mind it is useful to ask if there is a difference in life-time of the compared products.

Table 1 Various examples of functional units

Service provided by the product	Functional unit	Product	Alternative product(s)
fresh teeth	"..giving the impression of clean teeth, twice a day, for one year...."	0,25 electric toothbrush, tooth-paste, electricity, ...	two toothbrushes, toothpaste,
amusement	" ..providing amusement during two hours in the evening, three evenings a week, for three years...."	0,2 TV sets, electricity, 1 remote control, batteries for remote control, 156 TVguides, ...	24 books
clean dishes and pottery	"..cleaning a specific amount of plates and dishes, once a day for one year...."	0,1 dishwasher, water, electricity, detergent, ...	two brushes for washing up, water, detergent, drying cloths

2.3. Energy (step 3)

In the third step of the EPAss method, the focus shifts towards the energy consumption of the required functionality. The results will be charted in the first of the 3-e fact sheets. This step starts with the description of the energy system and type of energy used. A full description of all energy conversion taking place in the product should be made; what type of energy goes in and type of energy comes out, how does the energy conversion take place and what is the total efficiency. An example (Fig 3) is given from the 'portable audio benchmarking study' (Jansen et. al., 1997).

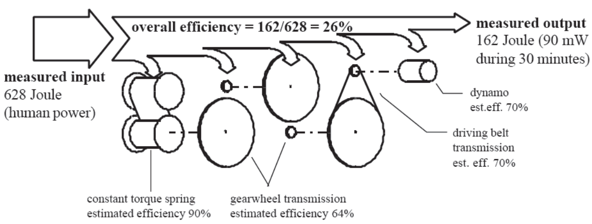


Figure 4 Input and output of energy, and estimated efficiency of transmission of the BayGen Freeplay radio

When analysing the energy consumption of a product, the process tree of the life cycle (Roozenburg and Eekels, 1995) proves to be a valuable tool in providing structure. Therefore, the analysis step concerning energy is divided into production, distribution, use and EOL. For various products large differences exist in environmental burden caused during production, distribution, use and EOL (Tab. 2) Finally, special attention is to be paid to batteries.

Table 2 Energy consumption during use phase as a percentage of total energy consumption

Product	% of total env. load caused by energy consumption in the use phase
Telephone (table top model, no portable)	22
Vacuum cleaner	70
Domestic electric water cooker	90
Light bulb	99

2.4. Embodiment (step 4)

In the fourth step of the EPAss method, the analysis is focused on the embodiment of the required functionality, in many cases this means the product itself. In this step, the actual disassembly of the product will take place. The results of this step are documented in the second e-fact sheet. Step 4 'embodiment' is divided into:

· product design; Take a holistic approach towards all aspects of the product, including e.g. quality and durability. These aspects can only partly be described into technical terms because the impact of the product is -for a considerable extent- determined by user behaviour and even consumer perception (van Nes et.al., 1998).

· product structure chart; When analysing the embodiment of a product, insight should be gained into the products' physical structure by making a schematic representation of the product (product structure chart). This scheme contains main components (or subassemblies), their physical/ mechanical principle of operation and their relation(s).

· materials application, production, assembly; Used materials, presence of hazardous substances and the number and type of attachments are specified.

· electronics: Specification of electronics technology and materials.

· packaging and directions for use; Packaging materials and material and contents of the directions for use are specified.

2.5. End-of-life (step 5)

The chapter end-of-life, concerning the last step in the life cycle of a product consists of three series of actions. The results of this step are documented in the third e-fact sheet. They are divided into:

· before the disassembly of the product; The disassembly sequence of the product needs careful consideration, this sequence can be documented in a disassembly plan.

· during product disassembly; Difference between destructive and non-destructive disassembly should be marked. Record the disassembly session (on video) and register all components or sub-assemblies for later analysis purposes.

· end-of-life scenario; Based on gathered data, the most probable EOL scenario can be determined. A choice should be made for the most likely collection system and processing route.

2.6. Conclusions (step 6)

The sixth and last step of the EPAss method consists of:

· definition of (re)design opportunities ('green options')

· the green options matrix

· sensitivity analysis on used benchmarks

· conclusions and evaluation

(Re)design opportunities or so called 'green options' must consist of an objective environmental benefit, coupled to possible benefits for the consumer and the company. These benefits are analysed based on physical parameters as described in the 3-e fact sheets. Besides the benefits, investments and technical feasibility take part in the evaluation process (Stevels, to be published). The presented Green Options Matrix (Tab. 3) can be filled using data from an LCA software package (e.g. EcoScan) (second column) and conclusions from the analysis of the 3-e fact sheets.

Table 3 The Green Options Matrix

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

After having completed the green options matrix, the sensitivity of used benchmarks and assumptions has to be analysed. Will the results show major changes when altering the functional unit slightly? Will the conclusions remain the same? At the end of the EPAss session look back at the start, step 1; Has the goal, as described when starting up the EPAss session, been reached? How did the EPAss method suffice?

3. Experience so far

Recent experience with the EPAss method in analysing various products (portable audio products, computer monitors, VCRs and audio systems) show good results. For instance the monitor benchmarking project (Eenhoorn, 1997) resulted in approximately 50 green options which -when fully implemented- will result in savings of: energy consumption (15%), less weight of plastics applied (33 %), less packaging materials (35%) and shorter disassembly time (42%). The product resulting from these improvement actions, the Brilliance Typhoon II monitor has won the Philips Environmental Award 1998.

Especially, the careful definition of the functional unit, as described in step 2 of the EPAss method, makes the results valid in helping to make design decisions. Ongoing use of the EPAss method by graduate students at the Subfaculty of Industrial Design Engineering will extend the experience with this analysis method.

When linking LCA results (EcoIndicator calculations) and other data in the Green Options Matrix at the end of the EPAss session, it is of greatest importance to make sure that the way in which the functional unit(s) have been defined is identical. The EcoScan software package (Turtle Bay, 1998) offers a complete match, this is one of the reasons why we use this package.

Our goal at Delft University of Technology is to keep improving the EPAss method based on practical experiences. Therefore we are looking for extensive co-operation with companies, for example in projects done by graduate students. Our experience so far shows good results, for the environment as well for business. These results are achieved with relative little efforts and small investments.

4. References

Eenhoorn, G.J. (1997). Environmental benchmarking of computer monitors. Final report of graduation project at the Faculty of Industrial Design Engineering, DUT, The Netherlands.

Jansen, A.J., Ram, A.A.P., Stevels, A.L.N. (1997). Renewable energy and the road towards 'green' portable audio products. In: Ritahuta, A. (editor) Proceedings of ICED 97, Tampere, Finland ISBN 951-722-788-4

Nes, C.N. van, Cramer J., Stevels, A.L.N. (1998). Intensity of use, its relevance in environmental product assessment. In: Proceedings of IEEE, Chicago, USA.

Roozenburg, N.F.M., Eekels, J. (1995). Product Design: Fundamentals and Methods, John Wiley & Sons, Chichester, England.

Stevels, A.L.N. (to be published). Integration of Ecodesign into business, a new challenge. Submitted to: Journal of Industrial Ecology.

Stevels, A.L.N. (1997). Moving companies towards sustainability through Ecodesign: conditions for success. In: Journal for Sustainable Product Design, issue NR. 3.

Stevels, A.L.N., Jansen, A.J. (1998). Renewable energy in portable radios, an environmental benchmarking study. In: Journal for Sustainable Product Design, issue NR 4.

Turtle Bay (1998). EcoScan software, version 2.0 with NOH '95 database, for Windows 95 and NT 4.0, Rotterdam, The Netherlands.

Wenzel, H., Hauschild, M., Alting, L. (1997). Environmental assessment of products. Vol. 1. Methodology, tools and case studies in product development. Chapman and Hall, London. ISBN/ISSN: 0-412-80800-5

Rituals and Habits, 9

Jyväskylän Yliopisto

Finland has a special place in my heart because of its people, nature and history. Therefore I was particularly delighted to be invited to participate in a PhD committee at Jyväskylä University.

The preparations for the event went as usual. The manuscript had to read and comments and feedback had to be given to the candidate. If these are taken into account satisfactorily, the appraisal of the thesis can be written. This is the basis for a letter of approval stating that the thesis is in a form such that the candidate can be admitted to participate in a defense.

Parallel to this, the questions to be asked at the ceremony are prepared.

In the Jyväskylä case, things took a different turn when I got the PhD regulations two weeks before the defense. The good news was that the ceremony would take place in an auditorium and that as a committee member you were supposed to wear your gown and other university paraphernalia like a bonnet and a sash.

I like this great tradition which exists at Delft (and at other Dutch universities), and apparently at Jyväskylä too. It always feels a bit uncomfortable to have a defense in a class room in a business suit (like in many countries in Europe). To see committee members wearing polos and sweaters, like sometimes happens in the USA, is a weird experience.

The challenging news was that I was the only committee member allowed to ask questions; in Finland there is only one opponent and only one debate!

The real threatening news was that the minimum time for the disputation was set at two hours (maximum five hours). Realizing that Finns generally are not the most talkative people in the world exacerbated the problem. I wondered how to set up an interesting debate involving the candidate which tested the content of the dissertation in an in-depth way. What had to be done anyway was to prepare many issues to be raised in the debate.

Two weeks later the day arrived. It was a glorious day, the sun was shining on that day in June; giving that special light shimmering through the trees – so characteristic in Nordic countries near the mid-night summer.

For the defense, the PhD procession went into the auditorium, which turned out to be a chapel. Jyväskylä University started as a college to educate Ministers and Preachers. It was all there: Bible texts on the walls, the Ten Commandments, Lutheran sobriety. In this hall, the candidate, Hanna-Leena took the position at a desk at the left hand of the promotor/committee chairman. I stood at a desk on the right hand side: the numerous audience members were gazing at us with tense expectation. The debate started at one o'clock sharp and went the way I feared most. In the beginning Hanna-Leena always replied by saying, "Dear opponent, you are raising a very interesting point", then she added two or three sentences and that was her full answer. The debate ran quickly through one item after another. Disaster was looming, I would run out of steam after half an hour or so. I looked around the room and thought in the best tradition of the Old Testament, 'from where will my rescue come?' And then I saw in the corner that there was a blackboard, barely visible, but it was there. I left my desk and moved it to the front and started writing on it. It helped; the complexity of the issues could be addressed better.

Academic tradition says that a defense should rely on the power of the spoken word, but the board helped a lot. Our disputation was enriched through the use of it and the arguments gained depth and sharpness. After two hours and fifteen minutes it was enough for a clear 'iudicium', although proceedings could have taken longer. Both the candidate and the opponent were judged to have done 'very well'.

The final conclusion of the committee: the Doctorate is awarded with high honors!

For the opponent there is still one surprise waiting: the dinner party that night. This party is primarily in your honor, rather than for the young doctor.

It turned out to be a cozy candlelit quiet family style affair, with relatives and friends having prepared the dishes. There were no big speeches as the wine slowly changed to vodka. At the latitude of Jyväskylä the sun just goes under in the mid of June; what remains however is a violet light skimming over the horizon giving these weird shadows. This contributed largely to the wonderful mood in which my wife Annet and I walked to our hotel.

Vivat Academia Fennica Scientiorum!

6.3.2 Environmental Benchmarking and Design Improvement

The internal success of the EPAss method led to the idea of setting up an EPAss test lab at the University. This lab should support industry. Before doing so, the concept was to be tested in industry and it was obvious to do this at Philips Consumer Electronics.

PCE initially resisted the idea. It reminded them too much of their own testing lab, which was scrapped during the 'Centurion' reorganization because "it was not contributing to the business". This, as such, was true. However, this was not due to lack of interesting or challenging items in the findings of the Test Lab. It was due instead to the lack of communication with the product managers and with the development labs, the internal value chain issue, see chapter 5.1.

In view of the experience described above, it was difficult to sell the EPAss idea.

However, it was an opportunity which had already been demonstrated by the Delft students to have much wider implications than just 'green'. In practice it was a big difficulty. Who was prepared to take these ideas on board? Graduation students work almost for free, there is no risk, but even pointing to that did not take away their reluctance to try EPAss out.

Finally, Business Group Monitors in Chungli (Taiwan) agreed to do a test. On one hand this was due to credibility that had been built up earlier (see Tidbits, 11), on the other hand the fact that the business group was loosing ground to Sony and Samsung and needed a helping hand. This circumstance brought in a new element as well; not just benchmark (as EPAss did), but compare also with EPAss results of products from the competition.

Soon the student Geert-Jan was allowed to come over to Taiwan and carry out the project together with a local crew. He did a great job, converting the relatively formal EPAss approach into a more practical one. The results were transformed into design ideas through a brainstorm (see Tidbits, 12) in which the EcoDesign matrix (see chapter 6.4) was developed as well. In 1998 BG Monitors won the Philips Prize for the Best Environmental Product of the Year.

The results at Monitors meant that the other Business Groups became interested too. Several Delft students then got the opportunity to show their skills through environmental benchmarks. The Delft EPAss manual was transformed into a Philips Consumer Electronics focused environmental benchmark manual. It gained wide acceptance. In this way benchmarking became the cornerstone for PCE's EcoDesign activities. Moreover, it was used to select products for obtaining a Green Flagship status. These are products of which the environmental performance was significantly better than the ones of the competition – for 'significant' there are well defined (proprietary) criteria in all focal areas.

In terms of the methodology the core position of Environmental Benchmarking was a breakaway from traditional EcoDesign. Gone were design rules, no upfront LCA analysis and no specific EcoDesign-projects anymore. Both the link established between 'eco' and the traditional Product Creation Process and the use prioritized design options and thinking in physical quantities in 5 focal areas were new. A 'life cycle check' at the end of the Product Creation Process was kept in place. It is based on an Ecoindicator (abbreviated one-point score LCA) calculation. In this way LCA is being used for validation purposes rather than creativity purposes.

How did it all this work out in practice?

First of all benchmarking created tremendous awareness in the organization. It took two forms; "I never realized that" and "my competitor is better in...". Especially realizing that the competitor is better turned out to be very 'powerful'. In this way environmental issues are taken out of the charity for society domain (which even today at proactive companies is the perception of many employees) and moved into the business domain.

An important finding was that there are big differences in the properties that are measured - even for products (like Cathode Ray Tube based TVs), which are at the end of their learning curve. Indirectly this is an indication that in practice the designs of electronic products have more determinants than simple physical or economic rationale; design tradition and insufficient drive to update supplier bases seem to be very important as well.

With regards to improvement potential, experience suggests that no company scores best consistently in all departments. Products which rank number one overall score best in only some half of the individual parameters. The application section (chapter 6.4) will show that the combination of environmental benchmarking and brainstorms are very powerful tools to generate proposals for product improvement both inside and outside the environmental domain.

Casper Boks has made tremendous strides to bring together all the experiences with Environmental benchmarking and its applications into one document. The results of this effort are described in the publication *"Theory and Practice of Environmental Benchmarking for Consumer Electronics"*.

Theory and Practice of Environmental Benchmarking for Consumer Electronics

Casper Boks and Ab Stevels

Abstract

Environmental benchmarking has since 1997 been the basis of many EcoDesign related activities at both Delft University of Technology (DUT) and Philips Consumer Electronics in Eindhoven, The Netherlands. Cooperative efforts have led to a robust, reproducible and practical Environmental Benchmark method. The method is based on the assessment of the five focal areas Energy, Material & Weight, Packaging, Potentially toxic substances, and Recyclability. The generation and prioritisation of 'green' improvement options is done by addressing consumer and societal feasibility as well as technical and financial feasibility. Ongoing research continuously stimulates the methodology and practical implementation. This has created a tremendous awareness in the Philips Consumer Electronics organisation regarding product related environmental matters, because the method is embedded in an overall strategy that considers the interests of all internal and external stakeholders.

Keywords: *Environmental Benchmarking, EcoDesign, Feasibility analysis, Consumer Electronics*

1. Introduction

Since 1997, environmental benchmarking has been an ongoing activity at both the Delft University of Technology (DUT) and the Environmental Competence Centre (ECC) at Philips Consumer Electronics in Eindhoven, The Netherlands. Cooperation during this period has resulted in an Environmental Benchmarking Method that is robust, reproducible and practical to work with. Currently, environmental benchmark studies are carried out frequently at the ECC. The most recent work in cooperation with DUT involves the synthesis of results from individual benchmark studies.

This article provides an overview of the activities carried out since 1997. Commencing with some background on the motives for environmental benchmarking, it reports on the frameworks for environmental benchmark approaches that have been developed at DUT and the ECC. Thirdly, the practice of environmental benchmarking is shown. Also, it will be explained how the further elaboration and synthesis of benchmark results that are currently available can provide additional data. Finally, attention is given to Philips' view as regards the implementation of environmental benchmarking in a corporate (EcoDesign) strategy.

2. Background

In the early nineties, leading electronic companies started with EcoDesign (also referred to as Design for the Environment). Early activities were primarily defensive such as organizing compliance with upcoming legislation and regulation, making mandatory design rules and setting up an internal organization to ensure that such items are followed up. For electronics companies in Europe the issue of take-back and recycling of waste of electrical and electronical equipment (WEEE) in particular received an increasing amount of attention, providing the necessity for such actions. In many respects, the first initiatives that led to the German 1991 draft ordinance for recycling of WEEE can be seen as the starting point for the societal, technical, juridical and scientific debates about these issues (Stevels and Boks, 2000). Soon it was discovered however that 'green' offered far greater potential both for cost saving and for enhancing sales – and consisted of more than just end-of-life related issues. It was revealed that saving made on resources directly related to price reduction. Strong environmental performance was realized to be a good vehicle for enhancing brand image and sales. These notions initiated some important paradigm shifts for the EcoDesign activities at Philips Consumer Electronics (Eenhoorn and Stevels, 2000):

- It was found that focus should be on business aspects as well rather than just on technicalities;
- It was found that focus should be on those environmental parameters which can be influenced by the companies themselves -- rather than just the holistic perspective of Life Cycle Analysis;
- It was found that splitting into five focal areas was of the utmost importance to properly manage processes

with respect to EcoDesign. These areas are Energy, Materials application, Packaging and transport, Potentially harmful substances and Durability/Recyclability;
- It was found that in order to externally communicate these five focal areas, a language should be used which is understandable for customers and other audiences that are generally non-experts;
- It was found that market driven environmental performance means being better than the competition rather than scoring on an absolute scale, as most traditional environmental considerations do.

At the same time the Design for Sustainability Lab at Delft University was looking for ways and means to enhance creativity and idea generation for integrating environmental aspects into product design. Additionally they were looking to bring EcoDesign closer to the attention of the designer in general, and Industrial Design Engineering students in particular. Although some level of awareness was already in place – chiefly as a result of lists of environmental design rules and guidelines that had been set up based on earlier case studies (Brezet and van Hemel, 1997) – it was also found that such guidelines failed to deal with specific product characteristics and with priority setting, especially in a corporate environment. Environmental benchmarking was seen as the ideal link between creating awareness and design itself because a proper benchmark tells where current products stand thus creating a platform for discussions and brainstorms to determine where to go.
From the very beginning at the ECC and DUT tools have been in place that are aimed at fostering the progressing of knowledge and insight about environmental issues. For early benchmark-type initiatives, the then-called Environmental Weight Method was used at the ECC up until 1997 for determining environmental impact in combination with the End-of-Life Cost Model for assessing end-of-life costs (Brouwers and Stevels, 1995). The Environmental Weight Method consisted of criteria such as the number of wires to cut, the number of different packaging materials, the number of environmentally rejected and (temporarily) released components according to a company internal data registration system, as well as a few other criteria. For each product benchmarked its performance based on all criteria was reflected in a one-figure score, on the basis of which products (including those from competition) were compared and evaluated for improvement.
Simultaneously, at Delft University of Technology the need was felt to develop a structured method for the technical evaluation of products, specifically aimed at (but not limited to) environmental attributes. The need for comparing analysis results retrieved by different staff and students was a particular driver for this. In 1997, this resulted in the developments of the Environmental Product Assessment (EPAss) method (Jansen and Stevels, 1998). This method was comprised of six elementary steps, as indicated in Figure I.

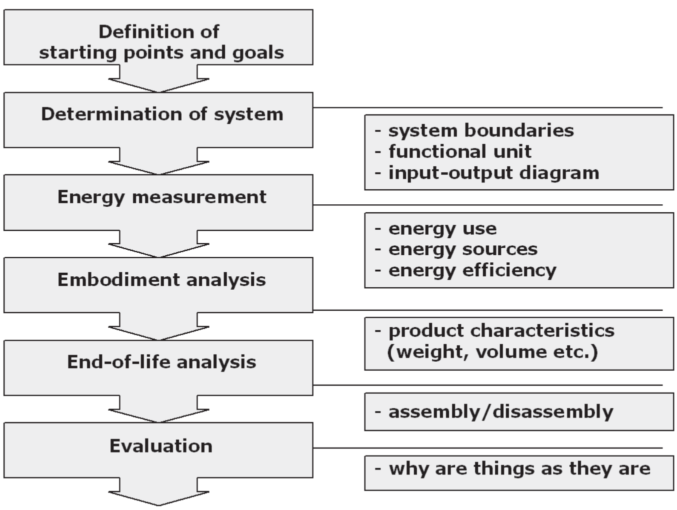


Figure 1 The EPAss method (1997)

The EPAss method in particular stressed the importance of the functional unit as the basis of each benchmark approach. Although by nature it was a method to evaluate products based on technical aspects in general, it provided the basis for the generation of 'green' improvement options and was as such used by several DUT graduate students during their final projects at several companies, including Philips CE.
At the ECC, one of those very students combined elements of the DUT EPAss method, the ECC Environmental Weight Method as well as scientific theories on benchmarking (e.g. Kotler, 1994) into the basis of what would become known as the Environmental Benchmark Method (see Figure 2). Fed continuously by practical experiences, the Environmental Benchmark Method grown to become by 2001 a robust, reproducible and practical method that has resulted in over 40 benchmark studies, and has been used as the basis for over 10 student graduation projects. In the next chapter the Environmental Benchmark Method in its current form will be explained in detail.

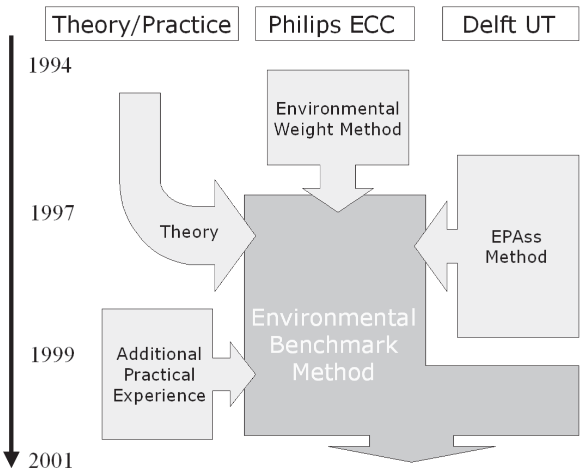


Figure 2 History of the Environmental Benchmark Method

3. Benchmark Theory and Methodology

The environmental benchmark method, as recorded in an official Philips document (Ram and Salemink, 1998), is laid out in the Environmental Benchmark flowchart as depicted in Figure 3. The method does not only comprise the benchmarking of products itself, but it positions this activity within an integral approach that facilitates the exploitation of the benchmark results. The flowchart explains that there are three main elements: the actual benchmark procedure itself, the link to EcoDesign and the exploitation of the results in the market.

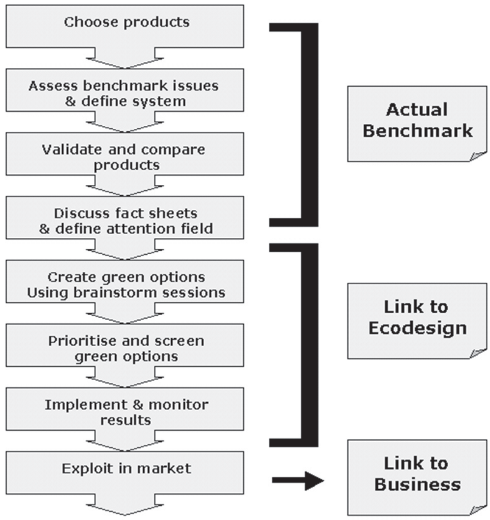


Figure 3 The Environmental Benchmark Method

3.1 The Actual Benchmark

The actual benchmark procedure consists of four elements: the choice of products, the system definition, comparing and validation of products, and the review of results.

Choice of products

The first element of the actual benchmark procedure is to decide on the products to be benchmarked. In the Philips context, one of the reasons to perform benchmark studies is the determination of so-called Green Flagships – the selection of Philips products that perform on environmental criteria better than competitors' products. The selection of the Philips product which potentially qualify as a Green Flagship is left up to the product management. This product is then compared with 3 to 4 competitors' products that are selected as follows: first of all, the best commercial competitor should be included. The additional products should preferably be chosen based on known or expected performance on environmental criteria. In addition, all products in the same benchmark study should display similar characteristics in the following areas:

- Functionality
- Commercial availability
- Price/performance ratio
- Size
- Product generation

Assess benchmark issues and define system

This step includes two elements. First, it is important to consider which are the important criteria to include in the benchmark. The five focal issues packaging, energy, materials, potentially toxic substances and recyclability are always included, but additional issues can be relevant as well for particular products or product groups. Environmental perception from the consumer market (including consumer test organisations) as well as legislative bodies should be considered an important indication for relevant issues. Secondly, these considerations are to be used in the definition of the system boundaries and functional units (which are for example required for the energy analysis).

Comparison and validation of products

In this step the actual comparison of products is done, according to the five focal areas and possibly additional criteria identified in the previous step. The analysis should include product characteristics as given in Table I.

Table 1 Issues to be checked in the Environmental Benchmark Method

FOCAL AREA	ISSUES CHECKED IN THE BENCHMARK PROCEDURE
Energy	• Consumer behaviour (usage scenarios) • Power consumption ◦ On-mode ◦ Stand-by mode(s) ◦ Off-mode • Battery and adapter applications • Alternative energy sources
Materials/Weight	• Per (sub)assembly ◦ Embodiment ◦ Picture tube (if present) ◦ Drives (if present) ◦ Electronics subassembly ◦ Electrical components ◦ Accessories ◦ Directions for use ◦ Remote control (if present) ◦ Functional parts (antenna, speakers) ◦ Wiring and connectors (mains cord etc.)
Packaging	• Packaging materials (documentation, box, buffer, bags) • Product weight and volume • Box volume • Number of materials • Presence of recycled cardboard
Potentially toxic substances	• Type of plastics and metals • Use of recycled materials • Presence of PVC • Chemical content ◦ Check for released components ◦ Check for banned components
Recyclability	• Plastics application ◦ Mono-materials ◦ Halogenated flame retardants ◦ Markings • Type of connections • Disassembly time for selected components • Check for valuable electronics • Material recycling efficiency • Processing yield

In addition to checking the five focal areas, it is recommended to use some LCA method for the validation of the environmental performance of the benchmarked product. At the ECC, this is always done. The main idea behind this is to include the life cycle perspective in the final assessment of the product, and also to enable the determination of its environmental feasibility, which is one of the steps preceding the prioritization of the 'green' (re)design options as explained below.

Review of results

In the Philips benchmark procedure, fact sheets are made on which of the measurements derived in the preceding step are compiled. From these fact sheets, per focal area all measurements for all benchmarked products can be seen at a glance, which makes them easily interpretable. In Chapter 4 examples are given of fact sheets that were derived for a VCR environmental benchmark.

3.2 The Link to EcoDesign

The second main part of the Environmental Benchmark Method comprises the creation, prioritisation and implementation of 'green' (re)design options.

Creation of 'green' options

Brainstorms and screening sessions are useful methods to create opportunities for environmental improvements. Two major sources exist for doing so:

- *Learn from competition*: experience tells us that in practice, no single product outscores – on all criteria – all other products against which it is benchmarked. This means that from benchmarking options for improvement can always be generated, based on design solutions found in competitors' products.
- *Smart technological alternatives*: these can include alternative plastics applications, alternative fixing solutions, alternative energy sources, alternative finishes, et cetera.

Prioritisation of 'green' options

Apart from environmental considerations, a multitude of other considerations are to be taken into account in product design. Whereas in the first instance the generation of improvement options should not be hampered by, financial restrictions for example, in the second instance the improvement options generated are to be assessed regarding their feasibility. For each option, at least the following aspects should be verified:

- *Environmental feasibility*: a (qualitative) assessment whether the improvement option indeed reduces the impact on the environment, also when the full life cycle is considered.
- *Consumer feasibility*: an assessment whether the consumer is likely to accept the option as a benefit to him or her.
- *Societal feasibility*: an assessment to what extent society as a whole will benefit from the proposed improvement.
- *Company feasibility*:
  - *Technical feasibility*: an assessment whether the improvement options are technically feasible in a way that timely implementation can be ensured.
  - *Financial feasibility*: because of the implementation of the improvement options no unwanted costs or investments should be incurred.

For each type of feasibility it is generally possible to indicate a score per improvement option. Depending on the weight factors that can be appointed to the various types of feasibility, an overall score can thus be derived. Based on these scores the improvement options can be ranked.

After improvement options have been generated, ranked and validated, the results of this process need to be deployed in the actual core business. In Chapter 7 this issue is further elaborated.

4. Benchmark Practice

In this article, the main purpose is not to supply extensive benchmark results, which is partly due to the proprietary nature of the data. Instead, selected results from one particular benchmark report (for VCRs) are shown to illustrate the practicalities of the method itself and how results are communicated to the readers of the benchmark reports. For this purpose, four out of eleven fact sheets are displayed below in which any reference to individual products and brand names have been altered. In the figure, it is shown how important differences can be visualized using tables, graphs and text.

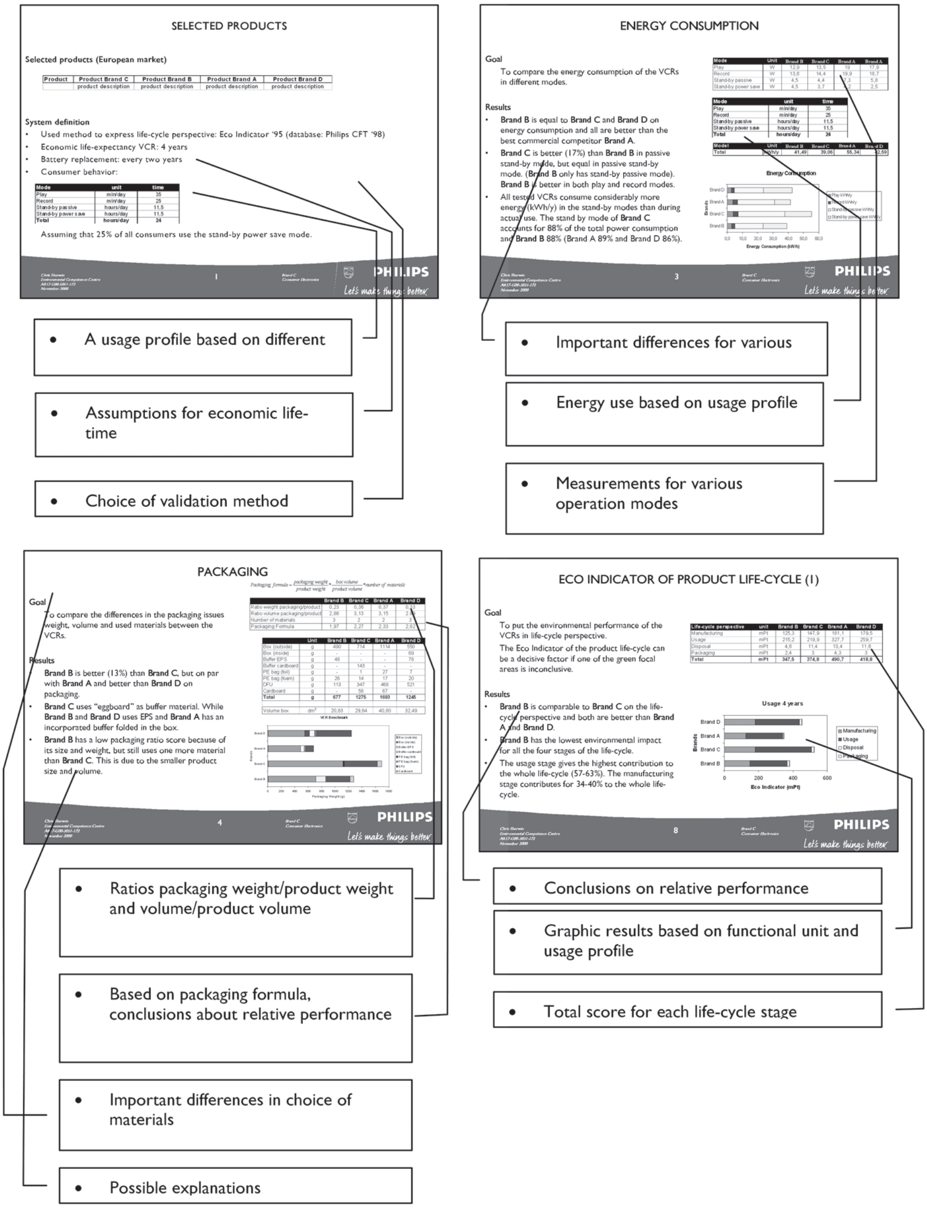


Figure 4 Examples of Environmental Benchmark fact sheets

5. Synthesis of benchmark studies

To date, about 40 environmental benchmarks have been performed and reported on at the Philips ECC (see Figure 5). Products covered in these benchmark reports cover most of the brown goods consumer electronics category, ranging from cellular phones to large 55" projection TVs, including audio sets, VCRs, CDRs, DVDs and a large range of TV sets and monitors. This has resulted in a large reservoir of information. Whereas the individual benchmark reports have contributed to product improvements, cost reductions and general environmental awareness through the organisation, it is believed that from combining data from individual benchmark reports additional data and pointers for improvement can be generated. This umbrella view would in theory provide information about the following items:

- Structural over- and/or underperformance in relation to competitor performance;
- The performance according to environmental characteristics of products over time;
- Opportunities for further exploitation of results for communication purposes (internal and external);
- The effects of, as well as the need for, (structural) design improvements;
- Priority setting for further research.

Figure 5 Philips Environmental Benchmark Reports

The large amount of available benchmark reports would make it possible, in theory, to obtain information about these items would for individual products, as well as per product category but in particular also across product categories. Starting in the summer of 2001, projects are underway to synthesize the available data. At this time these projects are focusing on packaging and energy issues in particular. In the following subparagraphs, this work in progress is reported on briefly. Although not yet part of an established procedure, it shows what type of additional information can be derived from synthesizing benchmark data. In the future, these approaches may be incorporated into the standard Environmental Benchmark procedure.
In addition, it also proved useful to extend existing benchmark datasets with data from consumer test organisations in order to increase the number of observations and to obtain even more meaningful results.

Correlation between benchmark variables
One possibility of synthesizing benchmark data is to investigate how the performance of the various benchmark variables is correlated, in particular those variables where distinct design efforts are focused but that are related to each other in practice. In this way, interesting results have been obtained by for example:

- Dividing product volume and packaging volume
- Dividing product weight and packaging volume
- Dividing TV screen size and energy consumption

The large number of benchmarks enables the derivation of what can be observed to be best practice in a certain field. At the same time, it also enables the identification of results for individual products that show a significant underperformance – results that otherwise might have remained unnoticed. For example, from Figure 6 (displaying the performance of Philips products next to those of the competition in terms of product volume /packaging volume) it was learned that for 7 out of 9 product categories Philips products score better than the competition, suggesting room for relative improvement for the remaining categories. Also in absolute terms conclusions can be drawn. From a similar graph for product weight/packaging weight it became clear that Philips portable CD players performed significantly better on this ratio than the competition. At the same time it became clear that this ratio was quite unfavourable for Philips DVD players, for no apparent reason. Results like these can be meaningful starting points for the further generation of 'green' options, in addition to those generated already by the established benchmark procedure as discussed in Chapter 3.

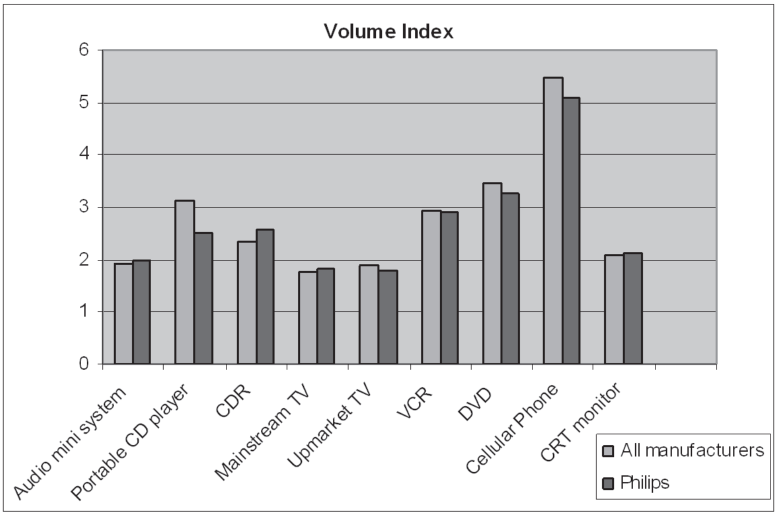


Figure 6 Correlation between product and packaging volume, based on multiple benchmarks

Trends

Another possibility is to trace trends related to particular benchmark issues, provided that sufficient benchmark data is available. For example, analysis has shown how power consumption data (in this case for audio sets) from various benchmarks over time have developed. Although those measurements appear to show a downward trend, it was also quite clear that there is a wide spread of measurements. Observations like these give rise to questions addressing correlations between functionality and energy consumption as well as the effectiveness of redesign efforts that have been made in the past.

6. Environmental benchmarking in relation to market research

In the form described in the previous chapters, environmental benchmarking is already a powerful tool on its own. However, an extended application is to combine the results from environmental benchmarking with market research data. In the benchmark procedure itself no distinction is made regarding importance across the five focal areas. Market research enables weighing a product's performance per focal area, and can thus form a basis for

- (Further) evaluating and prioritizing proposals for environmental design improvements
- Enabling the communication of benchmark results to the customer market.

On this topic, a number of research projects were carried out in cooperation with the Delft University of Technology (see also Stevels et al., 2001). The fundamental idea behind including market research data with environmental benchmark data is the notion that environmental issues are perceived differently among the relevant stakeholders in society. '*Customer green*' or *market driven 'green'* (what the customer perceives as important) differs from '*scientific green*' (for instance based on Life Cycle Analysis) and '*government green*' (what legislative bodies perceive as important). As an example, in Table 2 it is illustrated for audio products how the five focal areas are ranked (1= first priority, 5= lowest priority) according to the different perspectives.

Table 2 Environmental priorities from various perspectives

	Energy	Hazardous substances	Materials	Packaging	Recyclability
Customer	1	2	3	4	5
Trade (sales staff)	1	2	3	5	4
Science (LCA-based)	1	5	2	4	3
Government policies (EU)	3	1	5	4	2

The differences in perception create a dilemma for producers in terms of how to prioritize the 'green' improvement options derived from the environmental benchmarking procedure (as is done in "the link to EcoDesign"), and for product managers how to exploit them in the market. In order to deal with this dilemma a compromise can be made by weighing improvements having an affect on the various 'green' focal areas. In the case of the environmental benchmark of audio products, a total of 45 ideas for environmental improvement were generated during a brainstorm which were evaluated according to a weighing procedure and multiplied by their expected environmental impact. This resulted in a ranking of redesign priorities that were in the domain of energy consumption - in contrast to 'classical' EcoDesign solutions where much emphasis is put on material applications and recyclability issues.

7. The implementation of environmental benchmarking in a corporate EcoDesign strategy

Historical perspective

Before Environmental Benchmarking was developed into the powerful methodology it is today, environmental issues related to design were believed to be best introduced in organizations (design bureaus, industrial development) through projects with a specific focus on environmental issues (Stevels, 2001). In later years it turned out that the main weakness of this approach was in the follow-up - the projects were mostly carried out in relative isolation from the day-to-day business. After completion, project teams were disbanded and team members were dispensed in their organization - with little opportunity to disseminate the 'green' experiences and skills acquired in often very successful projects.

To ensure that environmental thinking and EcoDesign became more widespread within the projects of the Philips Consumer Electronics, an Environmental Design Manual was developed at the ECC. The general purpose of this manual was to achieve better environmental performance than for previous product generations, particularly by stimulating learning by doing. This Environmental Design Manual consisted of the following elements:

- Environmental Vision, policy and strategy
- Environmental organization
- How to deal with:
    - power consumption
    - materials application
    - environmentally relevant substances
    - packaging issues
    - end-of-life/recycling
- How to do environmental design evaluation

- Supplier, purchasing issues
- Manufacturing issues (use of chemicals)
- Customer information, working, labelling

Design manuals as environmental specialists of the organization usually write the one described above. The same people are generally in charge of implementation and development of tools to support these processes. However, the responsibility of releasing products to which the Environmental Design Manual refers, rests within business management. As a result, the link between environment and business was sometimes ill-interpreted, resulting in unsolved issues like environment being a boundary condition or a business opportunity, a technical or a strategic issue, or even a legislation or customer driven activity. It became clear that in order to make EcoDesign in industry a success, an additional translation step was a necessity in order to provide business management with the proper yardsticks to base their decisions on.

Current vision and implementation strategy

At Philips Consumer Electronics the insights sketched above resulted around 1998 in a new EcoDesign approach, in which environmental benchmarking has grown to be a fundamental cornerstone. This approach involves the following steps:

1. Fact-finding mission using environmental benchmarks
2. Creativity approach towards (environmental) performance improvement, based on benchmark results and brainstorms
3. Validation of environmental improvement options against scientific methods such as LCA or other methods
4. Feasibility checks against customer and societal benefits
5. Feasibility checks against physical and financial boundary conditions
6. Implementation in the product creation process

In this approach the first three steps, and in particular the order in which they were executed, were as novel as they were essential to ensure a proper translation from environmental facts into something that the business management was ready to understand, accept and implement. The fourth and fifth steps are based upon the prioritisation of 'green' options, as explained above in paragraph 3.2. By inclusion of appropriate feasibility checks – other than just environmentally related – the groundwork is done for further implementation in the product creation process. From Table 3 it becomes clear that environmental benchmarking, as it is described in this article, is the first essential element on which the remainder of the steps of the approach is based. The key to embedding the EcoDesign of products in the business is by linking the 'green' idea generation stage, in which the focus is exclusively on environment, into the standard product creation process. Assessing 'green' options for improvement in terms of company, customer and societal benefits and in terms of technical and financial feasibility, do this. A next crucial step is the transition from product creation to 'green' communication/sales. This is done by assessment of tangible benefits, intangible benefits, perceptions and emotions for the company, customers and other stakeholders in society. In relation to this issue, work has been done in cooperation with Stanford University to develop the Environmental Value Chain concept (Ishii and Stevels, 2000). In short, this concept entails the mapping of physical (= goods), money and information flows between stakeholders. In an environmental value chain the main stakeholders are suppliers, producers, customers and authorities. By making an issue correlation matrix, priorities given by involved parties to the various aspects of the system are ranked. By aligning the various flows and stakeholders, the success or failure of 'green' product development and environmental programs can be predicted. Current research at Philips Consumer Electronics and Delft University of Technology addresses the application of the Environmental Value Chain Concept to examples from industrial EcoDesign practice, both internal and external to the company.

8. Conclusions

In the present article it has been shown how an environmental benchmark procedure was developed in a cooperation between Delft University of Technology and Philips Consumer Electronics. The cooperation has resulted in an established, robust, reproducible and practical Environmental Benchmark Method that is frequently used. The many environmental benchmark reports that have been produced since have created a tremendous awareness in the Philips Consumer Electronics organisation regarding product related environmental matters. It is believed that the representation of results in terms of relative performance against the competition (instead of 'just' absolute figures) has been a major contribution to this.

At the same time, the method has been particularly helpful for many DUT students in preparing and finishing their graduation reports. The comments and suggestions for improvements made in these reports have often proved useful for product redesign, and have improved and added to the environmental benchmark procedure itself as well. Current work addresses opportunities for extending the method, in particular to incorporate lessons to be learned from the synthesis of benchmark data.

In addition, it has become clear how the actual gathering of benchmark data is not an isolated process, but is best embedded in an overall strategy. In this strategy, interests of stakeholders other than the company itself should be clearly addressed. Also within the company, issues other than environmental ones are important to consider for a successful implementation of environmental benchmarking in an EcoDesign strategy, and of the successful implementation of an EcoDesign strategy in an overall business strategy.

References

Brezet, J.C. and van Hemel, C.G. (1997). "Promise, a promising approach to sustainable production and consumption". UNEP, Paris, 1997. ISBN 92-807-1631-X

Brouwers, W.C.J., and Stevels, A.L.N. (1995). "Cost Model for the End-of-Life Stage of Electronic Goods for Consumers". Proceedings of the 1995 IEEE International Symposium on Electronics and the Environment, Orlando, Florida

Eenhoorn, G.J., Stevels, A. (2000). "Environmental Benchmarking of Computer Monitors". Proceedings of Electronics Goes Green conference, September 11-13, 2000, Berlin, Germany, pp. 743-748

Ishii, K., and Stevels, A., (2000). "Environmental Value Chain Analysis: A Tool for Product Definition in Eco Design". Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment, San Francisco, USA.

Jansen, A.J. and Stevels, A.L.N. (1998). "The E-Pass Method, a systematic approach for Environmental Product Assessment". Proceedings of CARE Innovation Conference, Vienna, Austria, November 1998

Kotler, P. (1994). "Marketing Management". Prentice Hall Inv. ISBN 0-13-098005-b,

Ram, B. and Salemink, S. (1998). "Environmental Benchmark Methods. Comparison of consumer products with competitors for determination of Green Flagship products". Philips Consumer Electronics Internal document code AB17-G98-5051-035/2, updated version, October 1998

Stevels, A. (2001). "Applied Ecodesign at Philips Consumer Electronics and Delft University of Technology: Ten years of Dynamic Developments". Delft Research Int. Magazine, 2001, to appear

Stevels, A., Agema, R., Hoedemaker, E. (2001). "Green Marketing of Consumer Electronics, II". Proceedings of Ecodesign 2001, December 12-15, Tokyo, Japan, to appear

Stevels, A., Boks, C. (2000). "Lessons learned from 10 years take-back and recycling". Proceedings of the 7th CIRP International Seminar on Life Cycle Engineering, November 27-29, 2000, Tokyo, Japan, pp. 30-37.

Cities, 9

San Francisco, sempervirens

If there are no clouds an aerial view of San Francisco is spectacular. It is an amazing city clamped between a big sea and a big bay which are split by the Golden Gate bridge. The city has a regular pattern of avenues and streets.
There is color, all over the place, like the green or yellow gold on the hills (depending on the season). The buildings seem to have colors too.
BART (Bay Area Railway Transport) is finally ready and brings you to town. It is a special one. Everything is nicely built, no dirty parking lots in between dilapidated buildings. The earthquake of 1905 has done thorough work. After the quake, a lot has been rebuilt in a consistent way. It is the nice architecture of the beginning of the century, 'American Jugendstil'. It is everywhere. It seduces you to walk, or take the tram, and enjoy the smell and the noise of its brakes and most of all the sound of its bell. You find yourself looking, looking and looking again.
Both the early morning and late evening have a hazy atmosphere so unique to San Francisco. In and of itself it makes the trip worthwhile.
In San Francisco several environmental conferences took place which were important to me. There is ISEE 1977, where I realized for the first time the necessity of the integration of EcoDesign into business. There is ISEE 2000 and 2002, where Stanford and Delft University presented their ideas about the value chain (chapter 5.1), recycling strategy (chapter 7.2) and environmentally weighted recycling quotes (QWERTY, see chapter 7.4). In 2006, the paper 'What went wrong with the implementation of WEEE in Europe' was presented in San Francisco as well; it had tremendous impact on both sides of the ocean.
And then there was the famous meeting in San Francisco of the Electronic Industry Alliance about a voluntary initiative on take back and recycling in the USA. Held behind closed doors, it was very sensitive. I explained the experiences in Europe and made a pitch for a collective system with an Advanced Recycling Fee with an opt out clause for those products which can be treated more cheaply individually. There was almost an agreement, but not a total agreement. It was not good enough. Due to lack of agreement the industry also lost the initiative in the USA, and will have to pay dearly for this in the future.
Anyway, San Francisco, is always alive, it is sempervirens!
City & Country walk: Do not walk, rent a bike at a place near the Cannery (Fisherman's Warf), Jefferson street around the corner of the cable-car-terminal. Bike along the shore (Fort Mason, Marina Green), Mason Street, Crissy Field, Long Avenue, Marina Drive, At Fort Point get up to the Golden Gate bridge.
Bike over the bridge and back to Long Avenue, go R to Lincoln Boulevard, L 25th Street, Right Clement Street, L&R Lobos Avenue to Cliff House. Go South, enter Golden Gate Park near the Windmill, follow the John F. Kennedy Drive (or alternatively the Martin Luther King Drive) all the way through the Park, go L and R to Fulton Street, L at Steiner Street, all the way (approx 1 mile), R Chestnut Street, Magnolia Street, left (Van Ness Street), R back to North Point.

6.3.3 Environmental Benchmarking and the soft side of EcoDesign

After some five years of implementation of Environmental Benchmarking in industry it was felt that the benchmarking method was ready for a make over. Particularly the results of applying it should be more successfully exploited. Until recently the focus has been a technical one with a clear link to product development.
In a recent study a link was made to a general framework in order to study environmental benchmarking from a socio-psychological perspective with the special goal to facilitate better acceptance of benchmarking results in the complete internal value chain (see also chapter 5.1). Factors to be considered were: 'Culture', 'Strategy', Structure, Technology, Goals and People. In the paper *"Environmental Benchmarking in the Electronics Industry: Integration in Business Processes for Design Improvement"* on next page the outcome has been described.
On the basis of this work the benchmark procedure has been reformulated in order to achieve a better fit with the organisation. It is a clear example that, apart from technicalities, the 'soft side of EcoDesign' (the terminology and a lot of trailblazing work in this field has been done by Casper Boks) plays a very important role.

Environmental Benchmarking in the Electronics Industry: Integration in Business Processes for Design Improvement

Frouke van den Berg, Casper Boks, Jaco Huisman, Ab Stevels

Abstract

The integration of environmental issues in mainstream business processes in the electronics industry is a process with ups and downs. In addition to known approaches to study this process, which are mainly of a technical and strategic nature, company cultural and people-oriented aspects have been usedto come to a more complete understanding on how
this integration process can or should be studied. A framework for analysis is proposed, introducing explaining factors taken from occupational and organizational psychology. A detailed case study, focusing on improving an established but suboptimal environmental benchmarking process in a major electronics firm, is reported on. It illustrates the benefits of the new research approach, when an increased attention for communication issues directly influences optimal goal-setting and operationalisation of the environmental benchmarking process. Based upon the results for the case study, the generic value of this new approach for studying the integration of environmental issues in mainstream business processes is discussed.

Keywords: *Environmental benchmarking, electronics industry, product design, ecodesign, environmental management*

1. Introduction

Environmental Benchmarking as a tool for environmental product improvement has gained an increasing amount of interest in the past years. It involves the systematic analysis of a company's own products in relation to competitor's products to stimulate creativity for finding, ranking and implementing feasible improvement options(Boks and Stevels, 2003). Since cooperation between Delft University of Technology and Philips Consumer Electronics in the mid-nineties resulted in a dedicated method for environmental benchmarking, it has also gained interest outside these institutions. Nowadays, the so-called EcoBenchmarking methodology features prominently in the second edition of the United Nations Environmental Programme EcoDesignManual, which is to be published by the end of 2005 (Boks and Diehl, 2005). Here, environmental benchmarking of products has been applied beyond the context of multinationals in the electronics industry, to include a wide range of product categories and a wide range of audiences, both in terms of industry type, size, and geographic location.

Meanwhile, environmental benchmarking research *within* the context of the electronics industry has continued at Delft University of Technology, in close cooperation with the Sustainability Centre at Philips CE. In recent years, research attention has expanded from a purely methodical approach, to include a focus on implementation, more or less given current methods and tools for incorporating environmental criteria in product development processes. In this context, research has been done based on two pillars. Firstly, it has been studied to what extent environmental benchmarking has indeed contributed to greening of Philips CE' product lines. Secondly, research has been done to better understand and address the so-called soft side of ecodesign. This relatively new research perspectives aims to investigate, more than is done traditionally in sustainable product design literature, the role of a number of 'sociopsychological factors' present in the internal value chain of a company that may obstruct or facilitate the acceptation of sustainability criteria in product development processes (Boks, 2006). This is done as one of several possible explanations why ecodesign implementation in recent years has not fulfilled its expectations; since the end of the 1990s, where it was still common to express optimism about opportunities for competitive advantage from ecodesign activities, researchers and practitioners have increasingly expressed dissatisfaction about the frequency, quality and speed of the process of implementation of DFE practices, particularly in the electronics industry.

Whereas in the late nineties the focus was on showing that products with improved environmental attributes could indeed be made at little or no extra costs, little evidence was created that such individually successful activities could deliver the promised competitive advantage when integrated in existing business. Evidence was mainly created in the form of prototypes and/or in niche markets; the lack of convincing evidence remains especially persistent in mainstream industrial business-to-consumer activities.

Although repercussions of economic recession undoubtedly contributed to this retrenchment of environmental optimism, the lack of demonstration that existing paradigms can successfully materialize in regular industrial activities should is likely the principal source of dissatisfaction. This observation is shared by fellow scholars like Tukker et al. (2001), stating 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...', and Baumann et al. (2002), stating that '...there has been a lot of talk of environmental product development, but relatively little change in practice...'.

In McAloone et al. (2002) it was pointed out that the academic community has produced great numbers of increasingly sophisticated modelling tools and methodologies, assessment techniques and design rules/guidelines over the past fifteen years, but that relatively little focus had been given to how ecodesign as a discipline ought to be implemented into industry – in particular: beyond the environmental departments, into product development, marketing and sales departments, and in fact, throughout the whole business. Although the importance of integration of ecodesign in an industrial context has since the 1990s always been stressed by most scholars active in this field (e.g. Brezet and Rocha (2001), Ehrenfeld and Lenox (1997), research so far has apparently not been able to explain why the integration of ecodesign activities into mainstream business processes has been cumbersome until now. The use of scientific disciplines like change management, organizational control, and occupational and organizational psychology to explain this lack of integration is so far virtually inexistent; the ecodesign research community is indeed persisting in focusing on the role of the designer and experts tools (e.g. Lindahl, 2005).

In the period between February and September 2005, in order to increase knowledge about the soft side of ecodesign, recently acquired insights such as reported in Boks (2006) have been used in a case study at Philips CE with the aim of incorporating these newly acquired insights back into methodological development of environmental benchmarking. Philips CE hires undergraduate trainees, graduates and research students on a continuous basis to evaluate and optimize the status of the environmental benchmark procedure. This is done to make sure that their environmental benchmark procedure remains a state of the art procedure, aimed at decreasing the environmental impact of all Philips CE's products. Furthermore Philips uses this opportunity to fulfil their social responsibility, by offering on-the-job training to undergraduates and PhD students and increasing the academic knowledge on environmental design in a company context. This paper reports the results of this case study.

In chapter 2, some background and explanation on environmental benchmarking in general and at Philips CE in particular will be provided, and will conclude with the present status of environmental benchmarking in that company. Using this background information, in chapter 3 the research question underlying this case study will be refined and further motivated. Chapter 4 discusses a theoretical framework for analysing areas of improvement of the current environmental benchmark practice, resulting in a recommended action path for adaptation of the methodology as well as for implementing the subsequent result.

2. Environmental Benchmarking

For reasons of clarity, in this chapter environmental benchmarking is first discussed in the context of Philips CE, after which Philips' practices are discussed in a scientific literature context.

2.1. Environmental benchmarking at philips consumer electronics

Environmental benchmarking of products has been systematically done at Philips CE since the mid- 1990s, when the so-called Environmental Benchmarking Method was developed in cooperation with Delft University of Technology (Boks and Stevels (2003)). Since the 1998 launch of the EcoVision corporate program within Philips, environmental benchmarking has also gradually been embedded in mainstream business activities. Today the environmental benchmarking serves mainly as a means to verify the presence of so-called Green Flagships in the Philips product line. These are Philips products that outperform their direct commercial competitors on the five environmental focal areas, which are energy, weight, packaging and transportation, potentially toxic substances and recyclability.

The results of environmental benchmarking are integrated in the Business Excellence Model which is used to evaluate business performance. This Business Excellence Model – initiated by the European Foundation for Quality Management (EFQM), and founded by amongst others British Telecom, Renault, Philips and KLM– is becoming an international standard of best practice performance (www.efqm.org). Through self-assessment, or third party assessment, this model is a practical tool to help organizations identify where they are on the path to excellence, helping them understand the gaps, and initiate systematic continuous improvement programmes and then monitor the areas that they want to improve.

The integration of environmental benchmarking in this Business Excellence Model has created one of few examples so far where a multinational has succeeded in structural integration of environmental performance criteria into mainstream business criteria. As such, environmental benchmarking has been successful in generating environmental improvements for numerous products, but has also provided eyeopeners for cost reductions and opportunities for innovation outside the environmental context. One of the first examples where environmental benchmarking as been successful this way has been reported by Eenhoorn and Stevels (2000).

Since the start of benchmarking at Philips CE over 100 benchmark studies have been performed, solely on a product level. The standard procedure involves the identification by a business division of a candidate product for benchmarking analysis, which is then carried out by the Sustainability Center. The Philips product is then benchmarked against its best commercial competitor and one or more other direct competitors. The environmental performance of these products is compared on five focal areas, namely energy, weight, packaging and transport, potentially toxic substances and recyclability. For each focal area standardized environmental indicators have been developed by which the products are judged. Each benchmark study results in a report which concludes whether or not the Philips product under evaluation can be named a "green flagship". For further explanation on Philips' environmental benchmarking procedure is referred to Boks and Stevels (2003).

2.2. The original environmental benchmarking procedure

The environmental benchmark procedure, as it was originally designed in cooperation with Delft University of Technology and Philips CE consists of different steps. In Figure 1 these steps are visualised and ranked on their level of green. First there is the actual benchmark, involving the choice of products to be benchmarked, taking measurements, and analyzing these. This part of the method addresses a relatively low level of environmental improvement, as environmental performance is measured only, and no action towards environmental improvement is taken yet.

In the second part of the procedure, the link to ecodesign is made. Suggestions for environmental product improvements (so-called green options) are generated and prioritised using the eco design matrix (Stevels, 2002). In this eco design matrix green options are compared and ranked on environmental, consumer, business and governmental benefits and technical and financial feasibility. The level of greenness' in this step is higher than in the previous step, because of the active search for green product improvements.

Finally the green options with the highest priority are implemented in the business and exploited on the market. This step has the highest possible level of green, because here environmental improvements are actually achieved.

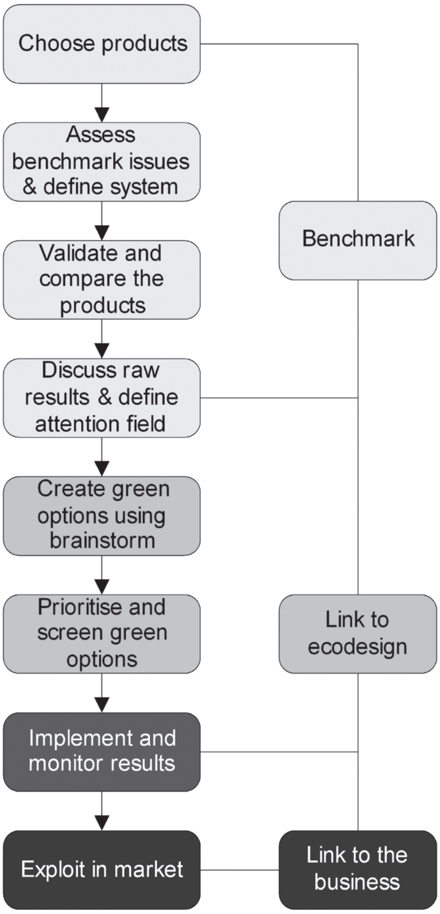


Figure 1 The flow chart of the original environmental benchmark procedure (Ram and Salemink, 1998)

3. Problem Formulation and Research Goal

Preliminary research has shown that in practice, the highest levels of green are in some cases not exploited to its full potential in practice. These steps concern the generation of green options and the implementation of these green options in the business. Hence, the suboptimal nature of these levels implies that the intent of the environmental benchmarking procedure is in practice not always served. This observation was the starting point for the research reported on in this paper. The research itself addressed the following research question: How can the environmental benchmarking procedure be improved in order to better serve the original goals, which is to facilitate the generation and implementation of environmental improvement options in Philips CE products.

As stated in the introduction, preliminary research at Delft University of Technology had addressed the socalled soft side of ecodesign, suggesting a number of 'socio-psychological factors' present in the internal value chain of a company that may obstruct or facilitate the acceptation of sustainability criteria in product development processes. As such factors had not previously been considered in the development and implementation of the environmental benchmarking procedure, the research was done based on the hypothesis that appropriate consideration of these 'soft side issues' would be beneficial to understanding the current suboptimal use of environmental benchmarking, and in a broader context, to better understand the role of environmental issues as (still) a relatively new phenomenon in mainstream business processes.

3.1. Research methodology

Chapter 4 discusses the theoretical framework used to analyse the situation sketched above. To this end, in section 4.1 a general framework has been constructed based on factors known from the field of occupational and organisational psychology. In sections 4.2 to 4.4, this framework has been made specific for analysing the environmental benchmark procedure at Philips, using specific knowledge and insight from ecodesign literature. In chapter 5, it is reported how this specific framework has been applied as a method within Philips. Results of this application will be discussed in chapter 6, and in chapter 7 conclusions are presented, both for the generic approach and the case study.

4. Towards a Framework for Analysis

With the research goal being the analysis of the current operationalisation of the environmental benchmark procedure with the aim of improving the likelihood of implementation of green design options in Philips CE products, a theoretic framework was required to start the analysis. Particular attention would have to be paid to the organisational setting in which the phenomenon to be studied was taking place. In order to determine a proper framework the problem had to be categorised in a more abstract way. It became clear that the environmental benchmark procedure matches the definition of an organizational change process and can best be studied with a contingency approach. This contingency approach is deducted from the general contingency theory (Morgan, 1986). This approach can be described in three statements (Morgan, 1986):

- "Organisations are open systems that need to be studied carefully to satisfy, balance and adapt internal needs to the conditions of its environment".
- "There is not one optimal way of organising. The most appropriate way depends on the nature of the task or its environment".
- "The management needs to create tailored solutions. Different types of management may be necessary to perform various tasks within the same organisation, but other types of organisation are needed in another environment".

It can be concluded from above statements that each company and situation in a company is unique and needs a tailored solution. However, general theoretic frameworks can be used to create this tailored solution (Morgan, 1986).

Based on the contingency approach the following method could be created, see Figure 2. In light grey all steps needed to come to a tailored method are represented. In dark grey the application of the tailored method was explained.

The steps mentioned in this flow chart will be elaborated in more detail in the subsequent sections. Each step is represented in one section. The methodology steps will be described in chapter 4 and the application steps will be described in chapter 5.

4.1. The general framework

From the field of occupational and organisational psychology an appropriatemodel was chosen for creating the required framework to come to a tailored approach for this case study. This model was based on the contingency approach and is called 'the octahedron model' (Van der Vlist, 1981). In this model the six important factors in analysing a change process are visualised together with a description of the relation between the factors. This description of the six factors will be used as theoretical framework, the suggested relations between them will not be included in the theoretic framework. The description of the six factors was provided by Allegro and Van Breukelen et al. (2000) in the sixth version of the Leiden Organisation Checklist.

Figure 2 Research methodology for creating a tailored method to study the environmental benchmark procedure

These factors are:

- Culture can be defined as a combination of values, beliefs, expressions and behaviours that also determine how people within an organisation deal with each other and to what extend they put energy in their work and the organisation.
- Strategy can be defined as the decisions made on the way targets can be met by deploying people and means, taking into account the demands from its environment.
- Structure can be defined as the internal differentiation and mutual relations between departments and organisation units.
- Technology can be seen as a combination of technical facilities, the machinery, work procedures and work methods. But also procedures like purchase- and sale procedures, or procedures and tools related to human resource management are part of technology.
- The organisational goal is to be regarded as a set of primary tasks of an organisation in society (producing products, offering employment options)
- People are individuals and groups within the organisation (number, education, capacities, motivation and tasks)

With this general theoretic framework in mind a tailored step-by-step approach was created to analyse the environmental benchmark procedure at Philips CE. In order to generate this approach a quick scan of the case study was needed. In this quick scan several assumptions regarding the definitions of the factors were made that highly influence the way of approaching the problem. After creating the approach specific for this case study, the case study was analysed in depth using the tailored approach.

4.2. The specific framework

First a short introduction to the case study situation will be given. In this case study the environmental benchmark procedure can be seen in two parts. Firstly, there is the benchmarking itself which aims at defining the benchmark criteria, measuring, comparing and finding best practices. Secondly, there is the analysis of best practices in the product design processes in the industry.

The first part of the benchmark procedure was studied at the Sustainability Center of Philips CE in Eindhoven. The second part was studied at one part of one of the three Philips CE' Business Groups involved in the environmental benchmark procedure, the Business Line of Upmarket Flat Displays in Brugge, Belgium. In this case study the approach was used to come to a series of guidelines and boundary conditions for optimising the environmental benchmark procedure at Philips CE. In the subsequent subparagraphs the application of the step-by-step approach will be explained.

In this quick scan the factors of the octahedron model are discussed specifically for this case study.

- Culture: In this case study culture will be defined as company culture. The company culture of the sustainability centre and the business line will be assessed individually, in order to identify any significant differences in culture between the two departments.
- Strategy: In this case study the strategy on the issue of environmental responsibility, as described by the Philips Corporate Sustainability Office will be described. This will be done to verify if the strategy is in line with the environmental action programme found in practice.
- Structure: In the case study structure was defined as the internal value chain and the flows between the different players in this value chain. Describing the internal flows facilitates the identification of common and conflicting interests within the internal value chain.
- Technology: In this case study technology was defined as all procedures related to the environmental benchmark procedure both at the Sustainability Center and at the business line.
- Organisational goal: In this case study the primary task of Philips CE will be considered.
- People: In this case study the capacity and motivation of people at the sustainability centre and the business line, directly related to the environmental benchmark procedure will be considered.

4.3. Verification of the specific framework

To verify whether the specific framework covers all relevant factors, a literature study revealed one particular case study quite similar to the present case study. In previous literature success factors for applied ecodesign at Philips CE were determined (Cramer and Stevels, 2001). In this project, these factors were used to verify whether the current list of factors is complete. The factors found by Cramer and Stevels are described in Table 1. For each factor it is verified whether it is in the specific description of the octahedron model or not.

Table 1 Factors influencing the implementation of applied ecodesign

Factors (Cramer and Stevels, 2001)	Matching factors in octahedron model
1. Internal factors	Strategy
Management attention	Organisational goal
Environmental skills	People
Cross-functional linkages	Structure
Eco-efficiency activities already in place	Technology
Personnel motivation	People
2. Business conditions	
Profitability	Organisational goal
Market share	Organisational goal
3. External influences	
Customer pressure	Not in yet, Structure
Legislation	Not in yet, Structure
4. Room to manoeuvre	
Product functionality	Not in yet, Technology
Product alternatives	Not in yet, Technology
5. Competitive edge	
Competitive environmental benchmarking done?	Not in yet, Structure
Is competition active?	Not in yet, Structure

From the above analysis, it was concluded that external influences, room to manoeuvre and competitive edge should be added to the list of factors resulting from the octahedron model, to complete it. Furthermore the culture component was not considered as an important success factor by Cramer and Stevels, whereas in the octahedron model this is an important factor. Previous research by van Hemmen (2005) on the influence of culture on change processes, indicated that this factor is very important for the success of a change process. Given the fact that it is not known yet whether this factor will be important or not in this case, it will be included in the approach used for this case study.

4.4. Creation of tailored method to analyse factors

The factors, as described for the case study in the previous step, need to be analysed. For some steps a tailored method was needed, for other steps a qualitative description of the factor was sufficient to analyse that factor (see Table 2). In this section the composition of these methods will be described. First a general overview of all factors and its general approach (tailored method of general description) will be provided.
The results of this search for tailored methods will now be described in more detail for each factor.

Culture

In describing the company culture two important directions can be distinguished. In the first direction culture is seen as something a company has and in the second direction culture is seen as something a company is. The first implies that culture can be changed, the second implies that culture must be seen as a boundary condition and cannot be changed (Hofstede, 1991; Van Muijen, 1992). In this case study the second direction will be assumed to be true, because eventual changes as a result of this optimisation process will take place long after this case study. As a result this influence of the optimisation process on the company culture is not within the scope of this case study.

Table 2 The general approach for each factor

Six factors	General approach
Culture	In order to describe the culture an existing model was used in a new way.
Strategy	Strategy was described qualitatively, without tailored method.
Structure	A stakeholders' analysis (inspired on an existing stakeholders' analysis method) was used to analyse the structure of both the internal and external valuen chain.
Technology	The benchmark and resulting environmental design process were analysed with the help of two descriptive evolutionary process models.
Organisational goal	The organisational goal was described qualitatively.
People	The human capacity was described qualitatively.

In the case study of Van Hemmen (2005) on the relation between company culture and change processes, the company culture model of the Focus group was described as a way to analyse the company culture. In this case study this model will be used as well to qualitatively describe the company culture of both departments. In this model four dimensions are described to measure company culture. These dimensions are visualised in Figure 3.

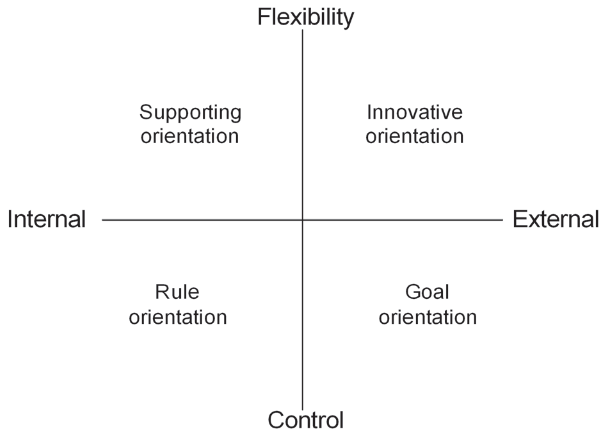


Figure 3 The company model of the Focus group (Van Hemmen, 2005)

The four orientations can be considered as dimensions. This means that every company has elements of all orientations in its company culture (Van Hemmen, 2005). In his case study Van Hemmen uses a validated questionnaire to assess the scores of the company on the four dimensions. Based on Van Hemmen's description the four orientations can be summarised as follows:

- Supporting orientation: An informal culture aimed at cooperation and mutual growth.
- Innovative orientation: An informal culture aimed at individual development and innovation.
- Rule orientation: A rule-oriented culture aimed at rational procedures. The culture is hierarchical.
- Goal orientation: A culture aimed at realising targets in a rational and well-thought way.

Given the fact that in this case study more factors need to be analysed than just company culture the dimensions were described in a shorter, qualitative way, based on discussions with all people involved at the Sustainability Center and at the business line.

Strategy

The environmental strategy of the company will be described qualitatively.

Structure

A stakeholders' analysis is used to describe the main players and flows both in the internal and external value chain. In this stakeholders approach, theory on environmental value chain analysis (Rose and Stevels, 2000) is used to describe the different common and conflicting interests of stakeholders both internal and external.

Technology

In this factor the room to manoeuvre is defined qualitatively. Furthermore the two relevant processes: environmental benchmarking and the implementation of ecodesign are assessed as follows.

Preliminary research revealed that both the benchmarking process and the resulting actual application of ecodesign should be seen as evolutionary processes.

In this first step the primary goal is to put the environmental benchmark procedure in larger context to be able to position current Philips activities and forecast the future steps in the evolutionary cycle.

Two models resulting from previous research studies are used to describe the evolutionary process of environmental benchmarking at Philips CE. Both evolutionary processes can be summarised in two main characteristics:

- All phases should be run successively, no phases should be skipped.
- The higher the level, the more effective and efficient the process. The goal is to reach the highest phase. To describe the benchmarking evolution the model of Watson (1993) is used, see Figure 4.

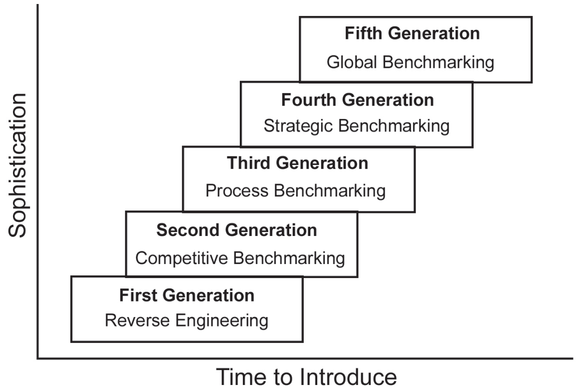


Figure 4 Evolutionary process of benchmarking (Watson, 1993)

To describe the evolutionary process of the company culture needed to enable applied ecodesign (resulting from the environmental benchmark procedure) the evolutionary model of safety culture is used. In this model the cultural values and beliefs (expressed in trust and informedness) within the company is linked to the company's performance (not the management strategies, but the actual implementation) on safety aspects. According to Hudson five general phases can be distinguished for the safety culture, see Figure 5. In this paper these phases are translated for the situation of applied ecodesign.

- The pathological phase: The company does not see environmental design as an issue.
- The reactive phase: The company considers environmental design as important, but reacts in a defensive way.
- The calculative phase: The company has a system to address environmental problems structurally. This system is applied in a rather mechanical way. As a result the system is not used to its full potential.
- The pro-active phase: The company starts to act in a pro-active way on environmental design. People start to become convinced of the importance of environmental aspects.
- The generative phase: People are convinced of the importance of environmental aspects and no system is needed anymore to deal with ecodesign.

With the help of these models the current position of the benchmark procedure and the current level of applied ecodesign resulting from it can be described and a rough indication of the next step in evolution can be discussed.

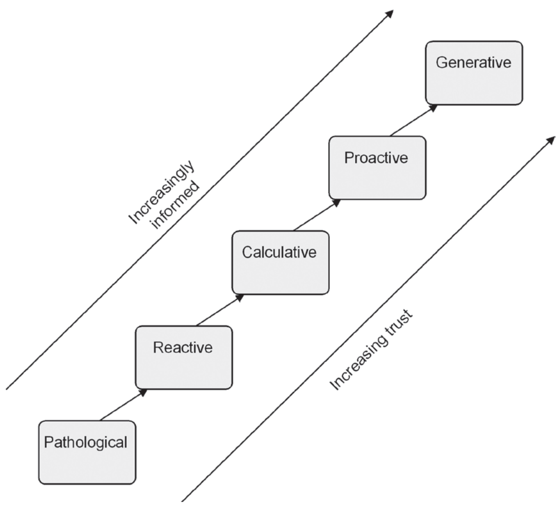


Figure 5 The evolutionary model of Safety Culture (Hudson, 2001)

In finding the right evolutionary step it is important to find the right balance in level of progression. If a next evolutionary step is too progressive people will become discouraged, because they will never succeed in making such a big leap forward at once. Besides too big leaps forward will harm the continuity of the current processes. If the evolutionary step is too small simply nothing will change.
With the help of these two models also the size of the gap between the environmental strategy and the environmental actions in practice can be monitored. Within each multinational there is a difference between the talking (strategy) and walking (actions). This is because strategy aims to set targets for the future, whereas the current actions aim to solve problems in the present (which is often far more difficult). However procedures like the environmental benchmark procedure can be used in a positive way to minimise this gap.

Organisational goal
The organisational goal will be described qualitatively. This will be done to check if the benchmark procedure is in line with the organisation goal of the company.

People
The issues related to the people, number, educational level, capacity and tasks will be described qualitatively.

4.5. Conclusion
In this chapter, all tailored methods have been described for each of the six factors. It turned out that especially the factors of culture, structure and technology were difficult to measure and needed a tailored method to guide the analysis process.
In the next step results from the application of this tailored approach in the Philips case study will be summarised.

5. Application of the Tailored Method
In this chapter it will be described how the application of the methods was performed in practice. For reasons of company confidentiality only some of the results can be used to illustrate the application of the method. The goal of this chapter however is not to describe the current environmental benchmark procedure of Philips in full detail, but to describe how such a problem can be tackled in practice. Though lots of descriptive models are available in literature, very few prescriptive and relevant approaches and methods could be found for this case study.

5.1. The tailored method in practice
In this section the application of the method in practice is explained in more detail.

Culture
The four dimensions of Van Hemmen were used to qualitatively describe the company culture within the internal value chain. In order to do this it is necessary to visit the departments personally. Only if you have been part of the culture you can describe the cultural dimensions for each department qualitatively without time-consuming validated questionnaires. In this case study it turned out that the Sustainability Center and the case study Business Line could best be used in this analysis. This is because the first part of the benchmark procedure had to be performed at the Sustainability Center, whereas the second part had to be performed at the Business Line by the product designers.
Though the dimensions itself can not be changed it turned out to be useful to adapt the environmental benchmark procedure to the differences in cultural dimensions. In this case it became clear that the benchmark part (the product measuring) needed to fit in other cultural dimensions than the environmental design part of the procedure (the creation of green options and the implementation in the business). Several differences in company culture were identified between the two Philips departments with the help of the company culture model.
In order to illustrate the usefulness of the model one example of an important difference will be provided. This

was the difference in scores on rule orientation and goal orientation. The Sustainability Center scored higher on rule orientation and the business line scored higher on goal orientation. Whereas the Sustainability Center focused on performing the fixed procedures in the best possible way, the focus of the Business Line was more on redesigning the product in the most environmentally friendly and profitable way.

Strategy

In this factor the current environmental strategy was described qualitatively. This description is used later on in the evolutionary process models to analyse the gap between the environmental talking and walking. In the case of Philips CE the part of the current environmental strategy relevant to the environmental benchmark procedure could be found. Philips CE wants to be on par or better than her best commercial competitors on all green focal areas. These green focal areas are: energy, packaging, weight, hazardous substances and recyclability.

Structure

In this factor the groups of players and relations in the internal and external value chain were analysed in a stakeholder analysis. Furthermore the influence of the environmental activeness of competitors was evaluated and the influence of this factor on the environmental design within Philips CE. The stakeholders in the environmental benchmark procedure can be split up into people in the internal value chain and people in the external value. Furthermore it turned out to be useful to divide the internal value chain on several levels as well. In this case the internal value chain was split into three levels, Philips corporate, Sustainability Center and the Business Line. For all levels the flows (money, product and different types of information flows) were visualised. An example of such a flow chart of the external value chain is shown in Figure 6.

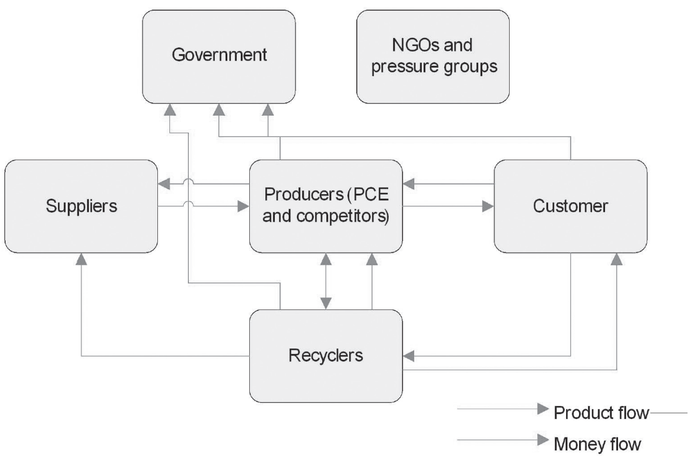


Figure 6 Overview of the main stakeholders and flows in the external value chain

The same thing was done for the internal value chain containing all stakeholders within Philips CE. In both value chains several conflicts in interest can be traced between the different stakeholders. Mainly due to these conflicting interests the creation of green options and the implementation of green options in the product design process are facilitated or obstructed. In the stakeholder analysis both the common and conflicting interests were all described and ranked on relative importance.

For the external value chain the following main conflicting interests could be found, using the stakeholder analysis. Firstly there is the difference in perception of green between the consumers and the government. Secondly there seemed to be a gap between what can be seen as environmentally friendly from a scientific point of view and the previous two perceptions of green.

This ranking is based on money, product and information flows. In general it can be concluded that the more money is involved, the higher the priority of the conflicting interest.
It is difficult to evaluate how active competitors are on environmental design, because of lack of opportunities to verify what they are actually doing in practice. However there are some indications of their environmental performance that will be described next.
The level of green activeness of the competitors was evaluated based on the amount of their green marketing actions. Furthermore their environmental awards and labels were benchmarked against the environmental awards and labels Philips has. This information is used in discussion with environmental policy experts within Philips to verify the level of influence of the competitors green involvement on Philips' green involvement.

Technology
In this factor both the room to manoeuvre in the production design process and the processes related to the environmental benchmark procedure were assessed.
Both the benchmarking part and the applied ecodesign part can be seen as part of a larger evolutionary process within Philips CE. With the help of the two evolutionary process models the environmental benchmark procedure and the environmental design process could be assessed.
First both models were used to sketch the historical evolution of both processes within Philips. Second the models were used to indicate the difference between the strategy on environmental design and the environmental benchmark procedure and the action programme that was performed in practice.
Based on this analysis the desired next step in evolution for the environmental action programme could be determined. In this step the gap between the strategy and the actual practice is minimised. The environmental benchmark procedure could be used to minimise this gap. This led to design guidelines for the environmental benchmark procedure. In section 5.2 examples of these guidelines will be provided.
Organisational goal
The primary organisational goal of Philips as a whole will be described. Furthermore the specific organisational goals of the Sustainability Center and Upmarket Flat Displays of Philips CE and the primary goal of benchmarking in general were described. The environmental benchmark procedure should fulfil all these goals.
It became clear that the overall organizational goal of Philips CE and the department of Upmarket Flat Displays was making profit, whereas the primary goal of Sustainability Center was more on improving the environmental performance of the CE products.
Under the factor of structure this information was used to verify if these goals are all met in the environmental benchmark procedure.

People
In this step only the capacity of people directly involved in the environmental benchmark procedure (the employees of the Sustainability Center and Philips Upmarket Flat displays) was analysed. Factors that influenced the environmental benchmark procedure turned out to be:
- The amount of full time employees available for performing the environmental benchmark procedure.
- The level of product/benchmark experience of the people
- The continuity of people: how long did they work in the environmental benchmark procedure on average?

Describing these factors led to important guidelines for optimizing the environmental benchmark procedure, which will be discussed in section 5.2.

5.2. Design guidelines and improvement options
All the information gathered in the analysis of the six factors was used to create design guidelines for the new environmental benchmark procedure. No specific information on the content of these design guidelines will be described in this paper, for reasons of company confidentiality. But it will be described which aspects of the environmental benchmark procedure were found that could benefit from optimization.

These factors turned out to be:
- The environmental benchmark criteria
- The environmental benchmark goal and steps
- The internal awareness on the benefits of the environmental benchmark procedure
- The incentive of the designers to involve in the process of environmental benchmarking
- The green marketing of the environmental benchmark results
- The usability of the environmental benchmark procedure

For each of these factors design guidelines were generated based on the analysis. These design guidelines were discussed with experts in the different fields and improvement options were generated by the people of the Sustainability Center and the Business Line. These solutions were discussed with some key stakeholders, at different levels of the internal and external value chain. Based on this discussion and the gap analysis resulting from the two evolutionary models, one redesign action programme for the environmental benchmark procedure was designed. This action programme was in the format of a roadmap, describing step-by-step what actions should be taken first and providing suggestions for the capacity that was needed to do this.

6. Conclusions

In this chapter the effectiveness of the followed approach in this case study will be evaluated and the general value of this approach will be discussed.

6.1. Effectiveness of method in this case study

In this case study the approach was effective in providing solutions to optimise the environmental benchmark procedure. In general it can be said that a lot of insights were gained and that Philips was happy with the pragmatic results of this analysis. The results aimed at aligning environmental benchmarking and design further in the organisation. It turned out that there is always a tension in the company between making profit and decreasing the environmental impact of the products. But some useful common interests could be identified and implemented in the environmental benchmark procedure.

Furthermore Delft University of Technology gained more insight in how these problems can be analysed in a systematic way. In this case study it was not only explored how the current situation could be described, but also how to come to a prescription of redesign steps based on this description.

6.2. Generic value of method

Though the tailored methods used in this case study will have to be redesigned specifically for every new situation, the general framework has a large general value. Furthermore some lessons could be learned from this specific case that may be interesting for similar case studies as well. These lessons will be described next:
- Visualising the evolutionary process is a good thing to do, because this forces you to look at both historical successes and future possibilities. In larger companies there are often a lot of historical developments that should be carefully evaluated to avoid reinventing the wheel.
- The stakeholders' analysis turned out to be a good and motivating way to set priorities and obtain a clear image of the situation. Especially the money flows between the different stakeholders are easy to visualise and give valuable information.
- The assessment of the company culture still needs more research. This is an extremely important issue in the success of proposed changes. It would be helpful to find a way to quantitatively describe this soft side of process changes.
- Though an external person is very suitable for identifying points of optimisation, people from the business are needed to create recommendations. This has two major advantages: The people improve their own process to certain extent, which will increase the acceptation of the propose changes. And the people have a lot of implicit business knowledge that external people don't have. This knowledge is essential for redesigning a process.

- It must be said however that this approach cannot be followed rigidly without subtly changing the method all the time to reach optimal analysis results. The generic value of this approach is more in showing possibilities to analyse complex situations, like a stakeholders' analysis, and a description of the evolutionary processes, rather than prescribing rigid ways of approaching these problems.

6.3. Final conclusions

It was found that the contingency approach was very suitable in the present case study, because it does not rigidly prescribe a method, but accepts the fact that a more dynamic way is needed to analyse processes in depth. It was also found that concrete solutions for optimising processes like the environmental benchmark procedure should always be created in cooperation with people from the business. In that light, the present study has significantly contributed to the existing knowledge base on what was earlier referred to as the soft side of ecodesign. Understanding how ecodesign can be implemented and operationalized given existing culture, strategies, structures, technologies, organisational goals and people, and given external influences, room to manoeuvre and competitive edge, starts with the ability to understand these factors and to establish their relationship with ecodesign processes. Future research at Delft University of Technology will aim at extending the current knowledge base by combining theoretical insights from adjacent disciplines with practical case study work.

References

Allegro, J., Breukelen, W. van et al., 2003, " the Leiden organisation Checklist." Leiden University, Leiden, the Netherlands.

Baumann, H., Boons, F., Bragd, A., 2002, Mapping the green product development field: engineering, policy and business perspectives. Journal of Cleaner Production 10 (2002) 409-425

Boks, C. and Diehl, J.C., 2005, "EcoBenchmarking for All", proceedings of Ecodesign 2005: Fourth International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, Japan, December 12-14, 2005

Boks, C., 2006, "The Soft Side of Ecodesign", accepted for publication in the Journal of Cleaner Production, article in press, available on-line.

Boks, C. and Stevels, A., 2003, "Theory and Practice of Environmental Benchmarking for Consumer Electronics", Benchmarking - an International Journal, Vol. 10, No. 2, pp. 120-135

van Breukelen, Q. H., Koolhaas, C.B., Kumpe, T., 2000, "Benchmarken van industri¨ele processen", Van Gorcum, Assen, The Netherlands

Brezet, H. and C. Rocha,, 2001, Towards aModel for Product-Oriented Environmental Man-agement Systems, in Sustainable Solutions, M. Charter and U. Tischner, Editors, Greenleaf Publishing: Sheffield, UK, (2001)

Christiansen, James A., 2000, "Competitive innovation management, techniques to improve innovation performance." St. Martin's press New York, USA.

Cramer, J., Stevels, A., 2001, "The unpredictable Process of implementing Eco-efficiency Strategies." In: Charter, Martin and Ursulat Tischner, eds. *Sustianable Solutions*. Greenleaf Publishing: 327. London, England.

Ehrenfeld, J.R. and M.J. Lenox, 1997, The Development and Implementation of DfE Programmes, The Journal of Sustainable Product Design., (1): p. 17-27

Hemmen, A.P.J. van, 2005, "Cultuur en Techniek. de invloed van bedrijfscultuur op het succes van automatiseringsprojecten." Erasmus University, Rottterdam, The Netherlands.

Hofstede, G., 1991 "Allemaal andersdenkenden; omgaan met cultuurverschillen." Contact, Amsterdam, The Netherlands.

Hudson PTW., 2001, "Safety management and safety culture: the long, hard and winding road". In: Pearse W, Gallagher C, Bluff L, eds. *Occupational health and safety management systems*. Crown Content, Melbourne, Australia.

Ishii, K., Stevels, A., 2000, "Environmental Value chain Analysis: A Tool for Product Definition in Eco Design." 2000 IEEE International Symposium on Electronics and the Environment, San Francisco, CA, USA.

Lindahl, M., 2005, Engineering Designers' Requirements on Design for Environment Methods and Tools, Doctoral thesis, Industrial Engineering and Management, Stockholm, Sweden: KTH,

McAloone, T., Bey, N., Boks, C., Ernzer, M., Wimmer, W., 2002, Towards The Actual Implementation of Ecodesign in Industry - The Haves and Needs viewed by the European Ecodesign Community, Proceedings of CARE Innovation 2002, November 25-28, 2002, Vienna, Austria

Morgan, G., 1986, "Images of organisation." Sage publications. London, England.
Muijen, JJ v. et al., 1992, "Focus op Analysis: organisatiecultuur." Academic service, Amsterdam, the Netherlands.
Pesonen H-L., 2000, "Environmentalmanagement of value chains: promoting life-cycle thinking in industrial networks." Green Management International 33: 45-58.
Ram, B. and Salemink, S., 1998, "Environmental Benchmark Methods. Comparison of consumer products with competitors for determination of Green Flagship products". Philips Consumer Electronics Internal document code AB17- G98-5051-035/2, updated version, October 1998
Rose, C. M., Stevels, A., 2000, "Applying Environmental Value Chain Analysis to Product Take- Back Systems," Electronics Goes Green, Berlin, Germany.
Stevels, A., 2002, "Integration of Ecodesign in Business", Mechanical Life Cycle Handbook, Hundal, M.S. (ed.), Marcel Dekker, Inc., New York, pp. 583-603
Tukker, A., Eder, P., Charter, M., Haag, E., Vercalsteren, A., Wiedmann, T., 2001, "Eco-design: The State of Implementation in Europe", The Journal of Sustainable Product Design, Vol. 1:147-161
Velden, R. van de, 2003, "Using Awareness in Product Design to Influence Sustainable Behaviour." Norwegian University of Science and Technology, Trondheim, Norway.
Vlist, v.d. R., 1981, "De dynamiek van sociale systemen: de bijdrage van de sociale psychologie aan de veranderkunde." Samson, Alphen aan de Rijn, The Netherlands
Watson, G.H. ,1993, Strategic Benchmarking; How to rate your company's performance against the world's best, John Wiley & Sons, New York.

Pictures, 9

Roxburgh, Selkirk and Peebles, sheep, green and electronics

6.4 Applications of Environmental Benchmarking

Since its inception, environmental benchmarking has been applied to far more than 100 consumer electronic products. It has been used at Philips Consumer Electronics for EcoDesign improvement, for product strategy making and for the selection of outstanding Green Flagship products (see chapter 4.4). A lot of that work is proprietary and therefore cannot be discussed in this book.
However, a paper with the title *"Environmental Benchmarking of Computer Monitors"* is presented on page 359. Although the paper was written in 2000 it represents very well what can be achieved through the completion of an Environmental Benchmark (The work is based on the very first benchmark done in Taiwan in 1997- see also 6.3 - and therefore refers to products from 10 years ago, see the figure below).
Apart from focusing on single products, combining data from a series of benchmarks can be used to derive conclusions for product categories (which ones are part of a general product line). Additionally this data can help to monitor developments as a function of time and identify structural (under) performance with respect to competitors. This 'multiple benchmarking' will facilitate communication between departments (better management of the internal value chain – product manufacturing, strategic developments, marketing and sales).

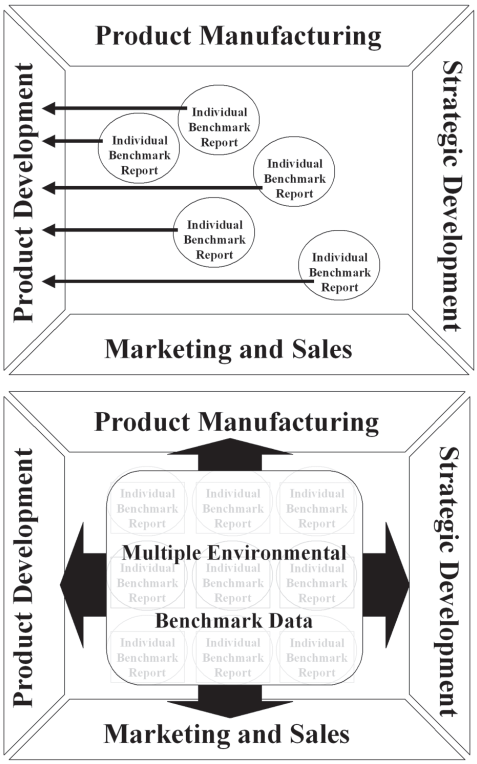


Figure 6.3 Process improvements in the internal environmental value chain through application of multiple benchmarking.

This figure shows that initial reporting from environmental benchmarking was almost exclusively directed towards product development (left hand side). Multiple environmental data sets facilitate the involvement of other departments (right hand side of figure 6.3).
The large number of benchmark reports available at Philips make it possible to obtain information about environmental issues, not only for individual products, but also per product category particularly across product categories. Starting in the summer of 2001, projects on packaging and energy issues were initiated to synthesize the available data. These are briefly reported on in this paragraph. Although not yet part of

an established procedure, it shows what type of additional information can be derived from synthesizing benchmark data. In the future, these approaches may be incorporated in the standard Environmental Benchmark procedure. In addition, it also proved useful to extend existing benchmark datasets with data from consumer test organisations in order to increase the number of observations and to obtain even more meaningful results.

One possibility of synthesizing benchmark data is to investigate how the performance of the various benchmark variables is correlated. Of particular interest are those variables on which distinct design efforts are focused but that are related to each other in practice. In this way, interesting results have been obtained by calculating indexes for variables such as product volume and packaging volume, product weight and packaging volume, TV screen size and energy consumption et cetera. The large number of benchmarks enables the derivation of what can be observed to be best practice for these indexes in a certain field. At the same time, it also enables the identification of results for individual products that significantly under perform – results that otherwise might have remained unnoticed. For example, from Figure 6.4 (displaying the performance of Philips products next to those of the competition in terms of product volume/packaging volume) it was learned that for 7 out of 9 product categories Philips products score better than the competition, suggesting room for relative improvement for the remaining categories.

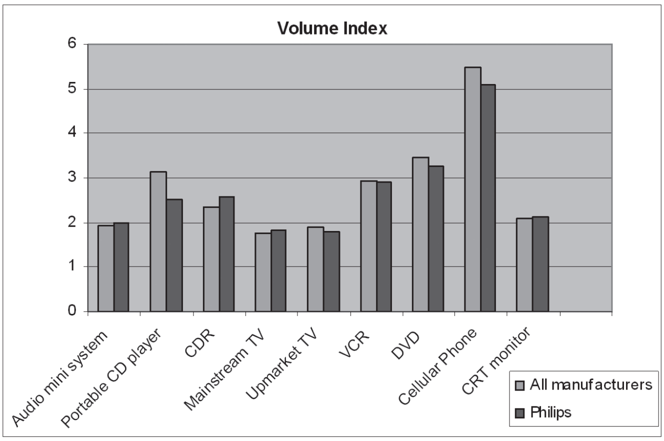


Figure 6.4 Correlation between product and packaging volume, based on multiple benchmarks

Also, in absolute terms conclusions can be drawn. From a similar graph for product weight/packaging weight it became clear that Philips portable CD players performed significantly better on this ratio than the competition. At the same time it became clear that this ratio was quite unfavourable for Philips DVD players, for no apparent reason. The results of this analysis can be meaningful starting points for further generation of 'green' options, in addition to those already generated by the established benchmark procedure as discussed in Chapter 6.3

Another possibility is to trace trends related to particular benchmark issues, provided that sufficient benchmark data is available. For example, analysis has shown how power consumption data (in this case for audio sets) have developed from various benchmarks over time. Although those measurements appear to show a downward trend, it was also quite clear that there is quite a spread in the results. Observations like these give rise to questions addressing correlations between functionality and energy consumption.

Environmental Benchmarking of Computer Monitors

Geert-Jan Eenhoorn and Ab Stevels

Abstract

The environmental benchmarking procedure, as developed by the Design for Sustainability Lab of Delft University of Technology has been applied to high-end monitor products of Philips BG Monitors of Chungli, Taiwan. The method has turned out to be a robust one in industrial practice. The results of the benchmark have created tremendous awareness in the organization and have prompted action to improve products. On a longer time scale the benchmarking results have formed the basis of an environmental brainstorm for new product generation. As a result of those brainstorms 'green' options have been incorporated in the specification of new products. This new product generation became the winner of the Philips best Environmental Product Award in 1998 and is a huge success in the market.

Introduction

In the early nineties, leading electronic companies started with EcoDesign (Design for the Environment). Early activities were primarily defensive, that is organizing compliance with upcoming legislation and regulation, making mandatory design rules and setting up an internal organization to ensure that such items are enacted. Soon it was discovered however that 'green' offered a far bigger potential both for cost savings and for enhancing sales. Saving on resources turned out to be directly related to price reduction. Strong environmental performance was realized to be a good vehicle to enhance brand image and sales. From these perspectives some important paradigm shifts took place in the Royal Philips Electronics EcoDesign activities:

- Focus should be on business aspects rather than just on technicalities.
- Focus should be on those environmental parameters which can be influenced by the companies itself (the 'internal' parameters rather than the holistic perspective of Life Cycle Analysis (internal + external)
- In order to communicate to the external world five focal areas in 'green' should be addressed in language which is understandable for customers and other audiences which generally are non experts. These areas are: Energy, Materials application, Packaging and transport, Environmentally relevant substances and Durability/Recyclability.
- Life Cycle calculations should take place to avoid suboptimalization in one particular focal area and to communicate the expert audiences.
- Market driven environmental performance means being better than the competition rather than scoring on an absolute scale.

At the same time the Design for Sustainability Lab at Delft University was looking for ways and means to bring EcoDesign (DfE) closer to the attention of the designer and industrial design engineering students.

The question of how to enhance creativity and idea generation in particular was addressed. Simultaneously it was realized that although at that time a lot of so called environmental design rules existed, they failed to deal with specific product characteristics and with priority setting. Environmental benchmarking was seen to be the ideal link between creating awareness (what is this all about?) and design itself (how to realize it?) because a proper benchmark communicates where current products stand, thus creating a platform for discussions and brainstorms focused on how to go forward.

In 1996-1997 the Monitors Division of Philips Consumer Electronics located in Chungli, Taiwan felt particular challenges. The business was strongly expanding, and highly successful in terms of revenue, market share and profit. It was felt however that product designs were gradually lagging behind and management was looking for a new impetus for strengthening the product line up, particularly in the high-end, high margin products. In view of this it was decided to commission an environmental benchmark project under the umbrella of the Delft University of Technology/DfS Lab – Philips Consumer Electronics cooperation.

In this project – which is explained in the present paper – the goal was to drastically improve, from both an ecological and economic perspective, the design of 17" monitors, taking the Philips 107A/CM88 product as a reference. DfS lab carried out the benchmark, thus enabling it to test the concept of the method and its applicability. The result, including first redesign proposals, were agreed upon to be used as the core of brainstorm in Taiwan

for the development of the next generation of computer monitor products.
In the present paper, benchmarking in general is considered in §2. In §3, environmental benchmarking is elaborated on. Results of the benchmark of the 107A/CM88 monitor and those of three competitors product are presented in §4. In paragraph 5 it is shown how these results have been used to indicate product improvement and feed into the standard Product Creation Process.

Benchmarking

The definition of benchmarking used in this paper is the one used by Kotler (see ref. 1) "Benchmarking" is the art of finding out how and why some companies can perform tasks better than other companies". This definition is broader than what most people using the term mean by it. In general when talking about benchmarking people refer to a process in which products are compared to similar products of direct competition: competitor analysis. In this way insight is obtained in the relative position of the company with respect to its competition. This insight in then used to improve product performance.
According to Kotler the basis is wider. Benchmarking should go beyond investigating the level of the competition and create the basis for insights how to be better than that. The following steps are to be taken in such an approach:
1. Determine which aspects and properties are to be benchmarked (system definition).
2. Identify key performance variables to measure.
3. Identify and position the most important competitors in the market
4. Measure your own performance as well as competitors.
5. Specify programs and actions to close the gap or even to surpass competitors.
6. Implement and monitor results. On the basis of these principles the DfS Group at Delft University has defined its approach for environmental benchmarking (see ref. 2 and 3).

Environmental benchmarking of monitors

For the environmental benchmark, 17" monitors with similar technical specifications were chosen: the Philips product to be improved, 2 products from Japan of which one was selling very well in the market and one originating from Korea. As a functional unit the monitor (including its packaging and user manual) was chosen. For the life cycle a period of 5 years before discarding was taken. In order to calculate total energy consumption and energy costs associated with that, a user scenario was assumed including a number of hours in full use, standby, shut off and complete off mode. Costs for the disposal of packaging were calculated on the basis of the so called DSD tariffs in Germany (the highest in the world). End of Life disassembly times and overall end of life costs were calculated on the basis of Philips proprietary calculations programs.
For the measurement of the product performance the following focal areas were distinguished:
<u>1. Energy</u>
Energy consumption in: operational mode
standby mode
sleeping mode
off mode
Energy cost in the 5 years use scenario.
<u>2. Material application</u>
Weight of plastics applied
Cost of plastics applied
Weight of ferro applications
Weight of non ferro applications
Weight of CRT.
<u>3. Packaging</u>
Card board weight of box
Weight of EPS buffers

Weight of plastic bags etc.
Weight of manual/user book
Cost of packaging recycling. According to DSD tariffs.
4. Chemical Content
Presence of flame retardants in housing
Area of printed wiring boards
Weight of printed wiring boards
Number of printed wiring boards
Length of cable and wiring.
5. Recylability
Calculated disassembly time
Calculated cost/yield with respect to reference disposal cost (mix of landfill and incineration).
6. Life cycle performance
Ecoindicator score (see ref. 3) of production phase.
Ecoindicator score over the whole life cycle.

4.1 Results from the environmental benchmark

Energy

The results from the environmental benchmark for energy can be summarized in the following table:

Table 1 Environmental benchmark of energy consumption

Items	Philips	Competitor 1	Competitor 2	Competitor 3
Operational mode (W)	78	82	81	77
Standby mode (W)	4	10	12	11
Sleeping mode (W)	1	4	3	1
Off mode (W)	1	4	1	0
Energy cost (USD) (European tauffs)	94	122	97	87

The energy consumption differences in the operational mode are very limited (less than 7%). However, in terms of cost this means a difference of 35 USD, corresponding to 30-40% on a relative scale.
This is due to high amounts of energy consumption in standby, sleeping and the modes of competitors 1 and 2; Philips is doing relatively well with respect to the best competitor.

4.2 Materials application

The results for the environmental benchmark for materials application can be summarized in the following table:

Table 2 Environmental benchmark of materials application.

Item	Philips	Competitor 1	Competitor 2	Competitor 3
Weight of plastics applied (g)	4597	3283	3123	3592
Costs of plastics applied (USD)	16,0	6,0	5.5	8.0
Weight of ferro (g)	2303	840	452	757
Weight of aluminium (g)	348	606	404	1698
Weight of CRT (g)	9200	10600	9400	9200

These results show that for Philips there was plenty of room for improvement in terms of plastic application in the housing; both weight and price/kg were far too high with respect to the competition. Also the amount of ferro was very high because the metal electromagnetic shield had not yet adapted to the development of modern electronics (note that competitor 1 and 3 use also aluminum for EM shielding). On the other hand Philips has thermal management of these products well under control; the amount of aluminum used for this purpose is relatively low. In the field of CRT weight one producer is stepping out in terms of weight due to different tube concept (tri nitron).

4.3 Packaging

The results of the environmental benchmark for packaging can be summarized in the following table:

Table 3 Environmental benchmark of packaging

Item	Philips	Competitor 1	Competitor 2	Competitor 3
Cardboard for weight of box (g)	2590	2468	2768	2645
Weight of EPS buffers (g)	576	705	430	411
Weight of plastic bagd etc. (g)	55	47	69	47
Weight of manual / user book (g)	282	106	214	180
Cost of packaging recycling according to DSD tar offs (DM)	260	300	250	250
Ratio packaging weight/product weight	0.17	0.18	0.19	0.17

The packaging results show the biggest differences in the way EPS buffers are applied; this also has impact on the cost of recycling of the packaging in Germany because tariffs for plastic based materials are high. None of the producers had replaced EPS by cardboard. This would result in halving the recycling cost to approx DM 1.10 - 1.30. Also the user manuals have strongly diverging paper weight differences, varying by almost up to a factor of 3.

4.4 Chemical Content

The results of a chemical content analysis and of A benchmark of materials applications which are strongly related to chemical content issues are as follows:

Table 4 Environmental benchmark of chemical content.

Item	Philips	Competitor 1	Competitor 2	Competitor 3
Presence of flame retardants in housing	No	Yes	Yes	Yes
Area of PWBs (dm^2)	15.5	9.8	12.5	12.0
Weight of PWBs (g)	2800	2300	2050	2250
Number of PWBS (g)	6	2	7	5
Length of cable/wiring	4000	2200	2800	2070
Number of components	1300	850	1100	800

With the exception of Philips, which has a flame retardant free housing, all other manufacturers are using brominated flame retardant housing materials, to which antimony oxide Sb_203 is added. This represents a serious environmental load and will also hamper recycling of housing components.

Regarding electronics and components competitor 1 achieves the best score; due to a high level of electronic integration, area, weight and low numbers of PWBs. In particular for Philips there is a vast improvement potential. This also applies for the reduction of cables, wiring and the number of components applied.

4.5 Recyclability

The results from the recycling benchmark are summarized in the table below:

Table 5 Results of recycling benchmark.

Item	Philips	Competitor 1	Competitor 2	Competitor 3
Calculate disassembly time (S)	750	470	580	480
Calculated cost/yield (with USD respect to reference disposal)	-1.2	+2.1	-1.4	+3.1

Due to its complex construction the heavy EM shield the disassembly time for the Philips monitor is long and receives a negative value in comparison with the reference scenario.

4.6 Life cycle impact

Ecoindicator calculations showed the following results:

Table 6 Ecoindicator calculations.

Item	Philips	Competitor 1	Competitor 2	Competitor 3
Ecoindicator of production phase (mPt)	575	756	599	541
Ecoindicator of user phase (mPt)	437	357	369	387
Life cycle score	1085	1161	1015	984

The Ecoindicator calculations show clearly that the user phase is the most important part (53-65%) of the total life cycle impact. This means that the Philips product still scores relatively well in spite of its improvement potential, as shown in the tables 2, 4 and 5. For competitor 1 the opposite holds; a good score for the production phase is reversed in by an unfavourable performance in the user phase.

5 Follow-up of the benchmark

When the results of the benchmark were communicated to the organization, they provided a positive shock. It was realized that the competitor was substantially better in several focal areas like material application, chemical content, wiring and disassembly. It was decided therefore not to wait until the creation of the next generation of products but to make an improved version on the basis of the present concept. Due to the lack of time not all proposed improvement options proposed by the DfS lab could be implemented in the short term. An "emergency" program in June 1997 brought the performance of Philips Monitors closer to the competitor.
Results are summarized in the table below:

Table 7 Product characteristics of Philips monitors after the benchmark.

Item	Philips old	Philips adapted	Best competitors performance	DfS proposals	New generation (increased specification)
Energy life cost (USD)	94	91	87	85	80
Plastic materials cost (USD)	16	10	5.5	7	8
Metal Environmental Impact (mPt)	54	32	23	28	19
Aluminium environmental impact (mPt)	13	13	15	12	13
Total packaging weight	3563	3470	3283	3810	3120
Area of PWB (dm²)	15.6	14.3	9.8	13.5*	11.0
Number of PWB	6	3	2	2	2
Length of cable/wiring (cm)	4000	2270	2070	1925	1900
Number of components	1300	1250	800	900*	800
Item	**Philips old**	**Philips adapted**	**Best competitors performance**	**DfS proposals**	**New generation (increased specification)**
Calculated disassembly time	750	570	470	440	350
Production Ecoindicator score (mPt)	575	439	357	388	375
Life cycle indicators score (mPt)	1085	934	984	846	838

*Further improvement dependent on availability of a new IC generation.

This table evidences that the adapted version of the Philips 17" monitor is gaining on the best competitor (and in many respects, to other competitors). This particularly holds in the areas of energy, life cycle cost, metal environmental impact, number of PWBs, length of cable and wiring, calculated disassembly time and production Ecoindicator score. Plastic material weight/cost, printed PWB area and component count still lag behind due for various reasons such as increased usage of plastics as a result of the elimination of flame retardants and the lack of a new IC generation. However, due to the fact that the overall best score is not coming from one competitor but is a mix of several ones, the overall environmental score of the adapted Philips product is already the best (approx. 5%).
The best overall score would be even better if all DfS proposals had been taken into account; this would have increased the gap with the competition to around 15% with further potential ahead if a new IC would be available (see fourth column of table 7).
Across the board improvements would take place because the proposals refer to all focal areas as are substantiated in the following table:

Table 8 Number of benchmark suggestions for improvement.

Focal area	Number of (DfS) benchmark suggestions for improvement
Energy	6
Materials application	16
Packaging/transport	3
Chemical Content	8
Recyclability	9

After the product adaptation it was decided that the remaining suggestions of table 8 (approximately half of the total) would be used as the basis for a brainstorm on the basics of a new product concept to be held in September 1997.
It turned out however that the functionality requirements on 17" monitors had to be increased in order to be successful in the market. In particular, the scanning range had to be expanded by some 5-10%, resolution was upped by some 5% and brightness had to be increased by some 15%. This meant that the outstanding proposals could not be implemented straight-away.
Parallel to this development procedures for doing brainstorms and incorporating strategic environmental intent were put in place (see refs 4 and 5). This meant that the outstanding options were combined with newly generated 'green' options into one consolidated list.
In the brainstorm of September 9, 1997, a consolidated list of some 25-30 'green' options were generated, out of which 13 were selected on the basis of the so called EcoDesign matrix. Which analysis combined environmental, company, customer and societal benefit (see ref) In the last quarter feasibility of the 13 selected options were investigated further with the result that 8 of them were incorporated in the product concept complication in January 1998. In view of the large amount of concurrent engineering being done in 1997 the Product Creation Process in itself was very fast and the new product could be launched in May, 1998. The result of this development was excellent. The properties of the new generation surpassed – in sight of tightening the specification – the properties of the best competitors in almost all departments. Life cycle impact exceeded even the best score by 16%. (see last column of table 7).
This result gained wide recognition internally because the product was the winner of the Philips best EcoDesign award in 1988. Later on the product became a huge success in the market both in terms of numbers sold and in terms of margin.

7. Conclusions

The present paper shows that environmental benchmarking results in a tremendous increase in awareness within the organization, particularly because it focuses on comparing performance with that of the competition rather than focussing on absolute environmental score. Simultaneously it is instrumental in generating straight forward and completely environmental improvement options which are analysed in terms of environmental, business, customer and societal benefits. Environmental benchmarking has turned out to be a solid basis for creating source material for environmental brainstorming. These sessions have resulted in monitor designs which were superior to those of the competition and could be marketed as such.

From an academic perspective the Philips monitor case shows that the methodology developed at Delft University of Technology proved – with some minor adaptations – robust in industrial application.

8. References

1. P. Kotler, Marketing Management Prentice Hall Inv. ISBN 0-13-098005-b, 1994.

2. A.J. Jansen and A.L.N. Stevels, the EPass Method, a Systematic Approach for Environmental Product Assessment, Proc., CARE Innovation 1998, p313-320, Vienna, Nov. 1998.

3. A.J. Jansen, Environmental Product Assessment, Delft University of Technology internal report. Available on request from the authors.

4. J.M. Cramer and A.L.N. Stevels. Strategic Environmental Product Planning within Philips Consumer Electronics, J. Environmental Quality Management, p91-102 (1997).

5. A.L.N. Stevels, Integration of EcoDesign into the business, to be published in the Mechanical Life Cycle handbook; Good environmental Design and Manufacturing. M.S. Hundal, editor, J.W. Wiley publishers.

Highlights of the year, 2002

Roadmap, performance

It was 2002 when the integration of EcoDesign into product creation processes started to be well established in proactive companies. What this means is that the full range of EcoDesign actions are being considered. This ranges from defensive actions (for instance chemical content), cost reduction actions (less material, packaging, simpler product architecture) to proactive activities like radical redesign and product alternatives. Environmental benchmarking is the basis for contributing to the formulation of appropriate 'green' requirements for future product generations (see chapter 6.3). The EcoDesign matrix (see chapter 4.2.1) helps to set prioritized action agenda's.

Having achieved all this all this on a product level, a follow up step is to plan on a wider time horizon. Where do we want to go in the mid and long term? What actions have to be taken (for instance in the supply chain) to realize the technical targets and what has to be done to better communicate the results to customers and other stakeholders?

As of 1997, the first attempts were made to create roadmaps – that is tables with objectives (for instance reduce X across the whole product range), numerical targets (%), a timeframe (for instance to be realized in Z years time) and specific people responsible for doing the work.

Gradually, more items were included in the roadmap beyond the technical ones (strategy, communication, education, progress in corporate environmental programs). In 2002 roadmaps were considered to be fully developed and mature. As a consequence environmental roadmaps were broadly introduced in Philips Consumer Electronics. As a next step, a performance measurement was linked to the roadmaps through the so-called traffic light system, green (target reached), yellow (target not completely reached) and red (target far away).

Through a weighting scheme for the different items a 'balanced score card' can be developed. In turn, the balance score can be used for determining individual incentives as bonuses. At PCE this environmental roadmap score is being used as part of the performance measurement of senior executives. Its contribution to the total score is relatively modest but the good news is that it exists in practice, every senior executive is monitored on basis of it.

6.5 EcoDesign tools, new style

6.5.1 Introduction

In this chapter ideas are presented for EcoDesign tools, new style. It includes three items:

- A proposal for how to link the emissions, the resources and the potential toxicity dimensions, keeping in mind that apart from 'scientific green' there is 'government green' and 'customer green' as well (see chapter 6.1).
- Introducing environmental load and environmental value ratios (see also chapter 2.3)
- Introducing environmental 'bookkeeping' methods similar to the ones used in the financial world.

All three have the status of ideas. In view of time and budget pressures none of these ideas could be studied in very much detail. I feel unhappy with that. In order to move Applied EcoDesign forward, we have to dig deeper into such subjects. Unfortunately, this type of fundamental research will not be sponsored by industry. Attracting money from the university is possible at Delft in theory, but not in practice (see chapter 10.2). Gaining support from Science Foundations is difficult because the EcoDesign field is still perceived as a set of engineering tricks rather than real science. This is partly correct; Applied EcoDesign is surely not a 'discipline'; there are no set rules or commonly agreed conventions yet. I sincerely hope that in the end a breakthrough in this financing stalemate will happen. The subjects deserve it!

Tidbits, 10

Sandra made it!

It was an interesting subject: decrease the energy consumption of an electrically heated grill. Several students applied for it, including Sandra. She was not bothered either by the technical difficulty nor by the cultural risk – the project was to be carried out in Gelsenkirchen, Germany, in a very traditional 'male dominated' company. German would be the language of communication as well. Few Dutch students today speak this language fluently.

Sandra stated that she had finished more difficult jobs before. In order to make some money she had worked as a luggage handler at Schiphol Airport, a typically physical, male type occupation. I was convinced, she got the assignment.

There she went to conquer the world, starting with Gelsenkirchen. Her special appearance: showy clothes, short skirt, and piercings, was not the traditional idea of a female student in technology, at least not in traditional industry. Soon, people at the factory stopped working when Sandra walked in. In the canteen she was gazed at and her Dutch directness surprised many.

Her results were great. Soon she could demonstrate that the excessive energy consumption of the product was not due to lack of insulation. Instead, it was due to bad positioning of the grill elements, wrongly designed heat cycles, an energy guzzling internal lamp and an old fashioned time clock. In fact it was the same story as conveyed in different forms in this book: revisit decisions of the past, address the application perspective better, and exploit enablers (modern technology, supply chain).

The director of the organization called me, not to congratulate me on the success of my student, but to complain about the upheaval Sandra caused in the organization with her appearance. He asked whether I would be so kind as to correct this. The guy had a point. I had a problem, how to convey the message? Students have their own responsibility in such matters and have to learn it the hard way if necessary.

Sandra did not deserve that. I talked to her – not in my official capacity.

'If you are a guest somewhere, please adapt to the 'culture' of your host without giving up your identity – there are however various ways to express your identity, please change.'

Sandra made it. Sandra made it with high marks!

6.5.2 Linking the three dimensions of 'green'

In order link the three dimensions of 'green' (emissions, resources and potential toxicity), see also 6.1 the following formula is proposed for products:

Environmental impact = A × B × energy consumption over the lifecycle + C × D × weight of the product concerned + E × F × weight of electronics boards and flame retardant plastics.

In this formula, energy is to be expressed in kWh; this parameter includes the production phase, (including production of components, subassemblies, transportation, the user phase and the end of life phase). Since for the majority of electronic products the energy consumption in the user phase is dominant, evaluating this phase exclusively will suffice in many cases.

The weight of the product is a very crude representation of resource consumption. Material which will be recycled in the future can be deducted from the amount; the weight of packaging materials can be added. The resource term can be made more sophisticated if environmental weighting according to resource scarcity indices, or to Ecoindicators, is applied to the (physical) weight of the various materials.

Potential toxicity in electronic products is, to a large extent, found in the electronics (incl. connectors, wiring) and flame retardant housing. Again sophistication of this term can be increased by introducing weighting on the basis of toxicity indices and by deducting potential toxicity, which ultimately will be brought under control by appropriate end of life treatment.

The coefficients A, C and E are normalization constants. A is in 1/ kWh and refers to the way energy in generated in a certain country (for instance A is relatively low in Norway – hydro power – and high in countries where coal is used as a fuel for electricity generation).

C (in 1/kg) reflects the materials mix; it is higher when sophisticated or high impact materials are used (for instance in cell phones) and relatively low when a lot of standard materials are applied (for instance TV).

E represents the toxicity in a certain product category.

B, D and F represent social priority factors ('government green' and 'customer green', see chapter 6.1). Basically it is a political decision what numerical values these get. In my opinion such a decision should be taken explicitly; this will create a stable basis for the EcoDesign of products, which will last for many years. Currently such a decision is taken implicitly. In the European Union, D seems to be high (recycling, WEEE Directive) as well as in Japan, but remains low in the USA. F seems to be moderately high in the EU and Japan and seems to have a relatively high value in the USA. With the advent of the European EuP Directive and the nearing of the date by which the Kyoto targets (emissions) have to be fulfilled, B is now getting more important in Europe. This means that the relative importance of D and F is currently decreasing.

The importance of the proposed formula lies in its 'relative' character. In this way the various perspectives are balanced and it is appropriately expressed what environmental practitioners know: 'you cannot have it all'. Both physics (see the environmental dilemmas in chapter 6.1 and budgets (which have in practice a ceiling) make this a reality.

The proposal also demonstrates that political popularity of an environmental issue (which is often short term) is not a good driver for Applied EcoDesign (which has a much longer time horizon). The reason is that in political processes B, D and F have short term fluctuations in time.

For instance, in response to sentiment from the general public, it is seductive to assign a high value to F (temporarily) in comparison to B and D. This is what most likely has happened with the European RoHS Directive, because in the earlier European WEEE Directive, B and F have been put set at zero at the time of its introduction.

Although EcoDesign in general is supposed to be fostered through WEEE (in fact in its current form it is not a real Waste Directive, it is a kind of Design Directive) the life-cycle principle is ignored.

In the EuP Directive, currently energy consumption is placed in the limelight, which means B is high with respect D and F. As an undercurrent, material and potential toxicity are still present in the recommended design rules. It is not clear whether this is a held over from the time that a draft Energy Directive for EE (electronic equipment) and a draft design Directive EEE existed concurrently, or that there is a specific thought behind this.

Proper application of the proposed formula could prevent such priority setting. Once the coefficients in the formula have been fixed, it is possible to validate the effect of any 'actions' considered on a 'green societal basis'. Such actions can be EcoDesign efforts but also technology improvements, changes in the supply chain and proposed legislation. The effect of an action can be described simply as

$$\text{Effect (action)} = \frac{\text{Outcome of application of the impact formula before the action}}{\text{Outcome of application of the impact formula after the action}}$$

If this ratio is above 1, the action is basically environmentally sound.
It will be even more important to assess the outcome of different actions which are or could be envisaged. In this way the **priority of items** in an action agenda can be determined.

Personalities, 10

Konosuke ('Kos') Ishii: if it cannot be modeled, it cannot be sold

It is all Catherine's fault. She was working on a dissertation on recycling and was looking for support outside Stanford University. She stumbled across me and as a result I stumbled across Kos. I learned two things from him which few people in the environmental world have come to grips with, even today: it is about value chains (see also chapter 5.1) and about making recycling strategies (see chapter 7.2).
Why is dealing with these issues such a problem? Why are there still so many 'beliefs' in these fields? It seems that this is because both items cannot be modeled with quantitative formulae.
That kind of challenge fits very well in the great tradition of American universities in general, and of Stanford University in particular. If this could be done it would create a clear baseline and from that foundation you could tackle every issue in a pragmatic way. Even in territories where the model is not applicable in a precise fashion it will be helpful.
Kos and his group excel at this type of work; they are one of the best, if not the best, in the world.
I was taken on board as a visiting professor of Kos' group with the idea that EcoDesign would be the main subject. The initial assignment was to find out what it could mean for American industry. Soon the attention turned however to models of the value chain and recycling strategies.
The Delft engineering approach helped me – if you cannot 'enter through the front door' (with mathematical tools for instance) then 'try the back door' (through cases, studies and other empirics). If there is communality in the case studies you can develop a model or theory with a high likelihood of applicability in a wide field, or at least a direction for problem solving.
It worked, Catherine's research became unstuck and she completed her PhD. Value chains turned out to be considered in a socio-psychological way as well, next to all the mathematics which can be applied. Kos learned that technical problems sometimes need a non-technical solution. The National Science Foundations got an excellent report on recycling strategies – unfortunately the Bush administration went in a different direction.
Annet and I had a great time at Stanford!
The 'Ishii' Walk: Kos is usually not up for a walk – except when it is for a round of golf. Therefore my favorite walk in the Bay Area, is one of 22 miles. It can be reduced to 11 miles (one way only) but you have to be picked up at either end.
Start at sea level at Waddell Beach, halfway between Half Moon Bay and Santa Cruz (highway 1). Walk the Skyline to the Sea Trail (in the opposite direction obviously) to Big Basin Park HQ and back to Waddell Beach again; do not miss the Small Redwood Trail near HQ as well.
In April you should however see the spring flowers in the Foothills: Go by car from Stanford Avenue, all the way up Page Mill Road. Go right and park at Russian Ridge Open Space parking. Make a walk there of any distance you like (report to me if you have seen the Fritellaria flowering).
As of January 2007 you may also drive from the Bay Area up to highway 35 (Skyline Boulevard). At Saratoga Gap Vista Point take highway 9 to Boulder Creek. Park your car at milepost 19.72 next to the metal poles. It takes about 20 minutes

walking to reach a very special grove in Castle Rock State Park. Go a bit further down the highway, cross it and follow the Skyline to the Sea Trail downhill till the Saratoga Toll Road. Walk this road up to the cabin. From the cabin take 80 steps to a sign, subsequently 60 steps to a giant fir tree on the L, and 230 steps to a Redwood grove at a curve to the L. Another 170 steps will take you to a steep earth slide on the R and another 215 steps will lead to another circle of Redwoods on the R. Than it is another 60 steps to 'Stevels Family and Friends Grove' on the L, walk 100 steps up the hill and you will see the sign in the centre of the Grove which is 5 acres around it.

6.5.3 Environmental load ratio and Environmental value ratio

6.5.3.1 Introduction

Beginning in the summer of 2001, I had more and more mixed feelings about the status of EcoDesign. On one hand, it had been successful. This success is chiefly due to the strength of the concept. Integrating it into business bestows on it a significance which is far beyond just the environmental realm. In fact, it has become a management method which contributes to the bottom line through its principles:

- Be frugal in design (runs parallel with cost-down).
- Think in terms of functionality instead of embodiment (stimulates creativity).
- Life cycle perspective (more focus on user phase, customer).
- Supply chain perspective (more focus on suppliers and recyclers).
- Paradigm shift (asking 'why are things as they are', creativity).

On the other hand, from pure environmental perspective, traditional Applied EcoDesign does not deliver enough to society. Usually, improvements reach only as far as 20-50% with respect to the existing situation, with a few exceptions going beyond that. This is not enough to make real progress towards a more sustainable world, for which it is estimated that the improvements should be a by a factor of four or even by a factor of ten.

There are two reasons why Applied EcoDesign does not deliver enough:

* Limitations by "physics" (see chapter 2.1) and the business setting (focus on the supply side)

* The rebound effect. Generally, EcoDesigned products have a lower cost of ownership. This is due to its very success: due to the use of less material and of less energy, for instance, the cost for the user will be lower. Since the disposable income of consumers does not change as a result, consumers can afford to buy more, thus reducing the overall environmental gain (on a societal basis).

This unease brought me to explore the relation between environmental load and consumer spending. This is a basic change in thinking; it is looking at the demand side rather than to the supply side. It was the beginning of the Ecovalue thinking as explained in chapter 2.3. Two ratios were defined: the Environmental Load Ratio and its inverse, the Environmental Value:

$$\text{Environmental Load Ratio (ELR)} = \frac{\text{Environmental load of product/service}}{\text{Value of product/service (price paid by the customer)}}$$

$$\text{Environmental Value (EV)} = \frac{1}{\text{ELR}} = \frac{\text{Value of product/service (price paid by the customer)}}{\text{Environmental load of product/service}}$$

6.5.3.2 Some values calculated for ELR and EV

In order to get a better feel about what can be done with ELR and EV some values of these ratios have been calculated. These are listed in the following table:

Table 6.5 Environmental Load Ratio and Environmental Value.

		Environmental Load Ratio (ELR), mPt/ECU	Environmental Value (EV), ECU/mPt
Materials (Kg)			
Iron		25-35	0.03-0.04
Aluminium		30	0.03
Copper		40	0.025
Lead		100	0.01
Engineering Plastics		3-5	0.2-0.3
Glass		3-5	0.2-0.3
Fuels (Kg)			
Natural gas		2	0.5
Petrol		5-6	0.15-0.2
Heating oil		10	0.1
Kerosene		20	0.05
Electricity (kWh)			
Generated by	Gas	3.5	0.03
	Coal	11	0.09
	Oil	16	0.06
	Browncoal	27	0.05
Products			
Consumer Electronics		2-4	0.25-0.5
Cars		3-5	0.2-0.3

In this table the environmental impact (in mPt) has been calculated on the basis of the Eco-Indicator '95 method. Prices (in ECU) are market prices paid in The Netherlands.

Price ranges reflect fluctuations in the market. The table shows that, in the materials category metals generally have high ELRs and low EV. This is the driver behind 'dematerialization' programmes, which intend to replace products by services. Table 6.5 shows however that if this results in more energy consumption (for instance by more transport) elsewhere in the system, dematerialization can become counterproductive.

Figures from consumer electronics show that they are products with high added value, realized with a material mix with a relatively low impact (plastics, glass). This means that although energy consumption is a dominant feature of the environmental load over the life cycle of the product the ELR ratio is low and the EV is high. This trend would even be further exaggerated if the environmental load and cost of hook-up to a cable system would be included. It is estimated that this would reduce the ELR by a factor of approx. 1.5 and corresponding increase value by a factor of 1.5.

However, it is not known exactly what the environmental impact is/has been of building the infrastructure which enables the delivery of the services (deliver TV signals for cable). This is an example of important gap which has to be bridged in order to establish the real environmental value of service systems.

For cars the situation is different; although both the purchase of a new car and petrol are heavily taxed, ELR and EV are still worse than for consumer electronics. Since the car owner's road tax (which is intended to support maintenance of existing roads and building of new roads) is relatively low, the improvement of ELR and EV through including environmental load and value of the 'car system' in the consideration will be very limited.

The introduction of the value concept leads to different design concepts for consumer electronics and car producers. For TV and audio the environmentally beneficial strategy should be that more functionality can be added without rebound effects from communication systems (for instance Web TV, MP3 player) so that the consumer will (or will have to pay) for communication systems and may pay for the product itself (this is worked out in further in 6.5.4). For cars a similar strategy would be: let the owner pay more road taxes and build more roads. However, this is a strategy (apart from being not wanted from a societal perspective) which cannot be implemented by carmakers; the only strategy left for them is in the classical EcoDesign strategy of increasing fuel efficiency. If a car with improved fuel efficiency can not command a higher price, there will be rebound effects as well.

Table 6.5 also shows that labor has good ELRs and EVs. The category of services and systems, which is labor intensive, is costly in absolute terms. Only if such a service can offer more, such as material and/or emotional benefits like convenience, fun and quality of life, will consumers spend (more) in this category.

It is concluded from the above mentioned examples that adding services and developing service system could improve ELR and EV and this could contribute to more sustainable consumption. There is an urgent need however to map out the environmental effects of introducing services, particularly the environmental effects of building and using infrastructures.

6.5.3.3 An application of Environmental value to product strategy

In view of the concepts development in 6.5.3.2, the company challenge is to shift the environmental strategy from direct company benefit (cost down in relation with 'green'), easier to produce products and improved image to enhanced customer value; more convenience, more fun and higher quality of life, keeping cost of ownership tightly under control. Basically this means move up market, include more functionality at limited cost and allow more functionality generated on externally computed services on board. This means that the 'absolute' goal of reducing environmental load is changed into a relative one. Reducing ELR equals a decrease of the environmental load per unit of value. An example of how 'moving up market' works out is given below for TVs. In the table, data are given for various screen sizes:

Table 6.6 Environmental Value for various TV sizes.

Screen size (inch)	Shop price (EU) (average)	Energy consumption* (kWh/year)	Load/life cycle (mPt)	Environmental Value, ECU/mPt
32	1100	230	4800	0.25
28	900	190	3800	0.26
25	700	170	2800	0.28
21	475	105	2100	0.25
14	325	70	1200	0.30

* based on average use scenario's

All products have environmental values in the range of 0.25-0.30. The higher environmental load of the sets with bigger screen sizes is almost completely compensated by the higher price. This contradicts traditional wisdom that the smaller the screen size the better it is for the environment.

The value aspect also suggests extending this to the cable service. If this network just delivers TV signals, the environmental value of the TVs with smaller screen size will increase more significantly than for the bigger sizes. If the cable network is an advanced one it can deliver functionalities which an up market TV can exploit and therefore higher prices can be demanded from the owners of these sets. The environmental value will increase for this reason making it reasonable to assume that the environmental value a cable network is higher than the one for TV.

Apart from delivering customer value, a second challenge for industry is also to create society value. This partly coincides with customer value: reducing resource intensity for instance is a general societal interest but it also reduces ELR and increases EV.

Reducing energy consumption can also be worked out in the same way. However the success of this approach is not always guaranteed. It has been reported for instance that in mobile phone systems the energy

consumption of the transmission grid is very high which causes a service system, which is attractive for customers, to show little in terms of environmental improvement.
A third internal challenge for companies is to transform their Product Creation Processes. Focus on value rather than on reducing environmental effects make that business aspects come much more into play than the technicalities Managing Cross functionality and management of the processes as regards strategy, programs on execution, or in total management of the internal Value chain (see chapter 5.1) is gaining even more importance.

6.5.3.4 External effects on ELR and EV, the role of infrastructures

Creating environmental value and reducing environmental load ratios also requires a close look at the External Enablers necessary to achieve this goal. Of these, electronic technology and IT developments are quite important in this category. More powerful ICs, digitalization and information technology empowers the delivery of more function per unit of environmental load. This can be exploited both at the product (and is then close to classical design improvement) and a service level. Replacing mechanical technology (MT) by IT and OT (optical technology) or combining MT, IT and OT in an intelligent way has big potential, provided that the necessary infrastructure does not involve significant environmental loads during construction or use. This infrastructure issue means that in order to create environmental value companies will have to reengineer their external relationships because the infrastructures needed will – generally speaking - be built and managed by a variety of third partners. These partners can vary from existing suppliers to new ones, from start-up companies to existing ones never dealt with, regulators, government agencies and other institutional stakeholders.
Management of the complete environmental value chain (see chapter 5.1) will be the key ingredient for success. Formation of alliances based on common goals will be the core of EV management. Big issues in this arena will be how to set up and manage the required infrastructures, how to manage and distribute the benefits of the system and how to keep track of the changing value perceptions of the users.
Convincing stakeholders to think in terms of mutual benefits rather than simple benefits is a difficult task, which is not executed overnight but is a 'cultural process' as well. The best example of how this needs to be improved is the current discussion of take-back and recycling of electronic goods in the European Union. Although there is a clear goal which is endorsed by all stakeholders, the discussions which have already taken place for many years did not end satisfactorily. In the years to come no system delivering real environmental value will be implemented.
Basically this is due to the fact that the authorities involved communicate in environmental terms while the industry is concerned with financial terms. The positive roles that technology and economy of scale (infrastructure issues) play are underestimated. Also the 'value' delivered to the consumer and society (which will have to be paid for either directly or indirectly in the end) is unclear and not permitting comparison between the effectiveness of the proposed schemes and the effectiveness of other joint environmental actions (such as reducing CO_2 emissions, or reducing the use of potentially toxic chemicals).
This example shows that the road to sustainable services and systems is most likely a rocky one. The good news is that by mapping out the sustainable future using the results of pilot projects a lot of common ground can be gained. The reason that this works so well that pilot change thinking in terms of principles (in which we in the western world are so well trained for) to thinking in terms of solutions.
An illustration of this is the case of take back and recycling in The Netherlands. A breakthrough in the discussions which dragged on for many years was achieved by agreeing on a common pilot for recycling white and brown goods. After completion, a single system was supported by all stakeholders. The system is now operating satisfactorily and can be developed to further serve its goal of offering environmental value by rewarding performance.

Rituals and Habits, 10

Lemons

When there are negotiations in China about joint-ventures, technology transfer or subcontracting a double challenge is to be faced.

One is the business one. All details have to be spelled out and intensively discussed. There are checks and double checks and as a westerner this is satisfactory for reaching an agreement. The Chinese party may not necessarily have the same perception. Such negotiation processes can take many days and include many rounds and one thing is for sure: you will travel home completely exhausted.

The second challenge is the hospitality challenge. During the day there are the talks, but at night your Chinese hosts demonstrate their great hospitality through food and drinks. Course after course of excellent dishes arrives with plenty of drinks. If you are an honorable guest the drink is Moutai (strong Chinese gin); 2 bottles per table of 8 (the lucky number), which means that ratio of toasts is1:7. Be sure that bets will be made about how drunk you will get.

One strategy is to get modestly drunk. This satisfies your host (and gives themselves some opportunity too, it is accepted behavior), but your body and negotiations the following day only permit this occasionally. Therefore I had to invent something else to survive night after night. My lead was that the Chinese turned out not to like lemon juice. As a life long rugby player I was accustomed to swallowing lemons in pieces (during half time), so lemons were a source of competitive advantage. It was exploited to provide relief from Moutai drinking: if you want a toast with me, I would like that you swallow a lemon with me as well. This is the principle of trade: if I do something for you, you have to do something for me. It works! When excessive Moutai becomes a real threat this tactic seriously limits the number of toasts you will face. The net result is that in the end more Moutai is drank among the Chinese themselves and less with you.

In a short time I developed the 'lemon ceremony' (see below), it became famous in the city where I did a lot of negotiation (Foshan near Guangzhou). Once, directly after I arrived I was brought to the rotating restaurant on top of a big building in town. A lot of people were there. I was seated next to the mayor. Halfway through the dinner cut and peeled lemons appeared on a plate. I was requested to do the lemon ceremony with the Mayor. "Yes, of course!" I said. The spotlight went on and the lights went off. There we stood …"Ya, Ba, Ha, Wa,… in the name of her Majesty the Queen!" The next day we were featured on local television. It works. It works well in China; it works well for the inauguration of new members of my students-fraternity; it works well even in environmental circles!

The Lemon Ceremony

1. Order 2 lemons and a knife
2. Peel the lemons and cut them into 2 or 4 pieces depending on circumstances
3. Give pieces to the participants (first round to junior members, second round to more senior ones)
4. Stretch your arm holding the piece and focus your eyes on the piece
5. Make prolonged shouts and stamp with your feet on the floor. My recommended shout is "Ya, Ba, Ha, Wa…, in the name of Her Majesty the Queen!"
6. Directly after "Queen" swallow the piece. Check whether your co-participants do this as well
7. Enjoy!

6.5.4 Environmental bookkeeping

For EcoDesign an impressive array of manuals, tools and software have been developed. Almost all of them work on the basis of output and input. In order to offer a certain functionality (to fulfill a 'need' or a 'greed'), which can be considered a benefit (a 'profit'), an environmental load has to be accepted (a 'loss'). When the functionality has been realized with a minimum environmental load the environmental 'profit and loss' account is being maximized.

What is missing in the environmental world seems to be an 'environmental balance sheet'. The idea behind this is that in order to have functionalities really work well, their need to be investments in infra-structures (involving environmental loads). Cars need roads, TVs and cell-phones need networks, agriculture uses

land, transactions/trade need shops and offices, Medicare needs hospitals. In fact, in all these cases infrastructures are externalities, which are not accounted for in determining true environmental load. Especially for 'services' these externalities can be substantial – it may be that their exclusion leads to the general belief that delivering services is better for the environment than supplying products.
If the parallel with the financial world is drawn further, environmental investment in infrastructure depreciates and is this way impacts profits and loss accounts.
In this way environmental and monetary spending could be compared on a yearly basis.
For a product /service system this could look as follows:

Table 6.7 Items in the yearly Environmental Value account

Environmental load (mPt) of Products/services/systems (PSS)		Costs (ECU) of Products/services/systems (PSS)	
Environmental load of use of PSS	…	Cost of use of PSS	…
Depreciation of environmental load associated with PSS	…	Depreciation of the PSS investment	…
Environmental load of use of specific infrastructure of PSS	…	Cost of use of specific infrastructure needed for PSS	…
Environmental load of use of specific infrastructure (in connection with PSS)	…	Cost of use of general infrastructure	…
Environmental load of services to keep PSS going (maintenance, repair, upgrade)	…	Cost of use services to keep PSS going	…
Environmental load of general overhead (personnel, floor space)	…	Contribution to general overhead	…
Total environmental load/year	…	Total cost/year	…

The Environmental Value account is partly based on specific items (use, depreciation, specific infrastructure, services), in some cases figures of a more general nature (general infrastructure, overhead) will have to be used. Depreciation can be either at 'historical load' or at replacement load.
The yearly accounts will allow identification of improvement options for environmental value. Since these can be clearly quantified, prioritization is possible.
Also discussions among the stakeholders in the environmental value chain will become more fruitful.
Mutatis mutandis also environmental balance sheet can be set up. This will allow 'environmental asset management' that helps produce an environmental rationale for remanufacture, and upgrading of replacement.
The principle of environmental bookkeeping can also be applied to investment projects – each financial investment represents an environmental investment simultaneously in the form of the 'fixation' of a certain amount of environmental load in products, services and infrastructure. Parallel to financial payback times, environmental pay back times can also be calculated, particularly in transition cases when investments in capitol goods or infrastructures replace earlier investment. Interesting cases would be the replacement of production machines by a more energy efficient new generation of high speed trains aimed at replacing short haul flights (for instance Amsterdam-Paris of Düsseldorf-Frankfurt). Also less complicated cases like the transition from a videocassette recorder to a DVD player. Including the replacement of the tapes by disks could be analyzed in this way. When the calculations are done in parallel with the corresponding financial ones, environmental and economic payback times can be compared:

- When the economic payback time is shorter than the environmental payback the environmental investment can be considered to be too big.
- When the environmental payback is much shorter than the economic payback, the financial investment is too high.
- Cases where there is balance between economic payback and environmental payback need further analysis as well. The big question here is why such a balance occurs: is it by accident or by good management?

In a similar way assets, which are already in place, can be analyzed with regards to their impact value for current accounts. The outcome will strongly depend on which application the system is used. The investments can contribute (relatively) positively to the system's value performance or just the opposite. In the last named case the assets are identified as candidates for upgrading or replacement. This is creating the basis for 'green asset management'.

As shown above, the environmental value concept leads almost automatically to an environmental bookkeeping concept. It is believed that application of such concepts will lead to better management of operations and ultimately to 'greener asset management'.

Cities, 10

Milan, creativity and design

For me, above all, Milan is the city of plastic recycling. This is the subject that Philips Consumer Electronics worked on for many years in the nineties. Our work produced a set of requirements for the reuse of recycled High Impact Polystyrene (HIPS) in large quantities (up to 50% of total weight), for instance in housings for TV sets.

Unfortunately, recyclers at that time could not deliver the quantity nor the quality we required, so the company had to turn to the big plastic producers themselves. All of them listened politely and finally asked, how many tons do you already buy from us? Large amounts for us, but relatively little compared to others. Big Philips turned out to be a peanut in the plastic value chain. It was not even necessary to say publicly that the materials industry of this kind prefers to sell new plastic rather than to supply for recycled plastic as well. This viewpoint is implied in a lot of the plastics industry arguments in favor of incineration but as a dwarf Philips could easily be denied.

It turned out however, that one of the smaller producers located in Milan, was breaking rank. This producer even had a technology in place to do the necessary separation of mixed plastics necessary to produce material fractions suitable for reuse. It looked wonderful and promising… but the technology was not perfect. It needed further development and even more important application tests of the resulting materials were needed. It was decided that a consortium of stakeholders would apply for European funding for the project. As a consequence I made many trips to Milan to develop the project proposal with the partners. Scientific body, application value and strengthening of the European economy were all used as arguments for the proposal. These were wonderful creative sessions which opened new horizons. We devised a completely new industry with the boldness of Garibaldi and the wisdom of Cavour.

Like walking the streets of London, the streets of Milan give you a special feeling – your mind continues to grind until late at night. If it was possible, I visited the Duomo, with its wonderful mosaic floor. As a protestant I was always astonished by the many active confession booths. But most of all I went to climb to the roof. There you can sit between more than 200 sculptures of saints and angels. Some are big, others small, some are at protruding positions never to be reached by human beings, others are close. Once I fell asleep in this paradise, the guards had to wake me up at closing time. The sun was just starting to set.

The project never received funding. In the first round we got 42 of the 43 points necessary for funding. Our second try was better; however, in this round there were at least 7 competing plastic recycling projects. We were urged to cooperate with other consortia, which turned out to include the big plastics producers. Money cannot buy love… We decided to stop rather than to sell out.

City walk: Start at the Central Station and walk across the via Vittori Pisani to Plazza Republica, go R on Via Mocova and R via Via Volta. Walk in the Cimentero Monumentale and go back through Via Bramante, go R before the Arena or the park, where you have to end up at the front side of Castello Sforzesco. Go straight ahead to the Piazza Duomo or make a longer tour through the back streets.

Favorite Restaurant: La Porta Rossa, Via Vittori Pisani.

Country walk: Go by train to Pavia (the town itself is worth a city walk as well) and go by bus to Certosa di Pavia. Walk in this monastery complex and in the fields around it, till you can just make it back to town.