The Reverse Perspective:

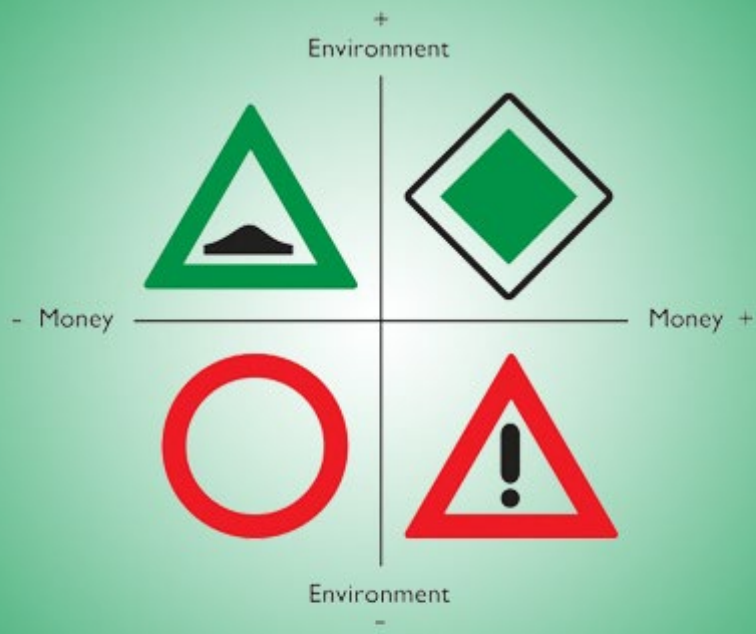
Fifteen years of EcoDesign

at

Philips Consumer Electronics, Part II

(1993-2008)

Ab Stevels



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PREFACE.

In the booklet 'EcoDesign at Philips Consumer Electronics (PCE), 1993-2008, the Reverse Perspective', the development of EcoDesign in this Division of Royal Philips Electronics has been described.

The vast array of concurrent and subsequent events were summarized in a model consisting of five 'waves'. Some fifty short stories illustrating these developments were presented as well. This material has much more value than just being a description of the past. It is thought to be a set of experiences of which many elements are relevant today for practitioners of Applied EcoDesign and for environmental managers wanting to introduce EcoDesign in their organizations. Soon after the electronic publication of the booklet (see www.self.gutenberg.org) or in fact already during the process of writing, the question came up why the developments as described did happen as they did? This is a very relevant question because in most research/academic literature the idea how EcoDesign should be introduced in industrial organizations is quite different from what happened at PCE. Is this because PCE is a special case, or are there more generic reasons that implementation of EcoDesign in the electronic industry requires a different approach?

On top of that the question arose how EcoDesign can be introduced much faster than the period it took at PCE where some 10 years were needed to reach maturity.

In this publication, the events at PCE are also put into a more general perspective: what are the similarities or differences when comparing the introduction of EcoDesign with the introduction of Quality Management and the introduction of 'new technology' in more general. Apart from several readers of the first booklet, two Ph.D. students, Siru and Jaco, deserve special thanks. Their curiosity has strongly stimulated me to write this publication.

Special thanks are even more owed to Hans Pieterse, editor and critical reviewer of this text and of part I, but most of all a friend for more than fifty years. Dear Hans, 'chef de gare', thousand thanks, duizendmaal dank, tusen takk!

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1. An intriguing question: why did the introduction of EcoDesign at PCE happen in the way it did?

In the book 'Adventures in EcoDesign of Electronic Products' (available through www.aeki.se), referred in this publication as 'book' the scientific background of the developments in EcoDesign in the years 1993-2007 has been described. In the booklet 'The Reverse Perspective: Fifteen years of EcoDesign at Philips Consumer Electronics (1993-2008), it has been described how EcoDesign developed more specifically at PCE. This booklet is available through www.self.gutenberg.org.

In fact EcoDesign at PCE developed in five partly concurrent and partly subsequent waves. These stages can be best described as:

1) Get facts, why are things as they are?
2) Fostering EcoDesign Creativity
3) Division wide Implementation and Validation
4) Structuring EcoDesign in Procedures and Programs
5) Communication and Green Marketing

These developments are illustrated by about fifty stories about all aspects of EcoDesign. A recurrent item in the (sub)conclusions of these stories is that EcoDesign got momentum in the organization because it contributed in domains far beyond the specific environmental one (cost reduction, shaking up and refreshing traditional beliefs, sharpening focus and strategy and improved supplier relations).

The stories demonstrate that the introduction of EcoDesign at PCE in the end became a remarkable success. However, this success has been preceded by a long struggle to get accepted first and to build further momentum later.

This success was not obvious. PCE used to be a conservative organization, proud on its successes in the past and with little inclination to take on board developments in the outside world. This mindset was upset by a painful restructuring which was necessary in the early nineties of last century. This very event opened the door for new idea's as for instance EcoDesign and intuitively and against the odds the decision was taken to become a trailblazer in this field.

The positive psychology of this was however counteracted by the usual prejudices against 'Eco'. Questions were asked, and doubts whether EcoDesign

would really contribute to the bottom line were widespread.. Moreover it was feared that 'Eco' would lead to conflicts between business functions like development, production, purchasing and marketing. Signals from the external world were not encouraging either; their often aggressive language evoked negative reactions and offered excuses to those in the organization not wanting to engage into EcoDesign.

Successes and still having to struggle for many years. This contradiction made it feel that EcoDesign developments at PCE were special (see part I, section 4). But in retrospect, why was it special? Was it because PCE was one of the first industrial organizations moving into the field? Was it because PCE as an organization had characteristics not in place elsewhere? Or was it because research on EcoDesign at that time could not adequately support the electronic industry in EcoDesign implementation so that PCE had to develop its own approaches.

In short: why did it happen as it happened?

In the next section of this publication, it is shown how organizational decisions, the recruitment of environmental managers and the attitude of senior managers contributed into a substantial way to the style in which EcoDesign at PCE has developed.

In section 3 it is described what lessons were learned during the fist steps on the rocky road to mature EcoDesign. These were in fact examples of the visible actions which helped to grow the credibility of green in the internal value chain of the organization. Simultaneously it was realized that the lessons learned were pretty at odds with the paradigms about EcoDesign as existing in the research/ academic community. As a result PCE realized that it had to develop its own way to deal with EcoDesign.

In section 4 it is depicted how the confrontation with the research and academic concepts of EcoDesign took place. It was centered around the so called PRO*M*ISE EcoDesign manual. In the end it led to a lot of enrichment of the EcoDesign process as envisaged by PCE itself. Another result was the cooperation agreement with Delft University of Technology which led to a lot of mutual benefit; in particular the environmental benchmarking method was developed in Delft and enhanced through application at PCE. In the methodology field, the concept of the 'five basic strengths of EcoDesign' was evolving from all the positive experiences when applying life cycle thinking into practice. At PCE it was realized that the significance of these methods was far beyond 'Eco' and that

through exploitation of these idea's it would be easier to get full acceptation for green in the organization.

A first full chance to do so (see section 5) was at Business Group Monitors which had its chief development group in Taiwan. Success here quickly spread to other BGs. Reversely, BG TV and BG Audio were the domain of several important contributions which added to the division wide progress.

Through all this, suddenly the integration of EcoDesign in the programs, the roadmaps and the strategy (section 6) got momentum. Also attention for green communication and marketing (section 7) is a logical consequence and also in these field the first actions followed pretty quickly. Achieving good green performance was now engrained in the organization and it became a part of senior management tasks to make sure it stayed in place.

It took EcoDesign in PCE some ten years to grow to maturity. Partly this was due to the fact that it was a trailblazer, partly because while on its way a lot of paradigms about 'Eco' in the internal and external value chains had to be shifted. Moreover the research community about EcoDesign pointed to a large extent into a wrong direction. Last named phenomenon has been well analyzed by Baumann et al. ('Mapping the green product development field; engineering, policy and business perspectives'), Journal of Cleaner Production, 10 (2002), 409-425 and by Boks ('The soft side of EcoDesign'), Journal of Cleaner Production, 14 (2006), 1346-1356. These authors generally confirm the PCE experiences. Although such analyses were too late for PCE itself to benefit from, these publications are of help to reflect how EcoDesign in industrial organizations could be introduced faster (section 8).

The outcomes of this can be summarized into fourteen recommendations to kick-start EcoDesign (section 9). In section 10 these recommendation are compared with the research/academic approaches.

The introduction of EcoDesign could also have learned from earlier experiences when introducing Quality Management into organizations. Also Management style and learnings from introduction of new technologies in general could have been of help (section 11).

The conclusions in section 12 are that in all cases chief elements for successful implementation of EcoDesign in the electronic industry are getting credibility and properly managing the internal value chains. Moreover, setting priorities and appropriate differentiation among products are the chief ingredients for success. Appropriate actions to develop the set a meaningful EcoDesign agenda

can be derived on basis of the five basic strengths of EcoDesign and functionality thinking. This can be summarized as looking at the opportunities first rather than looking at the threats (the so called outside 'drivers'). Mobilizing enablers in science and the supply chain can be of great help. Moreover, credible and consistent communication taking into account the right context have to be developed in order to exploit EcoDesign successes in the market.

2. Decisions and Circumstances.

2.1. Environmental issues were primarily to be addressed by the Quality Department.

When it became urgent for PCE to deal with environmental issues of products, the senior management decided that primarily the Quality Department should deal with it. This department had a support function in the organization. It should help business units to introduce good quality related practices and had a kind of audit function as well. However, in the end the Business Units themselves were responsible for the results (see also part I, 2.2).

Environment was therefore perceived as a quality matter, either intuitively or because there was in the organization still memory of what happened when quality management had been introduced in the organization some twenty five years before (see also 11. 1). How integral 'environmental quality' was to be achieved was an open question. There were no practices demonstrated elsewhere to rely on. There was no time to reflect as well. On the contrary, there were urgent matters to be dealt with, in particular chemical content issues (see book chapter 3.3 and part 1, 6.1) and take back and treatment of discarded products (electronic waste was in 1993 seen as a source of toxics, not as material with reuse or recycling potential). Insight in chemistry was therefore thought to be important and therefore several employees with a background in chemistry were transferred to the quality department. Plastics were seen as the chief source of potential toxics (flame retardants in housing, in printed wiring boards and additives in cable and wiring) and therefore specialists were hired from the Competence Centre for Plastics of Philips.

Quality matters were not popular inside PCE. Quality certification on basis of the ISO 9000 standards had been a lengthy and costly process. Moreover, the bureaucratic approach prescribed by the standards and the formal approach of most auditors had caused much friction. There had been no escape however and in the end everything worked out pretty well. The Business Units started to become more and more self driving in quality matters; as a result only a small support group had to remain.

Environmental matters were supposed to follow the same path and to start in a division support department and subsequently to be delegated to the Business Units. This prospect did not please everybody; the most successful business unit, BU TV (50% of revenue of PCE) decided therefore in their own development department an environmental activity which in practice operated rather independently from the activity in the Quality Department which was perceived as too theoretical and too bureaucratic. Primarily focus in TV was on chemical content but also on recycling of plastics and glass from discarded TV's. Since Philips had its own plastics and metal ware factories, its own glass factories and had its own in house recycling center BG TV expected that it could get a competitive advantage if legislation for take back and treatment of discarded products was to be introduced (and producers had to pay the costs of that).

Inside PCE the existence of these two activities was tolerated; it was seen as to give rise to 'positive friction'. Due to – generally speaking- good positive personal relations of those directly involved this inconsistency did limited damage.

The biggest issue to be addressed was however elsewhere: organizational decisions – good, bad or confusing- did not guarantee that EcoDesign was automatically on the agenda of PCE. Ensuring credibility and being on the action agenda were the first priority for the time being.

2.2. All Environmental managers and specialists should be 'one of us' .

Environmentalism has a long activist tradition. This was also apparent when environmental issues about products flared up in the early nineties of last century. Amongst these were scandals about poison leaking from waste tips, dioxin emissions caused by incineration of waste, ozone depleting chemicals (CFCs), halogen (in particular bromine) containing flame retardants and suspicions about PVC.

The electronic industry was seen as an important source of perceived or real (both apply partially) trouble and NGOs and also universities jumped on the subject and managed to mobilize public opinion and politics. This made industry to take action but also to become defensive; all claims and accusations were by far not justified.

This made that environmental managers and specialists were recruited at PCE from inside. 'Being one of us' was thought to be a protection against unfair criticism from outside. Simultaneously these managers got the instruction to act as 'advocates of the environment' and to give it 'a voice in all decisions'. This attitude of the senior management created a climate of trust. An even bigger advantage was that the environmental managers knew the organization very well and had friends and connections in many departments.

Specific environmental knowledge was lacking however; nevertheless it turned out that combining 'common sense' and experience in the organization were good enough in the initial period.

Moreover, learning can also happen at a later age; my own age was 49 when I was put into an environmental job at PCE, not because of specific ambition but simply because I had become redundant elsewhere.

Similar circumstances applied to others who entered (or had to enter) this new field. ***The communality was that all of them were 'experienced hands'. This turned out to be a valuable asset in the first task to be done: demonstrate to the organization that 'Eco' was worthwhile to consider in terms of being an opportunity and not just as a defensive item.***

2.3. Attitude of employees towards Environment and EcoDesign were initially neutral at best.

In their private life, PCE employees are consumers like everyone else. This means that their 'attitudes towards green' are basically described well by the analysis made in the book section 5.3 and in part I, 10.3.1, see also column (overall) of the table below:

	Overall	*Men only*	*Men, higher education*	*Senior managers*
Positive	*43*	*34*	*34*	*34*
Neutral	*30*	*33*	*30*	*28*
Negative	*27*	*33*	*36*	*38*

Environmental attitudes of overall public, men, higher educated men and senior management (in % of total).

This table indicates (in %) what attitudes (arranged in order of 'support for green') the groups to be analyzed belong. The overall column shows that for the general population there is a slight domination 'pro environment' (43%), whereas 30% is more or less neutral and 27% is negative.

PCE employees are to a large extent males; this means that these numbers have to be corrected (women are on average more pro environment). For the PCE population this means that positive, neutral and antipathy are almost equally divided (34, 33 and 33%) respectively, see column from left.

The fact that the PCE group has a higher education than average does not change these numbers substantially. There is a slight change towards the negative.

This trend becomes even stronger when senior managers are considered more specifically. Here there is an overall shift towards the negative, group sizes are now 34% positive, 28% neutral and 38% negative.

For all individuals the conclusion of this table is that that green is not necessarily perceived to be good for them when they act as consumers. For PCE

employees this attitude is 'on average neutral' whereas for senior management there is even a negative tendency.

In spite of this, it is to be realized that PCE was a 'liberal' organization as well. Individuals had a lot of freedom to maneuver, there were no specific assignments leave it alone precise job inscriptions in place. This meant that in spite of the general 'pretty neutral' attitude towards green, individual champions could manifest themselves. Motives to do so varied from a rationale ('an opportunity for PCE') to emotion ('we have to contribute to saving the world') and from ethics ('as a responsible company we have to do this') to opportunism (my wife is a Greenpeace member and wants me to do this'). Champions occurred throughout the organization, from the lowest to the highest senior executive levels.

In general there was a climate of 'positive tolerance' for green: if the environmental managers really deliver why not let it happen. This made that the priority number one was to build credibility. Since 'green' was not taken on board officially yet , this credibility had to be built bottom up (see part I, 4.2)

3. 1993-1994: Learning through Struggling.

3.1. Lessons from the chemical content activity.

The chemical content activity (see book, 3.3 and part I , 6.1) was in the 1993-1994 period still in its initial stage. Huge amounts of information had to be collected, checked for validity and processed further. Cooperation by suppliers (and the purchasing department) was gradually improving. The change in style from 'you have to do this because it will be in the law' to 'please collect information so that we can do a better job' contributed to this. In fact this was the first example where the emotionally neutral 'let us collect data to improve' worked better than 'we should become greener' or even 'let us save the world'.

The environmental implementation strategy of 'doing better' in green turned out to work out more effectively than appealing to convictions (which are not necessarily shared) or suggesting that something was wrong and had to be corrected.

This was an important lesson learned by the environmental managers of PCE and this approach became the usual one to address issues to be tackled.

Eliminating superfluous code numbers for components and materials in the PCE data base was another cumbersome task. Many of these code numbers were the 'hobbies' of departments and even of individuals and with all the room for particularism at PCE this turned out to be pretty tough. Once it was clear to the purchasing department that there was a lot of benefit in this action (volume discounts, less contracts to be made), this approach got traction and went ahead much more smoothly.

Making clear that environmental benefits combine often with tangible business benefits (cost reduction, more simplicity of operation) and putting the business benefits first in the communication in the internal value chain added a lot to the credibility and acceptance of the environmental activities.

3.2 The real significance of environmental tools; playing with numbers.

In order to assist product development to deal better with chemical content issues in the design process, the environmental managers of BG TV developed an interesting tool: the Environmental Weight Method (see book 6.2.1 and part I, 8.4.2). In this method the physical weight of materials and component is to be multiplied by a factor dependent on its chemical content and its surface treatment. The total environmental weight obtained through addition for the complete parts list is divided by the total physical weight. The ratio obtained in this way is to be compared with a target (which has to be set in a sensible way).

This approach introduced two important elements:
****The use of ratio's instead of the use of absolute numbers. After the success of the Environmental Weight Ratio, this idea has been extended to many environmental issues. Comparing with the environmental performance of the competition is the ultimate form of this.*** The core of this idea is that right or wrong is being replaced by a little bit more right (or wrong) or pretty right (or wrong). This use of ratio's links therefore well with the 'do better' approach.

*The introduction of tangible (and sensible) targets. Tangible means in this context 'everybody can understand this, irrespective whether you are an environmental specialist'. Sensible means here 'ambitious enough to stimulate new creativity, not too far reaching to be seen as unrealistic'.

Because of the complexity of most PCE products there are several ways and means to realize the target environmental weight. Dealing with the environmental weight target developed therefore into a game.

Most development people like playing number games better than following up on environmental requirements. Ratio's are the perfect way to appeal better in the techno culture of PCE.

3.3. Help of technology and system organization are needed to ensure success of EcoDesign.

The work of BG TV on applying recycled material in TV housings (see part I, 7.2.5) was successful pretty soon. It could be demonstrated that up to a weight percentage of 50% could be reapplied. Main supply group glass also demonstrated that secondary picture tube glass could be reapplied in the cone glass of the tubes.

In order to get proper parts however the processing conditions (in particular the mixing of the raw materials and temperatures used) for molding and melting have to be slightly changed. In both cases this implies pretty long transition times during which there are much higher reject rates. This is no problem if the transition is to be made once; in such a case the advantages surpass the one-off drawback. The condition is of course that the one-off takes place only once.

This situation makes that percentage of secondary material to be applied has to be constant; changes of percentages imply transition times as well with all the drawbacks connected to that. Therefore apart from the appropriate technology conditions also the right volume of material need to be in place on a continuous basis; last named condition was definitely not fulfilled in 1994 for secondary plastic and secondary picture tube glass.

In the process industry, requirements as the ones sketched above are called 'possibility to keep the continuity of streams going'. This is a far more complicated requirement than just a one-off-change like a change in recycled content.

The recycled material experience learnt to PCE that having smart EcoDesign as such is not good enough but that also technological and system organization issues in more general have to be addressed to be really successful.

3.4. Superseding issues, the bitter lesson of elimination of flame retardants .

The plastics recycling issue also made that a lot of effort has been done to eliminate flame retardants from the housings of TVs (see book, p229 and part I, 7.2.4) This has a high amount of logic because only flame retardant free plastics can be processed easily into secondary material which can be reused at its original application level.

This proved to be possible without violating the safety regulations which were in place. An additional advantage was cost reduction, so for a period of time, the TVs which PCE sold in the market were flame retardant free. A further advantage would be that this would be a huge asset at the moment companies were to be responsible for the cost of take back and recycling.

However competitors asserted that the Philips TVs were unsafe at least less safe than theirs- not mentioning that the safety requirements were met, also by PCE. This created a row in the press which could not be remediated; also because internally the senior management made it clear that 'this boy scouting in the name of the environment had to be stopped immediately'.

As a result flame retardants had to be reintroduced. Another result was that international safety requirements were made stricter in such a way that even, if the PCE management would have supported elimination, flame retardant free housings of CRT TVs were not possible anymore. The consequence was use of more flame retardants by all brands with all the adverse environmental effects connected to that.

The bitter lesson for the environmental managers of PCE was that apart from money there were other superseding issues which can destroy any good environmental intent. Health and safety, even if abused, is definitely one of them.

The flame retardant experience also taught another lesson: 'green(est)' is not automatically OK. Only when it enhances the overall emotional functionality of a product it will really contribute.

3.5. Recycled material in packaging; common sense and the first clear link with direct money.

In an early stage of the development of EcoDesign, the use of recycled material has been considered in packaging material as well. Corrugated cardboard boxes in which PCE products were packed were the ideal candidates.

Like for packaging matters little was known about this issue. The business was thought to be about electronics, so why bother about other items like packaging (and waste).

Consequently, a little question by the environmental managers was not considered to be a big deal. The question to the production locations was: what is the percentage of recycled material which is being used in the corrugated boxes in which your products are packed ? It took a long time for an almost complete set of answers could be collected. In view of the foregoing, it was not surprising that numbers cited varied widely; anything between 0% and 100% turned out to occur. Some 40% of the respondents was honest enough to indicate that they did not know. These answers were enough already to conclude that the subject of using recycled material was not optimally managed.

In the meanwhile it had been established that in any climate circumstance in the world (Singapore throughout the year and the Netherlands in October and November turned to have the highest humidity's; this is relevant because fibers of recycled material are shorter and on average take up more moisture) 60% of recycled material is the maximum percentage to be used, taking into account the stacking height requirements of Philips warehouses.

It was also established that a 10% increase in recycled content would bring a 6% reduction of the environmental load and a 4% reduction of cost. The conclusion was simple: go to 60% of recycled content throughout the Division. At various production locations this transition involved some difficulty because of the (continuous) availability of recycled cardboard, but pretty soon consistent operation meant millions (of € or $) of cost savings.

For the organization this actions made visible for the first time a direct link between environmental improvement and cost reduction and thus added substantially to the credibility of EcoDesign.

To the environmental managers this made clear that a common sense review of decisions (or lack of them) and consistency in execution had a great potential.

3.6 Mobilizing enablers; EcoDesign cannot be done in splendid isolation.

PCE had a long tradition in mobilizing technology to manufacture products in a more efficient way. It had a network of in house production facilities and of suppliers inside and outside Philips. It was therefore very advanced in - for instance- the production and application of plastic parts. Over the years this capability made that it could replace more and more metal parts and thus reduce costs substantially (and the environmental load as well- even when it is taken into account that plastics have less recyclability, but environment was not considered before 1995). As a result, huge amounts of plastics were used, particularly for the housings of almost of all Philips products. As such housings were pretty clumsy, square and rectangular boxes. This 'solidity' was supposed to support the excellent sound and vision quality of PCEs products and were therefore difficult to challenge. As prejudice against green was still widespread in 1993/1994, challenging this as an environmental manager would be the worst thing to do.

Suddenly there was however an opportunity to attack this holy grail which was clearly closely linked to the still mechanics dominated perception of most managers and customers: the emergence of gas assisted molding. By applying gas pressure in the production process of plastics parts material could be saved

but also more complicated (for instance rounded) forms could be made. Mechanical stiffness could be achieved by having ribbon designs and more elegance could be by choosing for more playful forms. All of this was claimed to be the result of environmental thinking.

In fact the message was: technology can be an powerful enabler to produce products with a better functionality, while simultaneously saving material and costs. Or – when effectiveness of EcoDesign is considered- mobilizing 'enablers' is just as important as to have smart designs as such.

3.7. The environmental design manual: a lot of awareness created but showing the need for integration in all operations as well.

It was a simple thought: provide designers with information and they will design the right product. It was an even simpler thought: provide designers with environmental information and they will design the right 'green' products.
Within PCE it was even a too simplistic thought: providing (general) environmental information to designers turned out to be of little help.

The reason for this is that in PCE the responsibility for product creation is ultimately with product managers. In close cooperation with the marketing and sales departments, they decide how the the product line up should look like and assign subsequently product creation tasks to various departments (mechanical, electric/electronic, software etc.). Since electronic products are very complex this can only be done on basis of written target specifications which are to be agreed in the internal value chain. Designers inside the various departments have therefore an 'executing' task that is realizing the required targets (in terms of physics and economics but also inside time limits). In this setting, the room to manouver for EcoDesign is pretty limited. An Environmental Design Manual (see book 4.11 and part I, 8.4.1) was thought to alleviate this task and therefore such a manual was made available already in 1994. It had a structure which consisted of what has been called later the five focal area's: electrical, mechanical (materials), packaging and transport, chemical content and end of life/recyclability. The life cycle responsibility was with the Product Management assisted by the Environmental competence Centre for these matters.

The Environmental Design Manual became an instant success in terms of raising awareness in the organization. The fact that there was a hundred page, well referenced document, about environment evidenced to all employees that the organization was serious about green. Its design rules worked out only partly well, chiefly in assisting to eliminate stupidity or ignorance of the past. They did not (and could not) contribute to a new kind of creativity simply because the structure of the Product Creation Procedure prevented this to happen. Moreover the rules were of a 'one size fits all ' kind. Due to the large variety in material composition, size and energy consumption, much more tailored made support tools had to be developed.

The chief learning from this was that an isolated Environmental Design Manual did not work. Environmental requirements had to be integrated into the Product Creation Procedure and as a consequence an environmental chapter had to be put into each target specification. This would also open the possibility to cater better to opportunities of individual products.

4. 1995-1996, EcoDesign is really taking off.

4.1. July 7, 1994, E-day at Philips Consumer Electronics, a clash of cultures.

On July 7, 1994, the PRO*M*ISE Manual (Productontwikkeling met Milieu als Innovatie Strategie, published in February 1994) hit the desks of the environmental managers of the Environmental Competence Centre of PCE. The English version of PRO*M*ISE (a Promising approach to sustainable production and consumption, has been published in 1997, ISBN-807-1631-X). A professor from Delft University called Han presented the idea behind it and the content at a meeting in Eindhoven. The 195 page document had been initiated and financed by two Dutch Ministries (Housing, Spatial Planning and Environment and Economic Affairs) and two government related organizations (Novem/RIVM and NOTA). The execution of the research and the pilot projects was with TNO (the Dutch organization for Applied Research), Delft University of Technology and some smaller

consultancies. The international edition of 1997 has expanded to 346 pages, its chief supporter outside the Netherlands had been the United Nations Environmental Program (UNEP). The claim of both documents was that Environmentally Oriented Product Development (EOPM, later called EcoDesign) is a new perspective for innovation since it is a combination of environmental improvement and economic advantages. The evidence for this claim was based on the results of several pilot projects carried out in the Netherlands in the years 1992 and 1993, mostly at small and medium sized enterprises.

Moreover EOPM/EcoDesign was considered as a way to supersede interests of individual stakeholders and to come to more cooperation in the value chain.

The content of the PRO*M*ISE manual was presented at PCE as THE WAY TO GO in EcoDesign, also for Philips and thus for PCE. However the style and content of the presentation were not fitting with what was required for an multinational company making complex products and having a lot of self pride. In fact there were three double sided messages:

* For EcoDesign, product development procedures do not have to change (reassuring), but also environmental requirements can be conflicting with the core activities of the company (alarming)
* Product alternatives represent the highest level of green design and are to be preferred; product adaptations is still better than remediating the past (revolution instead of evolution)
* EOPM/ EcoDesign was represented as an opportunity for companies as well (OK), but more details about the issues at stake for companies contained a substantial amount of threat: go green or go broke. (In view of other business threats to which PCE was daily exposed this was pretty ridiculous.)

In fact the PROMISE messages were completely at odds with the lessons which the ECC already had learned in the hard way: when EcoDesign is introduced into an organization its culture has to be taken into account and 'green' should not want to put upside down immediately the core activities of a company.

4.2. The PRO*M*ISE EcoDesign procedure: inspiring, but as such not feasible for PCE.

Phase 1 of the PRO*M*ISE EcoDesign was planning and organization of a pilot project for a green project. Such an idea was simply conflicting with the 3 year product planning cycle of PCE. This cycle included adaptions of the product functionality one year and two years after market introduction and a major overhaul after 3 years. For such an overhaul several brainstorms were held (electrical, mechanical, software, marketing strategy etc.). Idea's generated in such brainstorms were consolidated into one target specification.

For 'green' to get taken on board into this product renewal cycle, it needed acceptance (credibility and maturity) to become part of the target specification of products. Moreover, a specific 'green product' needed to be planned as part of the total product line up to be developed anyway.

The green TV, (see book, p5 and part I 7.3.1.) was therefore in fact an illegal project in PCE terms and as a result of that status it never made it to the market; through the tremendous spin it had, it can be better characterized as a successful predevelopment activity.

Phase 2 of PRO*M*ISE is about the selection of a product. In fact this chapter recommends to consider products which have a big chance of becoming a success. The PCE translation of this was to set up activities which contribute to the credibility of EcoDesign through visibly contributing to the bottom line. These open the door for more capacity and budget for the environmental department and as such enhancement of 'green'.

Phase 3 of PRO*M*ISE is about problem analysis and priority setting; this phase is basically about environmental information. In the MET matrix proposed here, environmental issues are still expressed in terms of physical parameters. Later strong pressure from the upcoming Life Cycle Analysis (LCA) community came to replace this by impact profiles. However, PCE has kept physical param-

eters throughout the years as the basis for environmental analysis (environmental benchmarking, see book 6.3. and part I, 6.4). In LCA terms this is best to be described as a primitive life cycle inventory.

Phase 4 is about generating idea's. The proposal made here are strongly design oriented and as such did not reflect the functionality and commercial requirements which PCE products have to fulfill. This brought up however an important issue: how to organize an environmental brainstorm to ensure appropriate input into the PCE product development procedure.

Phase 5 is about detailing the concept and detailing the design. This phase is leapfrogging the important milestone in the PCE development procedure: concept consolidation. However indirectly this phase brought up the issue how to position the EcoDesign proposals generated in earlier stages so that they survive (to a large extent) the confrontation with idea's generated in other brainstorms. The answer turned out to be (see 5.3) the EcoDesign Matrix (see also book p432 and part I , 7.4).

Phase 6 is about communication and marketing. What PRO*M*ISE is proposing here is too simplistic; 'green' is not necessarily good from the perspective of consumers which are often selfish in their behavior. As a result of this green products or products promoted too explicitly as being green can be perceived as freaky, having less functionality or ease of use or simply cost more. Although most of these prejudices are not supported by facts, they exist in the mindset of many prospective buyers (and of senior executives). The environmental managers of PCE had to spend a lot of effort to remediate this (see book, 5.4 and 5.5 and part I, 10) but even today this issue has to be considered again and again.

Phase 7 (evaluation and follow up) was considered to be less relevant for PCE.

From the analysis presented above it is clear that the EcoDesign procedure as proposed by PRO*M*ISE did not fit at all with the realities of PCE.

It stimulated or even challenged the PCE environmental managers to come up with idea's which would fit better. Most important however was the more general notion that it is OK that industry has criticism on the one sided

and sometimes naïve idea's of environmentalists, provided it can propose realistic alternatives which make environmental sense. At least for PCE, this was the big learning from the PROMISE experience.

4.3. The cooperation between PCE and the Design for Sustainability Lab of Delft University of Technology (DUT).

The PRO*M*ISE manual came as a surprise to the PCE organization, both in terms of general approach and its detailed content.

It was a confrontation of two different worlds. Several aspects of PRO*M*ISE were appealing and inspiring, others were completely missing out on issues which were very relevant for EcoDesign at PCE (compare section 3) or simply demonstrated a poor understanding of the way in which companies operate. In spite of this the first meeting with DUT had a positive atmosphere and it was the clear intent of all participants to keep it that way. I - being considered the most scientifically oriented person of the environmental managers at PCE- got the assignment to write comments on behalf of PCE to this manual. It would become a six page handwritten document which was intensely debated as well. The next meeting was two weeks later; it showed little agreement and a lot of disagreement.

Indirectly, the advent of PRO*M*ISE stimulated a critical analysis of PCE's own environmental activities. In spite of all lessons already learned (see section 4.2), it was felt that there was overall too little progress on the critical issues: get more credibility for green, show the benefits of doing EcoDesign to get a position in the PCE procedures and organize enablers to enhance EcoDesign effectiveness. Delft University had one of these enablers: students. They are relatively intelligent, have curiosity, can be creative and many of them are highly motivated to work in the environmental domain. PCE could offer interesting challenges to them, simultaneously the students could earn their diploma when working on these in the form of a graduation project. The EcoDesign concepts as promoted by Delft University could be enriched by implementing them in a clearly applied setting. This was the common ground and while the initially stormy and emotional discussions about PRO*M*ISE decreased, attention was

more and more turned to developing jointly a new field with the name Applied EcoDesign. In this context DfS could get access through master and Ph.D. students to 'insights and data of real life at PCE' and could test their idea's and methodologies. PCE would benefit from these insights and would benefit from the creativity and open minds of the students. Moreover a part time chair was to be set up at Delft University of Technology in Applied EcoDesign to be financed on a 50:50 basis.

The essential element of this agreement was 'mutual engagement' and this turned out to have a lot of added value; much more than just sponsoring or just exchange of data.

4.4. The Delft engineering style, a great traction for Applied EcoDesign.

The connection with Delft University of Technology through the Design for Sustainability Lab of the Design Engineering department of the Faculty of Industrial Design Engineering (official university names are long and complicated) brought apart from conceptual items and challenges also a cultural element; the Delft approach of engineering. This style includes three chief elements:
* Measure = get tangible data about the issues to be addressed. If such measurements cannot be done, do a little experiment through which some data can be obtained.
* Find the best direction to go, set priorities = make calculations or estimates - based on the data obtained - to establish what is most important and what is less important.
* Look to the application and guesstimate – on the basis of physics- what will work in practice and depart from there to do the design job.

This was a style which was appealing to the environmental activities of PCE. Soon after the cooperation Delft University-PCE had been set up students came up with project reports containing a wealth of suggestions. These included for instance:
* A set of 'standard disassembly times of fixtures' allowing to predict upfront the disassembly time of a product without having a prototype. Indirectly this allowed to predict (more roughly, but good enough) assembly times of designs as well. From the start this directly contributed to cost reduction.

* Analysis of weight of material applied in products and weight and volume analysis of packaging. This laid the basis for the systematic analysis of weight and volume reduction activities.
* Measurements of energy consumption in various user modes of PCEs products and of subassemblies used in these products. Initially this was experienced as 'shooting at the holy cows' but innocent students were excused. When it had calmed down, it turned out that there were several opportunities to save energy without sacrificing image or sound quality.

Environmental analysis of competitors' products were deliberately included in the measurements as described above. Inconvenient conclusions could be put aside -at least temporarily- because the originator was no part of the organization and thus could be declared a non-expert.

In practice however, there was mostly a very positive response to what the students achieved; particularly flagging up when the competition was better had a tremendous effect; this worked even for the non-believers in EcoDesign.

4.5.Translating the Environmental Challenge into Business Strategy.

The experience with the PRO*M*ISE manual and with Delft University had been inspiring and led to a meaningful long term cooperation. The challenge was how to operate EcoDesign activities which are well integrated in an commercial setting. This issue was abbreviated to the question: 'how to do Applied EcoDesign'.

When this is done properly, the question what strategic significance 'Eco' can have for an business like PCE is not answered yet. Externally, a consultant was found who – being strongly motivated for green as well- was prepared to think with the environmental managers of PCE about this issue. So, Jacqueline was hired and with her help order was created in the often intuitive thoughts of the PCE green crew. The logic underlying this order was as follows:

- Look at product/market strategies and the most important driving forces in the business.
- Take into account the organizations culture and skills.
- Look at the business conditions (profitability, market share)

- Look at the (green) external influences which can be exerted by stakeholders.
- Estimate the room to maneuver for the product line up; both from an environmental and an economic perspective.
- Look to the degree to which environment can contribute to gain a competitive edge.

Such an analysis has been carried out for the three most important Business Groups of PCE (TV, Audio and Monitors), see for details book, chapter 4.1.3. It showed that the position of the three business units was quite different. Therefore the ambition of the environmental brainstorms to be held should be different as well.

In all of these brainstorms, a very important approach was tried out for the first time. It was to go first for the most radical environmental ambition which the physics underlying the functionality allows. Subsequently it is mandatory to go back to just inside the reality domain based on the analysis as described above. The slogan was 'radical in the beginning but realistic in the end'.

The brainstorms were all held in 1996. For BG Monitors the general manager (he was a strong supporter of 'green') even allowed such a brainstorm to be an integral part of the preparations for a new generation. BG Audio on the contrary was not convinced at all and the results of the brainstorm took years to materialize (book, 4.6, part I, 7.3.2). For the BG TV, the outcome was channeled (by the environmental managers) into the 'semi-legal' green TV project (see part I, 7.3.2).

The outcome of the brainstorms was therefore very diverse. For Monitors it was closest to home: getting considered as a full fledged contributor to the Product Creation Process. For Audio the maximum was that some realized that there is more than just good technical characteristics (the Philips stronghold) and that these have to be combined with other positive emotions. For TV, the green TV was not more and not less than a strategic wake up call; a green treasure grove, but most of all that it made that EcoDesign got recognized as part of the strategy.

For Applied EcoDesign itself, the brainstorms contributed to methodology: how to be green and yet realistic.

5. Breakthrough of EcoDesign at the Business Groups.

5.1.BG Monitors was the first real mover.

The BG Monitors was a kind of exception at Philips Consumer Electronics. It sold its products chiefly to business customers - most of their products did not even carry the Philips brand. From the environmental perspective this was an advantage and a disadvantage. The advantage was that the B2B customers had a rational look at 'Eco'. The disadvantage was that as a supplier, BG Monitors had to follow the environmental requirements of the customers, irrespective whether these were rational, political correct or really proactive. In practice, the requirements were a pretty mixed bag.

BG Monitors had most of its operations in Asia, the production center was - in the period considered- located in Chungli, Taiwan (moved to mainland China later on); the factory in Saronno in Italy was catering to special applications.

Competition in the monitors market was fierce. In the nineties of last century, Sony, Samsung and Philips were the three big vendors. As a result of this, specifications, prices and delivery performance converged; minor difference in performance could already tilt the balance. One of these 'minors' turned out to be environmental attributes. PCE had been an early mover in this field with Sony and Samsung following (and turning out to be fast followers later).

One of the big B2B customers organized – stating that all other items are equal- a contest: each supplier was summoned to come to their (European) headquarters to present about environmental activities. I was selected to do this on behalf of BG Monitors. The contest was won; BG Monitors got orders for 500,000 extra products (I heard somebody (from Philips) say: the weird professor made it) the two competitors got correspondingly less.

This event showed a new role which environment can play: the role of tie-breaker: if all is equal and if on top of that 'green' can be delivered for free it is an important lever.

5.2. Reducing cost through green, the final argument for EcoDesign to get accepted.

This success in supporting sales enhanced considerably the progress of EcoDesign at BG Monitors. Time was ready for an EcoDesign seminar in Chungli.

Teaching there (and soon after in many other locations of PCE) had the character of a practical demonstration of what EcoDesign can achieve. This was done on basis of the very products developed and produced on the location where the seminar was held. The approach was taking them apart on the spot and putting the observations into a more general EcoDesign perspective and extending this – if relevant- to conceptual items. This reverse way of teaching turned out to work very well for groups which were not familiar with environmental issues and which have still to accept that EcoDesign is an opportunity for their department or for themselves.

In order to generate improvement idea's participants of a more focused workshop are asked to take apart products themselves in groups of 3-4 persons, preferably from different departments. Such an exercise generally mobilizes a lot of 'hidden creativity'; people have a wealth of idea's for their products but these only come out when they are set free from day to day worries. Moreover in such sessions there is 'interaction between departments' and there is fun. A next step to be taken after such meetings is a full (environmental) brainstorm for the next generation of products.

In Chungli these three session were held in 1995-1996. Participation was overwhelming and and implementation of the results was smooth. There was a lot to gain: the interior design of the monitors were outdated. This was because the first monitor models were in fact converted TV's. Also the fact that there was a big geographical distance between the Chungli development group and the development centers in Eindhoven made redesigns more difficult.

For an environmental manager it was therefore an easy score in the beginning but that was exactly what EcoDesign needed; easy to grasp opportunities at the beginning of the learning curve. Initially, focus has been on the easy scoring subjects like:

- Weight and weight ratio's of packaging (see book, 3.3.2)
- Use of recycled material in corrugated cardboard (see part I, 6.3)

- Cable and Wire reduction (see book p525 and part I, 7.2.2)
- Where does production waste go to?

All of these subjects have in common that they bring environmental improvements (particularly if designs are outdated, as was the case in Taiwan, the gains can be substantial) but the chief issue is that these bring cost reductions which are directly visible.

The subject which was superseding all of these successes was however the disassembly session organized in Taiwan (see book 7.3. and p584 and part I, 2..1.). Reducing the number of fixtures is good for recyclability (both in terms of direct cost and of the purity of secondary fractions) but most of all it gives clues to reduce assembly cost. The results of the disassembly analyses brought BG Monitors many millions of dollars of savings in a time frame of a few years.

The Taiwan activities were a kind of breakthrough. The news spread quickly, first in Asia. Audio which had big development centers in Hong Kong and Singapore wanted to follow-soon.

All other BGs followed and even the big, sturdy and self-confident BG TV had to recognize that this kind of EcoDesign approach was effective and helpful.

5.3.The first environmental brainstorm.

The success as described above paved the way to proceed towards the goal to make an environmental brainstorm an 'equal contributor' as compared to other brainstorms for a new product generation. The general manger (Bob) who was a strong supporter of 'green' allowed organize such a brainstorm and thus it was up to the environmental manager from Eindhoven to set this up and to deliver. The early experiences with the Applied EcoDesign brainstorms as advised by Jacqueline (see 4.4) were helpful in preparation: I stuck to the principle 'radical green first -go back to business reality later'.

Moreover, environmental benchmarks (see book 6.3. and part I, 6.4) had shown that Sony and Samsung were better, and not just from an environmental perspective. All ingredients to make the environmental brainstorm seemed to be in place, only one missing; how to go back to reality after all creativity before. This meant a sleepless night in Chungli for me (see book, p432). The solution

found for this issue was to prioritize idea's first of all according to their environmental merit but next according to expected benefits (for the company, the customer and for society, both in terms of money as well as in terms of emotion) and consider feasibility (ease or difficulty of implementation). Later this approach was called 'apply the EcoDesign matrix'.

The brainstorm became an outstanding success: many of idea's generated (including 8 out of the top 10) were finally incorporated in the target specification. Long term mission completed!

5.4. Environmental Benchmarking; the key to the breakthrough of EcoDesign at PCE.

The key to the breakthrough of Applied EcoDesign at PCE has been the development of the Environmental Benchmark procedure as described in the book, 6.3 and part I, 6.4. The core of it is measuring physical parameters of products (or parts of it) which related to environmental properties. Students of Delft University have pioneered through applying the method in practice and from their results a comprehensive method has been developed, taking into account the conceptual principles of 'Eco' as for instance the life cycle concept. The Environmental Competence Center of PCE have translated the Delft concept (called initially EPAss) into a form which would fit to the PCE approach like the five focal area's. The method also got a standardized reporting format which included all the calculation procedures as well. By 1998 it was ready for PCE wide application. Since that time several updates have been given, for instance in 2002 and 2004.

Over time, hundreds of environmental benchmarks have been carried out. These turned out to be very useful for a variety of purposes like;

- input for the environmental brainstorms (see part I, 7.3.1)
- learning from the competition (for free)
- acquiring data for eco indicator calculations (see part I, 8.5)
- establishing whether a product satisfied the requirements of being a green flagship product (see I, 9.3.2)
- making meaningful targets for environmental roadmaps (see part I, 8.3.2)
- laying the basis for environmental communication to customers (see book, 5.4 and I, 10)

Environmental Benchmarking has been the final piece in a process through which Applied EcoDesign at PCE developed into its specific form. In fact it is a primitive Life Cycle Inventory. This forms also the basis for Life Cycle Analysis. Because of its simplicity it is easy to understand and this makes it possible to mobilize the EcoDesign creativity of a wide group of employees eager to contribute but with little prior environmental knowledge. As explained in part I, 8.5.1. the benchmark cannot validate design decisions or do a 'life cycle check' in order to make compromises for conflicting EcoDesign actions. For this purpose, PCE has taken Eco-indicator '95 and later Eco-indicator'99 software on board and has invested strongly in a specific database for components and materials.

In practice in PCE, few conflicting EcoDesign actions turned out to occur. Therefore Environmental Benchmarking was a solid basis to do EcoDesign.

5.5. Developments at BG TV and BG Audio.

5.5.1. BG TV, adding to EcoDesign progress in their own way.

In environmental matters (and not only there!) BG TV followed its own course. Developments at BG Monitors were observed with much interest but the environmental managers at TV had their own focus. This lead to a number of contributions which were very interesting for PCE as a whole, but sometimes also to heated discussions and even disagreement. Environmental aspects of plastic application got a lot of interest at TV simply because the amounts of plastics products were big. As a rule high impact polystyrene (HIPS) was declared to be the standard construction material. Other types of plastics were only allowed to be used if there were specific reasons to do so. Soon 92% of the plastics used was HIPS. This led to better recyclability of TV products and to price discounts because of high volumes purchased; the other BGs happily piggy backed.

BG TV also pioneered the gas assisted plastic molding technology and thus put the concept of enabling technology on the map.

Flame retardant reduction through better internal thermal management was pioneered as well, although in the end (emotional) safety concerns turned out to be the superseding issue (see book p 229 and part I, 7.2.4.). What stayed in place of the better thermal management was a potentially longer life time

(due to less local overheating of components). It was therefore difficult to communicate this simply because data supporting this conjecture were lacking.

A tremendous breakthrough was also achieved through the 'green TV' project (see book p.7 and part I, 7.3.1). Although this product never made it to the market, it made that the need to have an environmental strategy at product level was recognized at the highest executive levels of PCE and Philips. The 'green flagship' requirements in the corporate environmental program were indirectly a result of the green TV- a link with environmental benchmarking made it possible to establish whether a green flagship status could be awarded.

Student projects at BG TV showed evidence that actual buying behavior of consumers differed substantially from what a general public said in interviews. This initial conclusion has been detailed later in the identification of the seven archetypes of green consumer behavior (see book, 5.4.1. and part I, 10.3.1)

Contrary to BG Monitors there was till the turn of the century little interest at TV for energy reduction. This was thought to go at the expense of image quality and therefore rejected. When the benchmarks were performed, PCE TV products showed nevertheless a lower energy consumption than the products of the competition. This was due to the good relationship with the IC supplier, Philips Semiconductors and in fact good luck in the first instance.

This observation brought up however the concept of making explicit joint road maps with key suppliers and after the year 2000 this concept has been exploited to the full.

5.5.2 BG Audio; a pronounced example of green as change agent.

Like the other BGs, Audio followed closely the developments at Monitors and at TV. It implemented quickly the ones which were thought to be relevant and to be applicable. This saved many millions, particularly in packaging reduction, simplification of product architecture and in plastic application. BG was the oldest business of PCE, its origins date back to the twenties in last centuries. As a consequence it had a long design history - any challenge to the solid square and black boxes it produced was seen as an attack on the excellent sound quality which was delivered. Competition which had more lean and mean and most of all more playful products and was gradually improving sound quality almost to

the Philips level. It gained market share even in the product segment intended for 'techno freaks' and in the nineties of last century, Audio was in serious trouble.

This inconvenient truth was discovered by Eelco, a Delft student. His graduation project had the title: gender and green of Audio products. It turned out that more than 50% of Philips Audio were bought by men; the market share among single women was on the contrary very low. When asked this group responded that they detested the awful Audio designs. Although women are more environmentally conscious than men (see 2.3) this seldom had come up as an issue before. In the first instance, the proposal to address in the design the emotional dimension of functionality stronger (feel good, quality look, nice design, funny) did not get support. Subsequently, green turned out to be the tiebreaker of this stalemate; environmental was accepted as a 'no escape' and this opened the door for a much comprehensive overhaul of the designs.

Environmental activities at BG Audio delivered another interesting clue. After a long struggle a human powered radio was brought to the market. The discussion took three years; the first human powered (HP) radio brought to the market was laughed about because it was seen as lousy (Sony products when brought to the European market in 1965 were laughed about too). The product was lousy indeed, but that was not the issue, it was sending a signal. Philips with all its experience in audio could very easily do a substantial better technical job. The real problem was however that it was caught in old fashioned paradigms. And finally, there it was (see book 4.6 and part I 7.3.2), a Philips branded human powered radio. It was an instant success. Most buyers bought the radio not for personal use but to give it as a present to somebody else. Profit margins in this special market are much higher than in mass markets. It had not been realized by Audio that the HP radio belonged to this category however. Competitors did so and made much more money. In Japan for instance human powered radios were sold as to be earth quake proof (independent from the net and from batteries) at very high prices.

All these items showed the importance to consider intended functionality in very much detail and to link pricing closely to it. This is the core of the (Eco)Value process (see book, 2.4 and part I,10.4).

6. Consolidating Applied EcoDesign through integration into procedures, programs and overall strategy.

6.1.Procedures, roadmaps and strategy.

The successes of Applied EcoDesign through activities in all Business Groups paved the way for integration into procedures and roadmaps and for making an overall business strategy.

The Product Creation Procedure (PCP) is the most important one as regards product innovation. An environmental chapter has been added to it; the most crucial aspect was that the outcome of the environmental brainstorms had to be considered in the (environmental) part of the target specification - this gave EcoDesign activities a really clear status.

The requirements in the target specification were organized in the five focal area's: Energy, Material Application, Packaging and Transport, Chemical Content and Recyclability.

In the energy department the performance of PCE was usually good; this led sometimes to a lack of ambition ('why should we do something'). The advent of roadmaps could overcome this attitude: stay better instead of just be better.

For materials application and packaging/transport there was usually a lot to gain. Requirements in these fields almost never gave rise to discussion.

PCE was leading in chemical content. Keeping this leadership position was very widely supported both because of the high relevance of this attributed by customers and because of ethics, most employees were feeling the same way as customers.

On the other hand there has been a lot of discussion about recyclability. Originally, PCE had the idea to go alone in the organization of take back and treatment of discarded products. Since it had been established that the treatment costs would be lower than its competitors, there was a strong stimulus to

proceed along this road. However the extra cost for logistics and system organization (particularly in countries where PCE had a low market share) made this a questionable strategy. In the end PCE decided to go for collective systems which reduced through their economy of scale total cost to a minimum, see for more details the WEEE handbook, chapter 29 (Woodhead Publishers, 2012, ISBN 978-08579-089-8). Moreover it turned out that in many countries fees could be asked from last owners for take back and treatment, thus reducing costs to PCE to zero. From a technical point of view, allmost all PCE products fulfilled the recycling requirements of the WEEE Directive of the European Union (and the national legislation resulting from that) by a wide margin. Therefore there was little incentive to pay special attention to 'design for recycling from a compliance perspective.

However, internal cost savings were big drivers to deal with this form of EcoDesign. Simplifying product architecture resulting in reduced (dis)assembly costs (see book 7.3 and part I, 6.3 and 5.2) saved millions and this made that a dissembly analysis became mandatory for all PCE products, even the ones which would never be disassembled. Also the mono material requirement (see I, 6.1) had been primarily inspired by recyclability considerations but in the end the price discounts on purchasing the high volumes of high impact polystyrene led to an easy acceptance of this rule .

Requirements for different focal area's were almost never a result of mutual trade-offs. For PCE products energy use represents by far the biggest part of the environmental impact over the life cycle. This means that materials reduction has to sacrifice for energy saving. In turn, materials reduction prevails over increasing recyclability. Packaging/Transport and Chemical Content reduction usually do not interfere with other focal area's at all. The life cycle check calculations by the Environmental Competence Centre (see I, 8.5) were used to find out whether for proposed individual design actions the general rules of a thumb mentioned here were applicable.

Once the environmental chapters in the PCP were in place, the follow up in other procedures - like for instance for purchasing and for marketing were straightforward.

In the roadmaps, the targeted development of environment related parameters over time was described . The fact that competition was moving was considered as well. Since PCE did many comparative environmental benchmarks

over the years accurate extrapolations replaced the educated guesses in the beginning (1998-2000).

The importance of suppliers in enabling PCE to realize its roadmap goals has been highlighted in part I, 9.2. Suppliers will engage themselves to reach the goals when they can share in the benefits of doing so. Before making available procedures and formats to manage EcoDesign issues, PCE needed to demonstrate that its own house was in order in this respect. If this can be demostrated, others in the environmental value chain can be convinced to follow. This strategy worked: with reference to the in house achievements, suppliers were asked politely and sometimes penetrative to participate and most of them did.

Going through a successful sequence of scoring successes through EcoDesign, building credibility and integration into PCE's procedures, the Environmental Competence won the trust of the Senior Management; its initial attitude had been pretty neutral. This meant that the development of an overall strategy and the audit of progress of EcoDesign was entrusted to a large extent to the ECC.

This PCE environmental strategy could be easily defined after the experiences described in the earlier sections. It was simply 'be better than the competition in green'. This was clearly inspired by the ambition to be a market leader in all departments (including the environmental one) and for all products and the evidence that this could be realized with a reasonable amount of effort.

How much better than the competition has been a subject of much debate. Becoming 'really green' was seen by many as 'freaky' or simply as not belonging to PCE values. The outcome of the investigation (see book, 6.3 and part I, 10.3.1) about green attitudes of customers supported this 'moderate green' strategy. Combining this with a linked benefit communication strategy (see below) made it possible to cater to a broad public.

6.2. Becoming better than the competition.

Being better than the competition in green is a moving target. It requires a continuous analysis of what competitors are doing and what new opportunities arise in the world, for instance through science and technology. Opinions and

feelings of customers and other stakeholders are changing too; these will also influence the regulatory environment as well.

As an early mover, PCE was initially clearly in front of the competition. However, this lead was gradually decreasing. This is obvious when competitors take more action and the physics underlying realization of a certain functionality is identical for everybody around the world. By the turn of the century, PCE had to take firm and more systematic action to stay ahead.

The Product Managers had to take into account such developments in the strategic product planning. In such an activity, functionality aspects (book, 2.2.4 and I, 10.4) had to be transformed into value proposals to customers. Environmental aspects were to be incorporated into this process as well. In spite of all support by the ECC, the Product Managers turned out to be not the most 'natural talents in green'. It was a continuous struggle to get the environmental roadmap targets translated into tangible product attributes. The Environmental Key Performance Indicators as described in part I, 9.3 proved to be instrumental to this. A more detailed description how this worked out positively is given in the book, 4.7.

Apart from supporting the strategy implementation at the BGs, the ECC was also in charge of monitoring the progress of the Philips Corporate Environmental Program. As mentioned in part I, 9.3. PCE could easily fulfill the demands of this program. It was ahead of other Divisions and the requirements were set in such a way that the weakest link in the corporate chain still could make it.

Selling a broad variety of products under one brand has advantages and disadvantages. The advantage is that such a big brand is better known, a disadvantage is that for building the image, including the environmental image, compromises have to be made. This is simply because the vast range of functionality profiles under one brand allows limited segmentation only.

6.3. Environmental standards and EcoDesign at PCE; the difference between how it should be and how it can be.

From the very start, PCE had an open communication policy about its EcoDesign activities. This was to show to a variety of audiences its progress but

also to get in touch with external parties which could enable PCE to do a better environmental job. Particular emphasis has been put on establishing contacts with research institutions and universities and as a result it became member of several international working groups and project consortia. PCE also presented its work in the field of 'Applied EcoDesign' at scientific conferences. The link with Delft University (see 4.2) further enhanced its status of being one of the leaders in the field.

It was therefore natural that PCE was invited to participate in international (ISO) standardization activities. In order to contribute successfully its delegates had to forget about specific interest. Representatives with other backgrounds had to do this too and did so with variable success. This was not the biggest issue however. The biggest problem was that in order to make environmental standards to be helpful in practice, a synthesis has to be made between 'scientific green', 'government green' and 'consumer green' into 'implementable green'. Out of this struggle, see part I, 9.4., 'scientific green' came out as the aspect to dominate overwhelmingly. Although PCE's EcoDesign activities were science based (nothing more and nothing less) they needed to be properly managed to lead to result. There is a big difference between managerial decisions (51% evidence is good enough to go ahead, but the complete context has been taken into account) and a scientific decision (in principle 100% proof in the scientific domain is needed).

The ISO experience demonstrated once more that there was a big gap between 'academic' EcoDesign and 'applied' EcoDesign; this is a gap which unfortunately still exists today. This means that companies wanting to engage themselves in effective EcoDesign activities can find little external guidance and have to do it to a large extent by themselves.

6.4. Environmental legislation: little impact on EcoDesign at PCE.

It has been described in the book chapter 9 and in part I, 9.5. how Philips and in particular PCE has tried to support development of appropriate legislation. It did so because it had the conviction that this was necessary to ensure a minimum of environmental care by all producers of electronics products.

This turned out to be a cumbersome task into which the Division invested a lot of time with in the end limited results only. On one hand legislators distrusted PCE because it was part of a multinational company and because it tried

to contribute in a pragmatic way that is based on its experiences in practice. However, the opinions and advice of others prevailed. Often such stakeholders based themselves on principles rather than on practicalities. These are mostly simplifications of a complex reality and have seldomly tested in practice for their real applicability. Moreover, policy makers think rather in juridical terms than in engineering terms and thus look rather to 'how to be right' rather than 'how to get it right'. A lot of advisors and consultants support such views and on top of that rather write what their principals like to read than reporting 'inconvenient truths'. Members of parliaments depart from 'political reality' (whatever that may mean). Even if they agree with industry views behind closed doors there is no guarantee at all that they will do so in the open. Non governmental organizations usually are anti industry anyway. They have sympathy from broad groups of the general public or at least have more sympathy than industry.

In such circumstances, the industry federations should have taken swift action to become and stay an active player. However, as shown in part I, 9.5.1. the federations were slow due to lack of internal agreement, partly because the electronics industry is representing a large variety of products. This variety makes that the EcoDesign opportunities are different, take back and treatment costs vary greatly and potential toxic content is varying from very low to big. Therefore it could be expected that the issue of differentiation would rank high at the negotiation agenda of industry. In fact there was no negotiation agenda developed at all; a recipe for disaster, not just for industry but for society as a whole. This is simply because in the end society has to foot the bill.

PCE saw this drama happen and could do little more than trying to limit the damage as much as possible. There is more however which made that current European Directives on environmental issues have still a large improvement potential. This is because the EU has allowed the emotional component (which is an undeniable part of environmental considerations) to develop into a dominating proportion. The industry federations should not complain however.

The Industry Federations got what they deserved because of their ineffectiveness. Lack of quick wittedness and lack of coming up with credible alternatives are the chief reason why they did not get a better deal.

7. Communication about EcoDesign, Green Marketing.

7.1. Communication; a moderate green profile.

In the previous sections it has been demonstrated that it took a long time before EcoDesign inside PCE became mature and had been implemented division wide. This meant that communication about 'green' took even a longer time before it could become credible and consistent and could address all audiences in the right context. On the way to this maturity in communication, quite some lessons had to be learned. Partly this was because of misunderstandings in the internal value chain, partly because effective communication about environmental issues has to link to the perceptions of the targeted audiences. In practice these turned out to be different from what was to be expected on basis of more superficial interviews published; to find the real opinions and emotions interviewers have to dig deep.

The first issue encountered when starting environmental communication was – like for introducing EcoDesign itself- the issue of credibility. Already In the internal value chain doubts about the value of communicating about the subject were encountered. In the outside world this doubt was more centered around the perception that PCE belonged to a multinational driven chiefly by profit. Since it was realized that all prejudices could not be addressed from the very beginning, it was decided to go for an open information policy: tell what PCE is doing, tell that the organization is on its way to do better and better and give an indication what is targeted to be achieved. This approach turned out to appeal to the reasonable part of the big variety of audiences. The far majority of these understands that an organization like PCE cannot 'turn green' overnight and gave it therefore at least the benefit of the doubt.

Since PCE was one of the early movers in EcoDesign, it was mostly well ahead of legal and other regulatory requirements. Combined with the intent and the plans presented it was therefore seen by a broad public as a caring company.

All of this was reassuring but it was realized that this is still a rather defensive approach. More tangible achievements were needed to keep a good reputation. Due to its tradition, PCE tended to think that environmental achievements were

in fact technical achievements and had therefore to be expressed in hard numbers as well. A report by a student doing an internship on environmental communication came therefore as a shock. His conclusion was that green communication in the external value chain is primarily about sending the right messages and about image building, number supporting the messages come second. A lot of these should be only available on request (in practice few people- including journalists- do not ask for them).

While debate about this was still going on, an external development helped to resolve the issue. At the end of last century, consumer organizations started to add 'environmental paragraphs' to their test reports. Particularly for more mature products like TV's and Audio; electronic products in a certain price category tended towards more and more equal general technical performance. The environmental paragraph could be (and in fact often was) the 'tie breaker'. PCE did well in such tests and and in this way the test magazines added momentum to its as yet shy communication of PCE itself.

The initiative of the consumer organizations was in fact helpful in two respects. In the internal value chain it overcame distrust, conservatism and fear to be 'freaky'. This development, together with the green TV project (see I, 7.3.1) made that the president of Philips changed his perception (before he had made some mishaps in communication about green) and ordered green flagship products to be in place for every business unit. This opened a new avenue for the corporate environmental programs as well. This brought in turn a clear boost for communication.

In the external value chain the consumers organization initiative overcame the widely entrenched idea that when it comes down to environment all companies (competing in other fields) should join forces. Moreover, the consumer organization judged from the perspective of 'consumer green' and not from the perspective of 'scientific green'. In last named field there was a de facto ban on any environmental communication through the ISO environmental standards of the 14040 series. Science did exclude itself in this way from the real world. It is perfectly entitled to do so but the consequence is that a lobby to make forms of Life Cycle Analysis based on the 14040 series mandatory for industry in not justified anymore.

While still communicating about its achievements in a reserved way (much more could have done), PCE managed very well the flip side of environmental

communication and avoided traps into several of its competitors fell into: unjustified claims, management showing not to be fully engaged and most of all avoiding environmental scandals (for instance through good supplier relations).

Moreover it is to be realized that environmental communication is primarily to add to brand image and therefore any Division effort should fit into the Corporate approach. Focus on brand image has also been the reason why Philips and therefore also PCE has avoided Ecolabels as much as possible. The reason is that such labels put a company on par with competitors, at least in the perception of the outside world. If the ambition is to be better than the competition, the label is of no use for brand image purposes. Ecolabels are granted by third party organizations; as such they claim and can be seen as to be more objective than corporate communication. As regards this issue the open information policy of Philips and PCE paid: it turned out the far majority of the public had no or (little) suspicion about the Philips communication. Critics of companies are there to stay whatever these companies do. For this group, having Ecolabels will not be convincing either; the superseding issue is that big corporations are perceived to be bad anyway.

As a result of these experiences, environmental messages were directed towards audiences from which a positive resonance could be expected.

7.2. Green Marketing, exploiting EcoDesign results.

Although the idea of 'selling more through being green' was in place from the very beginning of EcoDesign, it got real momentum before the turn of the century. Consumer surveys in Europe indicated that 75-80% of the general public was to prepared to buy 'green products' if they were available and that more than 50% was to prepared to pay a small premium price for it (and some 15-20% a more substantial premium). Good news about environment was and is scarce and there it was; it was making the headlines in all the media. Also Philips got the message and it might be that this news made the CEO of Philips make to change his perceptions. About at the time the green TV was shown to him. Soon after the Corporate Environmental and Energy Office (CEEO) started to push for green products and green marketing.

There is however a difference between 'general public' and 'buying public'. Last named category is rather inclined to think in terms as 'environment is nice, but what is in for me', or to say it more bluntly: buyers are more selfish. Parallel

to similar investigations in the USA, BG TV started a deep digging research in environmental attitudes of potential buyers of PCE products. The result showed the existence of seven archetypes of attitudes (book, 6.3, part I, 10,3.1 and 2.3 in here). Some 45% were positive about environment, some 25-30% neutral and some 25-30% clearly negative. Of the positives only half was prepared a premium price. In the traditional segmentation of buyers of PCE products there were 1/3 price buyers (mostly negative about green), 1/3 techbuyers (spread over all three segments and 1/3 quality buyers (mostly positive). The numbers about the customer base support the general conclusion that fetching premium prices because of 'green' is an unattractive marketing strategy for a player in the market wanting to appeal to a broad public.

These outcomes created a complex situation at PCE. What to do? The concept of 'green flagship products' was pushed by the CEEO but pricing and communication about such products could not consistently be done. What was to be gained in one consumer segment was thought to be lost in other segments.

This issue solved itself through good luck and the fact that Philips is rather a federation of Divisions than a centralistic company. Due to its early moves in EcoDesign, PCE had green flagships products in place before these were defined as such. Specific green communication about these products was kept low key; the communication was rather directed to support general green image. Customers correctly perceived in this way that they got at PCE 'green' for free.

PCE realized that its lead was not to last. Competition was improving its green performance steadily. This meant that efforts in EcoDesign had to be intensified in order to stay ahead and to realize year by year products which were significantly better in environmental performance. In the end the fact that physics is identical in the world makes that no significant better performance can be achieved for mature products. This made that after a few years the concept of green flagship products died a natural death and as a consequence disappeared from the corporate environmental program.

In the meanwhile the concept had been an enormous stimulus for EcoDesign. Real green marketing for the green flagship products never took of, but green marketing to support the brand was a great success!

7.3. EcoValue, a logic way to proceed with traditional Applied EcoDesign.

In the concept of EcoValue, environmental load is directly linked to money in the form of a ratio: (EcoValue = total costs over the life cycle/environmental load over the life cycle). It has been developed in the years 2000-2002 (see book, 2.4 and part I, 4.2). It brings together three lines of thinking:

- The necessity to link 'ecology' and 'economy' directly. Money is a reality of life sharply influencing environmental thinking of consumers.

- The necessity to consider 'eco' from a demand perspective, next to the usual supply perspective. Environmental load is a multiplication of the load by one individual product multiplied by the total volume sold. Good environmental performance as such is therefore just a potential; consumers decide through their spending behavior whether this potential will materialize.

- The necessity to add as much value as possible to the raw materials used in primary production of goods. This is considering environment from a resource perspective and not just from an emission perspective.

At its lowest level of implementation, EcoValue is a consistency check of environmental load and pricing of products. Although studies by Delft University students indicated that PCE could make meaningful improvements in this respect, it lead to the rejection of the EcoValue concept altogether. This was a sign that in the end, after all the positive experiences, environment was still considered to be just environment and not as an opportunity to enhance the business.

The EcoValue concept implies in fact an explicit design strategy through which products are more attractive to the user. For PCE there was still a lot to gain in this respect, particularly in the intangible and emotional functionality departments. Studies even indicated that if through design changes implying a small increase of environmental load, much higher prices can be commanded in the market. This is a very sound EcoDesign strategy; the EcoValue of the products increases and since money can only be spent once there is a positive rebound effect as well.

An example of implementation of such a strategy (without realizing that it does so) is Apple: maximum user friendliness combined with average environmental performance. This strategy is contrary to traditional eco thinking, but it produces products with a low environmental impact per dollar spent.

Using the EcoValue for the PCE product line up would have been an opportunity to escape from the saturation phenomena in traditional EcoDesign. Moreover it would have given an impetus to a gradual change in product mix, in its business models and last but not least to its sales channels management. Instead of that PCE and Philips in general turned to EcoDesign philosophies like Cradle to Cradle. In the opinion of the author this was a fall back to the period in the nineties when EcoDesign started with addressing chemical content and recyclability issues only..

Also broadening the scope to wider sustainability issues did no good to environmental issues as such. Since budgets simultaneously were rather decreased than increased indirectly less could be spent on EcoDesign.

The EcoValue concept would have been the opportunity to take Applied EcoDesign to a next level. Particularly through its inherent concept to get more value out of the same use of resources. As such it would prop up a component of the present 'Circular Economy' approaches as well.

8. Introducing EcoDesign into Industry faster.

8.1. Making of an EcoDesign Potential Profile (EPP) at the very start would be of great help.

In the previous sections, it has been described how EcoDesign has been introduced and developed inside PCE. It took almost 10 years before a real maturity stage had been reached. Partly this was because Philips Consumer Electronics was one of the trailblazers in the field and a lot of the issues to be addressed had to be developed by trial and error. Moreover, management was on one

hand sympathetic and/or tolerant towards the EcoDesign idea but on the other hand left it to a 'bottom-up approach' to develop- this is by nature a slow process. This attitude created additional further delays in the division wide acceptance of 'Eco'; a little push in the back from the senior management is helpful for the department heads and employees hesitating or doubting.

Another circumstance has been that as regards the application of EcoDesign in practice the conceptual insights of most of academia (and related institutions) and industries like PCE grew apart. Section 10 with the title 'EcoDesign in academia and the electronic industry' eight reasons underlying this unfortunate development have been described.

Below it will be described below **how EcoDesign could be introduced into industry faster**. In order to do so a broad question should be asked first: **what role can green play in business**? The answer to this question is definitely not a 'one size fits all', so each company has to find the answers for themselves. Generally, it will depend on a variety of factors:

- Internal ones (management interest, skills available, cross functional linkage, eco learning so far and personal motivation (eco champions)
- Preparedness to review decisions made in the past (technology, investment, suppliers, ...)
- Business conditions (profitability, market share)
- External influences (legislation, customer pressure)
- Room to manoeuvre (product functionality, product alternatives)
- Competitive edge (what can 'eco' contribute, what is competition doing)

An analysis of such items would allow to make an 'EcoDesign potential profile' and would allow to set a tailor made background (or even a strategy) which would assist in operating EcoDesign in an way which is optimally adapted to the organization.

8.2. Exploit in the EPP to be made the five basic strengths of EcoDesign.

Making an EcoDesign potential profile in 2016 is much easier than it used to be before. A lot of information is available, including the PCE one as described in the book, in part I and in the previous sections.

The PCE experience shows that Applied EcoDesign has five fundamental strengths which have benefited the organization in fields far beyond just 'Eco'. These include:

1. **PREVENTION**. This is preventing that bad (environmental) things happen in the future. Even more importantly, this also includes reviewing decisions made in the past. Many of such decisions were the right ones given the time and the insights that these were taken. However in the meantime insights, technology, prices, supply opportunities, customer preferences and societal views might have been changed. Since in Applied EcoDesign a first question is 'why are things as they are' it has been functioning many times as a very meaningful wake up call for the whole organization.

2. **LIFE CYCLE THINKING**. This principle has led in particular to enrichment of relations with suppliers (beyond just price), investigations how products are used (with particular reference to energy consumption) and inspiration by recyclers (product architecture and number/type of fixtures).

3. **DO MORE WITH LESS.** This principle is calling for more 'integration' both as regards mechanical aspects and as electrical aspects. Mechanical integration is mostly enabled by new technology (for instance of plastic moulding and numerical machining of parts) and the electrical one by more powerful integrated circuits and more miniaturization. Apart from lowering power consumption, such actions allow to reduce the amounts of components on printing wiring boards. Doing more with less stimulates also closer relations with suppliers which get an enhanced function as 'enabler of good environmental performance' both through their designs and reducing their environmental load of production.

4. **FUNCTIONALITY THINKING.** 'Eco' as experienced by customers (and as society in more general) has a strong emotional and intangible component. Realizing this and applying it to the wider concept of product functionality, it has helped technically and money oriented organizations like PCE to look beyond this narrow horizon. As a result, by now four functionality domains can be discerned:

- Physical functionality: 'Eco' = design not more (overkill!) and not less functionality than is needed for the target user group (tailored products: other target groups might need more or less functionality).
- Economic functionality: EcoDesign can contribute through less material use (including packaging), less energy in the use phase, longer product life.
- Intangible functionality: Eco is generally on the defensive here; do not sacrifice ease of use, health and safety etc. in the name of environment.
- Emotional functionality: feel good, nice design, quality feel, reuse potential/recyclability, 'green', less/no hazardous substances. Here is a big opportunity!

5. **PARADIGM SHIFT.** EcoDesign does not take anything for granted and as such challenges anything which is engrained in an organization: 'no holy grails'. This is an enormous boost for creativity and if put into practice in a non activist way it has brought tremendous benefits for the organization.

Capitalizing on these strengths and applying them to the relevant products and using the experiences like the ones of PCE will make a company move ahead in EcoDesign.

8.3. Companies design primarily for value. EcoDesign is part of value creation.

Companies design for customer value and value is something different than price. It includes intangibles and emotional components. If the value for an individual customer is higher than the price asked for the likelihood that the product will be bought is high; for the reverse the opposite is true. In rich societies, intangibles and emotions play an important role in buying processes; people buy often products because they like them not because they have a (basic) need for them. This is a reality of life which the Eco community has to accept. This observation is also putting what companies claim to do in the field of EcoDesign on a relative scale in two ways:

- EcoDesign is in practice subordinate to value creation.

Perceptions by consumers of what is 'green' (which is as such one of the value constituents) are quite diverse. One thing is for sure however: these consumer perceptions are not based on science. In their feelings the strongly emotional issues are getting an overweight compared to scientific reality (for instance potential toxic substances), others which can be made more objective (energy- which represents a high environmental load for which has to be paid) is underweighted. The reason is that more energy use is in the mindset of many consumers to be associated with better image or sound quality (or in the case of vacuum cleaners with a cleaner home) although this is not needed if products are well designed.

In this maze companies have to find their way out; life cycle analysis in small or capital letters as is often recommended to be the 'helmsman for EcoDesign' will not be applicable in such a situation. Only a careful study to closely match the functionality requirements of consumer groups and the minimal environmental load is the best which can be done.

'Educating consumers' is often recommended as a solution for this issue. Personally, I do not believe in this. What might work better is a differentiated tax system, tax products with a higher (scientifically calculated) environmental load over the life cycle more than products with less environmental load. This is an explosive political issue however (food has for instance a high environmental load).

The very variety in consumer behaviour calls for a differentiation in EcoDesign strategy for companies wanting to appeal to a broad public.

As has been discussed elsewhere, the attitudes of buyers of consumer goods can be divided into three groups (which are correlated to seven basic environmental attitudes): price buyers, feature buyers and quality buyers.

* Price buyers go for the lowest price, which means that the only EcoDesign strategy possible is 'EcoDesign for cost reduction' and forget about all the other EcoDesign elements which can contribute to a lower environmental load. This strategy has a negative rebound effect, since when goods become cheaper people can buy more (assuming that their income is constant)

* Quality buyers are the best candidates for EcoDesign for value creation especially if 'being green' can be linked to other 'feel good' features. Since the prices commanded in this sector are higher there is a positive rebound effect, especially if more buyers are moving to the quality segment. In some cases these even allows an EcoDesign strategy in which a higher environmental load can be accepted if the prices which can be commanded are disproportionally high (for instance the gift market)
* Tech buyers are somewhere in between. Wanting more features generally leads to higher (scientific) environmental loads, wanting to have the latest technology leads to lower loads. Therefore in most cases new technology leads to more EcoValue creation. Whether this is mechanism works in practice is determined by preferences of consumers. Their perceptions prevail. So in such a situation the best strategy is 'EcoDesign enabled by (new) technology', but closely follow in the market in order to see whether it really works.

Linking value creation and EcoDesign is an approach which further enhances the EcoDesign Potential Profile analysis as described in 8.1 and 8.2.

9. A kick start in Applied EcoDesign; 14 recommendations to get on the road quickly.

Once a product has been identified to be Eco designed (better), a kick start can be made by following the fourteen recommendations as set forth below. These recommendations have been developed primarily to support Delft students who did a graduation project in Applied EcoDesign and have to show their ability and creativity within a six months time frame. The basis for the recommendations came from the experiences when introducing EcoDesign at PCE; later the students themselves have contributed to their final form mostly through successes but sometimes through failures as well. The organization of the issues to be considered is in six groups:
- Vision on (Applied) EcoDesign.
- Nature of Applied EcoDesign activities
- Fostering Eco creativity

- Integration of Applied EcoDesign in to business operations
- Production aspects
- Communication about results

All aspects are elaborated on in the book, part I and the previous sections. This chapter is therefore to be seen as a summary of how Applied EcoDesign can be operated in practice.

Vision on Applied EcoDesign.

1) EcoDesign should be considered as an **opportunity to add value** to products and services. In all four functionality domains (physical functionality, economic functionality, intangibles (health and safety, ease of use, fun, ...) and emotional functionality (sense of quality, feel good, ...) there is potential to add such value.
Reason: Doing EcoDesign out of 'self-interest' works better than being forced to do it by external drivers.
Remark: 'Eco' should therefore be included in the companies vision, in the strategy and in the roadmaps.

Nature of Applied EcoDesign activities.

2) Applied EcoDesign is in its initial phase **a radical approach** with strong focus on 'environmental issues'. Balancing with other business issues is in a later stage only.
Reason: Practice has shown that a design strategy which has far-reaching ambitions brings more than an incremental one, provided that the design team is prepared at a certain moment to give in (partially) on the ambitions.
Remark: In the processes needed to go 'back to reality', the non-eco business factors are the only boundary conditions.
3) Applied EcoDesign has **six 'focal area's:**

* Energy
* Material Application
* Chemical content
* Production
* Packaging and Transport
* End of Life/discarding by first owner

Reason: These six fields link up the best with the organization of companies. Design teams will have to mobilize expertise from outside their own group in order to get the best results. Organizational issues should not hamper this.

Remark: The Life Cycle principle is the link between the focal area's. This could lead to mutual contradictions in the action agenda to be formulated. However, in practice this occurs pretty seldomly.
Nevertheless a life cycle check of the action agenda is recommended.
4) EcoDesign issues have **three dimensions** and all of them have to be addressed in Applied EcoDesign.
* Emissions: this is the dimension which is the focus of 'scientific green'
* Resources: this a domain mostly addressed by governments (not necessarily on a scientific basis, 'government green')
* (Potential) Toxicity: this playing an important role in the public domain. The approach is primarily emotional (green opinions).
Reason: Emotions and non-science based policies/legislation are a societal reality, cannot be denied and therefore have to be addressed. 'Education of dummies' as regards this issue has turned out to be ineffective, particularly when this is done by companies.
Remark: Resource aspects and (potential) toxicity are generally underrated in attention.

Fostering Eco creativity.

5) Eco creativity will flourish if it is developed on **basis of facts** about:
* the company environmental strategy and the environmental roadmaps
* environmental characteristics of previous product generations
* competitors behaviour
* customer characteristics
Reason: If you know where you stand it will be easier to find out where you want to go.
Remark: Collecting and bringing together relevant facts already stimulates creativity. Transferring these facts to design teams has an even stronger effect ('I never realized that'...)
6) The first step in EcoDesign brainstorms is about **generating idea's only** (talk about money and feasibility is absolutely forbidden).
Reason: People should be set free from all other day to day worries to be creative in green.
Remark: In a later stage, the step of 'going back to reality' stays a boundary condition and is not trade off (keep focus on environment as much as possible). Experience is that for 75% of the 'environment only' design actions, no or almost no restrictions from the ongoing business practices apply.
7) Green design options need to be **prioritized**.

Reason: Some options are more environmentally relevant than others- you cannot have it all!
Remark: On top of that design teams are in a time (to market) and budget squeeze anyway.
8) **Tools** to support EcoDesign should be selected on basis of their **capability to support** environmental **creativity** and/or setting priorities of green options. Validation tools do not support such processes.
Reason: Doing EcoDesign in a business setting is about doing better in 'eco' and making meaningful contributions on basis of 'eco'. It is not about finding the 'environmental truth' seen from a holistic environmental perspective.
Remark: For instance Environmental Benchmarking supports creativity, LCA based tools support environmental validation and contribute little in the creativity phase.

Integration of Applied EcoDesign into business operations.

9) Prioritized green options **need to be assessed further** by assessing their benefits for the company, the customers, and society. Benefits include money/cost of ownership, positive emotion/image, better intangibles and (proactive) compliance with regulation.
Also feasibility of the options is to be considered; from a technical, a financial as well as an organizational perspective.
Reason: Eco idea's have to be integrated into mainstream business processes.
Remark: Experience shows that this assessment makes that the priority of the options changes but that few idea's really drop of the list. The assessment greatly assists however in getting eco idea's (which now are in fact idea's based on eco considerations) accepted in the product concept consolidation meetings.
10) Design options which are **accepted by the product consolidation meeting** are to be brought into a written form in design briefs/target product specifications.
Reason: Due to time (to market) and budget pressure, design teams/product development teams have no room for volunteering beyond the targets/specifications.
Remark: Practice shows that in the detailed design phase mostly the targets are surpassed because most designers are highly motivated to contribute to the eco field.
11) **Eco requirements** are to be **quantified** and therefore be 'measurable'. This is in two respects:
* in terms of physical quantities (allowing 'communication')
* in terms of environmental load (allowing 'validation')

Reason: All parties in the internal and external value chain understand 'the language of physics', few do understand 'environmental language' as well. The use of environmental language is necessary to do life cycle checks and to show to parties influential in the public debate (often not in the direct value chain) that a good job has been done.
Remark: Few people have time and are willing/wanting to go to the environmental language school.
12) In order to achieve the maximum result, **'enablers'** (expertise) outside the the design teams/product development teams are to be mobilized.
* From the internal value chain: purchasing, production, logistics, ...
* From the external value chain: suppliers, recyclers, knowledge centres,...
Reason: all expertise outside the design teams is to be used!
Remark: apart from knowledge and know-how, mobilization actions also contribute to more 'buy in' into the environmental ambitions.

Production aspects.

13) Apart from through EcoDesign, **eco improvements can also be achieved** through technology and through 'system management' actions like green supply chain management and take back and treatment. Therefore, 'eco reviews' of production technology and of product system management are relevant when new designs are introduced.
Reason: Experience has shown that for many products such actions bring quite a lot of improvement.
Remark: In such processes, 'eco' has the role of overcoming conservatism as well: decisions and practices which were good several years ago are not necessarily the best today. 'Eco' is a neutral (and non humiliating) compass in addressing in these issues in which company policy and personal pride play a role as well.

Communication about results.

14) Communication on Eco Designed products is to focus on the benefits (see 9) which are relevant for the audience for which the messages are targeted. **Only exceptionally**, **environmental performance is ranking as one of the top items** to be communicated about. Environmental messages should be aligned with the communication strategy and with the performance of the past (consistency).
Reason: All environmental messages are to be put into the right context. One sided green messages are seen by many audiences as 'freaky'.
Remark: apart from knowledge and know how, mobilization actions also contribute to more 'buy-in' into environmental ambitions.

The fourteen recommendations for a kick start in Applied EcoDesign have been used by many developments groups and/or individuals at PCE, inside Philips and at several universities around the world. In most cases it worked out surprisingly well, also due to the commitment and the zeal of the users.

10. Comparing EcoDesign as it happened at PCE with academic views how to do it.

EcoDesign includes a large variety of approaches, methods and tools to support it. Inside this landscape there are two orientations: an industry oriented one and an academic oriented one. The PCE way of operating EcoDesign can be seen as one which is strongly 'industry oriented'; the PRO*M*ISE approach (see section 4) and its successors as a good example of an academic one. In an analysis eight characteristics were identified which allowed to position a certain EcoDesign approach or methodology in the vast array of possibilities. This is relevant because each organization dealing with EcoDesign wants to have its optimum mix of elements from 'scientific green', 'government green' and 'customer green'.

These eight issues pertain to the following items:

1. Has 'Eco' priority or is it to be included on par with other aspects?
2. Is the environmental load to be minimized or to be optimized?
3. Separate EcoDesign projects or inclusion of EcoDesign in product development projects?
4. Who is calling the shots? The (Eco)designer or the Product Manager?
5. Analysis and communication in absolute or relative (better than…) language?
6. Making of environmental profiles (Life Cycle Analysis) or measuring physical quantities to characterize environmental attributes?
7. Action because of threat (climate change, legislation) or because of opportunity?
8. EcoDesign to be introduced by consultants or started by 'one of us'?

In order to further clarify these issues, the description below shows the extreme positions in the EcoDesign landscape. These are labeled academic EcoDesign and PCE style of EcoDesign respectively. It is to be noted that this is a very crude characterization, but it is hoped that this will assist in making appropriate positioning of individual EcoDesign operation profiles.

ad 1. Priority for 'Eco' or on par?

Ecodesign in Academia is to an overwhelming extent 'Environmentally oriented' ('milieugericht' in Dutch) product design. This means that environment has a clear priority and other aspects (functionality and cost for instance) have to accommodate to that. Design manuals like PRO*M*ISE (versions 1994 and 1997, developed by Dutch universities and research institutions) and D4S guide (more international, supported by UNEP) clearly reflect this approach.

EcoDesign at PCE is largely 'Product Design taking environmental aspects into account' ('milieukundig' in Dutch). In this approach 'eco' is put on par with other aspects This type of EcoDesign activity (as for instance practised by PCE is often indicated as to be 'Applied EcoDesign' to show in semantics the difference with 'Academic EcoDesign'.

ad 2. Minimization or optimization of environmental load?

Academic EcoDesign has as a clear aim to lower the environmental impact of the functionality to be designed over the whole life cycle. This impact is supposed to be described in scientific terms. For evaluation of design activities 'scientific green' is therefore the yardstick.

PCE Ecodesign aims to optimize environmental aspects in the functionalities to be designed. 'Optimize' means in practice a balancing act between 'scientific green', green as perceived by customers (which has often a strong emotional component) and 'government green' (this has a strong socio-economic component). Depending on what emphasis is being put on each of the three dimensions of green a variety of forms of Applied Ecodesign exist in practice

ad 3. Separate projects or integration into existing procedures?

In Academic Ecodesign the starting point is mostly 'organizing a (separate) project in which a 'clear Eco product' is being developed. The organization which has to market and sell this product has to 'follow'; other business aspects are subordinate or at best on par with 'green'.

In PCE Ecodesign first 'environmental activities' have to take place to earn credibility and acceptance in product creation processes. If this has been achieved, Applied Ecodesign can get (at best) a position on par with mechanical, electrical,

software, … aspects. Its position stays shaky because environmental load is not a parameter which can be changed independently; each green action will have impacts on other aspects. In practice 'violations of department territory' are a source of a lot of controversy.

ad 4. Who is calling the shots?

In projects aiming at Academic EcoDesign, a strong if not dominating role is attributed to the Designer. Making 'tools' available for this designer has been seen as one of the major tasks in developing academic EcoDesign further.
In a product development process - including the ones which have incorporated Applied EcoDesign - the chief person in the process is the Product Manager. He has the authority (and is for instance the principal of the development groups) to make sure that the product line up offered to market fits with the targeted customer groups (which can be 'green', but also can be 'neutral towards green', perceive green as 'freaky' or even be hostile (fear of a higher price). This can be incovenient as regards reducing environmental load, but is the reality of the market.

ad 5. Absolute or relative language?

In Academic Ecodesign 'absolute language' is being used. Impacts or impact profiles are not compared with references. PCE EcoDesign uses 'relative language' for instance: how much are the environmental attributes better than the ones of the previous product or (even more powerful) how much better in environmental respect than comparable products of the competition.

ad 6. LCA or physical parameters?

For Academic EcoDesign, a full Life Cycle Analysis based on the ISO standards of the 14040 series is the ultimate approach to plan and execute EcoDesign actions.
PCE EcoDesign takes mostly the view that LCA is perfect for validation of design from a holistic scientific perspective. It does not take into account however specific resource aspects like scarcity (one of the important issues of todays 'government green') and of potential toxics (an important source of emotion of customers).
Moreover, although LCA approaches can indicate chief area's to be addressed, these have difficulties to assist in making prioritized action agenda's (balanced with physical and economic design issues).

Therefore, at PCE an environmental benchmarking approach has been proposed and applied. This method can be seen at best as making a kind of life cycle inventory on basis of physical parameters .

ad 7. Threat or opportunity?

Academic EcoDesign has been often presented to industry in a context of 'threat'. External drivers as pending legislation, opinions of customers, actions by NGO or even potential disasters happening to the globe have been cited as reasons to take EcoDesign on board. However, it is not realized that senior managers are often in their business exposed to many 'day to day' threats and everything on longer term is less pressing. Moreover it is thought that when environmental threats really realize these will hit the whole industry. In such a case the industry federations rather than individual companies have to take action. When action by individual industry is really needed, this will lead to a do-just the-minimum approach rather than to exploit the opportunities which EcoDesign is offering.

In PCE EcoDesign this opportunity character has been stressed from the very beginning, simply because of the credibility which has to be acquired to be really taken on board by the organization. These opportunities are not just to be in wording these have to be demonstrated in practice: seeing is believing. If it can be demonstrated that the benefits even go beyond the environmental domain as such (cost reduction, ease of operation) prejudice against 'Eco' (which exists in industrial organizations, even today) will disappear even faster.

ad 8. Experts or one-of-us?

Introducing Ecodesign in organizations is in fact a cultural, often slow process. People doing this should preferable be considered as 'one of us'. Most likely for such 'internal recruits' the scientific knowledge about the field will be less, but this will be more than compensated by their know how about handling the organization, in particular bringing a cross functional item like EcoDesign safely across the borders of departments (academia tends to see companies as monolithic blocks. This is not true at all, like at universities there is tremendous infighting).

External experts claiming immediately that EcoDesign should be the co-pilot in product development will fail for these reasons. In spite of all their skills and personally I have seen several of them go down the drain (or being 'disassembled') because they could not recognize how internal value chains in companies work.

These eight characteristics as set forth above suggest a world of difference and unfortunately- in spite of some exaggeration- it is too a large extent for real. It is to be realized that such differences have given rise to a lot of misunderstandings. At least for PCE it meant it had to a large extent find its own way. Currently it is better realized that EcoDesign has many forms of implementation and the choices which have to be made are better understood.

Before choosing any form of EcoDesign the key question to be asked is – at least in the opinion of the author- what beneficial role can green play in business? The answer to this question is definitely not a 'one size fits all'. It will depend on a variety of factors:
- Internal ones (management interest, skills available, cross functional linkage, eco learning so far and personal motivation (eco champions)
- Preparedness to review decisions made in the past (technology, investment, suppliers, ...)
- Business conditions (profitability, market share)
- External influences (legislation, customer pressure)
- Room to manoeuvre (product functionality, product alternatives)
- Competitive edge (what can 'eco' contribute, what is competition doing)

Such an analysis will allow to make an 'EcoDesign potential profile' and enables to set a tailor made background (or even a strategy) which would assist in operating EcoDesign in a way which is optimally adapted to the organization.

11. Relating EcoDesign at PCE to different management perspectives.

11.1. EcoDesign and Quality Management, quite some similarities.

Quality management had been introduced in a systematic way at PCE in the seventies of last century. Several environmental managers have been witnesses of that process in the early phases of their careers and thus were a good source

of information. The experiences they told were confirmed by a short search on the internet.

The introduction of Quality Management *in western companies (in the seventies of last century)* shows striking similarities with the start of EcoDesign some twenty years later. Partly this is due to the nature of the activities. Both were considered in the first instance not to be mainstream, both had to be introduced and kept alive by a special support group and both needed to be in the end integrated into the operations.

Initially, Quality Management encountered similar issues with the culture of the organization. Like for EcoDesign, credibility had to be built first, doubts and fears due to superseding issues had to be remediated or patched up and champions for quality had to be found in the BG's.

However, there were very different issues too. Particularly these concern what goals are to be achieved. For Quality Management these could be easily set and subsequently measured easily as well. For EcoDesign this was cumbersome because it was unclear what the concept could deliver, particularly for the organization itself. Moreover doing EcoDesign appropriately for a complete product range calls for a lot of differentiation: universal EcoDesign rules do exist in theory but not in practice. This is the very reason that it is advocated in this paper to make upfront an EcoDesign potential profile.

The culture in the PCE organization necessitated that, both for Quality Management and for EcoDesign, managing of the internal value chain was priority number one from the very start. The human factor was equally important as well, although 'recognition and celebration' which was thought to be very important in Quality Management never played a role in EcoDesign. Instead training and most of all empowerment (you can do it, you do not need to be a specialist to contribute) were common key ingredients.

In the end, both Quality management and EcoDesign equally turned out to be change agents with a significance for the organization which went far beyond the scope of the activity itself.

Customer requirements played a big role in Quality Management. As regards quality, the primary customers of PCE were the trade channels; these are the ones which are directly confronted with the complaints and returns of the end users; ramifications of bad quality are direct, also in monetary terms. Environmental concerns and perceived bad environmental performance are less tangible and play much more a role in the emotions of end users. These are rather

linked to brand image and brand loyalty rather than to damage which is directly visible. Ability to demonstrate compliance with legislation is a minimum condition for EcoDesign (there is no requirement for minimum quality). This is an important goal to be achieved, but since PCE was ahead of competitors this has never been a real issue. Since 'Eco' is linked with emotions so strongly, avoiding scandals is a priority number one. This is however rather a result of good green supply chain management than of good EcoDesign.

Both for the implementation of Quality Management and of EcoDesign, facts were a strong driver; numbers assisted in making well prioritized action agenda's. For Quality Management the priority item was quite obvious, for EcoDesign not at all. Academic EcoDesign simply wants all environmental issues to be addressed. For the electronic industry it is primarily balancing act between scientific green, government green and consumer green. More general benefits and feasibility play a role as well . In order to make proper assessments of this complexity, PCE developed the EcoDesign Matrix (see I, 7.4)

The integration of Quality Management and of EcoDesign into all business processes was in both cases natural for PCE; in the end delivering quality and caring for the environment is nothing special for a product, a person or a department. Mobilizing enablers and involving suppliers is than a natural subsequent step. Both quality and good environmental performance are closely linked to the level of skills and of the technology in producing materials, components and subassemblies. Since a lot of these activities are done by suppliers and subcontractors, the outreach to these in quality and environmental matters is very relevant.

In the fields of functionality thinking (upfront creativity) and communication/green marketing (downstream creativity), eco activities brought clearly new elements to the fray. For Quality Management ('design for quality') this is clearly less the case.

It is concluded that starting EcoDesign activities in an organization could have learned a lot from experiences when introducing Quality Management.

11.2. EcoDesign and Management style, keep the human factor into account.

Literature about Environmental Management and particularly the style in which it has to be introduced has either a background in academia or has been

published by international organizations like the Organization for Economic co-operation and Development (OECD). Reports (see internet) rather address how it should be done than about how it has been done in practice. There are few reports supporting the idea that Environmental Management and/or EcoDesign is a cultural growth process and therefore can be introduced in different styles.

Mostly the approach advocated is a strong top-down one and that is clearly at odds with what happened at PCE. Customer driven or legislation driven (often in reverse order) 'Eco' are said to have the highest priority, ignoring the fact that customers often have diffuse or emotional idea's and that legislation is only setting certain minimum requirements. In this way the potential of EcoDesign will not be exploited to the full. The opportunity dimension, which turned out to be so important for PCE both for credibility and acceptance is addressed only marginally and mostly restricted to hints at cost reduction only.

The dimensions of 'culture' and of management of the internal value chain are almost absent. Also the human factor as a critical condition for successful implementation is underestimated.

As regards the implementation of EcoDesign, management follows closely the academic line of thinking as described in section 10. Elements like mobilizing new technology to make greener products and considering functionality to enhance value creation of products are missing almost completely.

All of this is – at least in the opinion of the author- a very reductionist interpretation of five basic strengths of EcoDesign (see section 8). It will help to comply but it will be of little help to practitioners who want to make EcoDesign really to move forward inside the business.

11.3. EcoDesign and the introduction of new technologies, more similarity than anticipated.

The experiences when new technologies are introduced into an industrial organization can also juxtaposed to the PCE experiences with the introduction of EcoDesign. To some extent this is an unfair comparison because EcoDesign is not a (design) technology as such, but when doing so in a pragmatic way and not looking to the financial/investment items, striking similarities were discovered.

An important observation was that models describing effects of introducing new technology (see internet) emphasize the importance of the human factor in general and more specifically the relevance of the internal value chain. 'Beliefs' (in this publication called 'perceptions of green') are said to be very relevant for acceptation. Demonstrability of results obtained through the new technology are to a large extent the equivalent of the learning by doing for EcoDesign.

The aspect 'how this new technology will affect my job' (sometimes seen as an opportunity, mostly however as a threat) is very relevant for new technology introduction. On the contrary, EcoDesign at PCE has never been seen or perceived by employees as a threat to employment. In the beginning it was thought that EcoDesign would lead to a few temporarily jobs only, later it was realized that these were there to stay The requirement that environmental managers should be one-of-us gave indirectly the opportunity to continue employment of some 'old hands' who had become redundant elsewhere in the organization. The integration of EcoDesign tasks in the organization has been seen by many as extra work but in later stages it became an enrichment at least for most of employees. Still, the presence of a small group of specialists is necessary to keep 'green' going at the Business Groups. This can be in the form of initiator of new activities, as supporter of existing ones and as auditor of results obtained.

The models for introducing new technology also point to the opportunity to exploit this in image building; becoming more high tech, becoming more sophisticated, creating better value adds to image. There is in fact a striking resemblance with the opportunity which EcoDesign is offering: to become a caring company, really engaged in reducing environmental load.

Interesting is the indication in literature that introducing new technologies in an organization can have ramifications for the organization which go far beyond the area of the technology itself. For EcoDesign this outreach is even so important that in the opinion of the author this should be the chief reason to take EcoDesign on board, even if the organization has little natural inclination for environmental care and weak outside drivers to do so.

Altogether the relation between introduction of new technology and of EcoDesign is an interesting one which deserves more study. The introduction of EcoDesign in PCE would certainly have benefitted from the concepts for new technology which were in place already!

12. Conclusions.

The PCE story about introducing EcoDesign tells first of all that the five basic principles of it (prevention, life cycle thinking, do more with less, functionality thinking and paradigm shift) represent an enormous change agents with significance for almost all business aspects. The positive ramifications of introducing EcoDesign go therefore far beyond just reducing environmental load.

The PCE experience shows therefore that EcoDesign is an opportunity to be exploited by all industrial organizations even if there is no outside pressure or other outside driver to do it .

Irrespective of the motives why EcoDesign is introduced, it has to be realized that EcoDesign has to earn credibility in an organization in order to get a status which is on par with other business aspects. In order to achieve this, the benefits of EcoDesign (lower environmental load, but also cost reduction, smoother operations, better relations between departments and with suppliers and last but not least better image in general) have to be demonstrated, particularly in the internal value chains of a company. This is very necessary because mostly a majority of employees and executives have doubts and even fear of engaging themselves with EcoDesign. Moreover superseding issues like budget, quality of sound and vision, health and safety and ease of use are thought to be counteracted by good EcoDesign.

Getting the credibility is a cultural process which by nature is slow. The PCE case demonstrates that this can be done best through self learning and can be best supported by environmental managers originating from the own organization. External support can be helpful but it is a must that it fits into the culture of the organization.

Introduction of EcoDesign has been shown to be a growth process; well chosen activities needed to be expanded to include all business groups and departments and more and more sophistication has to be developed as well. In order to achieve this active support of the senior management is needed. This support

includes a positive, preparedness to set the direction and regular checks of progress.

In order to speed up the processes described above it has been suggested to make up front an EcoDesign Potential Profile (EPP). This EPP describes where the best opportunities for EcoDesign are to be found given the product line up and the business situation of an organization, its culture and its skills. It also describes what needs to be done in view of activities of the competition and developments in legislation and regulation. As such it is primarily a managerial document rather than one based on scientific proof. However, hard numbers will be useful to support decisions for the directions into which to go.

Special situations to be identified in such an analysis are the ones in which - everything else being equal- 'green' can act as a tie breaker. In more mature markets this is highly relevant; for most customers 'green' is not the primary reason to buy. If it makes a difference (and if it is for free) it can tilt (digital) buying decisions.

'Green' has apart from a rational component also a strong emotional dimension. This is adding a new component to functionality thinking, at least for traditional tech oriented companies like PCE. Through 'green' a real window has been opened on 'emotional functionality' and this has become a new element in value creation.

For PCE, introducing EcoDesign has been a long journey; it took more than 10 years to get a real mature status. Partly this has been due to the fact that PCE was a trailblazer, partly this was due that the EcoDesign concepts and tools developed in academia were of limited help so self reliance had to happen out of necessity. On the other hand it could have learned a lot from the solutions found when of quality management was introduced in the organization twenty years before and from experiences on introduction of new technologies in more general.

The groundbreaking work of PCE has still value today. It will help to shorten the introduction of EcoDesign in other organizations, it will assist in avoiding pitfalls and hopefully it will assist in engaging people in this wonderful field.

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*.