The Reverse Perspective:

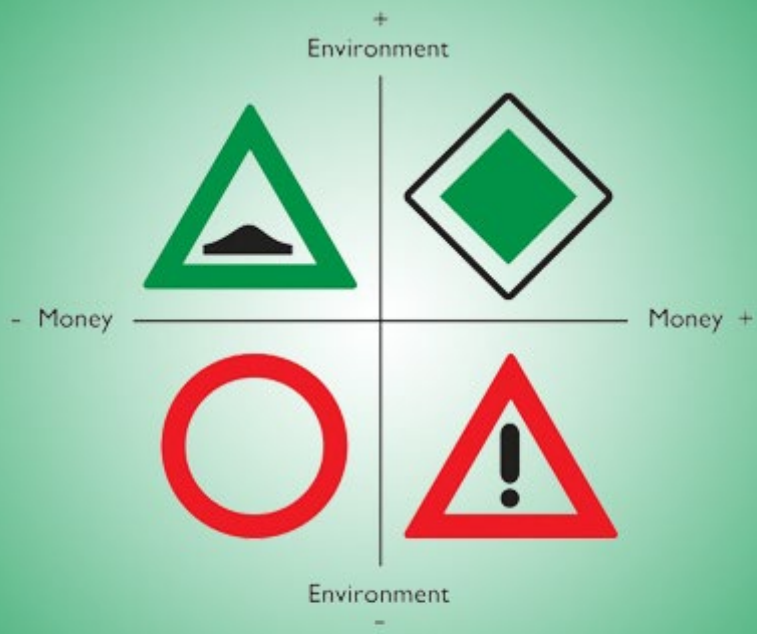
Fifteen years of EcoDesign

at

Philips Consumer Electronics

(1993-2008)

Ab Stevels



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PREFACE.

The electronics industry has been dealing with EcoDesign as of the early nineties of last century. There has been a variety of drivers to do so, varying from ethics to complying with (new) environmental legislation. After 25 years a new generation of EcoDesigners has entered the field. This generation operates from the wider sustainability perspective, that is taking apart from environmental also social and economic considerations into account. It is supported by a knowledge base which can be accessed through internet and through smart phones. This is quite a difference compared with the period when EcoDesign started. The scene has therefore changed but many issues to be addressed by EcoDesign have not. The key issues are still energy, materials, packaging and transport, chemical content and recyclability. Making EcoDesign successful in the business is facing similar hurdles as twenty years ago.

From this perspective it is worthwhile to describe what happened when EcoDesign was introduced at Philips Consumer Electronics. This paper is however not a history; it is hoped that current practitioners will recognize the issues at stake and can derive some learning from these earlier experiences.

This paper represents a personal interpretation —anno 2015— of the author of the events at Philips Consumer Electronics (PCE) in the years 1993-2008. Deliberately these have been considered from a broader business perspective rather than from a singular environmental perspective.

The scope of this paper is EcoDesign. As will be seen this fits into the wider concept of Sustainability, but in the time frame considered the Sustainability idea was still in the very beginning of its development (starting in companies, as of 2002 only).

I want to thank all the colleagues in this big EcoDesign adventure at PCE: the ones at the Environmental Competence Centre, the ones in the Business Groups and last but not least everybody inside the PCE organisation who assisted in making it really happen.

I also want to thank the Management of Philips Consumer Electronics for their great vision, their consistent support, their personal interest and —when needed— their understanding and their tolerance.

Delft University of Technology has had the vision to link with Philips Consumer Electronics and to jointly support the Chair of Applied EcoDesign. PhD students and graduate students operating under this umbrella have made great

contributions to the progress of insights in EcoDesign and to the practical implementation of its principles. They are owed many thanks for their achievements and their contributions.

Both the Environmental Competence Centre at PCE and the Design for Sustainability Lab at TUDelft consisted of persons with a big diversity in opinions and in background. This guaranteed open minds and lots of discussions. Simultaneously it led to a lot of flexibility, unconventional solutions and … a lot of fun!

Last but not least words of thanks to Daniela and to Paul. They belong to the new generation of EcoDesigners and have stimulated me to write this booklet.

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1. In what kind of company was EcoDesign being introduced in 1993?

The parent company of Philips Consumer Electronics (PCE), Royal Philips Electronics was founded in 1891 as a maker of incandescent lamps. After difficult start-up years, the company grew rapidly due to the acumen of its leaders: the Philips brothers. Gerard was the technical guy, Anton the commercial one. Mastering three core competences for making lamps was at the basis of the success of Philips: metalworking, vacuum and glass. These skills allowed (after the First World War) to expand into other fields like radio valves and X-Ray tubes. Soon also complete products were built around these core items. Such activities required a much wider knowledge basis on materials and components. This was provided by Philips Research, a lab which started its activities in 1912. Combining such knowledge and know-how with electrical engineering allowed Philips to enter a variety of fields ranging from Consumer Electronics, Domestic Appliances, Telecom, Defence/Military, Scientific Equipment to Acoustics next to 'good old' Lighting.

In order to supply parts, components and subassemblies to produce all these products, separate divisions were set up. By selling also parts and components to competitors, Philips was —at least in Europe— in 'control' of the whole sector.

After the Second World War, prosperity grew, and the Consumer Electronics Division benefited largely. This was due to the success of the TV products (first Black&White, later Colour). In this market Philips was clearly the leader. An important ingredient was the superior quality of its picture tube, developed and produced completely in-house. In parallel, superior sound quality was achieved for Audio products. The invention of the Compact Cassette player (1963) and the Compact Disc player added to the perceived superiority of the Philips products.

But competition came, first from Japan and later from Korea, Taiwan and China. These vendors had a different strategy: start with low end/low price products, and subsequently go upmarket while keeping the prices low. PCE did the opposite: offer quality and subsequently drive the prices down. In this fight the competition was successful and gained market share. PCE was still in a state of denial when there were some painful wake-up calls: the failure of the Philips video recorder concept V2000 and the semi success of the Compact Disc players

— Philips made a lot of money on its patents in this field but its share in the market for these products was low.

Philips as a whole turned out in the eighties of last century to be spread too thin to keep (or to gain) leadership positions in most of its businesses. It was overstaffed and there were unjustified superiority feelings. Complexity of products grew: the time in which brilliant individuals could do it all was gradually over and much more group work and cooperation between departments had to be done to score successes. This was not the Philips culture and definitely not the one of PCE.

In the end a painful restructuring of the company had to take place: by making people redundant, through outsourcing production and by selling activities the number of employees was more than halved. Many assets had to be sold to pay for all this; PCE operations came out of this whole process relatively unscathed.

EcoDesign activities started shortly after this difficult period (1993). Self-confidence at PCE was bouncing back; *we are still the best, we are going to make it, we will do it***.** In this period, PCE could keep its market shares and even gain some back — average profitability was however structurally too low. The transition from analog to digital could be made pretty well but one development turned out to be killing in the long term: the transition from Cathode Ray Tubes to LCD displays in TVs and monitors. (TV's and monitors constituted 65% of the revenue of PCE). The superiority of the Philips CRTs had hampered investment in LCD: there was widespread disbelief that LCDs would ever take over. And when this finally had to be acknowledged it was too little.... too late to get the leadership position in this new field. In the end (after 2008) all business groups were (or had to be) sold to low-cost operators. Monitors went first, with Audio, Video, Miscellaneous to follow and TV was last.

The EcoDesign history of PCE described here took place in the relatively stable time window between 1993-2008. In 1993, it was new, and PCE could become —in the best spirit of its traditions— a trailblazer in the field. *It developed a style of dealing with EcoDesign which was quite different from the ideas and perceptions about it in academia.* In this paper this style is called the 'reverse approach'. Around the year 2000 the reverse approach had grown to its maturity and it has been operated at PCE till about 2005. After that the structural problems of PCE started to have a clear negative impact.

Simultaneously, developments in the field had an impact too. Instead of basing EcoDesign on facts and science, design philosophies like Cradle to Cradle started to get a bigger impact at Philips in general and therefore at PCE as well.

EcoDesign also became a part of the wider Sustainability concept as well. This is basically a logical and a necessary development. However, the net effect for EcoDesign has been that attention in terms of content and budget has decreased.

The author hopes that elements of the story about EcoDesign at PCE (1993-2008) will be recognized by practitioners. It is also hoped that these experiences of the past will help to move forward EcoDesign inside commercial companies faster than its current pace of progress.

2. EcoDesign inside companies in the Electronics sector.

2.1. Why take EcoDesign on board?

The publication of the Brundtland report (United Nations World Commission on Environment and Development, 1987) evoked a lot of attention for environmental aspects of products. Whereas the environmental aspects of production processes came into the limelight as early as in the 1960s, it took several decades before the resulting products became the subject of scrutiny.

Environmental issues of electronics products got a special interest. This is because of the (special) materials needed to implement the required functionalities, the use of (potentially) toxic substances and the energy consumption associated with production and use.

EcoDesign can potentially remediate —or at least alleviate— such problems. The concept got therefore attention from researchers, legislators and environmental organisations. Also inside companies in the electronics sector there were proponents of this approach. However, there were tacit or even open opponents as well. Will EcoDesign really be of help in our business or is it a hobby of

a few zealots or activists? Will it add to our bottom line? Is it just a fad; will it lead to another shake-up of our operations? Or, should we just have different priorities and worries? Many people had no outright answers to such questions and in view of these uncertainties, the majority of employers was caught somewhere in the middle between sympathizers, neutrals and criticizers.

The present story is giving a 'reverse perspective' of EcoDesign. It will demonstrate that an organisation (or a person) in the electronics industry *should deal with the subject out of self-interest* — even if there is no specific interest in 'eco items' at all. The reason for this is that EcoDesign has its roots in concepts like Life Cycle thinking, internal/external value chain considerations and thinking in terms of paradigm shifts. When put into practice these concepts will have positive ramifications for completely different business issues than just 'Eco'. The combined benefits are so relevant that Eco-benefit is the originating but mostly not the dominating element in the results obtained.

Supporting this proposition by the experiences in practice at Philips Consumer Electronics is the chief goal of this paper.

In 1992, the leaders of PCE had the vision to enter the EcoDesign field in spite of the fact that in that period of time the Division was making substantial financial losses (and that the restructuring of Philips Electronics as a whole was in progress as well, see section 1) This vision was a very wide-looking one or at least much wider than just responding to external pressure from stakeholders outside. As a result of this, a small group of people was parachuted into this unknown territory. The qualification requirements for this assignment were: 'know the company, know the products, and know the people', in fact 'be one of us'. Required eco-knowledge: none. Look to what is happening in this field elsewhere with an open mind; take on board what is useful; dogmatic approaches will not be tolerated. The paratroopers got the freedom to act according to their findings and observations; prescriptive goals were not in place. From this starting point, *the EcoDesign activities were developed in a pragmatic way.* Apart from activities which were expected to have a substantial eco-effect, others were taken on board with a smaller eco effect but with the advantage that their benefits were very visible for the organisation — visible meaning in this context a direct positive effect on the bottom line (example: packaging reduction). Successes of this type supported the credibility and thus the authority of the 'eco-crew'. An important effect too was that in this way no budget problems were encountered in expanding the program.

2.2. The organisation of Environmental activities at Philips Consumer Electronics.

Since the 1960s Philips Electronics had a corporate environmental office. It issued guidelines on how to deal with issues related to environment. These were thought to occur chiefly in the factories.

When it became clear that there were also issues related to products (after 1987, see 2.1) the Product Divisions were directly involved and made responsible for the environmental quality of their products. The very idea of 'environmental quality' made that the environmental managers at Division level were positioned in the quality department; a happy coincidence. Soon it turned out that the introduction of environmental issues in the operational departments would encounter similar issues as introducing 'quality' twenty years before.

Copying a structure similar to the one for quality, environmental managers were positioned inside the business groups as well. At the various locations there were part-time (or very part-time) environmental managers as well. These folks were really in the midst of day-to-day-operations. This structure resulted in a vast community of people involved in environmental matters. Most important was however that from the very beginning environment was well-integrated. Simultaneously there was a very relevant consequence for *the 'language' in which environment was to be communicated. This was ordinary physics/factory/business language*; quite a difference with the 'environmental language' of research institutions and academia. This is a world of difference which still exists today. Also the spirit was quite different; it is about 'getting it right' (as good as you can) and not about 'being right'.

In the Philips structure, the corporate group was made responsible for the corporate programmes, the corporate communication and outside relations more generally. The groups at the divisions were primarily to assist the business groups: demonstrate how —for instance— EcoDesign works in practice. This includes also providing tools and formats to assist in implementation. Other tasks included teaching by illustration and (in a later stage) audit of progress. At the same time, management had to be instructed about the best ways to follow up on the results. The divisional environmental groups were financed by the business groups and thus were obliged to deliver 'value for money'. Simultaneously this was seen —at least by some senior executives— as protection against 'theoretical and philosophical' achievements.

The products of Philips Electronics vary widely in size, weight, chemical content and energy consumption in the user mode. This diversity called for differentiation per product category or at least the recognition that there is 'no one size fits all'. On the other hand all divisions, business groups and locations operate under one brand name, so a set of common items is to be addressed in a coherent and consistent way. This sometimes created 'healthy' (or somewhat less healthy) tensions between headquarters, divisional groups, product groups and local managers. Nevertheless there was on average one style: bottom-up with occasionally some top-down to bring disputes taking too long to and end.

3. What is EcoDesign?

3.1. The definition of EcoDesign.

Before telling more about the PCE involvement in of EcoDesign, it is useful to dwell for a while at the definition of EcoDesign: a discussion of the definitions offers clues to the historical developments but will also explain why —still today— there is so much confusion about the subject.

The traditional definition of EcoDesign is:

Design activities leading to a lower environmental load over the life cycle of products and services.

In this definition the word environmental can refer to three dimensions:

- **Emissions** (for instance CO_2 emission). Emissions are tangible and can be measured directly. This is the reason that Life Cycle Analysis tools are chiefly based on emissions.
- **Resources** (for instance depletion of resources). This aspect is much more difficult to measure. Mostly it is modeled, but opinions about what model to apply vary greatly. Therefore it is difficult to incorporate this dimension properly in emission based life cycle tools.
- **Potential toxicity.** In this category the wording 'potential' means a risk (and not something to be taken for granted): toxicity is in place, but is not released under the present circumstances (the situation for

almost all electronic products). However if conditions change the potential can materialize (for instance if discarded products are incinerated or thrown into an uncontrolled landfill).

As a consequence the wording 'environmental load' can be understood quite differently. Companies including Philips and PCE have been *struggling therefore with the question 'what is (really) green'*. The dilemma's resulting from this are described in more detail in section 10.

3.2. The content of EcoDesign has changed over time.

Originally, EcoDesign activities (and concerns of stakeholders) were focused on potential toxicity. This was the result of some environmental disasters happening in the early 1990's. After a short spell of focus on reuse and recycling (1995-1998) , focus emissions took the upper hand, chiefly due to the fact that emission based Life Cycle tools became available; the global warming debate enhanced the emphasis on emissions further. Rising material prices brought the resource issues back again resulting in the 'circular economy' concepts of today. Science-based approaches were mixed with ones based on philosophies like 'Cradle to Cradle' and 'Biomimicry'.

As a result of these developments, mindsets (and priorities/preferences) of employees, customers and other stakeholders about what EcoDesign should really achieve vary widely, both in terms of actual perception and as a function of time.

Environment is apart from science and technology also emotion, PCE had to discover this and to learn how to deal with it.

3.3. The different faces of Design.

The other word in the EcoDesign definition is 'Design'. In its core 'design' is a set of actions to create an artefact with a certain functionality. EcoDesign is therefore aiming to create artifacts with 'Ecofunctionality'. Part of this Ecofunctionality can be measured (emissions); part cannot (resources, potential toxicity). Moreover the emotions associated with products cannot be measured, at least not in physical terms. For appropriate EcoDesign it is necessary to balance with these elements. For Philips Consumer Electronics in general this has

brought tremendous *emotional side of products. EcoDesign has therefore helped to break the traditional PCE mould* learning: *as a high-tech company there used to be limited attention for the* of making products with top (physical) functionality for an attractive price. Through this mechanism, PCE products became 'less tech dominated' and more 'human'.

An organisation needs a common way of working as well. Incorporating EcoDesign into existing procedures and plans is therefore a must. Just assigning some people to stare out of the window and dream up some environment-friendly product or process is by far not good enough. This observation from practice is teaching humility to ecodesigners. It tells too that in big organisations special ecoprojects are less effective through their self-chosen apartheid (see also section 7.3.1 for the Green TV disaster). Many ecodesigners thinking they had a special mission in industry have failed for this reason. Their failure is however rather due to their attitudes than to conspiracies to keep their good ideas out of the door.

Procedures and planning are a necessary but not a sufficient condition for success. These have to be put in the perspective of a strategy. Top management has to be actively involved (and not just-passively allow eco-activities as many outsiders seem to think) and follow/manage progress of eco-programmers and roadmaps. Doing this at PCE has been an eye opener: to the surprise of many senior managers 'Eco' turned out to be a very good instrument to revitalize practices and boost creativity in more general.

And, if a good EcoDesign job has been done, the world should know. Just saying 'we are so green, so green' is not good enough. A wide variety of audiences should get the message — in their own language and from the perspective they see as relevant in the environmental arena.

An Ecodesigner is therefore still primarily a designer, but also a design organizer, a design planner and a design communicator. A dazzling set of requirements! There are however many ways and means to get help to do these jobs properly. Recognition that you are not the greatest of experts in all these aspects will make it easier.

Science and technology can help you; the supply chain can do that as well. But most of all people in your own organisation can be of help; 95% of them are basically positive about environment and will contribute if circumstances allow

it. Set them free, involve them, work out the ideas and confront them with the sometimes harsh reality.

This means concessions and sometimes defeat, but the good news is that mostly a lot of positives stay in place; in terms of 'eco' but also in terms of quality improvement and job satisfaction.

From above it can be concluded that an EcoDesigner is primarily a promotor of creativity, not an ecospecialist. The backbone of this creativity is:

- Functionality thinking
- Life Cycle approach
- Prevention
- Do more with less
- Thinking out of the box

3.4. The very significance of EcoDesign.

All the elements cited above are not necessarily new for creative organisations. Nevertheless: budgets and time to market pressure limit severely the time to think. Narrow job descriptions, detailed procedures and too much fixation on realisation limit the room to maneuver further.

Seen from this perspective, EcoDesign is a bit naughty because it is challenging existing practices and procedures.

At least at PCE, Ecodesigners have always been positively tolerated, the tacit condition being that results are delivered. The reason for this tolerance has in my opinion also a broader background: in spite of all restrictions, management of PCE has always *perceived EcoDesign as a cross-functional activity which has led to real creativity and innovation*. This is the very significance of EcoDesign.

3.5. A modern definition of EcoDesign: contributing to EcoValue.

The EcoValue concept is a fundamental paradigm shift in thinking about EcoDesign. It recognizes that the *environmental load of consumer goods is primarily determined by the buying (and use) behaviour of consumers* and not by

the products themselves (if these are not sold, only few of them will be produced). Products for which relatively high prices are paid in the market are perceived to have 'value' for the buyer. High value represents high functionality, physical, economic, intangible (for instance ease of use, but also health/safety) and emotional ('new', quality, feel good). Usually, such high-value products have also high 'EcoValue', that is a high ratio between the prices paid and the environmental load over the life cycle. Since consumers can spend money only once, such products have a 'positive rebound effect': the high price paid makes that some of the money (which would have been left if a cheaper product would be bought) cannot be spent on other goods.

A design for EcoValue strategy contrasts therefore with the traditional EcoDesign approach as outlined in 3.1. There lowering of environmental load is priority number one. Such a result is realized for instance through using less materials and energy. This means that in the very competitive market of electronics, prices can be lowered as well. As a consequence consumers can buy more goods for the same amount of money spent. In this way, the positive effect of EcoDesign is partly annihilated — a negative rebound effect.

Environmental attributes can contribute to value creation and for that reason, applying an EcoValue concept leads to interesting EcoDesign strategies which are clearly different from the traditional ones. For instance it is positive for the environment, if prices commanded can be increased (percentage wise) more than the increase of environmental load needed to boost attractiveness. An example of this is making products more attractive for instance: through nice outer design a positive EcoValue effect is obtained. A more radical strategy practiced (implicitly?) by some electronic producers is creating very high EcoValue by focusing completely on excellent functionality in all its dimensions and making environmental issues subordinate to that.

Philips Consumer Electronics has never taken the concept on board. However this could have been fruitful for its 'quality buyers' (1/3 of the total customer base, the other two groups being 'tech' buyers and price buyers). Quality buyers are interested in a broad variety of quality aspects. This includes environment, social aspects of the supply chain, recycling etc. Tech buyers are chiefly interested in new functions and features and have limited eco sensitivity; price buyers even have the perception that ‘green adds to the price’.

Mapping (see section 10.2) demonstrated that PCE behavior in value creation (and the pricing linked to it) was inconsistent. A missed opportunity, but sometimes as an environmental advisor you have to accept defeat.

4. EcoDesign at Philips Consumer Electronics: a special case.

4.1. The complexity of writing the PCE EcoDesign history.

EcoDesign activities at PCE have started in 1992. These were initiated from inside the organisation. This is remarkable because it is a widespread idea that electronics companies only started with the subject because there was pressure from outside. For PCE this was not the case: *a combination of curiosity, intuition that 'eco' could be a change agent in a conservative organisation , ethics and gut feel made EcoDesign kick off*; each of the senior executives had their own mix of arguments pro (and sometimes also anti) — external drivers were less important.

In the following years EcoDesign grew; both in width and depth; from 9 initial EcoDesign themes which could be addressed to more than 45. The activities also moved from defensive/reactive to proactive. It got organized better and communication in the internal and external value chains gradually improved.

The initial idea that EcoDesign is just a set of eco-based design rules which have to be combined with some technical tricks was abandoned soon. EcoDesign got a more and more holistic approach in which strategy, planning has been combined with meticulous execution. Due to the wide variety in opportunities, priority setting and differentiation got a more important role: tailored solutions instead of 'one size fits all'.

The author has been part of these developments as of 1/1/1993 as an Environmental Advisor till 31/12/2004 and as a consultant of PCE till 2006. Parallel to this I was a (part time) professor in Applied EcoDesign at Delft University of

Technology (1996-2008) and in that capacity there was a lot of collaboration with PCE.

My experience of this period has been described in a book with the title 'Adventures in EcoDesign of Electronic Products'. It is a 600+ page book with a wealth of technical and scientific details (available for free from www.aeki.se). Apart from that it is 'telling the story' why certain subjects were addressed at at certain moment, what the approach has been and how it worked out for the organisation. In principle it is possible to construct a techno-history of EcoDesign from this book. For the history of take back and treatment of discarded products I did this a few years ago. This history has been published as chapter 29 in a book with the title: Waste electrical and electronic (WEEE) handbook, Woodhead Publishers (2012), ISBN 978-0-85709-089-8. The electronic waste subject is however a 'kind of stand alone'. It is less interwoven with the other subjects. Moreover events in the field of E-waste can be placed on a clearly defined time scale. For Ecodesign and managerial aspects of Eco in an organisation this is much more complicated.

4.2. Five reasons to believe that the EcoDesign approach of Philips Consumer Electronics has been special.

4.2.1. The approach has been bottom-up and has been based on common sense.

After the kick-off by Senior Management and the hint to start with chemical content and to consider recycling of discarded products, the EcoDesign activities got their own internal dynamics: the environmental managers got a free hand to develop activities. The only boundary condition was at that time: keep our organisation at least out of (environmental) trouble. The activities were to be financed by the business groups; this was to ensure that better eco-performance was to be combined with business benefit. It worked; in the eleven years I was involved in the field there has never been a budget problem. The business groups even paid so lavishly that relevant environmental issues could be addressed in which the direct link with the business items was unclear (for instance

collecting data for an Eco-indicator database) or even questionable (a study on audio equipment with zero recycling cost).

This organisation form required *the environmental managers to be 'bilingual':* issues had to be explained in simple terms of physics and money — for a long time using environmental language in PCE was a clear disqualifier. On the other hand this language was needed to communicate with for instance the scientific world.

4.2.2. Tools to support EcoDesign were developed starting from the business perspective, not from the environmental perspective.

Tools to support EcoDesign were meant to be used by people —for instance in product development groups— who were no environmental specialists. The consequence was that tools as proposed by academia mostly could not be used; these were felt to be too esoteric.

Also the goal of applying the tools differed: since EcoDesign was to be integrated into the (usual) Product Development, the goal was to develop products with a better eco-performance than the previous generations of products (or better eco-performance than the ones of the competition) and not to develop specific 'ecoproducts'.

Such being the situation, tools had to be comparative (not absolute), preferably using physical parameters (W, kg, % etc.). These have an environmental relevance as well. Several of such tools developed in the 1990s are still in use (see Adventures in EcoDesign…, chapter 6).

As a consequence, Life Cycle Analysis according to the ISO 14040 series never took off inside PCE. Instead, an Eco-indicator data base was developed by means of which simple Life Cycle calculations could be made. This was relevant because in order to align EcoDesign activities with the existing organisation, these activities were applied to five focal areas: Electrical, Mechanical (materials application), Packaging and Transport, Chemical Content and Recycling. Actions in one of these fields can in principle lead to wrong outcomes on a life cycle basis because gains in the focal area addressed can be outweighed by losses in others. In practice, however, this almost never occurred — at least not for the PCE products.

Nevertheless, a life cycle calculation is helpful to support evaluation of progress; in this way the net results ('the opportunity to be grasped') are being quantified rather than looking for potential problems

This positive psychology is relevant for the whole environmental community as well: look first to the opportunities and then to the problems ('the threat') and not the other way round.

4.2.3. Emphasis on creativity.

Sparking environmental creativity has been the chief reason why PCE has put so much emphasis on getting answers to the question *'why are things as they are'. This question is relevant for all EcoDesign focal areas as described above. This question is an open invitation to do better* without introducing upfront requirements or obligations. It poses a challenge to review decisions of the past (which could be right at the time they were taken, but can be overturned by later developments) and remediate mistakes and/or neglect. But most importantly this question raises awareness:

... I never realized that... This approach has turned out to be a powerful instrument to overcome conservatism. When confronted with it, more than 90 % of employees are willing to cooperate and to spend time on thinking how to do better from an environmental perspective. This contrasts with imposed environmental requirements. In such a case excuses are manifold: we are already so busy, this is not for us, only for activists, this is out of reality, not in this country/part of the world etc.

A wealth of ideas has been obtained through the 'why' question. Often so much that there was need to prioritize. For instance the top 10 environmental ideas were selected by evaluating their company and customer benefits. This approach may not deliver the maximum of environmental benefit (although practice shows that the package of proposals offered to the organisation comes pretty close to it. In terms of credibility and acceptance this procedure is however perfect. And for the ideas not on the list... there is always a next product generation... This approach is a horror for the dogmatic environmentalists but lack of pragmatism is the very reason that they would fail in an organisation like PCE.

4.2.4. Freedom to ensure the maximum of success, but to be embedded into procedures.

As has been described above, freedom and mobilising creativity result in the maximum of success. This is not good enough. It has to be ensured that success has continuity and therefore attention for environmental issues has to be included in the procedures. This is because 'enthusiastic' volunteers are essential to pull the activities; these will stall if folks involved get different assignments, are moved to the next department or even leave the company. Moreover, 90% of the employees are positive about green, when properly approached, but that does not mean that they are natural talents — they may need a little (or a bigger) push in the back. What is often encountered too are 'superseding issues' like time pressure, budget pressure, fear for bosses who are not 'green' etc. *These are all reasons why environment should be codified in the procedures of the organisation.* This codification is the reference if environmental issues cannot be addressed in a natural way. It is also the reference to find a way out when apparent or real conflicts of interest arise (This happens in practice less than academic authors seem to suppose).

Through this 'formal integration', EcoDesign got really Division-wide attention at PCE. This allows in turn to properly monitor environmental progress of business groups (and even of individuals). The chain is as strong as its weakest link.

4.2.5. Coherent action in EcoDesign and on the value proposition to customers.

Since actions on EcoDesign inside PCE and Philips Electronics were coherent, it has been possible to communicate about these to the outside world in a consistent way and thus to contribute to the brand image. Underlying this environmental communication is a paradigm shift: most customers buy products because they have 'value' for them, not because of their environmental performance. This means top functionality, from a physical and economic perspective but also from an emotional (quality, feel good) and intangible (ease of use, health and safety) perspective. Environment and EcoDesign *can perfectly add the value proposition to the customer*. Less energy, lower weight, smarter materials, less packaging and transport, top recyclability and long product life are all perfect contributors. Concluding from this 'we are so green' can however be

counterproductive; electronic products are never experienced as 'green', although some of them can be more green than others.

4.3. The development of EcoDesign inside Philips Consumer Electronics.

The special attributes of EcoDesign as sketched above were not in place from the very beginning in 1993. They developed in hard practice and through ups and downs. In all these experiences there has been one thing in common: things which went well brought —apart from being positive for the environment— a lot of enhancement for the business.

This observation suggested the way in which the story of EcoDesign at PCE was to be written: organize the writing according how environmental issues worked out in terms of business. This is the 'reverse approach' to highlight the developments. All of them are related to the technicalities as described in the book 'Adventures in EcoDesign of Electronics Products', but the organisation of this paper will be primarily determined by the cultural and organisational development rather than to technical categories. The organisation of the present story will be described in next section.

5. The 50 Stories about the development of EcoDesign at Philips Consumer Electronics.

These stories tell the development of EcoDesign at Philips Consumer Electronics. Emphasis is being put on how 'Eco' has deeply affected operations, even for items which had little to do with 'Eco' itself. It will be argued again and again that this unintended effect of the introduction of EcoDesign has not been marginal but —on the contrary— has made that PCE has embraced EcoDesign as an important contributor to the efficiency and the quality of its operations.

EcoDesign came in five overlapping waves. The first wave (section 6) can be best characterized as *'Getting facts' and asking 'Why are things as they are'*. This part includes stories about chemical content, design for disassembly, recycled

content of corrugated cardboard, environmental benchmarking and pursuing environmental logic.

The second set of stories (section 7) is about *fostering creativity* through techniques like using EcoDesign to enrich existing processes, looking at consistency of materials application, the 'green TV', the human-powered radio and brainstorms.

In a third wave (section 8) *implementation and validation issues* are addressed. Stories here are about what is happening in the (outside) world, the making of environmental strategies, environmental roadmaps / internal validation and about external validation.

A fourth set of stories (section 9) is about *structuring EcoDesign activities*. Here are included integration in procedures, supply chain management, corporate programmes and ISO standards. Also the impact of the environmental Directives of the European Union on EcoDesign at PCE are discussed.

The fifth wave (section 10) is about *environmental communication*. Subjects like 'what is the function of environmental communication', 'what are the conditions for success', consumer behavior, EcoValue and messages/language are addressed here.

From the very beginning instruction and teaching of EcoDesign have played an important role. Stories about this subject refer to the complete period considered (1993-2008) and include ones about the EcoDesign manual issues , courses, disassembly sessions and how to look at 'Eco' from an MBA education perspective.

6. Stage 1. Get facts, why are things as they are?

6.1. Chemical content; clean the data bases as well.

The chemical content inventory of approved materials and components used in Philips Consumer Electronics turned out to be a task of Herculean proportions. Two chemical engineers were working full time on sending the questionnaires, giving explanations to suppliers, checking the answers and adding

environmental indicators for items in the database. Since PCE was a first mover in the field a lot of trailblazing work had to be done — the technicalities of it are in Adventures of EcoDesign of Electronic Products, chapter 3.4.

The work on chemical content brought soon after its start an important signal for the management. It turned out that there were some 25.000 code numbers in the data base (still excluding the so-called local code numbers). For one specific material, there was a multitude of code numbers available which could be ordered. This was partly because the database had never been cleaned for inactive numbers (originating from products which were not used anymore). Moreover —and this was more severe— it turned out that every person in the development department was entitled to list a component or a material in the base. (Subject to approval, but very few proposals were rejected). Hobbyism was all over the place. The chemical content activity triggered therefore an important 'non-eco' activity: reduction of code numbers and introducing more 'discipline'. This resulted in tremendous cost savings, less supply contracts to be agreed, volume discounts from the suppliers and lower cost of operating the base.

The chemical content activity added a new dimension to the purchasing discussions too. These were not focused on just price anymore. 'Can you as a supplier eliminate this substance' (it has been banned under our rules), or at least diminish the concentration (we know that these substances are needed to get the right functionality, but no overkill please) When presented in a positive fashion, such requests stimulated the creativity of many suppliers. What is for sure is that a 'shotgun approach' which some purchasers wanted to apply did not work.

The biggest resistance against the chemical content activities came initially from the purchasing department inside PCE itself. There was widespread fear that chemical content requirements or requests would drive up prices. In practice this turned into the opposite; after a difficult start it was realized that vendors and customers have a common problem. What helped enormously in overcoming barriers was that it was soon realized as well that chemical additives have a high cost and already for that reason have to be used as little as possible.

Chemical content activities are therefore basically 'cleaning up the environmental mess'. Inside PCE this turned out to result in cleaning up the 'organisational mess' about application of components and materials and to enrich supplier relations.

6.2. Design for disassembly; simplify product architecture.

Design for disassembly was the big fad in the beginning of the 1990s. It was supposed to be a remediation for all treatment issues of discarded electronics products. A cult of the designer as the chief wizard taking away the environmental sins of this world developed.

Many institutions dealing with EcoDesign believed in it, seemingly unconditionally. In this period more than 50% of the papers at scientific conferences about environment and electronic products were addressing disassembly.

At PCE a more pragmatic view has been taken: count how many joints there are in our products and see what can be done about it. The development departments initially did not like this initiative. It was perceived as 'environmental criticism' of their work. Only in far away Taiwan, general manager Bob of the monitor products factory was positive; his customers (business-to-business) had a positive interest in this work, but most of all the business needed a 'quantum leap' in the design of his product. Philips monitors were in fact 'modified consumer TVs' and in view of increasing competition the designs needed a general shake-up. Why not place a small bet on these environmentalists too?

Off to Taiwan, everyone felt uneasy about what was to be the first disassembly session in a long row (see Adventures in EcoDesign…, chapter 7.3 and section 11.2). In order to loosen the atmosphere, I had bets made about the number of joints which would be found. Guesstimates ranged between 30 and 60 — nobody knew the real number. This is already significant: if nobody knows, the likelihood that the issue is properly managed is close to zero. I put my personal bet at 90 to amaze the Taiwanese, the real number turned out to be even higher: 108. Bob confirmed the number (by counting the number of screws put in an empty coffee cup) at the closing of the session and the bottle of whisky was mine. The engineers stayed overnight and next day came up with a design with 50 joints only; soon after it had been reduced to some 30.

Reducing the number of joints is reducing the assembly costs too (not precisely 1:1, but still close) and this very fact made that doors were opened even to the disbelievers.

The Audio group heard the story and asked for a disassembly session, video and the group for miscellaneous products followed soon. And in the end even the TV group gave up its pride. From that time I was received in Taiwan with

honors not because I was the greatest of environmentalists but because I contributed in reducing their disassembly costs substantially.

Joints in electronic products are not just various types of screws. There are clamps, soldering joints, there are glue based joints and many other types. Student Wendy made —based on real time measurements at a recycler— a 'standard disassembly times' table (which was later confirmed by a theoretical study by Ehud Kroll, see also Adventures in EcoDesign…, chapter 7.3). This allowed predicting product disassembly times up front, that is without having a prototype available. This table has been used by PCE for a long time to check on product architecture, even for products which were never to be disassembled.

Apart from disassembly time, the nature of the joint should be balanced with the requirements (for instance mechanical ones). Student Ferry made a 'picture guide' of good and bad solutions. It was called 'the devils picture book' (available from the author on request).

In this way 'design for ***recycling' got a significance far beyond its original objective: simplifying product architecture and thus lowering assembly cost.***

6.3. The recycled content of corrugated cardboard used in packaging.

A simple question to all product groups and production sites: what is the percentage of recycled material in the corrugated cardboard used in transport packaging of the products? Some answers came in quickly; others took a while or had to be pushed for.

Approximately one third of the respondents said 'zero'; one third came up with a figure between 0 and 100% and one third had to confess that they did not know. First conclusion: with these numbers (or lack of numbers) it is highly unlikely that this environmental (and cost) issue has been properly managed!

Once this is realized the next question is: what percentage is adequate? This is determined by the permitted stacking height for pallets with products. Philips warehouses have been constructed for a maximum stacking height of 6m and the box design is such that even under the worst humidity conditions boxes do not deform or collapse when the maximum stacking height is applied. The worst humidity is in Hong Kong (9 months of the year), Singapore (almost all year) and

in the Netherlands (October, November only). Taking this into account it was established that 60% of recycled material is safe under any conditions. Since the fiber length of recycled material is on average shorter, it is susceptible to take up more humidity; this makes that in total some 10% more material has to be used (increase of wall thickness).

This rule of thumb guided a Division-wide action: bring recycled content to 60%! Since each 10% increase of recycled content results in some 6% reduction of the environmental load and some 2% reduction in material costs (these figures include the extra material which has to be used) this adds up to enormous amounts if such measures are consistently applied.

Managerial lesson learned from the recycled cardboard issue: once an 'ecological/economic' action has been identified, exploit it to the full!

6.4. Environmental benchmarking: measuring physical attributes related to environment.

How do our products look like from an environmental perspective? Can this be measured and if the data are known can a tangible action agenda be developed? The disassembly experience as discussed in 6.2 had been a very encouraging one and therefore broadening to a much bigger set of parameters was being sought. The principle however was the same: mobilise departments to work on EcoDesign with help of numbers about their own products. This made that the measurements were organized according the responsibilities of departments in the organisation: the electrical development (energy consumption), the mechanical development (materials application, packaging design (packaging and transport) and purchasing (chemical content). Recycling/treatment after discarding were not within the responsibilities of any of these departments, so the Environmental Competence Centre had to take it on board out of necessity. Who would develop the method, which departments(s) would have to apply it? Initially, none of the departments involved was really interested or (still) had the expertise. In the past, measurement of product attributes had been done to glorify Philips products in comparison to imports from Asia. When Philips had to restructure (in 1992), little of the glory was left and the department for 'competition research' had been scrapped.

And now, a few years later, these environmentalists wanted to to this kind of work again.

Sorry, this is for design action, not for glory. No way, but my (part time) chair in Applied EcoDesign at Delft University turned out to be of help. Students developed the methodology for 'environmental benchmarking' and did the first measurements (see Adventures of EcoDesign…, chapter 6.3) — and earned their degree with it.

In addition to Philips products, products of the competition were included as well and yes, there was a lot to be learned (for free) from the competition. Even a pattern could be recognized:

- Energy: PCE mostly better, due to close links with the components Division.
- Materials: PCE used often more material — it produced, basically, 'solid rectangular boxes'.
- Packaging: PCE used more material, due to more severe drop tests requirements (originating from the time that trucks were loaded manually).
- Chemical content: PCE is better (due to more awareness in Europe about potential toxicity).
- Recyclability: PCE mostly worse (design complexity through a long 'design history').

In their reports the students made meaningful proposals to do better. These were a combination of their creativity and their open mind (be prepared to learn from others).

The last item brought also a new language: 'be better than the competition' (= relative, tangible) rather than improve environmental performance (= absolute, intangible).

The student reports got a huge resonance in the PCE organisation. It started to produce benchmarking reports itself through a somewhat simplified method. Environmental benchmarking got an official status in the preparation of new product generations.

Brainstorms were based on it, yielding useful inputs for action agenda's and product target specifications.

Apart from the strength of the language (business, not environmental), the strength of the underlying physics (presentation of results in W, kg, sec, % m3, etc.) but most of all the strength of the resulting astonishment was doing the trick. … I never realized that… this product was using so much energy, was so heavy, was in a so big a box, or the competition is simply better and shows that it is not forbidden for us to do better.

Astonishment is the basis for creativity. Environmental benchmarking has been touching this nerve to the full. It did and does a great job!

6.5. Looking for 'logic': mapping and beyond.

6.5.1. Comparing similar products and make this visible through graphs and maps.

Numbers and facts about one single product already spark creativity. Comparing numbers and facts about a product group and finding out whether there is consistency between them is another source to start actions (or to set priorities). Even if the underlying physics is unknown it is possible to check 'logic' of product (or of production) data through 'mapping'. This is making graphs, diagrams or visualizing flows (of waste for instance).

Mapping has been used by PCE to get clues for action. In this section three examples are given from the early EcoDesign period.

6.5.2. Mapping of packaging using ratios as parameter.

Companies in electronics have strict time schedules for bringing products to the market. Missing windows like the Electronics Show in Las Vegas or its European counterpart (IFA in Berlin) is killing for the business. In such a hurry, all attention is focused on the products themselves and not on items which are considered to be side-issues like packaging. This means that these are often neglected; at the very last moment suddenly boxes have to be rushed out. This leads to mistakes in their design, simply copying the box of the old product (which is not optimal for the new one) or leaving it up to the cardboard supplier to come up with a last minute solution (which might be not optimal either).

However presenting this observation as an environmental manager is not a good idea. You are supposed to talk environment and not to criticize (directly or

indirectly) other departments. By reframing the same message however by presenting a 'map' it suddenly becomes an eye opener and is seen as positive. This mapping was first practiced in Taiwan (see also 6.2.) In a graph the ratio between packaging weight and product weight was plotted against screen size of all the monitor products. The minimal ratio was 0.15 for a 14 inch product and 0.165 for 21 inch products with an approximate linear relationship for sizes in between (for instance 16 inch and 19 inch). Some 40% of the products had higher ratios; up to 0.21. 'Why are things as they are?' There was no upfront explanation for the deviations from the minimum line, so better check what had happened and correct if no satisfactory explanation can be found.

This mapping activity brought a simple design rule. It has been —mutatis mutandis— applied to many other product groups (TV, Audio, and Video).

Checking of the packaging design brought hundreds of thousands of Euros/dollars in cost savings. Even more has been saved by plotting packaging volume against product volume. The minimum ratio is here 1.75 for Philips products (competitors dared to go as low as 1.72!). Double dip: saving of packaging cost and of transport cost (more items per container) and substantial savings in the environmental domain as well.

Packaging and transport turned out to be the ideal environmental domain to score results which are visible immediately and worked out positively on the bottom line!

6.5.3. Mapping energy consumption: where do the Watts go?

Mapping of energy consumption is basically very simple; measure how many watts go in (in the operational mode, standby mode etc.) and measure where the Watts go out, either to serve a functionality or being dissipated in some form. Consider all subassemblies (picture tubes, printed wiring boards, motors, transformers, speakers, etc.) separately and also look at items like cable and wiring. For incomprehensible reasons such an analysis had never happened at PCE before. Through Delft University one was done at a producer of household appliances and it was an outstanding success (see Adventures of EcoDesign, chapter 3.1.2 and also p. 361). The energy consumption of an electric grill was reduced by 40% through electrical redesign. In fact this was an easy win because the product investigated had been old-fashioned.

Inside PCE, the outcome of the benchmark results worked against mapping of energy consumption: PCE scored mostly better than the competition, most

likely through the superiority of the ICs which were applied (and which were obtained from the in-house semiconductor Division). Conclusion was therefore 'we are better', although the correct conclusion should be, the competition is even worse. A simple catalogue exercise by another student showed that on the level of traditional components and subassemblies like motors an energy saving was possible of some 15% (for equal functionality) — just change suppliers! Transformers are a point in case; more copper in them means higher efficiency. Environmental gains in the energy domain surpass the losses through the use of more copper.

The price of such transformers is higher (to be paid by the producer); the financial benefit of less electricity used is for the consumer. This 'life cycle battle' has been lost by the environmental department.

A similar situation exists as regards chargers of cell phones. More copper in cell phones themselves helps in realising longer periods between charging: this increase in functionality has been implemented by all brands. More copper in chargers results in (much) higher energy efficiency. How many producers applied EcoDesign to their chargers? None, with one exception; LG is my hero!

Last named issues show that in the domain of energy saving there are value chain issues to be overcome. This is highly relevant because energy consumption represents 50-90% of the total environmental load of electronic goods.

This issue is in my opinion so relevant that if the industry is not capable of taking the responsibility resulting from energy mapping, legislation requiring minimum efficiencies for subassemblies should be in place.

6.5.4. Mapping of waste streams; where does it come from, where does it go.

Initially, student Günther felt the subject of mapping waste streams at the Philips Video factory in Vienna to be a boring assignment. Environmentalists do not like waste. Scientists are more lenient about this; the second law of thermodynamics teaches that there is always waste — so accept it as a natural given. This kind of reasoning is deficient however; the amount of waste in practice can be close to or far away from the thermodynamic limit. In Vienna last named situation clearly was the case.

Mapping the waste streams: what is their volume and their weight, where does it come from and where does it go. Mapping with brains: students are relatively intelligent, have learned to connect data and to draw conclusions. Soon doing this kind of work became fun for Günther. He came up with a map of the waste flows pretty soon. This map visualized the issues: at some spots in the factory quite some waste was generated, at others relatively little. Going back to the sources and asking the question: 'why is this as it is' gave useful clues to reduce it: either through changing the way of production or increasing manufacturability through design.

At the 'out' side waste streams taken by collectors for free turned out to contain lots of valuables like copper and even traces of precious metals.

The waste map became a very useful guide to waste (cost) reduction!

Like packaging and transport, waste is not a mainstream issue in the electronics industry, addressing it from an environmental perspective brings a multitude of benefits however!

7. Stage 2. Fostering Creativity.

7.1. Using EcoDesign to enrich existing processes.

As has been shown in section 6, getting facts and collecting data in a systematic way is a sound basis for environmental improvement. When linked to business issues, in particular with cost reduction, it raises awareness and creates credibility. By adding '(design) logic' based on environmentally-linked issues disbelief, skepticism and outright rejection (they all exist in an organisation) can be diminished.

Parallel to this stage 1, a second stage was prepared. The chief goal of this stage is to use environment as a positive jumping board for creativity. In the first instance this has been done by taking a close look at the environmental functionality of products and find out how this functionality could be improved in future product generations. It was an activity which was mainly of technical nature. Smart design was still the core.

Mobilising enablers from outside (science, technology, suppliers) turned out to be a powerful addition.

7.2. Materials application.

7.2.1. Thinking about functionality of materials.

One of the most important principles in environmental thinking is about functionality. An artifact should have precisely the right functionality, not less (the materials applied are not used to the full), not more (waste of material). Therefore, the first question to be asked when materials are applied is: what is the proper function really to be fulfilled? A precise answer to this question gives clues to the types of materials to be applied and ensures the use of minimum amounts.

For products which have a basic design which is repeated during many product generations this issue is particularly relevant. Keeping the basic design saves time. Simultaneously the product design can get 'polluted': what used to be optimal in the past is not necessarily optimal in the latest generation. This is particularly the case when parts or subassemblies have interrelated functionalities or when technology changes.

An example of such phenomena was the design of the Philips monitors in 1997. The basic design had not been changed after the very start of the production of monitors. The first types used quite some electricity. This necessitated to surround the Printed Wiring Board (PWB) with a metal 'cage of Faraday' to protect against electromagnetic radiation. Due to the introduction of new generations of integrated circuits (ICs) power consumption was reduced substantially and the solid metal cage was not needed anymore. In the meanwhile, the cage had been discovered by designers as a solid anchor to attach for instance loose wires. The cage was kept in the design for many years; millions of products in which too much material had been used were sold. Finally environmental benchmarking showed that competitor products had a much lighter cage and after some creative thinking the cage could be eliminated completely in the Philips designs. It nevertheless required a lot of deliberation between departments involved to get the new design accepted.

7.2.2. Cables and wires; aligning the spaghetti.

The function of cables and wires is to connect between various subassemblies. Some of these are chiefly of electrical nature (like printed wiring boards) others are of mechanical nature (like motors). Whatever the precise category, one thing is for sure: the interior of a product needs to be organized. Proper communication between designers in different departments is needed to ensure that there is proper 'balance' between the functionalities and to ensure that the interior of a product is organized in such a way that cable and wires can be minimised- more cable and wire means that more copper is used and that there are more potential toxic substances in the plastics. This combines with cost reduction as well. This reduction can for instance (partly) be realized through designing in more connectors resulting in less soldering and thus less factory rejects and in the end less customer returns.

Irrespective how the benefits of reducing cable and wire are exploited, it is useful to bring together the relevant designers and to brainstorm about how cable and wire can be reduced. My experience is that designs managed from this perspective can have at least 15% less cabling and wiring; 20 % is quite common. Environmental benchmarks (see 6.4) showed that many brands, including Philips, badly needed such brainstorms!

It is all a matter of communicating about the organisation of (sub) designs in a product!

7.2.3. Plastic housing, benefits from technology.

Rectangular, solid boxes like the ones produced by PCE require a lot of material. A more attractive look includes more playful forms and —contrary to the expectation of the traditional designers— requires less material. Modern plastic molding techniques enable to make these — just being aware that such technology is available. Even when wall thicknesses are reduced, solidity can be assured by applying so called internal ribbons in the housing parts. Suppliers may not (yet) have available the appropriate techniques to make parts with reduced wall thickness . They are to be put on this track and most of them will be thankful as this suggestion will increase their competitiveness. In most cases, the material savings will pay for the investments to be done in new moulds and new technology.

A condition for success is a long lasting supplier relationship to really reap the benefits!

7.2.4. Thermal management of the interior of products; controlling amounts of flame retardants.

Through measurement of internal temperatures in products which are in the operational mode, 'hot spots' can be identified which can be eliminated or at least mitigated by architecture changes. This way, the amount of flame retardants (mostly containing potential toxic substances) to be applied (in order to fulfill safety requirements) in for instance the housing can be diminished or eliminated. The TV product group of PCE was a real champion in this field: all flame retardants in the housings were eliminated while staying within the safety limits by a wide margin. This made the housing material much more suitable for recycling and thus contributed to the fact that Philips TVs (out of the 1994-1998 periods) have a much lower take back and treatment cost than the competing products. There was a direct cost reduction as well: flame retardants plastics cost much more than ordinary ones. These advantages lasted till the PCE products made it to the headlines: Philips TVs were said to be less safe than the ones of others. Basis for this was university research paid by competitors. Environment is also emotion and mentioning only part of the truth is enough to spark a wave of negative publicity. As a result the safety requirements for TVs were made stricter; PCE had to put in flame retardants again, be it less than in the products of the competitors. However, the advantage in recycling cost was lost. This has been one of the reasons why PCE changed its attitude as regards take back systems and supported —from 1998 onwards— collective treatment systems — there was no competitive advantage anymore in a brand only (a so-called 'individual' system) take back and treatment system.

Environment is a new battlefield for competition; emotions play an important role and often get the upper hand. Decisions made on this basis do not serve the environment optimally.

7.2.5. The use of recycled plastics; an issue which brought changes but the desired success did not materialize.

The success of reducing the disassembly time (see 6.2) and of eliminating flame retardants from TV housings brought up the issue of using recycled plastics. PCE used some 50.000 tons of plastics per year chiefly in TVs. Using recycled plastics would be a tremendous environmental gain and a substantial cost saving. The plastic specialists at the TV group jumped on the subject. Benchmarking showed that the time to unscrew the housing could be approximately halved (the competition showed that this is not forbidden) and this design item was

introduced at very short notice. High Impact Poly Styrene (HIPS) formed already by far the majority of the plastic materials used but was now declared to be the 'chief construction material', which meant that other types of plastics were only allowed to be used if it could be demonstrated that there was a clear functionality reason to do so. In one year's time more than 90% of the plastics applied was HIPS. This resulted in simplification of the supplier base (and higher volume discounts).

Small cross contaminations of other plastics destroy the good mechanical properties of the main constituent material. So a very important issue to consider was the amount of cross contamination in HIPS. Student Marco worked this out in his graduation project.

Generally, less than a half percent could be tolerated; for polyamides this amount was even less. On the contrary, polycarbonate was acceptable up to a few %.

In a next step housings from rejected projects were disassembled and their plastics reapplied. It was found that up to 50% recycled material could be used in housings. An important criterion is here that housings should have no 'wrinkles'. With recycled material these occur more frequently, but stay within the limits of the specification when the amount is below the 50%.

With this information recyclers and suppliers of primary materials could be approached. The recyclers were quite willing; it meant for them more yield. However the quantities which could be made available were limited for the time being. Most of the suppliers of the primary materials refused to step on the learning curve; in the first instance only a small Italian producer stepped on board. This made the whole project to stagger; if the volumes are unappealing there is no drive to invest on a bigger scale. If continuity in supply cannot be guaranteed, the producers will not apply the material in their products. And thus the application of recycled HIPS stayed limited to some small interior parts — waiting for better times.

The issue of applying recycled plastics created awareness, contributed to better EcoDesign, brought some cost reductions, got application in some small interior parts. It missed however the support of one important enabler (the material suppliers) and therefore it stayed a distant opportunity.

7.3. Green products.

7.3.1. The green TV, failure as a product, success in technical and managerial terms.

With all the positive experiences with EcoDesign (see previous sections) it seemed time to consolidate all these into one 'green' product. Bert, the environmental manager of the TV group was personally very motivated and took the challenge. He managed to get a special budget from the TV development director and also got money from the Dutch Environmental Ministry to implement the project. The project team worked frantically on the subject and in a very short time they scored an excellent (technical) result. Energy consumption in operational mode was down by 39%, weight of plastics was down by 32%, the percentage of recycled material was 69% and almost all potential toxic substances were eliminated. Recyclability was a record at the time: 93%.

The product never made it to the market. The product managers said that the 'green' TV did not fit in the product line-up. Marketing managers said that the communication material for next year already had been printed. Production managers were scared because some complicated parts would give rise to more rejects. Purchasing managers were not amused because they (partly) had to change the supplier base. Last but not least the safety and reliability engineers were negative because all the safety tests still had to be done.

The project seemed to fail because the internal value chain of PCE had not been involved.

Nevertheless there were two important spin-offs:

- The 'green' TV was a 'treasure grove' for green items and many of these have been used in future product generations.
- The 'green' TV was put on the table of the CEO of Philips — Bert was not deterred by all the setbacks but kept on fighting for his 'baby'. The CEO liked and suddenly there came top-down support for EcoDesign. This paved the way for real integration of environment into operations.

Apparent failure into success; amongst others, due to the green TV, Philips got a corporate Environmental Program. At PCE, each business groups got the assignment to have at least one 'Green Flagship Product' in their portfolio.

7.3.2. The Human Powered Radio, illustrating what PCE can and cannot achieve.

Human powered devices appeal to independence and self help. It brings freedom, in space and time. Electricity interruptions do not matter anymore. Use in remote areas. No problem when batteries run out (or if they were forgotten to be charged).

Human power represents top functionality which saves the environment — less energy consumption. It means also less use of batteries with their doubtful chemicals.

Therefore, there are plenty of opportunities; more than enough to ask the Audio group again and again to venture into the field of human power.

It took however a product from a startup to set things in motion; the BayGen human powered radio made it to PCE headquarters. Some managers laughed about the simple receiver technology and the clumsy spring to store energy. Few understood the real message this product was sending: this product is primarily about 'feel good' and positive emotion, sound quality is not the number one.

Another one and a half year of wrangling and there it was: the Philips human-powered radio. The winding mechanism was elegant, good sound quality, a bit a clumsy design. It was a success and many more products were sold than anticipated There was more demand than the 200.000 pieces which had been planned. This resulted in a lot of positive free publicity. Profit margins were quite reasonable — in fact as usual for the standard Audio products. This product turned out not to be usual: it was mostly sold for special applications or as a present to be given to somebody else. In such cases prices which could have been commanded are higher.

Overall, the experiences with the human-powered radio were positive. How to proceed?

- The Audio group decided not to go for a second generation of human powered products. It had been classified a niche product; 'not the type of business we are in';
- adding a second function, for instance a cell phone one (or reversely make a human powered phone and add an audio function) turned out to be impossible in the business group configuration of PCE;
- transferring the experiences to the field of remote control for TVs ('zap yourself fit') turned out to be one bridge too far either, although student Eelco demonstrated a nicer prototype.

For the environmental managers the conclusion was that within PCE environmental improvement actions are very well feasible and also very rewarding. Therefore, spend all the capacity and budget on such items.

More daring and radical innovations require a different type of organisation, for instance of the incubator type or the start-up type. And thus the dream of human-powered products in PCE evaporated.

7.4. Environmental brainstorms; the entrance ticket to the product creation process.

The events around the 'green TV' and about the human-powered radio showed the necessity of involving from the very start all parts of the internal value chain. This was a clear departure from the earlier idea that apart from incremental improvements, radical environmental thinking was necessary to achieve real breakthroughs. It was felt that this radical thinking had brought big leaps forward, but simultaneously that the products proposed were too much out of touch with business reality. It was decided to keep the radical element in the first part of the environmental brainstorm, but to link to the business through screening of all ideas developed in the first part for their business and consumer benefit and to analyse feasibility as well (this was called the EcoDesign Matrix analysis). In this way the environmental brainstorms got an on par status with the mechanical brainstorm, the electrical brainstorm, the software brainstorm and the marketing brainstorm. Moreover, due to the combination of 'radical green' and screening through the EcoDesign Matrix, departments got a positive interest to participate: this mechanism was now a guaran-

tee that 'green' would contribute to the business properly. Moreover, the common-sense approach in the sessions guaranteed that also non-specialists could contribute to the business.

In an environmental brainstorm the data from benchmark reports (see section 6.4) are the basis. Focus in the first part of the session is exclusively on environment; money or feasibility talk is forbidden (and will be addressed later). All ideas are welcome, even ones which have failed in the past (circumstances in technology or supply chain might have changed.).

Usually a huge number of ideas are generated in such sessions. After classification the next step is the prioritisation of ideas.This is primarily ranking them according to expected environmental benefit.

Next, other benefits (for the company, the customers and for society) are analysed. Finally also feasibility technical, financial) is addressed. Even if such analyses are carried out in a very quantitative way (for instance with help of pluses and minuses) it turned out in a meaningful way to position the 'green design options' and thus to get these accepted in product concept discussions. It paved the way to giving environment a clear status in the program of requirements and subsequently in the complete product creation procedure more generally. Moreover it turned out in practice that the top 10 environmental design options remained standing after the benefit and feasibility analysis — mostly only the mutual order being changed.

But most of all this analysis helped the green design proposals to survive in the concept consolidation meetings.

8. Implementation and Validation.

8.1. Environmental strategy, what is happening in the world?

Getting facts raised awareness, asking the question 'why are things as they are' helped to overcome lack of attention and to update decisions of the past.

Systematic data collection created the basis for creativity and mobilising enablers like latest technology made EcoDesign more effective. It all worked out positively for the company.

Gradually more systematic procedures and support tools came in place like environmental benchmarking, and mapping. Creativity turned out to be the result of interaction between various disciplines and the 'green TV project' in 1997 showed that the complete internal value chain had to be involved to get the best out of EcoDesign. Simultaneously, the human power project showed that there are limits to what an organisation with an established culture can do.

These developments showed that it was beneficial for PCE to exploit the opportunities of EcoDesign systematically and throughout all business groups, but on the other hand it demonstrated the necessity to give guidance on what subjects to address and what not to address.

The general policy formulated earlier was not good enough for this purpose, being just about some general principles. A clear environmental strategy had to be formulated. Formulating such a strategy —apart from the subject itself— is nothing special, the principles how to do it through a SWOT (Strengths/Weaknesses/Opportunities/Threats) analysis are well known.

New however to PCE was the effort to look at what was going on in the external (environmental) world. Just formulating an ambition to be the best in 'green' was tempting in view of the earlier successes obtained. However, in practice, goals and resources needed to reach them have to be carefully balanced. While this debate was going on, it was discovered that the appreciation of PCE customers for good environmental performance was pretty mixed. A minority was clearly positive, another minority perceived it as freaky and feared it would go at the cost of other functionalities, whereas almost half of the customers were somewhere in the middle of the road, see section 10.3 and Adventures in EcoDesign of Electronic Products, chapter 5.4, and were taking more or less the attitude of 'yes, why not if it is for free'.

Managers at PCE are human beings too and have, apart from rationality, feelings as well. These turned out to correspond to the ones of the general public; so a substantial effort was required to developed a balanced environmental strategy.

Irrespective of what the feelings were, it was very clear that in the world there became more and more awareness about environmental issues; more legislation and regulation was bound to come, and competition was picking up the subject as well.

Environmental action groups would target companies like Philips either because of their visibility or because of bad performance of the company itself or its suppliers.

Science and technology developed and could be useful enablers. Methods like Life Cycle Analysis (LCA) came into existence and these gave the opportunity to specify environmental impact in a detailed way. Being able to speak 'LCA language' became a must to communicate with the world of science and with authorities as well. For this reason, companies need to validate their results in terms of LCA. To a large extent this is to be justified; environmental results have to be put into a broad environmental perspective.
However making action plans (mobilising 'creativity') needs a common sense approach and therefore most of the EcoDesign tools developed in academia could not be used, much to their regret or even to their indignation.

Also addressing most groups of customers requires a closer focus on their benefits than on scientific truth. For such audiences the language should be comparative (better than previous generation or, preferably, better than the competition).

Environmental managers in industry, at least the ones at PCE had to become 'bilingual'. This helped academic EcoDesign and applied EcoDesign to stay in touch.

8.2. Making of the environmental strategy, connect to the world and be proactive.

The making of an environmental strategy at PCE was a natural process after a number of experiences during the introduction of EcoDesign. The first and foremost discovery was that 'eco' is much more than just a set of technical tricks to be added to the know-how and expertise already in place. It is also about planning, organisation, communication and management. It pertains to the complete internal and external value chain as well and not just to the product development departments. It was furthermore recognized that design plays an important role but that also technology and mobilising enablers are necessary

to do a real good job. If applied appropriately, EcoDesign is an important lever to look 'with fresh eyes to old problems ' as well.

The core of a good 'ecostrategy' are these 'fresh eyes' while keeping watch on what is happening in the world. Also business conditions and the opinions/emotions of the customer are changing all the time. This has to be analysed and updated continuously. With a set of observations in these fields an environmental SWOT analysis was made in 1997. This analysis can be summarized as follows:

Observation	**Consequence for strategy**
— More legislation, regulation	— Be ahead of most demanding regulation
— Fragmentation of regulation in the world	— Global PCE standards
— Competition is taking 'green' on board	— Be better than the competition
— Consumers have a diversity of opinions	— Product differentiation strategy, also for EcoDesigned products
— Scientific institutions have a lot of knowledge	— Connect with them, speak their language
— Digitalization, miniaturisation	— Exploit this for 'eco' purposes
— Software to develop fast	— Exploit this for 'eco' purposes
— Shift of production to development countries	— Monitor consequences in particular for the supply chain issues and packaging/transport

In total this strategy can be summarized to be one which is proactive and one which is aiming at a positive green profile through science and technology-based green.

The strategy proposed had been developed by the environmental advisors and was happily accepted by the senior management. This demonstrated the credibility and trust which had been developed. Some critics said that the strategy had been accepted too easily: as long as the management is kept out of (environmental) trouble everything is OK. Personally I do not believe that this is

correct. Nevertheless it was necessary to enhance the engagement of the management further. This opportunity came when the overall strategy had to be translated into tangible goals: the roadmaps.

The making of an environmental strategy has opened a new window to the world. Wise or unwise environmental legislation demonstrated that PCE or the electronic industry was not calling the shots anymore. It is possible (or in the case of PCE not forbidden) to learn from competition, inside but also outside the environmental field. Customers are not in favor or anti green but split into a variety of groups with different attitudes and emotions. Scientific institutions can offer useful conceptual platforms on which practicalities can be built. The traditional skills of PCE in product creation were not good enough to stay ahead; new skills had to be obtained. And environment is global, not just for cozy Western Europe where many people have a positive emotional relationship with nature.

Such messages came as a shock for proud, traditional and fragmented PCE. This was the real learning of making an environmental strategy.

8.3. Environmental Roadmaps; the way to make the strategy tangible.

8.3.1. Making of roadmaps and giving them a clear position in the organisation.

Once an environmental strategy is in place, it needs to be made tangible. The core subjects of the roadmaps to be addressed were the products to be developed in the future. For these products specific targets were set according to two avenues (see Adventures in EcoDesign…, chapter 4.7):

- Performance in the five focal areas: energy, materials, packaging and transport, chemical content and durability/recycling.
- Performance in comparison with products of the competition.

For each issue in the roadmap a time schedule for realisation of the targets and an 'owner' were indicated. These owners were individuals — experience was that if groups or departments were owners this could give rise to hiding behavior when targets were not met.

Apart from chapters on product development there were ones about monitoring progress and follow-up (senior management). Production management got targets for the reduction of use of utilities and for getting ISO 14001 certification. Staying in line with the corporate environmental programmes and getting the data for the corporate environmental report were tasks which had environmental managers as an owner.

Last but not least there were roadmap items about organisation, deployment, internal communication and training.

The roadmaps turned out to be an important step forward: a variety of managers were addressed in a very tangible way. It moved environmental issues further out of the corner of sympathy and good intent.

But still the issue remained to make the roadmap really alive for the organisation. Here the 'Business Excellence Model' (BEM) which had been introduced at PCE for appraisal of managers came to help. In this system, leadership, process management and key performance results were the chief criteria for overall performance measurement. The category results, was subdivided in customer results (external), people results (internal) and society results. In a pragmatic move, the score for realisation of the environmental roadmap (the environmental key performance indicator, EKPI) was made the yardstick for the societal results.

The good news about this was that 'environment' got finally a clear position in the operations (although the environmental managers felt that 'green' should also be incorporated in other parts of the Business Excellence Model as well).

The best of news came when the performance according to the BEM was linked to the yearly bonuses. With excellent performance in the category 'society' (and therefore excellence in realisation of the roadmap targets), 8% of the maximum bonus possible could be earned.

EcoDesign moved from sympathy and feel good, to an item to be taken into account. It moved from a voluntary activity with an occasional push in the back finally to a clear incentive for green performance. It had been a long way, but it is the way to go!

8.3.2. Making meaningful targets for a roadmap.

Linking money and environmental performance of individuals turned roadmap compliance from an interesting game into a serious matter. Now the milestones and targets got even more discussed (and challenged) than before.

It has to be admitted that when the making of roadmaps started, the environmental managers had set the targets and milestones in a pragmatic way; ambitious enough to be challenging, but not so challenging that the organisation would see them as not realistic.

With environmental roadmap performance being put into the bonus, accountability of the milestones and targets had to be increased. The environmental benchmarks (see section 5.3) came to help. When the roadmap performance was put into the bonus, already more than hundred benchmark reports were available. These covered all products groups of PCE. Data about these product groups showed the progress already made and through extrapolation future targets could be identified. In addition, the evolution at the competition showed where to speed up. The key word of the environmental strategy 'be better than the competition' became in this way an important anchor for all discussions and decisions. It made the whole system to operate in a realistic way.

In order to measure performance a one point 'Environmental Key Performance Indicator ' (EKPI) was defined. Essentially, this meant assigning for each relevant element item of the roadmap a weight factor and a score of the performance (1=OK, ½= can be done better, 0=unsatisfactory).

By normalizing this can be transformed to a % score. *The system was called the traffic light system: 1 = green, 1/2 = yellow and 0 = red.* When putting the colored scores on paper, the supervising manager did not need to read all the details, but could get in one glance an overall impression. *A special application of 'mapping' (see 6.4)!*

8.4. Philips Consumer Electronics tools to support EcoDesign.

8.4.1. The Environmental Design Manual.

At the start of EcoDesign in 1993, PCE followed the widespread idea of that time that EcoDesign is best fostered through an Environmental Design Manual. This should give background information to designers, but most of all 'design rules' which would make EcoDesign very simple.

Within a year, a dedicated manual had been made available. The background information had been organized to what —later— would be called the five focal areas (energy, materials, packaging/transport, chemical content and recyclability).

The design rules proposed had been organized in three categories:

- Mandatory design rules; items which were not allowed (chiefly in the chemical content domain). Non-compliance was not acceptable; this would stop further development till remediation
- Directives; non-compliance is only acceptable with good reasons (to be endorsed by management)
- Recommended design rules; rules to be considered.

In the Environmental Design Manual the following items were addressed:

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

At the end of each paragraph of the chapters of the manual, the coordinates of specialists were mentioned. In this way, designers could get additional information.

Due to the wide distribution of the manual it became an instant success in terms of creating awareness. Environmental issues got much more attention in the organisation and the specialists mentioned in the manual got consulted frequently. The mandatory design rules were clear and obvious for the designers and got a very good follow up.

The recommended and suggested design rules got much less attention. This was basically because there was a multitude of rules which sometimes were (partly) conflicting. But most of all there was little attention because EcoDesign was still a 'voluntary' activity. There were no environmental requirements in the target specification for new products. With time pressure and budget pressure added to this, voluntary items would be low on the priority list.

The Environmental Design Manual turned out to be very useful in this first stage of the introduction. It had to be followed by other information which would allow the designer to operate more effectively in the field.

The most important conclusion from the manual experience was that designers do not like 'rules'. These had been promulgated with the best of intents for the environment. Designers put however 'Design Freedom' first.

EcoDesign tools should therefore preferably aim at unleashing their creativity rather than being perceived as to be prescriptive in any form.

8.4.2. The Environmental Weight Method.

The Environmental Weight Method (see Adventures in EcoDesign…, chapter 6.2) consists of assigning multiplication factors to the weight of materials and components. A factor 1 is for standard monomaterial, depending on the type of surface treatment of this material there is an additional factor ranging between 1.0 and 2.0. For temporarily released materials and components there is a factor 3, for materials and components with an unknown status there is a factor 4. Plastics without a recycling mark get a factor 5, and rejected components and materials get a factor 10. Application of recycled material earns a bonus in the form of a factor 0.5.

It is to be noted that these factors do not represent a science based environmental load (see also 'green perceptions of consumers', section 10.3). Their relevance is however linked to environmental management goals and also to subjective opinions of customers (for instance PVC gets a factor 3) and to legisla-

tion/regulation (which is only partly reflecting scientific insights). This makes Environmental Weight a first example where industrial and academic approaches of EcoDesign started to separate.

In order to come to a yardstick for the environmental friendliness of the design, all 'environmental weights' obtained through the multiplication as above, are added and this sum is divided by the physical weight: the result is the environmental weight ratio (EWR).

EWR changed the character of the EcoDesign game: instead of imposing design rules, the designers were now encouraged to improve their EWR scores. The new game, initiated by the environmental managers of the TV group, has been played by development groups throughout PCE with passion — with excellent outcomes. Targets were set for EWRs to be reached, leaving sufficient room to play but ensuring ambitious outcomes.

Environmental weight considered 3 areas only: material application, packaging and chemical content. Recycling was addressed indirectly only, but energy consumption not at all. The reason for this was that it was believed at that time that energy reduction would affect picture quality — the big asset of Philips in its fight with Asian competition.

The environmental managers recognized the energy issue, but the organisation was not yet ready for it. The outside world was not ready either; in the 1990s oil prices were low and awareness of the global warming issue still had to develop.

The managerial significance of the EWRs was that it meant a change from 'top down' to bottom up. Empower the employees (in this case the designers) to play in a well-defined playing field and this will free a lot of (environmental) creativity.

8.4.3. Transforming Environmental Benchmarking into a comprehensive EcoDesign tool.

Environmental Benchmarking (see Adventures in EcoDesign…, chapter 6.3) had been used inside PCE as a method to get facts to create awareness (see section 5), to create a basis for environmental brainstorms (see section 6.4) and to support the making of roadmaps (see section 8.3.)

What still needed to be done was to consolidate it into a comprehensive EcoDesign tool which could be applied to the complete lifecycle of a product.

For this purpose a list of 37 basic (physical) parameters has been defined (6 in energy, 10 in materials, 5 in Packaging, 6 in Chemical Content and 8 in Recyclability. For each parameter the way it had to be measured was defined. Results had to be presented in fact sheets per focal area. These were organized in such a way that products could be compared to products of previous generations and competitor products. Added to the physical parameters were lifecycle calculations according to the Ecoindicator method using data from the PCE Ecoindicator base (see section 8.5). For the energy part this included that user scenarios had to be assumed; an average user scenario and ones for 'light' and 'heavy' users. In this way a global standard (including formats for reporting and so-called calculations sheets for benchmarking) had been created and the product development teams were freed from collecting the information themselves — this could be done by a local environmental manager. Originally, full measurement took two days, with more routine this could be reduced to two days. Hundreds of benchmarking reports have been made; availability was in the first years in print, later through the companies' intranet. It was a very powerful data base on which authorized persons could extract all kinds of valuable data. Through mapping, progress of EcoDesign could be monitored in each product group.

Finding facts is good for making action plans, collection of (environmental) data helps to support comprehensive EcoDesign and give product management precise insights about their own product portfolio and the ones of the competition.

8.5. Ecoindicator calculations.

8.5.1. Calculations to support EcoDesign of products.

In previous sections it has been argued that facts with environmental relevance can be best expressed in terms of physical parameters. This is to ensure that a wide variety of employees of PCE can be involved in activities related to 'eco'. Nevertheless organisations should have the capability to do eco calculations on a life cycle basis. This is because it should be possible to have mutual

comparisons between focal areas (energy, materials) or even within one focal area (replacing one material by a different one). The other reason is that several audiences (authorities, scientific world) preferably want to be addressed in environmental language when it comes down to EcoDesign.

Considering to do full Life Cycle Analysis and making environmental profiles only lasted a short while. It is too cumbersome and too costly. Moreover such an analysis is describing 'the scientific truth' and is as such 'absolute'. This is less suitable for design purposes and for managerial decisions. These have a relative character; this means if A is better than B, go for A.

In 1995, an abbreviated LCA method became available: the Ecoindicator 95 method. Here environmental impacts are described in a one number score. Underlying these scores is a weighting method for the various impact categories. How this weighting best can be done is still a matter of debate today, but for PCE the weighting applied was good enough: A should be better than B. In calculations based on indicators with different weighting schemes it never showed that a decision had to be reversed (B better than A), although the margins between the two alternatives varied.

For Ecoindicator 95 a pretty good data base was available for materials and energy. For components there was almost nothing. PCE had therefore to add these to the database itself and had to invest some Euro 250k to do this job. The Philips group of companies had an important component production so the emission data needed to calculate the indicators were easily available. It was significant for the status of the environmental activities that the budget for these activities was awarded straightaway.

The advent of Ecoindicator 99 became subsequently as a shock. Essentially this is a different way of weighing the impact categories (and also includes some resource scarcity aspects). It was feared that this new system would invalidate the design decisions taken earlier. The ecoindicators had to be changed substantially but a quick check showed that the design decisions taken earlier were all right: A stayed bigger than B although the margins sometimes became smaller and in other cases became bigger. A big relief, inconsistency would have seriously undermined trust in the calculations.

Ecoindicators were also used in specific tools as regards take back and treatment of discarded products. Examples of this are the Quotes for Environmentally Weighted Recyclability and Eco Efficiency calculations (see 'Adventures in EcoDesign', chapters 7.4 and 7.5). Also in this field the chief goal of applying ecoindicators is to set priorities in improvement actions and to support management decisions.

Ecoindicators have their roots in environment-related activities but result in consequences which affect the complete business.

8.5.2. Calculations to support EcoDesign strategy and green marketing efforts.

In 1998, the introduction of EcoDesign inside PCE had progressed sufficiently to support the development of 'Green Flagship' products. These were products which should have environmental attributes which were significantly better than the one of the competition in at least two of the five focal areas (energy, materials, packaging and transport, chemical content and recyclability) and should be on par in the remaining three. Apart from the progress in EcoDesign itself, the support from the CEO (see section 7.3) had changed from passive to active: each business group had now been required to have at least one Green Flagship. Introduction of the concept was planned to serve three goals: further stimulate EcoDesign, add to the Philips brand image and —last but not least— to explore to what extent specific 'green marketing' could be done for these products.

In order to qualify as a Green Flagship, the life cycle impact of the product should be 10% better than products of the competition with comparable functionality and price. This requirement seems to be modest but it is to be realized that the physics underlying the functionality to be achieved is identical. Moreover, most products to be considered were pretty mature and all other main brands had become active in EcoDesign as well.

The first ecoindicator calculation round (based on benchmarking results) to search for Green Flagships showed that inside PCE most product groups scored Green Flagships very comfortably. This was chiefly due to superiority in the energy focal area — the links with the Philips Semiconductor Division proved to be very fruitful in this respect. The early start of PCE in chemical content (see section 6.1) paid off by a clear lead in this field. The design for disassembly activities (see section 6.2) resulted in good scores for recyclability as well.

Overall, the introduction of the Green Flagship project resulted in a strong traction for EcoDesign. Especially in the focal areas of materials and packaging/transport PCE had to catch up. Nevertheless some business groups were tempted —due to a 'too-easy win' for their products— to conclude that EcoDesign did not need much attention anymore.

Green Flagships definitely added to the image of Philips as a caring company. The ecoindicator calculations contributed greatly to credibility due to their transparency.

Green marketing efforts on based on the Green Flagships were, however, short-lived. Although a majority of customers in Western Europe said in inquiries that they would buy green(er) products provided that their price would be approximately identical, their actual buying behavior turned out to be quite different and only a minority was really interested in buying 'green' (see section 10.3). As result of this attitude Green Flagship products were seen with distrust as regards their pricing rather than as regards their environmental performance; maybe they were perceived as a bit 'freaky' for a high tech company as Philips as well. Sales of Green Flagships remained therefore modest. Sales of products closest to them got a boost; apparently the perception was that the ideas applied in the Green Flagships would have diffused further into the product line.

Therefore the overall conclusion was that a Green Flagship can mobilise the internal value chain and can boost sales in an indirect way. The broad customer base however prevented Philips from exploiting the concept more explicitly.

8.5.3. Ecoindicator analysis of electronic products, an inconvenient truth for EcoDesign.

The presence of a dedicated PCE ecoindicator data base allowed to analyse the environmental load of its products both according to the five focal areas for EcoDesign and for all phases of the life cycle. Since a large amount of benchmarking reports became available as of 1999, the ecoindicator calculations were easy and straightforward.

The outcomes came as a shock to the organisation, at least from the EcoDesigners. Energy in the use phase turned out to be the chief source of environmental load: 60-80% of the total; only cell phones scored lower (40-50%) in this respect. For TVs energy in the use phase was calculated 80% of the total for the average user scenario in the Netherlands: 3 hours in operational mode,

12 hours in standby and 9 hours off. For heavy users (6 hours on, 9 hours standby) this increased even to 90%, for light users (1 hour on, 11 hours standby) it constitutes still some 60%.

In the EcoDesign field most papers at conferences or published in scientific literature were devoted to materials (30%, in the 2000-2005 period), recyclability and recycling (50%) and methodology in general (15%). PCE had followed more or less this trend, most of its (internal) efforts had been paid to these subjects as well. Packaging got a lot of extra attention as well (only 2.5% in literature). However, due to its excellent links with Philips Semiconductors and Philips Components PCE had been enabled to minimise energy consumption through component integration and miniaturisation. These results were obtained through common roadmaps. From the PCE perspective this was rather an organisational than a design effort.

This experience made clear that Ecodesigners should not just be designers but also EcoDesign organizers: mobilise expertise to help to do the best of EcoDesign jobs.

8.5.4. Calculations on recycling; the real EcoDesign priorities are elsewhere.

From the very start of EcoDesign, discussions about recycling and the reuse of discarded products played an important role. Increase of recyclability played an important role and was supported by all important internal and external stakeholders. Actions like design for disassembly had been successful, particularly in economic terms (see section 6.2).

This left the organisation however with the question how much design for recycling would benefit the environment. The availability of the PCE ecoindicator database allowed filling this gap.

Averaging over the various types of materials involved it could be concluded that for PCE products some 75% of the environmental load of its parts is due to the materials production itself ('producing the kilograms') and some 25% is due to bringing the materials into a certain form (cutting, machining, molding, surface treatments,…). For components the percentages are: approximately 60% for producing the kilograms, some 20% for getting the form and another 20%

for bringing it into a function (for instance diffusion of dopes in integrated circuits) .

In bulk recycling only the 'kilograms' are recouped, but this represents a gross environmental yield of 70% on a product weight basis. This percentage as such is high; it has to be multiplied by some additional loss factors. These result from losses during upgrading of the secondary streams (10-20% for metals, for precious metals much higher, for plastics some 50%). Also energy consumption (collection, treatment, upgrading has to be taken into account).

All together this makes that the environmental efficiency of recycling of materials is (far) less than 50%. This low yield makes that for PCE products — in combination with the high cost of a take back and treatment system— the value of the recouped materials cannot pay for all operating costs. A 'radical redesign' project for Audio products of student Marielle demonstrated that the gap between value and cost could be reduced, but not to zero. The spin-off of this project was nevertheless substantial (simplification of product architecture), be it that the goal had not been reached.

For EcoDesign more generally the conclusion of the calculations was that 'design for upfront material reduction' has generally priority — even if this goes at the expense of recyclability.

Similarly it can be reasoned that miniaturisation of electronics which results in less energy consumption is to be preferred even if this requires more precious metals to be used and recyclability goes down.

From a managerial perspective the conclusion was that the paradigm that cost of take back and recycling will be brought to zero through appropriate EcoDesign is invalid for almost all PCE products.

However take back and treatment is necessary for saving resources and controlling potential toxic substances, and therefore a mechanism needs to be put in place to recoup the costs.

8.5.5. Calculations on reuse of PCE products; energy, not materials are decisive.

From an environmental perspective, reuse of products and subassemblies is better than material recycling. From an EcoDesign perspective 'design for reuse' implies a different design strategy than 'design for recycling ', for instance as regards product architecture. In terms of the business strategy, material recycling can be easily incorporated into the strategies already in place. Reuse requires a completely different approach.

While all kinds of debates on 'reuse' were dragging on, the ecoindicator database allowed to address the real driver behind a reuse strategy: what are the environmental gains to be expected from such a strategy? TVs were chosen as the carrier for such calculations: these products simply represent some 50% of the tonnes of materials of PCE products in the market.

While the discussion about the assumptions to be made for a 'proper and realistic calculation' were still going on, it was sidelined by a different development. By considering the decrease of energy consumption of 28 inch TVs over time, it was calculated that —on an environmental basis— consumers should replace their old products by new ones after 10 years. This is 2 ½ years less than the average age at which TVs are returned to take back and recycling systems. Extending the life of the bulk of the TVs is therefore only useful if the Printed Wiring Boards in it can be replaced by new ones bringing about less energy use.

Student Michael showed in his graduation study that this can be done, be it that this requires a lot of other construction changes as well. The discussion whether PCE should set up a 'life extension service' were still in place when a new development took place: the advent of Liquid Crystal Display TVs. The energy consumption of such TVs would be half of the ones based on Cathode Ray Tubes (at identical screen sizes). As a result the 'life cycle service' idea was abandoned. The potential energy reduction through transition to LCD screens never materialized; consumers massively opted for larger screens (42 inch LCD screens use approximately the same amount of energy as 28 inches CRT based ones.)

Parallel to these developments my PhD student Catherine brought some order in the complexity of reuse issues. Products with a high price and a long technology cycle are most suitable for reuse. Products with a high degree of design

complexity, high degree of function integration and short technology cycles have much less potential. Business to Business products have more potential than consumer products. Value chain issues rather than environmental issues determine to a large extent whether reuse will take place.

With this 'landscape' in mind it could be concluded that PCE products have limited potential.

Specific 'design for reuse' should have limited priority. Design for recycling has more potential as long as it does not interfere with design for energy and/of material reduction.

9. Stage 4. Structure.

9.1. Integration of EcoDesign in the Product Creation Process.

The successes of the EcoDesign approach through fact finding (section 6) and through enhancing creativity based on life cycle thinking (section 7) paved the way for integration of 'Eco' in all operations. Pre-eminently this was done in the Product Creation process. This is because in the PCP, the environmental strategy (see sections 8.1 and 8.2) as expressed in the roadmaps (see 8.3) is transformed into tangible products. When these products at the end of the PCP are released to be produced and to be sold, quite some environmental issues are still to be addressed ('green production methods', 'green' marketing) and therefore the EcoDesign requirements put into the target specification should take this into account as well. This is ensured by screening the eco ideas according to the EcoDesign matrix (see section 7.4).

The actual integration of EcoDesign into the PCP was done by adding the eco requirements as a separate chapter in the target specification and by defining for the the different stages of the PCP process the specific activities to be done. This looks as follows:

Stage in PCP	**EcoDesign activity**

•	Planning	Get facts, lifecycle thinking, align with environmental strategy
•	Conceptual design	Brainstorming, apply EcoDesign Matrix to ideas, consolidate in a specification.
•	Detailed design	Apply design approaches, mobilise enablers
•	Testing/Prototype	Evaluation of results against targets and specifications
•	Market launch	Add 'green' to communication plan
•	Product review	Consider environmental aspects

In practice this way of integrating EcoDesign went smoothly. The reason for this success was that the eco elements were an add-on to the existing procedure and did not require to change or to do something special. After the integration into the PCP all codified procedures of PCE got an 'Eco add-on'.

9.2. Green supply chain management; mobilising enablers for EcoDesign.

It has been estimated that for electronic products some 75% of the environmental load over the life cycle is caused either directly or indirectly form purchased materials and components. With increasing subcontracting and outsourcing this percentage has been increasing over the years, also in the period 1993-2008 considered here.

EcoDesigners have to become therefore increasingly EcoDesign 'organizers' and deal in this capacity with the supply chain as well. Preferably this is to be done through existing channels; 'eco' should therefore be integrated in the supply chain management (see Adventures in EcoDesign…, chapter 5.3)

When introducing EcoDesign to suppliers, similar phenomena showed up as with the introduction in the PCE internal value chain itself: doubt whether this would work for them, fear for higher cost (and thus inclination to increase prices) and sometimes silent or outright rejection. In order to handle this properly, it is first of all necessary that such doubts and fears are dealt with in PCE itself — your own operations have to be OK before others are required to join.

It is therefore necessary that the successes of EcoDesign inside PCE could be demonstrated and that the purchasing department gives full support to the involvement of suppliers — initially there have been doubts in this department as well.

It took some time to get this up and running but as of 1994-1995 green supply chain management was in full swing for the chemical content activity.

In the end, three types of activities were included as well:

1) A 'defensive' one: focus is here on chemical content reduction/elimination (see section 6.1 and Adventures in EcoDesign…, chapter 3.4). This turned out to be a difficult operation which needed continuous attention and help from the PCE side. This is for instance because a lot of suppliers do not have sufficient equipment for chemical analysis or have little idea about the mass balance (what is going in and what is going out) of their production. Sometimes, there is lack of improvement potential, at least not inside the domain of the supplier company. Changing suppliers just for disputes about chemical content remains a difficult decision, trying to educate them first turned out to work better.

It also turned out that that 5-10% of the suppliers are not sufficiently cooperative and 2-3% is cheating outright. Particularly last named observation is relevant because the reputation damage which can result from chemical content issues will mostly backfire on the producer company, not to the supplier.

2) A cost-related activity. PCE has assisted in reducing the use of utilities and auxiliary materials of suppliers. This has been done by comparing suppliers (of the same item) as regards their energy and material consumptions and looking at waste. The suggested formats were similar to the ones used during in-house actions to get ISO 14001 certification. PhD student Menno contributed greatly to further sophistication of the approach. Doing a kind of 'environmental benchmarking of production' created a lot of awareness; the making of action agendas was however the most important result.

Next to the reduction of the environmental load of the goods supplied, PCE got goodwill through its assistance. This made price negotiations easier. Also the cooperation in solving difficult chemical content issues got better.

3) A 'proactive' approach. This consisted in developing common roadmaps with key suppliers to assist PCE to systematically reduce overall environmental load. Philips Semiconductors (now NXP) has been the champion in such actions. As the supplier of integrated circuits (ICs) it played a key role in energy reduction

of PCE products. ICs with more functions on board also reduced material consumption, less other components were needed and the area of the Printed Wiring Boards can be reduced (PCBs)

PCE and Semiconductors had common roadmaps which were updated every two years.

This cooperation has been very successful. Specific successes include:

- First 'one-chip' IC for TVs (1994);
- Full electronic integration of the standby function (1997);
- Introduction of the 'Ecoknob' in TVs (2000);
- Integrated light sensor function (TV brightness adapts to ambient light) — 2005.

Such improvements made that in the domain of energy consumption PCE was for the latest models consistently ahead of the competition.

Vertical integration and close relations with key suppliers are very important conditions for success, also in EcoDesign.

9.3. Corporate Programmes on EcoDesign, a necessity for green communication.

9.3.1. A balanced level in EcoDesign performance is needed to support a green image.

When in 1997 stock was taken about the progress of EcoDesign inside Philips Consumer Electronics the picture was very mixed indeed.

The Business Group Monitors was most advanced. Management had supported EcoDesign in an active way. 'Eco' had helped to achieve a breakthrough in the design of the 1998 in terms of cost reduction and in environmental performance. Although the environmental skills in the group were limited, the enthusiastic design teams compensated for that. Strong support from specialists from Eindhoven helped to fill the gaps and to create some methodological order. What helped too were the demands from the —business-to-business— customers: they wanted Monitors to contribute to their success. A presentation

about ecoperformance of the Business Group to a computer maker had tipped the balance therefore in favor of Philips with extra orders as a tangible result.

On the other side of the spectrum was Business Group Audio. Interest by development groups and of management was fairly weak. The packaging reduction efforts on basis of 'green' was bringing millions but was rather seen as remediating an omission than something which was part of a new concept to consider design. There was no pressure from (private) consumers; consumer magazines paid most of their (environmental) attention for electronics to TVs. In specialist magazines about Audio, environment was not yet a subject. A brainstorm identified opportunities for energy reduction, but the ideas were rejected because they were thought to go at the expense of sound quality which was considered to be the last-ditch defense against Asian competition. The recognition that EcoDesign could help to regain territory would come only after the year 2000.

The Business Group TV (half of the revenue of PCE) was somewhere in between. Strong impetus for EcoDesign came from a few champions in the mechanical development group. Interest of management was moderate; the green TV experience had demonstrated that inside the Business Group there was not yet a full acceptance of EcoDesign. Because of the good relations with Philips Semiconductors the performance in the focal area energy was excellent. Chemical content was improving fast, in the field of materials application and of packaging there was still a lot to do. There was a lot of 'room to maneuver' in this area, simply because of the weight of the products (and the conservatism in the past).

Most of the attention of TV had to go to the focal area recyclability. Legislation for take back and treatment was close to be promulgated in the Netherlands and subsequently in the whole of Europe. If PCE had to bear the full cost of this all margin was feared to disappear. Moreover the industry got a lot a bad publicity about this issue. As a market leader Philips was one of the chief targets: 'tall trees catch a lot of wind'.

Also for smaller BGs the status of EcoDesign was a very mixed bag.

This picture about EcoDesign implementation showed that more consistency was badly needed. It demonstrated that EcoDesign is more than a set of technicalities. Integrating it into procedures and making roadmaps is not good enough. For PCE, the ambitions of the Business Groups needed to be balanced as well and management teams had to take a more active attitude in stimulating progress.

Only if results are obtained which are on a similar level for all groups, these can be communicated to outside stakeholders. Most of them took (and still take) a critical attitude towards industry including Philips: tall trees…!

9.3.2. EcoVision programmes to support the brand.

When PCE was considering how to deal with the disparity in EcoDesign maturity among the business groups, the Corporate Environmental and Energy Office (CEEO) came up with a first corporate program: EcoVision I (1998-2002).

Its goals were pretty modest; in fact the CEEO had to take into account different levels of sophistication among the Divisions in dealing with EcoDesign as well. There were however two common denominators. The positive one was that all Divisions were selling under the Philips brand, which meant one profile, one image also for environmental matters. The negative one was that all Divisions thought they were special so that exemptions should be possible to the 'one Philips' targets. Since the Philips group of companies as an organisation was rather a federation than a monolithic block common targets for a corporate EcoVision program evoked a lot of discussion. Finally 7 goals were set:

- All factories certified for an Environmental Management System (ISO 14001 or EMAS)
- 25% energy reduction in all operations
- 15% packaging reduction in all operations
- EcoDesign according to business needs
- Supplier requirements
- Creation of internal, external network.
- Active participation in legislation, regulation discussion.

The goals 1, 2, and 3 were easy to comply with by PCE because actions towards these ends had already been taken.

Although the levels of EcoDesign sophistication among the business groups was pretty big the open formulation of the requirements 4, 5, 6 and 7 left enough room to comply as well.

EcoVision II showed more ambition. There was a split in targets for manufacturing and for products. The manufacturing ones considered energy but reduction in use of hazardous substances (for instance as auxiliary materials), water use and of waste reduction as well. For products there was a requirement to

address the green focal areas in product communication. Moreover, each business unit had to produce one 'Green Flagship product" (see section 8.5.2) per year. X% of the products were to be 'fully ecodesigned' in 2002, Y% in 2004 with Y being bigger than X — the Divisions had freedom to determine their own X and Y percentages.

PCE could easy fulfill these targets. However, a big dispute arose about 'green communication'. In-depth research (see section 10.3) had indicated that the customer base of PCE was to be split into three groups, each representing 1/3 of the total. The 'quality buyers' group appreciated green information, the 'tech buyers' were neutral or not interested but the 'price buyers' were essentially negative about it. This finding went against the 'political correct' perception that the far majority of consumers is in favor of 'green'; an opinion shared by the CEEO. Green communication for PCE products has been pursued in this period, however with a very low profile.

In spite of this, the EcoVision II program has been very successful. It brought tremendous cost savings and it enhanced the Philips brand image. 'Green' turned out to support sales in an indirect way: Green Flagships promoted as such did not sell particularly well, but sales of adjacent product did very well. Apparent the perception of customers was that 'a bit of green' trickling down from the flagships was adequate (and not too costly).

EcoDesign III (2006-2009) took a completely different turn: the focus was now on CO_2 reduction (global warming) and the Cradle to Cradle design philosophy — these are only indirectly representing forms of life cycle thinking as represented by EcoDesign.

Also broader sustainability issues were included in EcoVision III, for instance the target to become nr. 1 in the Dow Jones Sustainability Index in the electronics sector.

As a conclusion it can be said a programme as EcoVision I and II very well supports the development of EcoDesign.

After a pioneering phase, the EcoVision programmes has given guidance to initiatives to deepen and widen application of the concept and the phase of integration. As regards communication the EcoVision III programme turned out to be ineffective, chiefly because its orientation has been the Philips organisation itself, not its customers.

9.4. Dealing with Environmental standards, keep it as practical as possible.

9.4.1. Development of Environmental Standards, a lot of academia, few practitioners.

International standards to support EcoDesign can be of great help. These will raise awareness and will assist in engaging suppliers and partners to move forward. PCE had to introduce its chemical content (see section 6.1) all by itself. It had been a success but it had been an uphill battle as well. To broaden support for its chemical content list, it had been proposed to the European Association of Electronic Manufacturers (EACEM) and —after some discussions— it had been accepted. The discussions about a chemical content list in the International Electronics Commission stalled however. A main stumbling block was the 'threshold concentration' (potential toxics should not occur in a concentration above the threshold). Such a limit is needed for practical purposes (for instance chemical analysis). The preferred concentration is however 'zero', the only concentration which cannot be measured by any analytical method.

This issue showed clearly the split in thinking in the environmental world between the practitioners 'relative thinking') and the theoreticians ('absolute thinking'). This split was also to dominate the debate about international standards for environment.

The International Standardization Organization (ISO) operates as of 1926. Its chief goal is to foster international exchange and trade through normalization. Traditionally, industry has strongly supported this goal. It did so by participating in all kinds of national committees as well as making experts available for international working groups.

As of 1990 there has been an important change in this attitude; industry started to cut overhead costs and this has hit standardization activities very hard. Fewer experts were allowed to participate in ISO meetings; they were replaced by others (consultants, academia) who were financed by governments rather than by industry.

Environmental standards are relatively new subjects for ISO. As a result of the developments sketched above, there were only few practitioners in the

working committees preparing the draft standards — these are being voted about by the national organisations in the global assembly. This makes that the current standards of the ISO 14000 series (the environmental standards are more formal and procedural, are more science dominated and require a huge effort for effective auditing. The original goal —widespread and 'fruitful' implementation by industry— is getting into danger through this and as such it is a missed opportunity to help Eco and EcoDesign move forward faster.

PCE has taken the approach that it will serve the intent of the ISO environmental standards in a practical way. This meant using the standards to enrich existing programmess and procedures instead of turning programmes and procedures upside down because of a standard.

9.4.2. ISO International Environmental Standards.

9.4.2.1. ISO 14001 for Environmental Management Systems, the practical approach of PCE.

ISO 14001 was the first environmental standard to be dealt with. Ignoring it was not an option, it is a must. Without ISO 14001 certification, a company does not have environmental credibility. In the report to be filed for certification, twelve chapters have to be written; a lot of paperwork. Many PCE production departments resisted also due to the very 'mixed experiences' with certification for quality, the ISO 9000 series.

ISO 14001 was special too because it proposed a system, but it ignored the managerial context in which the system was to be operated.

The issue 'who is (or should be) responsible for what' is in many organisations a bigger problem than content. This applies also for environment — senior management should do more than just formulate a vision and a policy.

In practice, this was overcome by simply starting with chapter 6 of ISO 14001, the operations; plan, do, check, action (PDCA). Many organisations are action oriented and like this approach. Actions are tangible, just do it. The first action to be selected for PDCA has been at PCE a very visible environmental action: energy saving. Reports about what had been done was the basis to 'work back' in the standard (5. Training, 4. Structure/responsibility, 3. Objectives and targets, 2. Legal and other requirements and 1. Vision, policy). The approach

also facilitated 'working forward': (7. Communication, 8. Documentation, 9. Operational; control, 10. Emergency preparedness, 11. Monitoring and 12. Records).

Through this the factories could be mobilised, there were excellent results, concise reports were produced and... the auditors approved!

9.4.2.2. The ISO 14062 technical report about EcoDesign, a useful compromise.

ISO 14001 had been meant for product development departments as well. In its final form however it turned out to be unsuitable. As a result of this, some of national standardization organisations wanted a separate EcoDesign standard recommending more specific tools, others wanted no standard at all, mostly out of fear that such a standard would become too prescriptive. As a compromise a committee was set up to make a technical report on the subject; this could be seen as a precursor to a standard, or just as a report, nothing less and nothing more.

In the expert group it turned out to become a discussion between one practitioner and 16 others. There were three basic issues to be considered:

- Is this about design procedures or about design itself?
- Is the main emphasis on fostering creativity or is this about validation of design results?
- Has environment priority or is this about enhancing business through addressing environmental issues?

It took many sessions to sort this out. No decisions were taken. All six elements got their place in the final document. The real good news was that for each of the items there were a number of choices how to address these. The user can therefore decide for him/herself about the style in which EcoDesign is operated.

Through the non-prescriptive approach of ISO 14062 it can be adapted well to the culture and style of an organisation.

9.4.2.3. ISO 14006, Guidelines to incorporate EcoDesign in Environmental management Systems, a missed opportunity.

This standard is a kind op follow-up of ISO 14062, but has simultaneously the ambition to link with ISO 14001.

In the working committee it was a debate of one practitioner against 8 others.

There were 3 issues:

- Will the document be chiefly ISO 14001 style or ISO 14062 style?
- Is the chief goal to support the designer or is it to facilitate the auditing process?
- What is (or should be) the role of the various parts of the internal value chain in EcoDesign, in particular the role of top management?

From the PCE perspective the wrong decisions were made: predominantly ISO 14001 style and emphasis on documentation and audit. Moreover, the part about the role of top management was relegated to an Annex. In the opinion of the author this is just the most important part of the standard.

Therefore ISO 14006 is a missed opportunity to highlight the important role of management in EcoDesign implementation.

9.4.2.4. The ISO 14040 series on Life Cycle Analysis, too theoretical to allow widespread implementation.

Numerous academic institutions were involved in the working group developing these standards for Life Cycle Analysis. Industry —like Philips— was represented through discussions in the national committees.

Inside Philips there was even an interdivisional group on this subject. Suggestions from the Philips side to keep the standard simple and practicable were all sidelined or rejected in the national committee. After long discussions inside ISO, the standards have been accepted — an important scientific achievement. However, to implement these in practice is requiring a lot of data, it is time-consuming and costly.

Philips decided therefore to implement a much simplified form of LCA (see section 8.5). Compared to the standard this is a 'quick and dirty' approach. It is however good enough for management decisions. These are to be based on a high degree of likelihood and not necessarily on the full scientific truth.

The experiences with the ISO environmental standards were interesting. They demonstrated that the gap between industrial and academic approaches of EcoDesign was (and is) pretty big.

From a managerial perspective this leads to a simple message; rely on your own strengths to make EcoDesign happen. If the organisation does not have these, build them through hard practice rather than relying on standards.

9.5. European Environmental Directives and EcoDesign at Philips Consumer Electronics

9.5.1. Directives will ensure maximum uniformity but will not reduce complexity.

European Environmental Directives are a must for two reasons. One is to make sure that all electronic products which are brought to the market have at least an acceptable environmental performance. The other one is that the EU prevents in this way that a disparate set of national legislation should come into place. This would seriously hamper trade and would represent a huge cost to European citizens.

At the start of EcoDesign in the early 1990s, pending legislation has been the driving force for PCE to take action. Potential toxic ('hazardous') substances are put into products because functionalities can be realized in a cost-effective way. Replacement or reduction of such substances is not self-evident and requires therefore regulation. Take back and treatment ('recycling') of discarded products cost money and will only start if this is required by law.

Soon EcoDesign at PCE got its own dynamics and cost reduction and proactive elements were added (see for instance sections 6.1 and 6.2). This meant that soon PCE products usually were well-positioned to serve the intent of the environmental legislation developed in Europe and elsewhere in the world.

The wording 'serving the intent' is used deliberately because Directives (and also national legislation) are juridical documents. Such documents cannot describe the complexity of the environmental issues associated with electronic products. Adding to this complexity is the large variety in form, material composition, energy consumption and chemical content of the products considered. Moreover the making of Directives and of legislation is a political process which does not follow scientific logic.

In the European Directives discussed here there is no distinction between 'basic rules' (which are not to be changed) and implementation rules (which can be changed if maturity increases or when industrial infrastructures develop or when technology or material prices change). This implies a lack of inflexibility.

In stakeholder consultations Philips and PCE were supposed to voice their opinions through the Industry Federations. This turned out to be not the best of channels. Opinions among sectors (CE, IT, Appliances, other) differ, opinions among competitors in a specific sector turned out to differ as well, often due to different cultures at the headquarters (which were located at different continents). This resulted in lengthy debates (slow responsiveness) and in the end compromises which easily could be perceived as being defensive. Through all this, industry got a negative reputation. Philips/PCE did not deserve this but did not have the courage to go alone or —which would have served its interest better— to form a coalition with other companies with a similar positive interest.

Environmental legislation is a must and it has become a reality. Contributing to it in a positive way is difficult for traditional industry or for Industry Federations. Being caught 'between the devil and the deep blue see', PCE could not exploit the competitive advantage it had through its EcoDesign activities.

9.5.2. The European Directive on Waste of Electric and Electronic Equipment (WEEE).

This was the first European Directive in the field of electronics. It showed numerous flaws which necessitated in 2008 a 'Recast' of the first version. PCE has —first on its own— but later through the channel of the Applied EcoDesign chair at TU Delft suggested improvements (see also chapter 8 of Adventures in EcoDesign…) and the chapters 3 and 29 of the WEEE Handbook, see section 4.1). The channel of the Industry Federations did turn out rather a negative than a positive one. Even after the Recast there is substantial room for improvement,

the worst of damage has been repaired, but still WEEE is an example where environmental dogmatism prevails; EcoDesign cannot reduce the cost of take back and treatment to zero. Investment in treatment technology and appropriate treatment and management can contribute more towards this end (see also the chapters in the WEEE handbook cited above). This will be even more effective if it is supported by tailored rule making; also for electronic waste there is no 'one size fits all'. Most of all it would be helpful to listen better to what science has to tell (and less to environmental or industry lobbyists).

PCE did so and reaped the benefits of this, (see chapter 29 of the Handbook) but still has to charge its customers for the unnecessary high cost of WEEE compliance.

9.5.3. The European Directive on Restriction of Hazardous Substances (RoHS).

This Directive is of a later date (WEEE already started to be debated in the early 1990s) and showed from the very beginning more realism. Nevertheless there are two important gaps:

— Failure to indicate threshold concentrations for the substances considered. This is a political item. The only emotionally correct concentration of potentially toxic (hazardous) substances is zero, whereas this is the only concentration which cannot be measured by analytical chemistry. Political courage is required to indicate a threshold, but apparently this kind of honesty is absent in the EU. The absence of a threshold can lead to arbitrary situations because the issue 'how zero should be zero' is not addressed. However, for the time being this is not the biggest problem — above the 'almost zero level' there are in the market still a lot of offenders to be caught.

— RoHS has exemptions for cases where realising the required physical functionality requires substances which are restricted. Logic suggests that for such products there would be special requirements (for instance higher than average collection rates) in WEEE. These are not in place; a gap in environmental policies which should be integrated much better.

(For the same reason as mentioned above —lack of thresholds— WEEE does mention that 'hazardous substances should be removed'; this is not detailed either.)

When RoHS was introduced, PCE had no problems at all to comply with it. This was due to its early engagement in chemical content issues.

There was however one exception to this. Lead-free soldering had to be introduced in all of its operations and into those of all suppliers. From a holistic environmental perspective, the decision to ban lead in soldering is a doubtful one. It is a good decision from the perspective of potential toxics, but bad from a resource (more silver and tin are used) and an energy perspective (lead-free soldering requires higher soldering temperatures). So, what has been the real argument for taking this decision? Has it been emotion, or the fact that Japan Inc. took the decision to ban lead in solder at an earlier point in time? Whatever it has been, one thing is sure; a careful analysis of the relevance of the three dimensions of green in this matter has not taken place.

PCE used the mandatory reduction of lead-free soldering to review all its practices in soldering, to bring them in line and bring them up to the latest level of technology. This resulted in substantial material and energy saving — more than compensating the potential extra environmental load and the extra cost of introducing lead free soldering as such.

This demonstrates once more that 'Eco' is a perfect way to reinvigorate old and —often—deteriorating practices.

9.5.4. The European Directives on EcoDesign of Energy using (requiring) products (EuP/ErP) and its effect on EcoDesign at Philips Consumer Electronics.

Although being the last Directive introduced for Electronics, EuP/ErP was the first one to take really the life cycle perspective into account.

Through this Directive producers are obliged to make an environmental analysis of their products (called life cycle analysis in the text; this is accidently (or deliberately?) suggesting to use LCA for it).

In EuP/ErP up-front focus has been put on energy consumption —rightly so— it forms for almost all electronic products the biggest part of the environmental load over the life cycle.

EuP/ErP is also acknowledging societal reality and says that EcoDesign should take a wider perspective than just environment. It is stating that EcoDesign decisions should balance environmental, economic, technical and societal aspects. A systematic review of new technology and new materials to realize better functionality is mentioned as well.

Much weaker is the mentioning of a strange mixture of generic design rules in the text. Differentiation (and priority setting) is a consequence of a thorough environmental analysis as advocated by EuP/ErP but these aspects are completely missing in the text. This deficiency also hampers to document properly the way in which design decisions have to be taken. Such documentation is necessary to support the conformity mark (the CE mark) as required through the Directive for products brought to the market.

PCE has positively supported the ideas behind EuP/ErP. It has made its experience with Applied EcoDesign directly available to the EU as well.

Also for this Directive the conclusion by PCE has been that Directives/legislation is helpful in kicking the subject off. However, EcoDesign for legal compliance (only) does by far not exploit the full environmental and business potential of EcoDesign.

Due to the slow pace of law making, legislation cannot be a real driver in a fast changing environmental world. Companies should take therefore the initiative themselves, show leadership and grasp the opportunities.

10. Stage 5. Communication and Green Marketing.

10.1. The functions of Environmental Communication.

Environmental communication is part of the third and —indispensable— ingredient for successful EcoDesign. Getting facts and fostering creativity (stages 1 and 2) form the technical basis for it. Full implementation, validation and

bringing structure in it are the managerial component (stage 3 and 4). Communication about the achievements of EcoDesign and exploiting these through Green Marketing are the 'third leg' supporting the EcoDesign activities.

The content of messages about EcoDesign can vary greatly; four basic functions can be distinguished:

1) A mobilising function. The basic message is here: EcoDesign can be done in a business setting, it can be done very well and everyone can contribute (there is no need to be a specialist). Chief audiences for this kind of message are the internal value chain and the supply chain.

2) The compliance function of EcoDesign: through the PCE EcoDesign activities all legal and other environmental requirements are met, preferably by a wide margin. Audiences for this type of messages are authorities, legislators, media, consumer organisations and non-governmental organisations.

3) A trust and credibility function. 'Philips is a caring company' and irrespective of the kind of product or service which is bought carrying this brand name, environmental issues are well addressed. This type of message is relevant for all stakeholders, but in particular for private and business-to-business customers.

4) The function to communicate environmental benefits like lower energy consumption, better material application (including use of recycled material), less packaging, lower chemical content and better recyclability. Often this is to be linked to lower cost of ownership to counteract the widespread prejudice that 'Eco' leads to higher prices or even can affect performance.

Such messages about results of EcoDesign need to be supported by facts. It is to be realized however that judgement of most stakeholders (at least the PCE ones) is not primarily based on facts. Instead most receivers of messages want to hear good news and this leaves room for unjustified claims.

High tech companies like Philips/PCE have difficulty in handling this situation properly.

Communication, in particular environmental communication is about achieving 'feel good with the brand', not about technical details. EcoDesign achievements have been often the core of such communication; care has been taken to focus on the real message and not on all the facts behind it.

10.2. Conditions for success of Environmental Communication.

Striking the right balance between 'feel good and technical details is a very important condition for success.

Messages should also the clear support by all top executives, both in words and by body language. This underlines that 'Eco' is not a hobby of a few motivated employees but is well engrained in the organisation. Till 1998 PCE and also Philips were clearly deficient in this and sometimes environmental managers observed with despair what their bosses had to say about their subject. The sudden swing to 'Environment is in the DNA of our organisation' was not very credible in the beginning; in total it took some ten years to get on the right track and to be balanced.

The other condition is straightforward but very difficult to control for a big organisation: no environmental scandals. A first stage is to make sure that in the own division no unacceptable things happen. For this purpose PCE introduced —apart from chemical content— also a system to control (amounts of) auxiliary materials used. It contained solvents, glues, solders and even cleaning agents. This has been helpful, but it has to be realized that the biggest liability however is formed by the suppliers — apart from components and materials more and more of the production is being outsourced as well. PCE never encountered big problems in terms of bad publicity because it had a constructive approach.

This in spite of the fact that approximately 2% of the suppliers turned out not to comply with all the requirements on chemical content. In such a situation, they were requested to correct at short notice. This control system turned out to be sufficiently effective to counteract negative publicity in the outside world.

The threat of negative publicity has been one of the reasons that PCE chose for a 'soft approach' (at least in comparison to most of its competitors) of suppliers instead of the 'shotgun' one. This has lead to better supply relations which paid off well inside and outside the very environmental domain.

10.3. Consumers determine the ultimate environmental load through their spending behavior.

10.3.1. Seven attitudes towards green and three types of buyers.

Having a positive environmental image is a necessary but not sufficient condition for selling products to individual customers; their focus is rather on benefits for themselves rather than on those for society in more general. This observation was already made in the nineties of last century: although 70-80% of consumers in Western Europe say that they will buy 'green products' (even if these cost a little more), actual behavior is different: only 25-30% show real interest. Confronted with this contradiction, PCE did a deep digging research on 'green' attitudes of consumers. Seven archetypes of consumer attitudes could be distinguished (see also Adventures in EcoDesign…, chapter 5.4.); these groups are about equal in size (some 15%):

Type and Attitude towards buying green products:

Environmentally Engaged: Motivated to buy, but not from multinationals.

Environmental Optimists: Ideal target group for green products.

Disoriented Consumers: Positive about green, but fear for high prices.

Environment too complicated: Green could go at the cost of functionality.

Environmental pessimists: Buying green products has no use.

Growth optimists: Fear to be freaky when buying green products.

Enjoy life: Green products will not contribute to fun.

This research confirmed that only a minority of buyers is really interested when products are presented simply as green, without adding other benefits which could be of interest.

Having realized this, PCE developed a 'linked benefit' marketing strategy. In this approach, environmental benefits of products are always presented together with other product benefits. Examples of such benefits are: lower energy costs/lower watts, simple/easy to operate, quality feel/nice design. Through this, environmental performance became a supporter or an extra positive product attribute rather than a new item competing with the traditional three chief consumer concerns: performance, price and quality.

For the broad product line up of PCE, this communication strategy has been diversified further by linking it to the categorization of customers it started to use after the year 2002:

- Price buyers (approx. 1/3 of total in W-Europe)
- Tech buyers (approx. 1/3 of total in W-Europe)
- Quality buyers (approx. 1/3 of total as well)

For products catering chiefly to the price buyers, the environmental communication theme has been 'reduction' (of energy and/or material).

For product catering to tech buyers, emphasis is 'green through technology' (latest components, miniaturisation, smart materials).

For the quality segment the environmental element added has been 'positive emotion' (recyclability, less chemicals, less (packaging) waste).

Considerations about environmental communication have led to adaptations of the product line up offered to the market and resulted in much more transparent profiles of individual products.

In general, the business conclusion of this story is that knowing the environmental attitudes of potential customers will be helpful to define the best product line up to be offered. The 'green of the customers' should match with the 'green of the company'. Just having the 'greenest' of products is not a good strategy for a company wanting to cater to a broad public - it can be a niche strategy only.

10.3.2 Times are changing; producers do not call the shots anymore.

Times are changing and the value chains of electronic products are changing with them. Although design and development of products are still in the hands of producer companies, production has often moved overseas and sometimes even has been outsourced completely. Sales to customers is only in a few cases still through electro shops and department stores but mass markets and internet sales take a big proportion of the market with specialized shops appearing

in the up market segment. Competition has intensified and is rather between sales channels than between brands.

Consumers have become more prosperous and have higher demands. The number of products to choose from has increased enormously but internet is offering a helping hand in making choices. In fact this is an enormous empowerment: functionalities and prices can be compared in a quick way. Through Facebook and Twitter experiences can be shared with followers and friends.

All these developments have enormous consequences for the product line-up proposed by a company. Producers have to listen better to customers and have to take into account the demands of trade channels. For EcoDesign this means that the strategy for reducing environmental load has to be adapted. In mass markets not the reduction per product counts but the reduction per product multiplied by the volume sold. This means 'value' for the customer first (see 10.3.1 and 10.3.2) and as has been demonstrated not necessarily based on the lowest environmental impact possible.

PCE was in a favorable position to deal with these issues. Backed by the positive environmental image of Philips and the green flagship products (which as such did not sell terribly well), the strategy of the three-tier product line-up (price, 'tech' and quality buyers) turned out to fit pretty well with what the trade wanted.

Changing circumstances had also a more direct effect on EcoDesign. The most outspoken effect has been for the focal area 'packaging and transport'. This can be summarized as below:

Issue	**Consequence**
Production overseas	Container transport, emphasis on volume reduction
Loading by clamp truck instead of by hand	Requirements for drop tests can be lowered (saves material)

Trade orders per container	Packaging for individual products can be reduced
A lot of sales 'out of a box'	Graphics of box should attract attention

The packaging and transport issues resulting from a changing value chain as mentioned above have been analysed in detail through the connection of PCE with TUDelft (see section 11.3). PhD student Renee did a wonderful job and the insights acquired in this way assisted tremendously in lowering environmental loads and reducing costs.

Stimulated by such EcoDesign successes PCE has been greatly encouraged to face reality and to acknowledge that times had really changed and that its dominating position in the value chain was over. EcoDesign activities revealed this painful truth but offered a helpful hand as well.

10.3.3. Gender and green.

In the investigation mentioned in section 10.3.1, it also appeared that there was a gender difference in environmental attitudes: women account for some 60% in the environmentally friendly consumer groups and only for some 40% in the negative ones. Simultaneously it appeared that for PCE products some 50% of the buying decisions were taken by men and only 25% by women (and 25 % jointly). An obvious question was therefore whether 'more green' in the products would lead to more sales to female buyers. This was particularly relevant for Audio products where the percentage of female buyers was even lower than for the PCE average. Student Eelco H got as assignment for his graduation project to answer this question. His answer came as a surprise: No. His recommendations however resulted in a lot of (Eco)Design action.

Women turned out to be less interested in the PCE Audio products because of their lousy design and because of lack of ease of use; environmental aspects only ranked third. This confirms that in buying decisions 'green ranks low' but can become a tiebreaker if the superseding issue (price, design, ease of use) are equal among competing brands. The action agenda for the Audio group was therefore straightforward: get on par with (or be better than) the competition on design and ease of use and (re)gain market share on positive environmental

image. In practice this meant: get rid of the square, solid and black boxes, introduce more 'playful' designs, and to introduce (modest) colors. More attention for ease of use, let the users get the excellent sound quality which PCE Audio products traditionally deliver in an easy way.

It worked, almost instantly after the changes made the market share of PCE Audio went up after many years. A lot of material was saved through the redesigns, in particular by redoing the housings of the products.

This Audio example is another support of the core message of this paper.

Environmental considerations are also instrumental in shaking up traditional businesses and therefore can have much wider implications than just realising environmental gains.

10.3.4. The need for priority setting in EcoDesign activities.

The experiences described in 10.3.1, 10.3.2 and 10.3.3 show that EcoDesign activities should fit in the value creation processes of producers and that priorities have to be set according to channels through which products are to be sold. Most of all a match is to be developed between 'scientific green' and green perceptions of potential customers/ target consumer groups. This means that just going for lowering environmental load can lead to disasters in the market. The author has seen several excellent ecodesigners fail in industry because they ignored the conditions for success as described above and because they were not prepared to accept that there is a difference between 'being right' and 'getting it right' or at least to get it right as far as possible.

Functional EcoDesign can contribute in many ways to the four functionality dimensions of a product:

Physical functionality. EcoDesign can contribute by realising the required functionality in an eco efficient way through eliminating all superfluous functions.

Economic functionality. Appropriate EcoDesign reduces energy and materials and reduces other lifecycle costs like maintenance, repair and end of life cost.

Intangible functionality. This includes contributions to ease of use, health and safety aspects and fun. EcoDesign can contribute by simplifications of designs and reducing chemical content.

Emotional functionality. This includes quality, feel good and positive emotions. EcoDesign can contribute by designing products with longer lifetimes, through use of recycled materials and achieving high recyclability.

The flip side of this is: — Do not compromise on for instance picture or sound quality (even if you feel as an ecodesigner that these are over-specified and far too good to be appreciated by average users). Most notorious example are vacuum cleaners: higher wattage is promoted as to clean better; design proposals to balance motor and auxiliaries to optimize suction power and thus to reduce total power consumption have not been accepted because less energy is supposed to correspond to more dirty floors.

— Do not think that a little bit more expensive is acceptable for most customers (although a lot of them say that this is acceptable). Example: more efficient transformers have a higher cost which is often earned back over the complete life cycle — not acceptable for product management and not accepted by trade).

— Do not compromise on ease of use. Example: the human powered remote control never made it to the market. Do not compromise on health and safety issues related to environment (even if common sense tells that some of the requirements are exaggerated). The example of this issue is the endless debate about what types and how much of flame retardants in consumer electronic products.

— Emotions of customers are for real. 'Educating consumers' is seen in a lot of western societies as moralistic and, if this is done by companies, as a form of hypocrisy.

Like all other activities in a company, capacity and budget for EcoDesign are limited. These should be directed towards activities which have the most potential to be successful. This means priority setting. Ecodesigners inside PCE have learned the hard way to do this!

10.4. The EcoValue concept: a clue to new EcoDesign strategies.

10.4.1. The concept and its possible applications.

In the sections 10.2 and 10.3, EcoDesign has been positioned as a contributor to value creation. Value relates specifically to the buying process and is therefore oriented towards the demand side (the external value chain, in particular to the customer).

For appropriate eco-communication, it is also necessary to link supply side (the internal value chain) and the demand side. This is particularly relevant for balancing the product portfolio offered to the market with respect to the customer base.

For this purpose the concept of EcoValue (EV) has been introduced. EcoValue is the ratio between the price paid by the customer (or the life cycle costs of a product) and the environmental load of the product (for production or over the complete life cycle). Scoring high EVs with respect to the competition means that relatively attractive prices can be obtained (apparently the products have a lot of value to the customers) or that the environmental loads are low (good traditional EcoDesign)

A modern form of EcoDesign could be that the attractiveness of products is being increased, so that higher prices can be obtained whilst the environmental load is kept constant. A more extreme strategy could be to increase the attractiveness enormously so that much higher price can be obtained allowing the environmental load to increase a little — in both cases the environmental load per Euro, $, RMB or other currency unit decreases, which is positive for the environment.

For an organisation like PCE wanting to cater to a broad public, this would imply that its product line-up would have to be further tailored to target groups like quality buyers, see 10.3.2.

Apart from this perspective EcoValue creation strategies deserve attention for another environmental reason: the so-called rebound effect. Traditional EcoDesign results generally in cost reductions as well (less energy, less materials). This means that consumers with a constant income can basically buy more

goods. Through this mechanism, part of the environmental gains for individual products is lost through this negative rebound effect, which is estimated to be 0.3 or 0.4 for well-designed electronic products. Products with a high EcoValue have mostly a higher price and have therefore a positive rebound effect.

In the market some companies (like Apple) follow implicitly an EcoValue product strategy. EcoValue considerations as above suggest implementing such strategies more explicitly.

10.4.2. EcoValue: one bridge too far for Philips Consumer Electronics.

The EcoValue issue has been brought to the attention of the product management of PCE in 2003. The reactions were cautiously negative; on one hand the idea was understood intellectually but since it came from environmental managers it was seen with distrust. In the resulting stalemate situation the side step was taken to let a TUDelft student collect more facts and see afterwards how to proceed.

Student Wilco started with great zeal and had some 100 benchmarking reports (see section 6.4) at his disposal. This allowed positioning accurately the PCE products (see section 6.5) as regards EcoValue.

The outcome of this study was very interesting:

- The environmental impact over the life cycle of PCE products was generally lower than that of comparable ones of the competition.
- The prices of the PCE products were generally lower than the ones of the competition as well.
- As a result there were little differences in EcoValue.
- For some 20-25% of the products, prices of PCE products were not in line with these observations; prices were either on par with the competition or just the opposite: disproportionally lower.

This allowed according to the student (and to me as a supervisor) the following conclusions:

- Traditional EcoDesign mostly well done.

- The cause of the lower PCE prices to be investigated (was this due to weak brand image, not enough intangible or emotional functionality or negative perception by trade?
- Irrational pricing to be corrected where still possible.
- EcoValue design strategies tailored to target groups to be postponed till the other issues had been addressed.

These conclusions created an outrage from the product managers; the student was reproached to have his study done in an unscientific way and I as an environmental manager had not been hired to say something about prices.

With this the EcoValue subject died an untimely death at PCE.

The managerial lesson from this is that after a lot of EcoDesign successes and after building a lot of credibility, 'Eco' telling inconvenient truths is not accepted. Instead, it evokes irrational defense mechanisms. After 10 years 'Eco' is not a real part of the mindset of many managers, at least not at PCE.

11. Teaching Applied EcoDesign.

11.1. Training modules and Courses.

Introduction of EcoDesign in organisations like PCE required a lot of training and teaching. Over time the appropriate curriculum was developed and by the year 2000 a system considering all items to be addressed was complete. From that moment, only updates and some additions were necessary. Basically three types of courses were available:

1) Courses addressing the technicalities of EcoDesign (energy, materials application, packaging and transport, chemical content and recyclability).

2) Courses addressing environment and business (organisation, integration into product creation processes, environmental benchmarking, green supply chain management and green marketing and communication).

3) Courses addressing take-back and recycling systems (design for recycling, materials compatibility, disassembly and mechanical treatments, eco efficiency of recycling and system organisation).

Apart from these main subjects there have been specific courses focusing on for instance how to start EcoDesign activities, optimizing the packaging and transport value chain , how to deal with 'Eco' in China etc.

All the teaching material has been organized in a modular way which allowed the presentation of courses according to the subjects and time requested of the hosting organisation. Any duration between 1 hour only and 2 weeks could be covered.

The style of presentation was according to the PCE approach as explained in section 4.2. Internally, groups were used to it; externally this approach came often as a surprise but brought a lot of appreciation as well.

All teaching materials have been consolidated in 2002 on a CD. Later this material has been updated and extended further. Selections from it have been used to make it suitable to teach classes at universities like for instance TU Delft.

Teaching materials (updates run up to 2014) are available from the author on request.

In courses taking more than five hours, a session used to be included with 'teaching by illustration'. The 'illustration' was a product which was relevant for the audience (for instance because it was developed/produced by the hosting organisation). This product was taken apart on the spot and the observations made during this disassembly were used to support information presented in the course. In most cases this led, through interaction with the participants, spontaneously to suggestions of all kinds for product improvements.

This kind of teaching by illustration and the interaction by the participants are the best way to introduce EcoDesign in an organisation. It is 'close', it is 'low threshold' and it is …. fun.

11.2. The Disassembly Session, learning by doing.

After 2004, a disassembly session has been often positioned as one of the first items in a training course. In such sessions, the disassembly activity is done by groups of participants (3 to 4 persons per product) instead of by the teacher. This ensures direct engagement and a lot of motivation of the participants. Simultaneously 'home work' can be connected to this session. Most of all it is empowerment; EcoDesign… just do it… yourself!

After an introduction of some 30 minutes, participants have to define their learning goals, get the products and organize the tasks within their group (who will make notes, who will do the reporting, who will jot down the ideas etc.). Subsequently attention has to be paid to 'analysis' before taking products apart: functionality analysis, value analysis and product analysis. As a next step physical measurements are to be carried out (energy consumption in various user modes, total weight). The actual disassembly follows; this leads to establishing type and weight of materials and subassemblies. Sometimes, extra time is allowed for 'internet analysis'; looking at comparable products to get background information for the creativity phase.

In this phase ideas are to be generated to improve environmental performance of products through EcoDesign. Depending on the goal of the course, such ideas can relate to overall improvement or more specifically focus on items like improving materials application or on recyclability.

At a set time, all ideas have to be consolidated and to be evaluated according to benefits (environmental, business consumer, society) and feasibility (technical, financial). The top three recommendations have to be reported and it has to be argued why these three are really the top three.

The enrichment of the 'disassembly first' approach is the motivation generated for doing EcoDesign. It turned out that this order allows to better taking into account the cultural background of participants. Among groups perceptions about what is important in 'green' and about what is the best functionality vary widely. Moreover there are several forms of creativity: the fact-based one, intuitive one and the one based on reasoning and/or lateral thinking. The perception of the importance of the role of the various players in the value chain differs greatly as well.

With a proper perception of cultural attitudes, subsequent teaching can be adapted to the audience. This requires some improvisation by the teacher, but enhances the effectiveness of the training.

11.3. Teaching EcoDesign from the reverse perspective; start from the business perspective and integrate Eco into it.

It has been an idea for a long time; teaching Environment and EcoDesign starting from the business perspective and show that companies should take Eco items on board out of self interest, even if ethics and societal responsibility attitudes are weak of absent. To make this possible I requested in 2004 to modify the description of the envisaged content of the chair of Applied EcoDesign at TU Delft. This idea has been rejected — the Faculty and the Board for Nominations had no idea what I was talking about.

A new chance came only recently: the Open University of Brazil put a course on Sustainability in its curriculum for MBA studies and was looking for somebody to take care of the content.

This was the opportunity to do what I wanted to do for many years: to demonstrate that applying a top-down business logic to the environmental domain leads to similar results as what the bottom-up approach of PCE starting with an environmental considerations did for the business.

The course consists of 11 lectures of 4 blocks of 15 minutes each. The titles and key messages for each lecture are as follows (in the language of today environment has been replaced by sustainability):

- Business and Sustainability: sustainability = a contribution to value creation.
- Business processes to foster Sustainability: organizing and managing is necessary to make sustainability really happen.
- Implementing Sustainability strategies in a business context: do as usual, just add a sustainability dimension.
- Implementation of Sustainability Approaches into business processes: the Philips example: it is a development process.

- Introduction to EcoDesign: EcoDesign evokes creativity far beyond the design domain.
- Sustainability of Production Processes: sustainability in production processes challenges traditional approaches
- Green Supply Chain Management: lots of opportunity.
- Communication of Sustainability: 3C= credibility, consistency and context.
- Measurement of Sustainability Performance: measure in order to know where you stand, where you want to go and what you have achieved.
- Legislation/Regulation: serve the intent of the law to the best of your abilities.
- Sustainability, Governance and Social responsibility: always be a human being; do not give in on your personality!

The course is available (for free — spoken English, Portuguese subtitles) via www.veduca.com.br. On the main page, under the heading 'Universidades e Instituições' at the bottom of the page, click on TU Delft.

This course has stimulated me to write the present paper — the 50 stories in it are a further support of the course material.

11.4. Linking EcoDesign activities at Philips Consumer Electronics with activities elsewhere: the cooperation with the TUDelft Design for Sustainability Lab.

At PCE, EcoDesign activities have initially been developed on a commonsense basis, taking into account the strengths and weaknesses of the business. Successes boosted self-confidence, but soon it was realized that a lot could also learned from 'Eco' elsewhere as well. As a result, PCE started to participate in relevant networks: conferences, joint projects and working groups about EcoDesign. In contrast to many companies, Philips and therefore also PCE followed an open information policy: tell what you are doing, talk about your successes and problems. Help others with the experience you have acquired and asked others to be helped where needed.

In the start-up phase of EcoDesign often just getting information could be highly relevant; proprietary matters were not at stake.

At conferences most presentations came and come from research institutions and academia. Often these tell how EcoDesign should be done rather than how it has been or can be done given the (business) circumstances. In spite of this gap, a more scientific view can be challenging and inspirational.

Moreover (PhD) students can do in a company a lot of exploratory work which is relevant but for which there is in commercial organisations little or no time or budget. For universities the benefit of working with companies is getting access to industry practice (which is particularly relevant for universities of technology) and getting access to much more data (either made available directly or through graduation projects in industry) and last but not least getting funding from industry.

Realising this win-win situation, PCE and the Faculty of Industrial Design Engineering of TUDelft came to a cooperation agreement in 1995. This agreement included an open exchange of information and the setup of a part-time chair in Applied EcoDesign and the opening of two PhD positions. Costs were to be shared on a 50:50 basis.

This set-up has been operating very satisfactorily for 13 years and had to be stopped due to external circumstances. There were tremendous benefits for both parties, first of all in terms of content. Moreover, for PCE there was a pay back through cost savings made through implementing suggestions of students. For TU Delft/IDE this was additional scientific output (for journal papers additional budget is made available for the department, in this case the Design for Sustainability Lab).

Most of all there is a societal benefit as well: more than forty MSc degrees and nine PhD degrees (through projects done at Philips but also at other companies) have been earned by young people. They got their degree on the basis of work which is highly relevant from a societal perspective.

Cooperation between business (PCE) and a university (TUDelft) in the form described above has been a clear 'win-win' and is strongly recommended!

11.5. Take a student on board.

Students generally show a lot of interest in the environmental field. It is new, it poses a lot of challenges and it offers plenty of opportunities to contribute to societal well-being. 'Eco' in industry offers even more: an opportunity to put lessons learned at the university into practice. Moreover this includes a confrontation with the 'real world'.

This is the very reason why so many students were interested in the PCE 'Eco' activities. In fact there was more interest than PCE could handle, so striking an appropriate balance between the educational interest (which required investment in time and attention from PCE employees) and business interest (mostly getting new ideas, getting extra capacity turned out in practice to be less important) has been difficult.

Once this issue had been resolved, it turned out in most cases to be pleasant to work with university students. These are creative are (relatively) intelligent, have excellent and crazy ideas and can do - in their smartness or their innocence - wonderful but also sometimes dumb things.

Although it is unclear how this is to be rated precisely, students have contributed a lot to the development of EcoDesign at PCE. In the stories presented in this paper, they have been major players in disassembly (6.2), environmental benchmarking (6.4), mapping (6.5), green products (7.3) and inn investing the relation between consumers and green (10.3). All of them have participated in disassembly sessions (11.2) either at Philips or through classes at TUDelft. A report about a disassembly session in which class material had to be shown to be well digested was the substitute for more formal exams.

For PCE, student projects showed on average a very good pay back both in time and money invested. Take a student on board!

12. Looking back and looking forward.

The present paper demonstrates that it is possible to develop EcoDesign in an organisation through a bottom-up approach using common sense. At Philips

Consumer Electronics, five 'waves of development' (get facts, fostering creativity, implementation and validation, structure and green marketing and communication) have in the end led to full maturity in EcoDesign.

Since PCE was a trailblazer in the field, this development took a long time. With the knowledge of today it could have been much faster. It has to be realized however that the development of EcoDesign is a cultural process too; changing mindsets is much slower than introducing a new set of technical tricks.

Introduction of EcoDesign had an enormous impact on an organisation like PCE. Apart from 'Eco', it has lead to more functional product designs in general, to cost reduction, to better supply chain management and improved marketing and communication. Management practices like for instance the Product Creation Process and developing business strategies have been thoroughly influenced as well.

Simultaneously, the developments at PCE showed that there are clear limits as well. In the end subjects like 'radical green' products and EcoValue were clearly beyond what a traditional organisation like PCE could swallow.

The environmental activities at PCE have contributed to good practices at the Philips group of companies as a whole and reversely Philips Corporate activities and exchange with other divisions have contributed to the good performance of PCE.

It would have been interesting to see where PCE would have positioned itself in the current Sustainability landscape. Unfortunately, Philips has sold almost all of the PCE business units to other parties and therefore the body of knowledge which has been built up is scattered now over many organisations. This is a pity but it is an unavoidable consequence of what can happen in the corporate world.

EcoDesign of products has become —also through the experiences of PCE— a field in which high levels of maturity can be reached. These can be used to address the next challenges for EcoDesigners. These include addressing systems/infrastructures in which individual products operate. This is even more relevant for 'institutional functionalities' like universities, hospitals, complex buildings and traffic systems. There are many challenges ahead of EcoDesign; it is

hoped that the PCE experience can be a building block in the house of expertise which still has to be built!

About the author

Ab Stevels studied Chemical Engineering at the Technical University of Eindhoven and took a PhD degree (cum laude) in Physics and Chemistry at Groningen University.

As of 1969 he worked for Royal Philips Electronics in many capacities: research on materials, production technology of glass, business manager in electro optics, project manager in Asia. In 1993 he became a senior advisor in Environment at Philips Consumer Electronics.

In December 1995 he was appointed as part-time professor in Environmental Design at Delft University of Technology. At various times he has been visiting professor at Stanford University, the TU Berlin, the Georgia Institute of Technology (Atlanta), NTNU in Trondheim, Norway and at Tsinghua University in Beijing.

This was followed by courses at Hong Kong Polytechnic in 2006, TU Ostrava (Czech Republic) in 2007, Pohang (Korea) and Guangzhou (China) in 2009 and Adelaide (Australia) in 2010.

Training courses on applied EcoDesign have been held at various universities (Netherlands, USA, Germany, Austria, Czech Republic, UK, Mexico, Norway, China), and at various companies around the globe.

In 2013 he developed an 'MBA and Sustainability' course in cooperation with the University of Sao Paulo.

Rewards for contributions to the development of EcoDesign:

- A honorary degree from the Surrey University for Arts and Design, Farnham (UK) (2008).
- The Cowbell Award from the International Electronics Recycling Conference (2007)
- The "Green Design Contribution Award" from the World Green Design Organization (2014)

Publications:

- More than 200 journal articles and conference contributions.
- *Adventures in EcoDesign of Electronic Products* (TUDelft, 2009, 600 pages).
- *Fifteen years of EcoDesign at Philips Consumer Electronics*, on how to introduce EcoDesign in companies.