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# The Journal of Sustainable Product Design





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## Editorial Board

# Welcome to the second issue of The Journal of Sustainable Product Design

**Martin Charter and Anne Chick**

Editors, The Journal of Sustainable Product Design

The recent Rio + 5 Conference in New York, highlighted the growing need to develop more sustainable patterns of consumption and production. The role of products and services is central to this debate. It will mean addressing key questions such as what is a sustainable product?, how does one develop and design sustainable products? and how does sustainable product design differ from eco-design? Sustainable Product Development and Design (SPDD) means exploring a wider set of economic, environmental, ethical and social (e3s) relationships in the product development and design process – not only 'green' issues as emphasised in eco-design. It means thinking through complex issues such as meeting the basic needs of the world's poor and reducing global inequalities. A key challenge is how to infuse sustainability issues at the front of the new product development process, where ideas and concepts are generated and the issues are often poorly understood.

Underlying both new and existing product development and design is the need to minimise sustainability impacts throughout the life cycle. This means incorporating SPDD principles into new product development, now! But in parallel, it means developing structures and systems to extend the life of the millions of products that come to the end of their first useful life, every day. An economic infrastructure needs to be created to collect and keep existing 'value' in 'the economic cycle' through upgrading, dismantling, remanufacturing, reconditioning, recycling and other strategies. Therefore it means managing both 'front of pipe' and 'end of pipe', and not either/or.

However, there is still inertia in the system. If your kettle stops functioning there is generally no clear collection mechanism to intervene between 'the product' going to landfill ie. a radio may have cost you $20 to buy, but $60 to repair and you may have to travel 20km to locate the repairer. That is why 'end of life' electronic products pile-up in office cupboards and in the home – based on the thought process 'it doesn't work, I can't repair it, but I still perceive it has "value", therefore I will not throw it away!'

This phenomenon is important from both an economic and psychological viewpoint. There is a need to keep the 'value' of physical goods in 'the economic cycle' if we are to move to 'Factor X'[1] levels of resource and energy reduction ie. why generate new energy or extract new virgin materials if we can retain and extend existing products. Antiques are a good example of the link between 'economic values' and 'psychological values'. Where there is a perceived 'value' of an artifact, it generates an 'economic value' related to the basic economics of supply and demand ie. as more people want a scarce artifact, the price goes up! Within the sustainability context, there is a need to generate a concept of the 'real value' of products amongst consumers.

'Factor X' levels of reduction in the consumption of materials and energy will not come about through incremental change, but will require radical new solutions. In addition, moving beyond eco-innovation to 'e3s' innovation will require new products and processes that provide customers with more 'real value' but with significantly reduced sustainability impacts. This will necessitate a new corporate framework to manage product/service innovation. The more radical the change required the more strategic the decision will need to be, and the closer to the 'front of pipe'. However, at

present, most eco-driven changes are at the operational level ie. incremental changes of existing products. Within the sustainability context, innovation cannot just create new 'substitute' markets unless they create more 'real value' and produce less impact. This will mean strategic changes in product development and design, coupled with changes in consumer perception and behaviour. For example, car sharing implies that the 'product' will be 'owned' by consumers paying per unit of 'service' ie. mileage and time. This will mean a shift in consumer behaviour from 'individual consumption' (outright purchase of cars) to 'organised consumption' (rental of cars). Such a shift will produce less traffic congestion, reduced emissions, and therefore less air pollution, but will mean fewer cars will be needed. A more intensified use of fewer products eg. cars, will produce significant implications for product design, technology, costing and 'end of life' management.

To enable shifts from products to services, there will need to be more systemic planning and management, an ethos of continuous improvement and ongoing societal programmes of stakeholder education.

The second issue of the Journal of Sustainable Product Design focuses on the eco-design activities of various research centres from around the world. These include the Australian National Centre of Design's EcoReDesign Program housed within the Royal Melbourne Institute of Technology; the Design for Environment Research Group at Manchester Metropolitan University, UK; the Gordon Institute, Tufts University, US and the Environment Product Development Section, Delft University of Technology (DUT), the Netherlands.

Carolien van Hemel, Researcher, DUT, describes the results and lessons learnt from their IC EcoDesign Project, which was conducted in collaboration with the Network Innovation Centres (IC). The aim of this project is to enhance awareness of eco-design amongst 900 small and medium size enterprises (SMEs) in the Netherlands. Patty Dillon, Research Associate at the Gordon Institute presents case studies from Hewlett-Packard Company, Nortel and Compaq Computer who demonstrate how electronics manufacturers are embracing product stewardship, 'Design for Environment' (DfE) principles and life cycle management programmes. The Kambrook Axis electrical kettle case study by Andrew Sweatman and John Gertsakis also demonstrates such product processes in action. Both authors worked on the EcoReDesign Program which undertook the re-design of the original kettle using 'a balance of design innovation, environmental understanding and common sense engineering principles'. The resulting environmental benefits of this approach is a kettle that uses up to 25% less electricity and significantly fewer materials and components.

This issue's interview is with Dr Braden Allenby, Vice President, Environment, Health and Safety, AT&T. Dr Allenby discusses issues such as sustainable consumption, sustainable product design and industrial ecology. Peter James, Director of the Sustainable Business Centre, UK, continues the Sustainable Product Design theme by proposing a new tool called the 'Sustainability Circle', which analyses both environmental and social dimensions of products and services.

The Journal of Sustainable Product Design has developed a partnership with the 'O2 Global Network', an international network of ecological designers. O2 will regularly update readers on eco-design and SPD activities worldwide and focus on O2 activities in one particular country each issue. They commence their 'O2 News' pages with the Netherlands.

As in the first issue of The Journal of Sustainable Product Design we continue to search for case studies and articles which explore eco-design research and new thinking and ideas in the areas of sustainable consumption and SPD. The aim now is to build the Journal's international profile as a platform for debate and analysis in this area. •

[1] *'Factor X': At present there is considerable discussion over the level of resource and energy reduction required to progress towards sustainability ie. factor 4, 10 and 20. 'Factor X' is a generic term that highlights that a significant reduction is required, but at present the level and changes required are unclear.*

# The IC EcoDesign project: results and lessons from a Dutch initiative to implement eco-design in small and medium-sized companies

**Carolien G van Hemel**

Researcher, Delft University of Technology, Faculty of Industrial Design Engineering, Environmental Product Development Section, the Netherlands, with Rene Hartman & Harriet Bottcher of the Network of Innovation Centres, the Netherlands

Carolien G van Hemel *(top)* is a PhD researcher at the Environmental Product Development Section, Faculty of Industrial Design Engineering, Delft University of Technology, in the Netherlands. She has been involved in the Innovation Centre EcoDesign project since it started in 1994, as methodological advisor, trainer and researcher. The IC EcoDesign project is the focus for her PhD research, with her thesis disclosing further results and interpretations on the project. The thesis will be available in English at the end of 1997.

Rene Hartman *(above left)* and Harriet Bottcher *(above right)* work for the Network of ICs in the Netherlands. Rene Hartman, an industrial design engineer, graduated at the TU Delft and is employed at the IC Amsterdam-Haarlem. Harriet Bottcher is a sociologist who graduated at the RU Leiden and owns a private consulting company. Together they initiated and coodinate the IC EcoDesign project. In addition they are co-authors of 'EcoDesign: benefit for the environment and profit for the company', which offers supplementary project information and six case descriptions.

**In 1995 the Network of Innovation Centres (ICs) in the Netherlands established the IC EcoDesign project, with the aim of enhancing the awareness of eco-design amongst 900 small and medium-sized manufacturing enterprises (SMEs). Firstly, this article describes the background, organisation and auditing methods used throughout the project. Secondly, it introduces the monitoring mechanism used and reveals the initial results of the research. Finally, it explores the stimuli and barriers to eco-design at a strategic level.**

## Introduction

*'How do we implement environmental product development or eco-design amongst SMEs?'*

In 1994 the Dutch government focused on this key question following the results from eco-design demonstration projects completed in eight medium to large-sized companies between 1991–1993 (Riele and Zweers, 1994).

The government decided to initiate a new eco-design project focused on the needs of SMEs, with financing through the Dutch Ministry of the Environment and the Ministry of Economic Affairs. The target group for this project was 4,500 SMEs and the project timetable was set from 1995–98.

The organisation that was selected to implement the project was the network of non-profit Innovation Centres. One of the reasons why the ICs were chosen was that they were familiar with many of the product-related issues faced by SMEs; one-third of the questions received by the ICs annually relate to new product development issues. Apart from this, the ICs had already built up environmental competence due to their involvement in an earlier 'Cleaner Production' project, in which 600 companies were audited in order to improve the environmental aspects of their production processes.

Between 1989–1990 a network of 18 ICs was established in the Netherlands, funded by the Ministry of Economic Affairs (Coehoorn, 1995). Every regional IC has a director and, depending

A key mechanism to motivate action is to instil the philosophy of 'learning by doing'.

on the region, 4 to 10 consultants. The aim of the ICs is to enhance access to newly-developed technological knowledge for SMEs, enabling them to innovate faster (the ICs are similar to Regional Technology Advisory Centres that exist in other European countries). The network includes 140 consultants who advise 20,000 SMEs annually.

## The aim of the IC EcoDesign project

The uncertainty surrounding the benefits and improvements resulting from undertaking eco-design has proven to be a major obstacle to development, especially amongst SMEs (Hemel and Keldmann, 1996). Most companies ask questions that are difficult to answer:

- is eco-design relevant to our business?
- how can eco-design be applied to our products?
- what will be the effects of product changes on the environment, on our organisation, on our market position, in financial terms, and on the motivation of our employees?
- in what direction will international legislation and consumer demand develop?
- how can we set clear targets for eco-design and achieve them if we don't know the consequences?

The aim of the IC EcoDesign project is to make SMEs conscious of the opportunities arising from eco-design, and guide them through the process of integrating environmental considerations into their product development processes. A key mechanism to motivate action is to instil the philosophy of 'learning by doing'. To achieve this, companies are given advice on environmental innovation for one of their products and in this way taught to appreciate the value of eco-design. When the companies integrate eco-design into their regular product development process, a major goal of the IC EcoDesign project has been achieved.

The aim of this approach is to develop competence and competition in eco-design, which others can follow. In larger companies, already working on eco-design, competitiveness seems to be a major driver. For example, in consumer tests, if a competitor performs better on 'green' aspects, this often adds a strong impetus to eco-design within the firm.

## The target group

The target group for the IC EcoDesign project was estimated to be 4,500 companies, with the most important criteria for selection being that:

- companies did not have more than 200 employees
- companies were responsible for the specification of the product
- products were developed in the Netherlands
- products were tangible products.

The aim was for 20% of the 4,500 SMEs (900 SMEs) to participate in the project, on the assumption that the effects of the project would cascade to another 60% of the total target group.

For 1995 the target was set at 100 SMEs and at the end of 1995, 95 were participating.

## The auditing method: the environmental innovation scan

The IC EcoDesign project was a successor to previous demonstration projects which had been completed in medium and large-sized companies. A new method had to be developed to focus on the needs of SMEs and the existing working practices of the IC consultants.

SMEs generally have limited time and money to perform activities that are additional to their day-to-day work. Due to this, the environmental action taken by SMEs had tended to focus on good housekeeping and cleaner production, with little experience of eco-design. Therefore, an auditing method had to be developed, taking into account the low awareness of eco-design and lack of time and money. Important characteristics of the IC EcoDesign approach are a three-phase approach and the short intervention period. Preceding the first phase, considerable effort was invested in raising the firm's interest in eco-design and in convincing them of the need for participation. To support this, a range of material was produced, including comprehensive project documentation, introductory interviews with entrepreneurs and public eco-design meetings.

**Phase 1**

The goal of the first phase was to create an awareness of eco-design, by helping the company to understand the environmental impact of its business and its products, and the possibility of turning environmental threats into opportunities. This was achieved through an auditing method derived from the Dutch PROMISE Manual for Ecodesign [(Brezet, 1997), (Hemel and Brezet, 1997)]. The audits are relatively short and concentrate on the strategic elements of eco-design decision-making. This procedure assists the IC consultant and the company representative in answering the following three key questions:

- what *must* the company do? (mapping the external factors leading to eco-design, like legislation, increasing waste costs, increasing consumer demands, new technologies etc.)
- what does the company *want* to do? (mapping the internal motivation for eco-design, like improving product quality, corporate image, cost reduction)
- what *can* the company do? (mapping the environmental profile of the selected product, following all stages of the product's life cycle).

The result of this first phase is a plan containing many options and actions to improve the environmental aspects of the chosen product.

**Phase 2**

The second phase starts after the company had been audited. At this stage, the company could apply for money for a feasibility study concerning specific aspects of eco-design, partly financed by the government. The aim of this phase is to investigate the technical, financial and environmental feasibility of one or more options suggested in the action plan. The feasibility study was generally undertaken by a consultancy or in some instances by the company itself, sometimes assisted by a graduate student.

**Phase 3**

The third phase is the implementation of the improvement options. The company has to pay for this, but is assisted by an IC consultant. In April 1996 the Dutch Ministry of Economic Affairs introduced a credit system, which enabled high-risk investments in eco-design to be partly financed.

## The IC consultants and the 'eco-design helpdesk'

A significant element of any consultation is the quality of the expertise that was offered. The IC consultants already had experience of advising SMEs about product and new business development. To create a strong support infrastructure, 23 IC consultants received training in the completion of eco-design audits.

The consultants started auditing the first group of companies in February 1995. Since then, all consultants and project assistants have come together every three months to exchange knowledge and experiences and to receive extra training in eco-design topics.

The IC consultants are assisted by a 'eco-design helpdesk'.

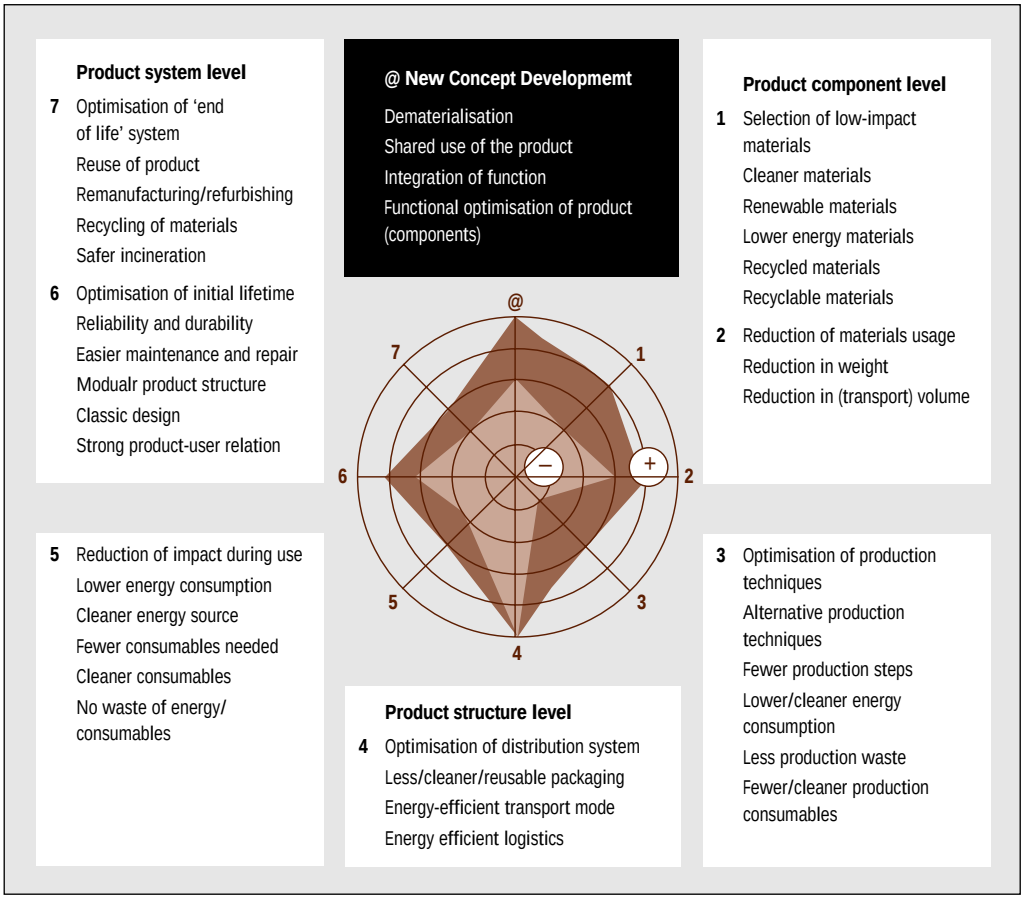



Figure 1: The EcoDesign Strategy Wheel©
*(Hemel and Brezet, 1997)*

Frequently the consultants are confronted with questions about environmental issues to which they have no clear answers. In these cases they can request support from the 'eco-design helpdesk', which is manned by an employee from Delft University of Technology (with answers reaching the consultants within three days). The most frequently asked topics include:

- product-oriented environmental legislation
- environmental aspects of materials
- environmental aspects of production processes.

## The EcoDesign Strategy Wheel

In the report completed for the company, the options for improvement are structured according to the classification of eight eco-design strategies, as illustrated in Figure 1. The model used in the IC EcoDesign project is based on this figure and is called the 'EcoDesign Strategy Wheel'. It gives a typology of the possible actions that can be taken to improve the environmental impacts of product(s). There is a strong parallel to the product life cycle starting with 'selection of low-impact materials' and ending with

'optimisation of the "end of life" system'.

As indicated in Figure 1, some strategies will influence the product mostly at component level, some at product structure level and others at product system level. For example, substituting a material with a more environmentally benign alternative may only have consequences for the design of a specific part of the product (product component level). Furthermore, if a clean energy source like solar energy is used, it will probably lead to changes not only in the design of the product parts, but in the architecture of the product as well (product structure level). If we want to extend the product's initial lifetime some more radical changes may be required that go beyond the product component or structure level. They may include changes in the product's repair and maintenance system (product system level). The 'New Concept Development' strategy is characterised by the symbol '@', in order to emphasise its special character, the '@' symbol refers to the innovative and eco-efficient email system (which saves paper and money). This strategy provokes companies to reconsider their actual product concepts. It leads to questions such as 'does our product perform optimally in functional and environmental terms?' and 'can we create market opportunities by developing a new product concept that fulfils this function in more innovative and eco-efficient ways'. The graph in the middle of the model is used to visualise the company's eco-design goals.

The EcoDesign Strategy Wheel that is used in the IC EcoDesign project is a simplification of this model. It has proven to be a valuable mechanism for showing a range of eco-design directions. The same typology is used to structure the IC EcoDesign database, in which consultants can look up advice that has been given in preceding eco-design consultations. The model as presented in Figure 1 is also used to classify the project results in the monitoring research.

## Monitoring the results of the IC EcoDesign project

In September 1995, after a preliminary evaluation of the first year's project results, it was decided to proceed with another 800 companies between 1996–98. The estimation was that 300 of those 800 would complete an eco-design project after an abridged scan. In the autumn of 1996 a mechanism was developed by Delft University of Technology, to monitor the environmental and commercial results of the IC EcoDesign project. This consisted of a questionnaire to be completed by the participating company and a methodology for interviewing company representatives, who were generally, the Director of the firm and in some cases the Head of R&D. This mechanism aimed to monitor various project results:

- direct environmental benefits
- indirect environmental benefits
- commercial benefits.

To test the monitoring mechanism, it was applied to a total of

The EcoDesign Strategy Wheel gives a typology of the possible actions that can be taken to improve the environmental impacts of products.

The solution chosen was to let the EcoDesign Strategy Wheel turn again and make an inventory of the extent to which all suggested eco-design improvement options had been achieved.

77 of the 95 companies that had participated in the IC EcoDesign project in 1995. 74 of them were willing to complete questionnaires; and 73 of the firms were interviewed by telephone.

In the process of developing the monitoring mechanism, it turned out to be difficult to effectively measure the results of the project. For example, there were two key questions:

- how do you define 'eco-design success'?
- how do you distinguish between those companies who have achieved 'poor' eco-design results and those who have achieved 'excellent' eco-design results?

This experience illustrated that it is hard to measure a firm's environmental attitudes, strategy or performance (Hass, 1996). One option was to undertake Life Cycle Assessments (LCAs) of all monitored products, but this would have proved to be an impossible task due to lack of time and information. In addition, an LCA does not reflect the indirect results of the project eg:

- increased knowledge
- development of eco-design routines (internalisation of the eco-design principles)
- increased cooperation with other organisations
- follow-up activities.

The solution chosen was to let the EcoDesign Strategy Wheel turn again and make an inventory of the extent to which all suggested eco-design improvement options had been achieved. The model of Figure 1 provided the framework for the inventory. In total 602 eco-design improvement options were recommended to the 73 interviewed companies. During telephone interviews, the company representative had to inform the interviewer about the extent to which the company had been able to implement its specific eco-design improvement options. They were also asked to indicate why a specific option had been of interest or not, in the context of external and internal stimuli and barriers for implementation.

If the option was close to being implemented, the interviewee had to indicate the environmental impacts of the improvement. For each option the interviewee had to indicate the additional value resulting from participating in the IC EcoDesign project. The companies were also asked to fill out a comprehensive questionnaire, mapping out the indirect project results.

A result of this method was an overview of the project outcomes for each of the studied companies. Since all eco-design improvement options had been classified according to the EcoDesign Strategy Wheel, the degree of implementation of the various eco-design strategies could be assessed. Next, the data offered insight into the stimuli and barriers to eco-design, at the detailed level of specific eco-design strategies and even the level of specific eco-design improvement options.

## Results of the IC EcoDesign project

Below are some results of the IC EcoDesign project research completed in 1995:

**Participating industries**

The best represented industries were metal products, machinery, wood and furniture, electronics, rubber and synthetics.

**Attitude towards eco-design**

75% of the companies did not have any eco-design experience before starting the IC EcoDesign project.

Most companies regarded eco-design as an opportunity rather than a threat. Eco-design was recognised by some for its marketing potential.

Some companies saw eco-design as a cost-neutral activity. However, the majority of the companies regarded eco-design as an initial investment, which would be paid back in the medium to long-term.

External parties that were perceived to be most concerned about eco-design were government, suppliers and trade associations. However, the parties which stimulated them to implement eco-design were government, industrial customers and the end-users of the product.

**Motivation towards eco-design**

The two most important motives for participation in the IC EcoDesign project were the wish to increase the quality of specific products, and the importance of anticipating future developments. A third motive was that eco-design was seen as an important aspect of product innovation. With a fourth motive being a feeling of personal responsibility felt towards 'the environment' by the company representative. The search for environmentally benign alternative materials or components, and supply chain pressures were also strong motivations.

**Direct project results**

A total of 602 eco-design improvement options were recommended to participating companies. 183 (30%) of these were (nearly) completed at the time of the research, which was 10–16 months after the advise had been originally given. Within 3 years from when the research took place a total of 247 options (41%) were predicted to be completed.

One-third of the options were new to the companies and were mainly concerned with low-impact materials, lower product weight and recycling.

The 77 companies provided the following results:

- eco-design had been applied to 1 product that was totally new to the company
- eco-design had been applied to 21 products that have been thoroughly re-designed
- eco-design has been applied to 13 products that were slightly improved. These products were being or will be launched in the near future.
- the packaging of another 4 products was environmentally improved
- in 7 companies the focus was on improving the environmental aspects of production processes

The majority of companies regarded eco-design as an initial investment, which would be paid back in the medium to long-term.

25% expected a profit to be generated through eco-design within two years, ranging from 10% to 50%

- in 9 companies the product had not yet been improved, but research was being undertaken
- in 11 companies the product has not been improved, but research had been concluded
- in 6 companies the product had not been improved, but research was planned
- in 5 companies the project had not produced any results.

**Focus on eco-design**

Some eco-design strategies proved to be more popular than others. These eco-design strategies were recycling, reduction of weight/components, low-impact materials and high product reliability. After these four types, the most popular options concerned cleaner production, more efficient packaging, low energy-use in the use phase and the application of recycled materials.

Eco-design strategies that had a greater chance of being implemented were cleaner production, the prevention of waste of energy/consumables in use phase, high product reliability, easy maintenance and repair and recycling.

**Indirect project results**

The greatest increase in eco-design knowledge concerned eco-design in general, environmental aspects of materials and the environmental burden of the product in its total life cycle.

Most companies said that they were now able to apply eco-design independently.

- 30% had already applied eco-design principles to other products.
- 60% said that they would apply eco-design in the future.
- 25% said that they had developed an eco-design checklist to be used during product development.
- 25% wanted to integrate product-related environmental information and requirements in their environmental management system.
- 25% aimed to integrate environmental demands in their quality system.

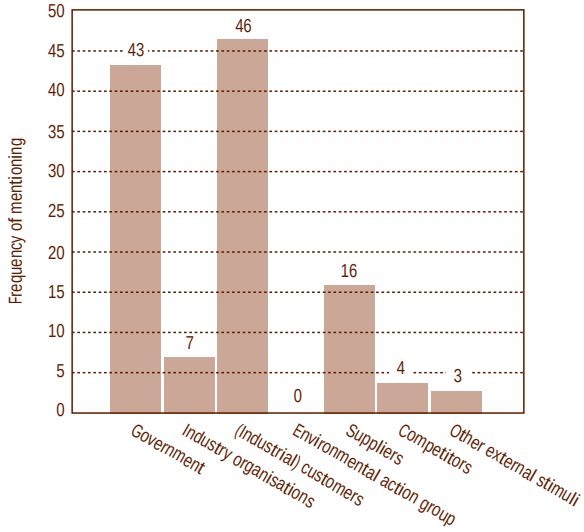
**Commercial results**

- 67% expected their 'eco-designed' products to increase their market shares.
- 56% expected to enter new markets with their environmentally improved product.
- 25% expected a profit to be generated through eco-design within two years, ranging from 10% to 50%; 27% expected a profit ranging from 1% to 5% (profit was defined as being based on costs savings as well as sales increases).

**Appreciation of the IC EcoDesign project**

- 64% said that the IC EcoDesign project has led to concrete results.
- 71% said that they would continue to use elements of the auditing method.
- 90% said that they would recommend the project to other companies.

Figure 2: The external stimuli for eco-design




The research highlighted that the government and the supply chain offered the most external pressure for eco-design.

**Stimuli and barriers for eco-design**

A secondary aim of the research was to determine the stimuli and barriers to eco-design strategies and options. Therefore all companies were prompted to tell the interviewer what they saw as external and internal stimuli, as well as the barriers to eco-design options. This part of the research resulted in an overview of the stimuli and barriers for the 602 eco-design improvement options, classified according to the 'EcoDesign Strategy Wheel'. Some preliminary conclusions are listed below.

## External stimuli for eco-design

Figure 2 shows how often the various types of external stimuli were mentioned.

- For 111 of the 602 improvement options a total of 119 external stimuli were mentioned. For 491 options (82%) no external stimuli were mentioned. The research highlighted that the government and the supply chain offered the most external pressure towards eco-design.
- 26% of the options for which no external stimuli were mentioned were completed. 50% of the options that have external stimuli are realised; of the options without external stimuli only 26% had been completed.
- Only in 3 of the 111 options with external stimuli were companies not interested.
- 26% of the options have been implemented but were not stimulated by an external stimulus.

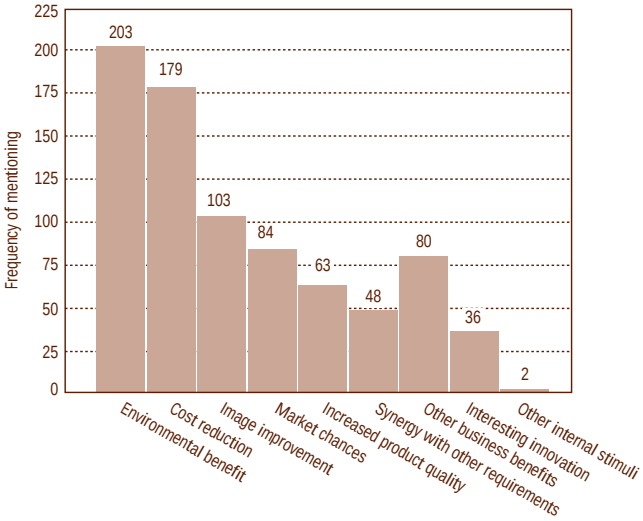



Figure 3: The internal stimuli for eco-design

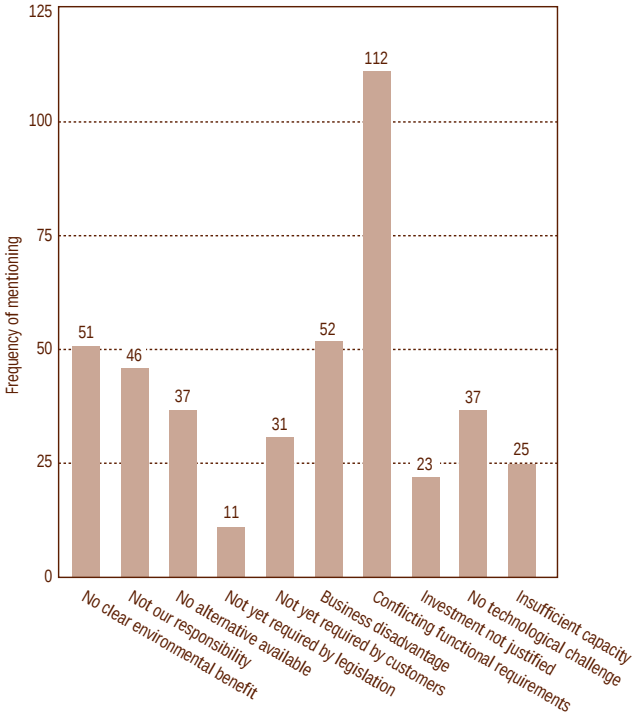



Figure 4: The barriers for eco-design

## Internal stimuli for eco-design

Figure 3 gives an overview of the 798 internal stimuli that were mentioned for 343 of the 602 eco-design options. The internal stimulus of the 'environmental benefit' was only noted when the company mentioned it spontaneously.

A greater proportion of internal stimuli (798 internal stimuli for 343 options) than external stimuli (119 external stimuli for 111 options) were mentioned. These indicated that internal stimuli played a bigger role in eco-design decision-making than the external stimuli. Further analysis has shown that half of the implemented options were completed regardless of external stimuli. Of all options with a lack of internal stimuli, only a very few have been implemented. Further research is likely to indicate which of the stimuli actually has had the strongest impact on eco-design decision-making in the SMEs.

Figure 3 shows that in many cases eco-design leads to a synergy with other business interests, like cost reduction, image improvement and new market opportunities.

For 343 of the 602 options a total number of 798 internal stimuli has been mentioned.

## Barriers to eco-design

Figure 4 shows that 425 barriers were mentioned for 329 of the 602 eco-design options.

The most frequently mentioned barrier to eco-design was

'conflicts with functional product requirements'. However, further analysis has shown that this does not prevent action. Many options have been completed, regardless of this barrier. This also applies to barriers such as:

- not yet required by legislation
- not yet required by (industrial) customers
- business disadvantage
- investment not justified
- insufficient capacity.

The real 'no go' barriers ie. obstacles that make eco-design impossible for companies, are:

- no clear environmental benefit
- not our responsibility
- no alternative available.

## The IC EcoDesign project in 1996–1998

The results of the IC EcoDesign project in 1995 justified the follow-up stage in 1996–98. In 1996, 151 companies participated in the project. The target for 1997 was set at 150; and the target for 1998 is 200 companies. Some preliminary results of the project in 1996 are described in the publication 'Eco design: benefits for the environment and profit for the company' (Bottcher and Hartman, 1997).

## Conclusions

The analysis of the IC EcoDesign project in 1995, indicates that the project appears to have enhanced the awareness of eco-design in almost all participating SMEs. The project appears to have acted as a catalyst for the application of eco(re)design principles in new or improved product designs in 45% of the 77 companies studied. The project indicates that most progress in eco-design was achieved when the company had a strong drive for (new) product development.

The implementation of eco-design improvement options was mostly driven by strong internal stimuli and/or external stimuli. Options that were environmentally beneficial – but lacked internal or external stimuli – did not obtain the interest of the participating companies. Therefore, if SMEs are to broaden their scope from specific eco-design improvement options that create direct commercial results to eco-design options that require investments, there are two clear rules:

*Rule 1:* Ensure strong and stable external stimuli, focused on specific eco-design strategies, especially for those options that require a major investment and create only long-term profits.

*Rule 2:* Try to motivate companies towards eco-design when there is strong internal motivation towards product innovation. A project like the IC EcoDesign project can create a synergy between eco-design innovativeness and the corporate drive for innovation, resulting in the creation of products that are highly innovative and that have a high (environmental) quality as well.

The IC EcoDesign project has been a stimulus for eco-design in Dutch industry, as well as for academic research. Eco-design is moving from its infancy in the

The project indicates that most progress in eco-design was achieved when the company had a strong drive for (new) product development.

Netherlands, and this is being supported by recent developments such as the recently published United Nations Environmental Programme (UNEP) manual 'Ecodesign: a promising approach to sustainable production and consumption' (Hemel and Brezet, 1997), the eco-design credit system and an ambitious new government programme 'Ecology, Economy and Technology' aimed at enhancing eco-efficient innovations. •

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# Improving the life cycle of electronic products: case studies from the US electronics industry

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**Product stewardship and 'Design for Environment' (DfE) programmes aim to improve the environmental aspects of a product throughout its life cycle. Leading companies in the US electronics industry, driven by emerging regulation and market opportunities, have embraced these principles with the tandem goals of enhancing products' environmental and economic performance. This article presents the case studies of three compamies – Hewlett-Packard, Nortel and Compaq Computer – to illustrate the practices and direction of US electronics manufacturers. The life cycle management programmes of these firms include supplier involvement management processes, design for upgradeability and recycling, improvements in energy efficiency, and asset recovery and recycling. These initiatives demonstrate progress in improving the environmental aspects of products; however, they are largely incremenetal when viewed within the context of sustainability.**

## Introduction

Electronics firms are subject to a proliferation of international environmental policies and standards that go beyond concerns about manufacturing process, wastes and releases. Pressures that impact on product design, marketability, and post-consumer disposal, most notably eco-label requirements and product 'take back' legislation. Their suppliers and customers are increasingly sensitive to environmental issues such as energy efficiency, material use (for example, recycled content, ozone depleting substances (ODCs)), and product recovery and recycling. Together these pressures are motivating electronics firms to re-examine their practices and product design to compete in a highly competitive market.

The following case studies highlight selected life cycle management or product stewardship activities of three US electronics companies — Compaq Computer, Hewlett-Packard and Northern Telecom (Nortel). The case histories illustrate the breadth of extended product responsibility programmes in this industry sector, including 'Design for Environment' (DfE), product 'take back', and new customer-supplier partnerships.

In many respects, these programmes are in their infancy, but represent the leading-edge of product life cycle management in US companies.

## Life cycle management

At the root of the life cycle approach is design — that is, design to minimise adverse health, safety and environmental impacts for the manufacture, use and disposal of products. A focus on product design is critical to achieving environmental improvement, given the rate of new product introductions in the industry. At Hewlett-Packard (HP) for example, more than half of 1995 orders were for products introduced in the previous two years (Annual Report, 1996).

Product stewardship efforts extend beyond product design in these companies. To influence the inputs to its products and processes, Compaq, HP and Nortel are developing supplier management processes, which adds environmental issues to supplier management alongside traditional concerns such as quality, delivery and cost. Energy consumption of products and processes are also a major target. At the end of product life, these companies engage in selected collection of products from customers for processing at recycling centres in the US and Europe.

## 'Design for Environment' at Compaq Computer

Worldwide competitive pressures have led Compaq to re-define the boundary of its product life cycle. In earlier years, Compaq considered its job done when the product left manufacturing and was sold in the marketplace. The introduction of a 3 year warranty extended Compaq ownership concerns through service and support. With the advent of 'take back' legislation in Europe, Compaq's view of the product life cycle has been stretched to the end of its product's life.

This paradigm shift created a new mandate for design. The ability to cost-effectively service and repair the product, as well as recycle the product at 'end of life', became an integral part of the competitiveness equation.

Product life cycle management at Compaq is market-driven. For this reason, Compaq is not developing complex Life Cycle Assessment (LCA) tools to identify environmental impact. Rather, customer needs, expectations and regulatory trends are translated into product, process or service features. The personal computer industry is also a high volume, low margin business. Therefore, Compaq pays particular attention to costs.

### Design guidelines at a glance

In 1994, Compaq completed comprehensive environmental design guidelines. The design guide promotes the adoption of a life cycle perspective in the design of products, and specifically addresses the following issues:

- material selection, focusing on recyclability
- design for disassembly
- packaging materials
- energy conservation
- design for reuse and upgradeability.

**Packaging**

- minimum 35% recycled content
- no heavy metals in packaging inks
- 100% Kraft paperboard, no bleach
- use of recyclable materials only

**Plastics**

- use only recyclable thermoplastics
- consolidate plastic types
- use ISO markings to identify resin type and exact blend
- no paint finishes
- labels: moulded in or use same resin type as housing

**Disassembly and recycling**

- use of standard screw heads
- design modular components
- minimize number of parts

**Energy conservation**

- comply with Energy Star standards

**Design for reuse**

- user upgradeability
- use of industry standard architecture.

Figure 1: Sample design guidelines from Compaq

Figure 1 highlights some design parameters within each category.

Compaq finds synergy between DfE and other priority design objectives, namely 'design for manufacturability' and 'design

for serviceability'. For example, fewer parts simplifies manufacturing, while facilitating recycling. Similarly, easy disassembly facilitates the servicing, upgrading and recycling of equipment as well.

**Easy upgradeability**

One of the most promising reuse and recycling opportunities for electronics can be found in upgradeable products. Product upgrade features help avoid early obsolescence and increase the product life by facilitating the replacement of electronic components, while avoiding the unnecessary disposal of mechanical parts, such as the plastic housing, power supply and metal chassis, which do not impact product functionality.

For example, a customer who purchased a 486/33 MHZ computer with 4 megabytes of RAM may have trouble running Windows 95. Rather than discarding the old computer and buying a new Pentium-based computer, a user can attain similar results by upgrading the microprocessor to a Pentium and adding additional RAM. The added bonus — the upgrade is a fraction of the cost of a new computer (for example, the upgrade costs approximately $300 compared to $2000 for a Pentium-based product).

While any PC can be upgraded, if you have the technical knowledge and are willing to replace the motherboard or manually de-solder the microprocessor chip and potentially end up with a mess, Compaq's designs are truly 'upgradeable' by the average user without the use of specialised tools and/or the risk of damaging your computer. This is accomplished through the use of alternative technologies for mounting components and easily accessible sub-assemblies. In Compaq's recent Deskpro models, a user can easily upgrade the video performance, the microprocessor, or the memory and easily access the hard drive and expansion slots to replace or add new features.

**Zero insertion force (ZIF)**

One technology that enables easy upgrades is the zero insertion force (ZIF) socket that holds the microprocessor in place on the motherboard. This socket replaces the traditional solder mounting, which is considered a semi-permanent connection technology. The ZIF socket uses a tension bar to hold the microprocessor and force a connection. This technology allows the user to easily remove and replace the old microprocessor and install updated or faster technology, simply by unlatching and relatching the bar.

From an environmental vantage point, upgradeable products conserve resources. For the most part, however, this is not critical to the purchasing decisions of customers, who are concerned predominantly about costs and product features. For Compaq and its customers, the upgradeable PC is important from another angle. It lowers the lifetime cost of computer ownership, a growing concern to customers as technological obsolescence occurs at an ever increasing rate. Upgradeable products also lower the costs of servicing products, for those customers who do not want to do it themselves.

The upgradeable PC lowers the lifetime cost of computer ownership, a growing concern to customers as technological obsolescence occurs at an ever increasing rate.

## Product stewardship at Hewlett-Packard

HP's environmental philosophy took a significant stride in 1992 with the launch of its product stewardship programme. The company made a commitment to move beyond the factory and an emphasis on the manufacturing process to embrace a new life cycle philosophy. The life cycle approach broadened HP's concerns to encompass product design, packaging, distribution, use, and disposal, in addition to traditional manufacturing issues.

Most importantly, the life cycle approach allows HP's Business Units to identify and address emerging global product legislation and market expectations. Indeed, it was a desire to stay ahead of legislative developments and voluntary programmes such as German 'take back' and US Energy Star requirements, and respond to an increase in the number of customers seeking more environmentally-sound products, that triggered HP's product stewardship programme.

As a result, Hewlett-Packard developed a global product stewardship network and management process that provides Business Units with support, tools and information, as well as autonomy, to develop responses that meet the demands of their product lines and customers.

Each of HP's product lines has a product steward who champions the programmes and coordinates efforts to identify, evaluate and respond to any market forces that could impact on that product line.

| Metric | Improvement |
|---|---|
| Number of parts | 1650 to 350 |
| Weight | 13 kg to 7 kg |
| Number of screws (to module level) | 4 |
| Time to disassemble (to module level) | 4 minutes |
| Number of materials (housing and chassis) | 2 (pure plastic and steel) |
| Energy efficiency | All 486s and most Pentiums meet Energy Star requirements |
| Batteries | No heavy metals<br>No batteries in some models |
| Flame retardants | No brominated flame retardants (housing and chassis) (PBB/PBDE) |
| Packaging | 75% recycled corrugated EPS foam<br>No heavy metals in inks |
| Manuals | 400 pages to 150 pages<br>50% recycled content<br>Recycling compatible binding<br>No heavy metals in inks |

Figure 2: Environmental improvements for HP Vectra personal computers *(Korpalski, 1996)*

The product stewards create cross-functional teams, as needed, to deliberate on issues and weigh up all aspects of design — from cost and performance to environmental impact.

### Product stewardship at the business level

The Computer Products Organisation (CPO) first tested product stewardship concepts within HP. As the producer of HP's widely-recognised and high-volume LaserJet and InkJet printers and personal computers, CPO was a good place to start.

CPO was subject to a proliferation of emerging 'green' market forces. Customers were increasingly asking about environmental features and the 'green' impact of HP products, including energy efficiency, packaging, recyclability and the use of ozone depleting substances.

Eco-labels and voluntary standards were driving competitors to introduce new products. European 'take back' requirements were pushing product stewardship (Korpalski, 1994). CPO developed a set of metrics to help drive product stewardship

improvements and to provide management with a mechanism to review and measure progress. Metrics were chosen based on customer inquiries, government initiatives, proposed ecolabel criteria and 'end of life' handling considerations. For products, consumables, and packaging, CPO chose to focus on energy efficiency and reducing its contribution to the waste stream.

**Vectra series PCs**

The environmental improvements achieved for one product, the Vectra series of personal computers is shown in Figure 2.

HP's Vectra VL series carries the comprehensive German Blue Angel label for PCs, a tribute to its environmental performance. The German Blue Angel is granted only to PCs that meet or exceed 65 requirements in a broad range of environmental and safety categories. Product recycling is an important aspect in PC Blue Angel certification.

Most of the Vectra PCs meet US Energy Star requirements and are easier to disassemble and recycle than previous models due to the use of fewer materials, parts, and screws. Indeed, it takes a recycler only four minutes to break down the computer into its component parts. In addition, the product mass was reduced by 46%, while the weight of paper-based manuals was cut by over 60%.

**A new 'packaging' concept reduces waste**

One innovative solution developed in HP's workstation division requires 30% less packaging because protective packaging is built into the product itself, instead of being wrapped around it. The new HP Packaging Assembly Concept (PAC) replaces the metal chassis with expanded polypropylene (EPP) foam. The foam chassis cushions sensitive electronic parts during shipping, while reducing the number of mechanical parts needed to hold parts in position. The foam chassis has an added benefit of reducing product development time, since prototypes require less preparation and assembly time with the easy to mould foam.

Hewlett-Packard's chemical analysis business adopted the innovative PAC technology in its new 1100 Series HPLC systems. This new packaging design resulted in major costs savings in assembly and disassembly, since fewer parts and no assembly tools are needed. For example, the new product design resulted in:

- a 70% reduction in mechanical housing parts
- a 95% reduction in screw joints
- a 70% reduction in assembly time
- a 90% reduction in product disassembly time compared to previous models.

EPP foam can also be 100% recycled into the source material polypropylene (Huber and Berndt, 1996).

**Asset management and recycling**

Managing the 'end of life' of electronic equipment provides multiple business opportunities for Hewlett-Packard, from improved customer service and sourcing of spare parts to new revenue streams in some cases.

HP Vectra PCs are among a growing number of HP products that are designed to be easier to take apart and recycle.

In the past, the Hardware Recycling Organisation programme was passive; they waited for equipment to come to them. This is changing into a more active programme that deliberately pulls products from markets into the HP recycling system.

The company operates product recovery centres in Roseville, California and Grenoble, France.

The primary mission of the California-based Hardware Recycling Organisation (HRO) is to recover useful service parts through the disassembly and refurbishment of HP and non-HP excess equipment and parts. HRO also serves as one of HP's recycling hubs. Equipment and parts that are not suitable for service are routed to environmentally-responsible, non-competitive recovery channels. This includes the re-sale of components and parts such as disc drives and motors, as well as the recycling of precious metals, non-ferrous metals and plastics. Overall, HP recycles or reuses 98% by weight of the material received from customers or HP operations.

Salvaging parts from used equipment allows HP to improve its service levels; in particular, it increases parts availability while lowering costs. Indeed, the origins of the HRO operation lie here. In 1987, HP found it difficult and expensive to obtain new service parts for some printers.

In its search for solutions, the service organisation found that 'tear down' of used equipment and subsequent refurbishment of parts to be a cheaper and more reliable source of service parts. HRO could fill an order for spare parts in 2 weeks, in comparison to over 6 months for some new parts.

HRO now stocks the service supply pipeline, resulting in an immediate turn around for service parts. Stocking service parts using the HRO organisation also frees up HP's manufacturing capacity, allowing production units to concentrate on manufacturing new product.

In addition, for some older technologies which are no longer in production, recovery of service parts from used equipment is the only option, and therefore, it is vital to keeping equipment in service.

In the past, the HRO programme was passive; they waited for equipment to come to them. This is changing into a more active programme, a programme that deliberately pulls product from markets into the HP recycling system in order to recover valuable service parts. For example, in late 1994, HP's marketing department initiated a 'trade-in' programme for LaserJets with a dual goal.

An obvious goal was to increase the sale of new LaserJets; an additional driver was to increase the supply of spare parts to the service organisation and to lower service costs. HP will also buy back equipment that they are interested in for service parts.

**Plastics recycling**

Finding solutions for the plastics waste stream from scrapped products is a priority for HP, with preference given to recycling. At the same time, HP product groups are looking towards meeting the expectations of an increasingly environmentally-sensitive customer base.

Merging these two objectives, HP is working with its suppliers, its recycling facilities, and its printer division to qualify recycled content plastic in HP

products, thereby creating a market for the output generated by the recycling facilities and improving the environmental profile of its products.

In July 1995, HP introduced its first recycled-content product to the US market, the DeskJet 850C InkJet printer. The printer outer cover contains up to 25% recycled-content acylonitrile butadiene styrene (ABS) plastic, a combination of post-consumer and post-process wastes. This was a major milestone for HP's product stewardship programme; the company was able to demonstrate and qualify 25% recycled-content in a cosmetic application.

Meeting extremely tight colour controls for this light coloured part was the biggest technical challenge to overcome in the project. As a result, in 1995 more than 1.1 million pounds of recycled plastic was used in the DeskJet 850 printer series. When the recycled-content is incorporated into the entire 850C platform, HP estimates a diversion of 6 million pounds of plastic from the waste stream annually.

Access to a consistent supply of recycled resin, in terms of quality, quantity, and cost, is a major issue. When HP embarked on this project, recycled plastic resin for this application was not even commercially available. HP's research and development staff, design engineers and procurement managers worked closely with resin manufacturers and injection moulders to co-develop and qualify a usable recycled product and identify a reliable and steady source of pre-consumer and post-consumer scrap.

Other HP product lines are exploring the use of recycled-content in plastic parts, although uncertainty in recycled-resin supply makes designers hesitant to specify recycled-content in new products and undergo costly and time consuming qualification and certification processes.

With a projected increase in demand for recycled resin, one of the significant challenges ahead for manufacturers such as HP, the information technology industry in general and its resin suppliers, is building up the supply of recycled resin. For example, HP has difficulty getting their printers back from customers due to their long life and secondary market value. Building an effective plastics recycling infrastructure will require coordinated efforts among manufacturers, recyclers, and resin suppliers to ensure product designs that facilitate plastics recycling, effective product recovery channels, and improvement in plastics identification, sorting and recycling technologies.

**Toner cartridge recycling**

Over the life of a printer, a customer may go through 50 or more print cartridges, amounting to a waste stream of cartridges and packaging that can exceed that of the printer itself.

To facilitate recycling these 'consumables', HP offers US customers a programme for returning toner cartridges for recycling. For LaserJet toner cartridges, customers are able to return used cartridges in the original packaging using a pre-paid United Parcel Sevice (UPS) label that is provided with the product inserts.

Since the programme's inception in 1991, approximately 13 million cartridges have been recycled, at no cost to the customer. Cartridges are disassembled and over 98% of the cartridge by weight is recycled or used in the manufacture of new cartridges. As an example, the following is a breakdown for one cartridge model:

- 37% reuse of parts, such as screws, springs, clips, magnetic roller, and corona assembly
- 38% parts re-moulded for use in new cartridges, including plastic housings
- 24% materials are recycled (eg. some plastic parts and electronic assemblies) and sold to alternative markets for use in new products; and 1% sent for landfill disposal, including seals, foams, and adhesive labels (McGavis, 1994).

## Product Life Cycle Management (PLCM) at Nortel

Nortel approaches its PLCM programme strategically. Consistent with corporate objectives, the PLCM programme aims to create customer value.

Customer value takes many shapes. Customer value is created when the lifetime costs of product ownership are lowered through increased energy efficiency, longer life products, or less toxic products; or through 'value added' recycling services of products at the 'end of life', for example.

PLCM also strengthens strategic alliances with suppliers, which are of growing importance to Nortel's overall business strategy.

Nortel re-oriented its corporate function to guide and stimulate PLCM efforts and to philosophically change how the company approaches its environmental responsibilities. Instead of acting only as a steward of regulatory action, through the PLCM programme Nortel Environmental Affairs has become a proactive business development unit. The goal is to improve the environmental performance of the corporation through changes in all stages of the product life cycle – design, supply management, manufacturing, marketing, distribution, and product disposal.

In its PLCM programme, Nortel Environmental Affairs work in two primary areas – Product Technology and Business Process Solutions – which respond to internal operations opportunities as well as the marketplace. In Product Technology, activities focus on research and development of cutting-edge, environmentally superior technologies and high leverage product solutions. In Business Process Solutions, the activities focus on developing innovative ways of supplying and managing operations to achieve resource efficiency in the supply chain. Below is a sample of some new directions.

**Supply management and chemical use reduction**

Nortel is embarking on an innovative business strategy with its chemical suppliers designed to reduce chemical use and lower costs. The hallmark of the strategy is a change in the once competitive nature of the manufacturer/supplier relationship. Traditionally, suppliers are financially motivated to sell more product to Nortel. Under a new 'shared savings' relationship being tested at Corkstown, Canada, Nortel and its chemical supplier will work together to minimise chemical use.


In its long-term contract, Nortel purchases the services of the supplier for a fixed fee, rather than purchasing the chemicals themselves. In this way, Nortel removes the financial incentive of the supplier to sell more chemicals. In this new relationship, the supplier is responsible not only for supplying the needed chemicals, but also for providing services such as chemical process expertise and chemical management, storage and disposal. As a result, the supplier has the incentive to help Nortel minimise chemical use by introducing innovations, searching for alternatives to hazardous chemicals, suggesting more efficient chemical processes, and delivering only the quantity of chemicals needed.

Such a supply management relationship allows Nortel to concentrate on what it knows best – network solutions in the telecommunications industry – while leaving the chemicals to the experts. The ultimate goal is to reduce chemical use and costs, and increase quality in products and processes due to the leveraging of outside expertise.

**Extending product life through design**

A modular philosophy was adopted for Nortel's new Vista telephone models, called Power Touch in the US. The new model allows the customer to upgrade the unit without buying a new one and scrapping the old one. The principle driver behind the design was to create 'user value' by leveraging the customer's initial investment through a flexible and upgradeable design.

The new model is designed in two parts – a standard base with basic telephony features and an upgradeable slide-in module that can add features such as caller ID, call waiting, a larger screen

size or a better graphics display. The base holds its design for a longer period of time, while the module can be replaced to provide the latest features at half the cost of replacing the telephone. This new design minimises product obsolescence and reduces the volume of product headed for recycling or disposal.

**Lead-free interconnection technology**

Nortel introduced the world's first lead-free telephone to the market in 1996, demonstrating a lead-free interconnection technology for printed circuit boards. The breakthrough technology follows several years of industry-wide research and development and is recognised as a significant step toward Nortel's objective to reduce hazardous waste generation and the use of persistent toxic substances in product. As part of its research and development efforts which began in 1992, Nortel in conjunction with suppliers and customers evaluated 200 alternative alloys for performance and cost, as well as environmental impact.

Nortel uses about 140 tons of lead in solder per year, approximately 80% of which is incorporated in products which may be disposed of in landfills. The remaining 20% is process waste which is usually recycled. The new alloy applied by Nortel uses 99.3% tin and 0.7% copper to provide lead-free interconnection comparable in quality to the standard industry solder containing 37% lead. To date, the new lead-free interconnection technology has been applied in the assembly of printed circuit boards in a test group of two types of Meridian office telephones. Test results are encouraging as the corporation prepares to expand testing of this new technology on a wider range of Nortel products.

Lead-free interconnection technology has several important benefits for Nortel. It will improve hazardous waste management and reduce special handling and process monitoring costs.

The new innovation also anticipates increasing pressure from governments in some European countries to control the disposal of electronic waste containing lead. This new technology will reduce the environmental impact of product disposal, resulting from lead leaching into soil and water from landfills. Elimination of this toxic heavy metal also reduces employee risk and associated monitoring costs.

**New packaging concepts to reduce waste**

For Nortel, packaging was an obvious and early target for waste reduction, as legislation worldwide focused attention on this waste stream and disposal costs skyrocketed. A packaging council made up of key functions in Nortel was formed in 1995 to promote returnable and recyclable packaging, and to assist Nortel sites in achieving the corporate target for reduction of non-hazardous solid waste.

For Nortel, packaging was an obvious and early target for waste reduction, as legislation worldwide focused attention on this waste stream and disposal costs skyrocketed.

As a result, packaging changes are springing up throughout Nortel, leading to significant cost savings and a 10 to 15% reduction in packaging volume. For example, standardisation and re-design of distribution packaging saves approximately $5 million annually. These savings were achieved by standardising, and thus reducing the number of packaging configurations. The resultant reduction in the number of box configurations led to a greater reuse of boxes, the need for less storage space and sorting, and fewer boxes purchased.

Shipping switching products in assembled mode, rather than packaging and shipping components separately for on-site assembly, saves an additional $5 million annually. This 'plugs in place' shipping method (eg. line cards pre-intalled) requires less packaging, and reduces installation time.

Nortel designed a new 'clamshell' packaging system for shipping circuit boards that eliminates cardboard and foam waste, and is reusable. The packaging is also designed to improve handling and storage for customers. The clear plastic allows customers to scan product bar codes without opening the packaging and risking damage to the product. The nesting and stacking feature of the clamshell also saves space on the production floor.

## Asset recycling

Nortel operates three recycling facilities in North America and one in the United Kingdom with a mission:

*'to provide entrepreneurial solutions and services for the valued recovery of materials and surplus assets while demonstrating environmental leadership.'*

To accomplish this mission, the reclamation operation provides Nortel divisions and customers with a full range of asset disposal and recycling services, from equipment test and refurbish to resale of useable components to recovery of precious and non-precious metals and plastics.

Nortel's reclamation operations date back to the 1970s, when they opened a facility in Barrie, Ontario to provide an equipment recycling service to Bell Canada, a major customer.

Today, Nortel's reclamation operations in the US and Canada process over 50 million pounds of equipment annually, including central office switches, private branch exchanges, cable and components from excess and obsolete inventory.

About 50% of the equipment processed is Nortel's own equipment and excess and obsolete inventory. 'Trade ins' and removal from customer sites account for the other 50%, although Nortel is actively trying to expand services to commercial customers and suppliers. In the United Kingdom, for example, Nortel negotiated with British Telecom (BT) to begin taking back some older varieties of PBX equipment for reuse and recycle. In addition, Nortel is working with other European distributors to develop tailored product 'take back' services to suit distributor and market conditions.

Over 90% of the equipment processed at the facilities (by weight) is recovered for reuse or recycling. Product and component reuse and resale (for example, circuit boards, memory chips, line cards) account for approximately 50% of revenues, playing a greater role today than in the past.

## Conclusions

The examples highlighted in these case histories are just some of the initiatives undertaken by these three companies. Similar activities are underway at Xerox Corporation, IBM, Lucent Technologies (formerly AT&T), Digital Equipment and Dell Computer, to name a few.

Common programme elements among these companies are a focus on product 'Design for Environment', supplier management, and improved asset management and recycling. For the most part, the initiatives of these companies are driven by business opportunities and external pressures, rather than a reliance on systematic, scientifically-based assessment of product systems such as Life Cycle Assessments (LCA).

There are good business reasons for undertaking product life cycle management (PLCM) or product stewardship initiatives. Indeed, the companies taking part in this research emphasised that 'if it doesn't make economic sense, it is not going to happen'. The examples highlighted in this case demonstrate the convergence of environmental and business

performance objectives, for example:

- Upgradeable designs can slow product obsolescence, increase customer loyalty, lower cost of product ownership, and improve product serviceability.
- Designing products with reuse and recycling in mind can lead to lower manufacturing costs and improved manufacturability due to parts consolidation and reduction in material variety, for example.
- Extending product life through asset management strategies may improve the service function, lower disposal costs, create new revenue streams, and introduce products to new markets.

This is just the beginning of product stewardship in the electronics industry. The companies highlighted in this study are in the early stages of programme implementation. We can fully expect continued progress as more and more companies and Business Units within these companies realise the economic advantages of life cycle management programmes and begin to focus their creativity and competitive spirit on eco-efficiency throughout the product life cycle. In addition, the application of ISO 14000 principles should help companies focus on continuous improvement.

The real question is how far the sum of these largely incremental improvements in the life cycle of electronic products, as outlined in Figure 3, will take us down the path of sustainability.

**More efficient use of energy and material resources**

- greater or same functionality using less materials (by weight)
- reduced power consumption through Energy Star products
- reusable transport packaging
- reduction in packaging materials
- selling functionality or service instead of products (eg. call answering service)

**Pollution prevention**

- elimination of chloroflurocarbons (CFCs) in manufacturing operations
- lead-free solders
- volatile organic compounds (VOC) - free fluxes
- removal of brominated flame retardants from plastics
- removal of heavy metals from packaging materials

**Reuse and recycling**

- reusable transport packaging
- recycled content in packaging and products
- product design for recycling (eg., reduced material variety, use of recyclable materials, plastics identification)
- equipment demanufacturing, component reuse and materials reclamation
- rechargeable battery recycling

**Extending the useful life of products**

- improved asset management, including product redeployment, remanufacture, equipment conversion and recycling
- product design for upgrades, expansion and serviceability
- recovery of service parts from used equipment
- lease-based programmes

Figure 3: EPA initiatives in the electronics industry

The challenge for public policy will be in monitoring these developments and recognising where economic and market incentives are insufficient and intervention is needed to achieve societal goals for environmental quality. •

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## Endnotes

1. Since HP currently cannot guarantee an adequate supply of recycled resin to manufacture this printer line, they were careful to label the product as containing 'up to 25% recycled-content'.

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# Mainstream appliance meets eco-design

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John Gertsakis is a Senior Programme Manager with EcoRecycle Victoria, Australia, a new State Government Agency responsible for encouraging, resourcing and supporting waste avoidance and resource recovery. Until recently he was Project Manager at the National Centre for Design at RMIT, where together with Chris Ryan and Helen Lewis, he successfully developed and implemented the EcoReDesign Program. As part of the same team he co-authored the newly launched 'Guide to EcoReDesign'. He has written and lectured widely in Australia, and has worked exclusively on the practice and policy of eco-design since 1991. He is a specialist in environmental matters related to electrical and electronic products, and recently co-authored a major report on the implications of extending producer responsibility in the Australian electrical and electronic products sector. He was also the editor of the EcoReDesign newsletter from 1992–1996.

**The following case study of an electrical kettle was developed by the National Centre for Design at RMIT and an Australian appliance manufacturer, as part of the EcoReDesign Program. This programme demonstrates how environmental improvements are possible through having a greater insight into the 'day to day' use of products. This case history demonstrates how some noteworthy ecological benefits can be achieved through a balance of design innovation, environmental understanding and common sense engineering principles. Although constrained by the usual factors found in most manufacturing companies, the project was underpinned by the simple view that 'the environment matters'. The resulting Kambrook Axis electric kettle uses up to 25% less energy compared to similar kettles and is designed with waste avoidance as the key driver. It is also 'designed for disassembly' to facilitate more viable and cost-effective 'end of life' recycling and materials recovery. The Kambrook Axis provides an optimistic glimpse at what can be achieved through a collaborative process that adopts 'environment' as a critical focus, serving both ecological stewardship and long-term competitiveness.**

## Introduction

Successfully blending environmental considerations into the product development process whilst still retaining functionality, consumer desirability and price performance, is increasingly becoming a key objective for many progressive companies around the world. Nevertheless, new technologies that offer substantial environmental improvements are not always readily available or cost effective. One way of moving towards more eco-efficient products is to better understand how people actually use products. The EcoReDesign Program has demonstrated how environmental improvements are possible by having a greater insight into the 'day to day' use of products. This socio-environmental approach to product development acknowledges the critical role of consumer behaviour in either exacerbating or minimising environmental impacts through the use of everyday objects. Too often the detailed interaction

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between user and product remains under-studied or under-valued, especially by volume producing small appliance manufacturers whose priorities are often the deadlines and demands of creating new models for special occasions such as Christmas.

## Process, ideas and collaboration

The Axis kettle is the direct result of an Australian-based eco-design demonstration programme known as the EcoReDesign Program. In summary, the project is about assisting Australian manufacturers from a wide variety of sectors to improve the environmental performance of their products through innovative research, design and development strategies. Funded by the Australian Government, the ultimate aim of EcoReDesign was to document several 'real life' case studies and produce an information video and manual for wider adoption by Australian companies, designers, engineers and others involved in new product development (Gertsakis, Lewis and Ryan, 1997). Although not always ground-breaking in its essential content, the EcoReDesign process was successful in applying eco-design within a highly commercial environment, on time, on budget and with the bonus of national design awards recognising the kettle's attention not only to environmental aspects but also valid consumer features. The process mapped out below provides an indication of how the kettle resulted and some of the eco-design improvements achieved.

The project involved a diverse range of designers and researchers. Interdisciplinary collaboration was a critical factor both in conducting rigorous research, generating novel design solutions, and realising the final product. Specific research tasks involved:

- optimising the kettle's thermal performance by conducting numerous theoretical and experimental studies of boiling kettles
- conducting a social survey to gain a more detailed understanding of how people use, maintain and dispose of their electric kettles, which was the predominant factor confirming where and how energy was being unnecessarily wasted
- an assessment of plastics and associated production issues with a view to both minimising the overall quantity and diversity of plastics, and ensuring 'end of life' recyclability.

The design of the kettle was significantly influenced by research, which showed that most people reboil electric kettles even when there was no need to. This issue was crucial in formulating the design brief and new design directions, as was the commitment to ergonomic requirements.

Early in the process, an all-day workshop was held at RMIT, as a way of exploring and generating innovative and environmentally-oriented responses to boiling water. This intensive brainstorming session also made a major

contribution toward developing a more productive relationship between company personnel (management, technical and marketing), National Centre for Design staff (designers, engineers, energy and environment experts, physicists, polymer specialists), and other stakeholders in the kettle's life cycle, including component and material suppliers. The workshop also identified and considered problems and issues related to current kettles and their use, highlighting several areas for further research and investigation (Fussler and James, 1996).

## The impact of kettles

An initial streamlined Life Cycle Assessment (LCA) identified that the 'use' stage of the kettle's life cycle was by far the most environmentally damaging. This was chiefly due to the energy used in heating and re-heating water, which in turn involves the release of greenhouse gases and other emissions to air from the coal-fired power stations used to generate that energy. The LCA also indicated that solid waste arising from discarded kettles, whilst not as critical as energy use, was also a minor but nonetheless noteworthy impact. The impact of boiling water 7 times a day (the calculated average usage) over the 5 year life of the kettle is evident through a range of environmental impacts, whether this be the production of solid wastes or greenhouse gases. The tables show the overwhelming impact of energy usage. Table 1 shows the expected impact of energy usage in terms of greenhouse gas emissions.

| Life cycle stages | Greenhouse gas emissions (kg) |
|---|---|
| Manufacture of materials | 18.6 |
| Materials packaging and transport | 0.2 |
| Assembly and testing | 0.1 |
| Kettle packaging and transport | 14.5 |
| Operation and use of kettle | 4703.5 |
| Disposal of kettle | 0.0 |

Table 1: Impact of energy usage in terms of greenhouse gas emissions throughout the life cycle

Table 2 shows that even the resulting solid waste from energy consumption is still more problematic than that from the final disposal of the kettle. This is a result of waste produced through the extraction of coal and waste by-products of energy production.

## Maximising the brief and minimising energy use

In addition to meeting the company's usual requirements for new product development, that is, safety, good ergonomics, styling and innovation – the brief also required the design team to ensure environmental factors were successfully integrated. The environmental objectives included:

- reducing energy consumption
- providing users with some form of information feedback about the kettle's performance (ie. water temperature and therefore, indirectly, energy use)
- using environmentally preferred materials, ie. recyclable plastics
- reducing material volume
- consolidating material types
- designing the product for disassembly and recyclability.

Overall it was shown that to significantly improve the environmental performance of the kettle energy consumption would have to be reduced. Other issues such as recyclability were considered but energy conservation was the greatest priority. To significantly reduce the energy consumption of a kettle proved to be difficult (Von Weisacker, 1997). Unless the product was significantly reconfigured, such as a kettle that use microwaves, the options for heating water are chiefly restricted to *heating element*s. As it is difficult to radically improve element technology other approaches

| Life cycle stages | Solid wastes (g) |
|---|---|
| Manufacture of materials | 428.1 |
| Materials packaging and transport | 0.0 |
| Assembly and testing | 1.5 |
| Kettle packaging and transport | 641.8 |
| Operation and use of kettle | 244661.3 |
| Disposal of kettle | 1140.9 |

Table 2: Solid wastes resulting from energy consumption throughout the life cycle

Overall it was shown that to significantly improve the environmental performance of the kettle, energy consumption would have to be reduced.

to reducing energy consumption were required.

Without a technological fix behavioural studies were required to better understand how consumers' usage of kettles affected the kettle's consumption of energy. The study identified a range of areas where the design of the kettle could be improved to reduce energy consumption. These included:

- The method of judging the water level. Only 26% of people actually used the water gauge, almost half relied on the weight of the kettle whilst others watched the rising water in the kettle and some noted how long the tap was turned on. Obviously if the gauge was improved, boiling excessive amounts of water could be reduced.
- Method of judging the water temperature. It was shown that most people re-boil kettles even when there is no need to. In addition to this it was shown that it was difficult for people to know whether a kettle did require re-boiling only, 10% attempted to judge this by touching the kettle to test its temperature.

These outcomes showed that three design improvements could be made to reduce the energy consumption of the kettle.

- Improve the water gauge. Make it easier to read by placing it on top of the kettle rather than the current position on the side of the kettle, which makes it difficult to read. By only boiling the required amount of water, substantial energy savings could be achieved.
- Keep the water hotter longer by insulating the kettle to reduce the energy required for reboils. The options available for insulating the kettle included using a vacuum (similar to those in thermos flasks) expanded foam or an air gap. It was shown that the least expensive option of an air gap could achieve similar insulative properties as the other systems. The design uses an inner and outer wall to create the air gap

| Time after boiling (minutes) | 10 | 20 | 30 | 85 |
|---|---|---|---|---|
| Minimum energy required to reboil Axis kettle (kilojoules) | 46 | 82 | 107 | 202 |
| Minimum energy required to reboil standard kettle (kilojoules) | 85 | 123 | 153 | 259 |
| Minimum energy saving on reboil achieved by Axis kettle (%) | 46 | 33 | 30 | 22 |

Table 3: Energy consumption during re-boiling

that reduces heat loss and also makes the kettle cool to touch.

- Include a temperature gauge to allow users to see how hot the water is, therefore reducing the number of reboils. A 'Temperature Sensitive Indicator' (TSI) was chosen to indicate the temperature. This TSI is positioned on top of the kettle and changes colour as the temperature of the water rises above 80°C. This shows the user that the water is still sufficiently hot to make a beverage without having to reboil.

Once these features were included in the kettle it was necessary to test the improved environmental performance. The improved water gauge and temperature gauge are difficult to test unless more behavioural studies are undertaken to test whether people do use less water and are not tempted to re-boil so often. In terms of the energy improvement from the insulation, the following table gives an indication of the energy savings possible.

It can be seen through the results in Table 3, that significant environmental improvements can be made in products by better understanding how people use them. When designing for the environment, breakthrough or leading-edge technologies may not always be available or viable. Therefore by observing inefficiencies of use, subtle changes in the product can be made that can make significant environmental improvement. Energy-star rated computers make use of the fact that most people leave their computers on even when they are not in use. Similarly the Axis is an attempt to maximise efficiency of use and thus and assist people to use an everyday small appliance more effectively and efficiently.

## Environmental achievements

The kettle's key environmental advantage is in its energy saving design. The solution was relatively obvious – keep the water hotter longer. The kettle's double-wall design acts like a high-tec tea cosy to minimise heat loss and thus reduce energy consumption on re-boils. On completion of the Axis kettle (market-ready model), a more focused environmental assessment was conducted in lieu of an LCA, as only two major areas were in need of comparison; that is, energy consumption and materials use (as they relate to 'end of life' options and solid waste).

Analysis of the new kettle was conducted using various scenarios, which took into account usage behaviour. Test and comparisons were carried out on both a leading-brand kettle, and the previous (now superseded) Kambrook kettle[1]. It was found that, on initial boiling, the Axis kettle require 6% energy to boil water. It subsequently required around 25% less energy to re-boil the kettle, for up to 45 minutes after the initial boiling depending of course on variations in ambient temperature. If the TPI was used correctly, and the kettle was not reboiled unnecessarily, total energy savings of up to 25% could be

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achieved. While these may not appear to be large savings, when put in context with the theoretical minimum amount of energy required to boil the water, they are somewhat more substantial.

If we examine the energy loss, the Axis demonstrates around 25% less energy loss on both initial boiling and re-boiling. The kettle's attention to waste minimisation principles is yet another environmental feature. It utilises less material in its manufacture, it is also designed for disassembly to assist in making 'end of life' recycling potentially more cost effective, especially for those markets and countries where 'producer responsibility' and product 'take back' regulations will require manufacturers and distributors recover discarded appliances, avoid waste and recover resources. The new kettle made significant savings in terms of its material composition: 66% of the weight of the Axis now consists of one recyclable material (polypropylene), as opposed to 36% for the previous company product. The total number of different materials has nearly been halved, while the total weight has been reduced by 16%. In addition, the number of components in the Axis has been reduced by 40% compared with the previous model. Glues and screws were avoided, to facilitate disassembly. Plastics components were joined together using either ultrasonic welding (which is compatible with recycling) or snap fits. All plastic parts were identified with internationally recognised codes.

In summary, the Axis kettle's environment achievements include:

- up to 25% less electricity used
- approximately 50% reduction in number of materials
- 66% of weight present in potentially recyclable materials (was previously 36%)
- 40% reduction in number of components
- 16% reduction in the overall weight
- construction techniques to facilitate easier dismantling.

As one indication of the new product's environmental potential, calculations suggest that if every electric kettle in current use in Australia was replaced with a new Axis kettle, Australia could save approximately 300,000 tonnes of carbon dioxide ($CO_2$) per annum. And given Australia's poor record and performance on significantly reducing its greenhouse gas emissions, Australian industry, governments and consumers need to save every tonne of carbon dioxide ($CO_2$) they can get their hands on. The Axis kettle is one small but significant indication of what is possible if products are developed as the environment matters.

## Conclusions

The EcoDesign process for the Axis kettle highlights a number of key issues for the product development process:

- Firstly, the company Kambrook had a strong culture of innovation and the ability to integrate new ideas into their products,

therefore they were receptive to environmental issues.

- An LCA is a key requirement within the process, not only to ensure the product's environmental impacts are prioritised, but also to identify options for environmental improvements – both technical and social.
- The EcoReDesign process was integrated at the start of the product development process and involved senior management and marketing, not just the designers. This factor is vital for the full integration of environmental issues into the product design and ensures that the product brief included environmental requirements.
- Support for the designers through training and publications was necessary after the specification stage to tackle detailed design issues eg. design for disassembly. •

## Note

[1] The Kambrook kettle project is simply one of the products conducted under the 'EcoReDesign Program'; it is not a different initiative, indeed 'Kambrook kettle project' is a bit misleading as it is all part of the same programme. In other words the Kambrook project under the EcoReDesign resulted in the Axis kettle – Axis being the model name.

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Dr Jonathan Williams, Head, Group for Environmental Manufacturing, UK, will publish an article on eco-efficient product development in Issue 3, not Issue 2 as previously mentioned.

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**What will be the key impacts of the sustainability agenda on product development and design?**

First, you have to define the scale. If you're looking at individual firms in the short term, I think what you'll see is further experimentation with 'Design for Environment' (DfE), product 'take back,' different ways of managing products, and perhaps more practice with leasing products – which are all heading towards a 'functionality economy.' I think the focus will remain on manufacturing and manufactured products; even though 70-80% of economic activity and employment in developed economies is in the service sector.

So then you get to a second set of questions. What is the interrelationship between services and products? How will that change over time? And how will that feedback into manufacturing? Then you're looking at medium- to long-term impacts. And that's where you'll see a far more fundamental restructuring of economic activity. Look at personal computers (PCs), for example. In the short-term, companies that are actively doing DfE will design PCs in slightly different ways. They may not use polybrominated fire retardants, or they may use some form of modular design. But then you need to think about the role of PCs in the 'service economy', where the revenue stream comes not from pushing more products, but from providing a product that is optimised as a platform for services. Over time, that means a lot less manufacturing per unit of Gross Domestic Product (GDP).

Now the interesting thing about this is that it begins to change a lot of things which have some fundamental social impacts. It changes the kinds of skills that you need within a firm. It changes the kind of education that you need to give your engineers. Over time, it also creates a very different industrial structure and we really haven't even begun to think about those implications, especially in business schools.

So I think over the medium- to long-term, products as cultural and psychological objects are going to become less emphasised and the provision of function

will become increasingly significant. I think that those who talk about the 'functionality economy' really haven't picked up yet on how fundamental a change in industrial structure that is going to be. And that is important because the countries that are now excelling in the production of services – everything from financial to telecommunications – are all developed economies. Now if you shift over in an environmentally constrained world to a more service/function-oriented economy, then you're looking at the possibility that the trend will exacerbate the existing problem of 'the rich getting richer'. If material demands begin to decrease, for example, by designing products that are optimised to last a long time and can be easily upgraded, rather than just simply thinking about selling more, then developing countries will be significantly impacted.

In aggregate I think you can make some fairly robust projections. Look at long-term cost trends. Cost trends for materials are fairly level, with ups and downs depending on the commodity. This also applies to the cost trends for energy. Cost trends on information and intellectual capital are all strongly down, so that begins to imply some fairly simple substitution of inputs. The difficulty comes when you think about specifics. In part, it's because we're so culturally bound to the patterns around us: the patterns of material consumption, the kinds of things that we consume, the way that we define ourselves from our clothes to our automobiles. It is very difficult to imagine what those shifts could lead to. But I think it's fairly clear that the pressures for those shifts are going to be very significant.

We all bring assumptions to the table which should be questioned. Perhaps the best example of this is the work that is beginning to be done on carbon sequestration. If you combine carbon sequestration with electricity and hydrogen production and move to a hydrogen-based transportation system, you could change the fossil fuel industry from everybody's bad guy (because of global climate change) to the system by which you govern the amount of carbon in the atmosphere over decades and centuries. You can control it by using the ratio of biomass to fossil fuel as the input, and the ratio of carbon sequestered to carbon released as the output. That kind of fundamental shift is going to be very common in the medium- to long-term and it probably means that we should be cautious in our projections.

**If we project forward and start to look at the whole scenario of sustainable consumption, both within the business-to-business and the business-to-consumer context, do you feel that it will generate greater opportunities for more resource- and energy-efficient products? Or do you view the whole concept of sustainable consumption as, say, producing and consuming fewer products?**

I don't think there's a clear answer. The problem with sustainable consumption is that it carries both an ideological and a material dimension. In the material dimension, it is very hard to change people's culture and their consumption pattern. So what that tells me is that in the short-term there is a strong responsibility on manufacturers and on industry in general to minimise the environmental impact of what they provide, while at the same time maintaining the perceived 'quality of life' of their consumers. If you go into a market economy and tell a consumer you're going to cut what's available by 20%, it's just not going to work. In the longer-term, I think what you're looking at is the need to de-couple 'quality of life' from material consumption and I think you can do that. This data is very sparse but there is some available in the US that indicates Americans' 'quality of life' has not increased since World War II, although per capita material consumption has increased significantly. Now that's interesting because what it implies is that there is already a de-coupling of 'quality of life' and material consumption. But that de-coupling has yet to be expressed in reduced material consumption, in part, because people haven't been provided with other alternatives with which to amuse themselves. That's where I think the 'information revolution' begins to look interesting. If you think about it, what the 'information revolution' is saying, in part, is 'we are going to provide information instead of materials to augment your "quality of life",' eg. 'surfing the internet,' digital

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video, and digital audio. There are a lot of products which begin to make entertainment a lot easier and a lot less resource intensive. So I think, in the longer-term, the perception of the consumer's 'quality of life' will actually start increasing, but the 'environmental footprint' required to provide a 'quality of life' unit will decrease. I think a big driver of that will be the substitution of information services for material goods.

That doesn't necessarily have to be just a hypothesis. The shift in appeal of electronics and information access as compared to automobiles for young people over the last 10–15 years illustrates a really interesting kind of evolution. Fifteen or twenty years ago, 'hot-rodder' teenage boys worked on their cars – it was the thing to do. Now with vastly more complicated cars and changing lifestyles, 'surfing the net' – even 'hacking' – are becoming modern equivalents. And if you look at computer ads, they are beginning to sound a little like the automobile ads, 'more horsepower,' 'faster,' 'blow away the competition'. That tells me that advertising people are beginning to understand that technology has a chance of displacing a main cultural icon, the automobile. So, we are seeing subtle sociological changes, without realising it. The same gradual changes are true in relation to environmental awareness and attitudes.

**How do you differentiate eco-design or 'Design for Environment' from sustainable product design?**

Again, I look at it in terms of scale. DfE is the implementation of fairly broad principles of industrial ecology in the short-term and at a very localised level, eg. a more environmentally-friendly way to clean circuit boards, rather than designing a sustainable computer. DfE is primarily an engineering concept whereas when you move to the level of sustainable product development, you have shifted categories in a philosophical sense.

There are two issues with sustainable products. One is an issue of systems. Unless the product exists in a world that's sustainable, it by itself cannot be sustainable because sustainability is a characteristic of the global economy. You can only define 'sustainable' by reference to the whole. The second issue is the matter of social choice. Sustainability is a matter of social choice or social free will; there are many possible 'sustainable worlds' and, in the end, we must choose which one we want. I could easily propose a world which is sustainable, which has high levels of inequality and maintains its sustainability by varied mortality levels among the poor. Now that would not be a world that any of us would want to live in, but it might be able to be maintained over some length of time. So the issue of sustainable products begins to ask a very serious question, which we, as a society, have yet to begin to respond to appropriately. And that is, what products do we choose to have in terms of the world in which we live and which we will pass on to our

children? DfE doesn't have those overtones because DfE essentially uses rules of thumb to achieve increased environmental efficiency in the short-term.

Some of these issues involving values exist even now, of course – if you are low-cost sourcing your sub-assembly materials from Indonesia rather than Sweden and the factory may in fact actually have good environmental standards, but they use child labour, but the child labour takes income back into the family and enables four or five of them to live... where do we all stand on this? I think to some extent we have not done ourselves a favour by overlooking all of these extremely difficult and complex value 'trade offs'. It's easy enough for anyone to say, 'well, you know, what we ought to do is design a product that uses less energy'. But there are always 'trade offs,' and right now we like to pretend they don't exist. But they do. And we can't run away from them forever.

**How do you see DfE and Sustainable Product Design (SPD) fitting into the context of industrial ecology?**

I think they are a part of it. If you look at industrial ecology as the science of sustainability, then one of things it begins to do is to develop the knowledge and data that will allow us to begin to define what DfE and SPD should look like. Take materials for example, which are a relatively easy problem. We really don't know the environmental impact of various materials and applications. It is an extraordinarily complex problem. I would view it as the job of industrial ecology to figure out how to answer that question. In other words it would be nice, in an ideal world, to have the knowledge to say 'Okay, if I use polycarbonate instead of ABS (acylonitrile butadiene styrene) for this application, the impact will be Y.' We're nowhere near that yet and, except at a very high granularity, we may never be. But that is the kind of question I would see industrial ecology research beginning to ask and to develop answers for. Those answers can then be applied in DfE, or more broadly, in the definition of a sustainable product. If you think about sustainability as a characteristic of the global system, then the product itself does not need to be sustainable as long as within the context of the system, it is sustainable. You may always have unsustainable activities but that may not be a problem as long as the overall system is sustainable.

**What do you consider to be the key steps that companies should take when establishing a DfE system?**

I think you begin by recognising that the DfE process should not be perceived as belonging to the company's environment, health and safety function. It should belong to the R&D function, to the manufacturing engineering function, to the product design function, and, to some extent, to the marketing function because that's where you get your inputs. But it should not be placed in the traditional overhead organisation, because if it's still there, then you're 'learning to talk', but you're not yet 'learning to walk'. So one indicator of establishing an effective DfE system is whether or not it has been driven into the operational side of the company.

A second indicator is the number of products which actually undergo that kind of process. It's important to focus initially on the process instead of the answers themselves. One, unless you are actually working with a complex product or technology – an automobile, a plane, a computer, you're not likely to know what the 'trade offs' involved really are. So for someone who is not working in electronics, it's a fairly easy proposition that you should replace lead solder with bismuth or indium solder. But for somebody who's actually working within the technology, those changes imply a set of manufacturing process changes, which may, in fact, cause more environmental problems, eg. the use of chlorinated solvent instead of aqueous cleaning systems, for example. When you look at it as a consumer of a product or as a service company buying a product, I think the most that you can do is to ask that your supplier uses the process rather than to actually ask for specific endpoints because you don't know enough to do that. That's their job, not yours.

The other reason I think it's valuable to look at DfE as a process is because we don't know whether or not the things we are doing in the name of the environment are making the

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world better or worse. We don't have the data. That's not to say that what we're doing is unimportant, because you have to practice, you have to learn how to think about this. But, in absolute terms, it is probably difficult to say if we are doing things better or worse. Now there are many exceptions. If you can cut down your waste by implementing good management and housekeeping in your plant, that's probably a victory for everybody. But those are trivial cases. I think looking at DfE as a process is very important because if you focus too much on trying to get the best outcome, it may lead to frustration rather than to incremental progress in implementing DfE across the firm.

**In the shift to products that fit within a sustainable society, do you think there is an increasing requirement for innovation and creativity? And if so how do you feel that should be stimulated within the firm?**

In a way what you're asking is, how do you stimulate culture change within a firm, and that is always extremely difficult. Business school gurus make hundreds of thousands of dollars by coming up with new theories every six months. The answer, I think, is you've just got to be very sophisticated about where the levers are in your particular firm and in your particular culture. If a firm is 'technology-driven' you can make a lot of progress by looking at DfE as a sophisticated enhancement of your technology. For example, if you're building a complex product, one of the things that increases the quality of the product and ease of manufacturability, is 'Design for Simplicity.' Two of the fundamental precepts for 'Design for Simplicity' are to reduce the number of parts and to reduce the number of different materials. In most designs, that's about 70% of the way towards DfE. A lot of progress could be made by understanding that, and then working with 'Design for Simplicity' algorithms to try to get DfE components accepted, in a 'technologically-driven' firm. In a 'financially-driven' firm, an effective approach is to implement activity-based costing, and then to piggy-back green accounting. But it depends on being sophisticated about grasping opportunities and pushing levers within your particular culture and your particular firm.

From a social viewpoint, I think one of the levers that has not been used adequately is the procurement lever. The problem with a lot of people in procurement is that they want to impose their idea of 'environmentally-preferable' on some very complex technologies. And you can't do that. You can't look at an airplane and say 'the best technology for that fighter plane is this kind of ceramic and composites'. Because you don't know what all the design 'trade offs' are. What you can do is implement a requirement that winning firms have to use some kind of DfE process and they have to document that process for the purchaser. Only a first

step, but it is that kind of thing that generates significant culture change within a firm.

There's an interesting dilemma there. Small firms are generally more innovative. On the other hand, the scale and the scope of most private firms are not equivalent to the scale and the scope of their environmental impacts, so we have begun to expand the control of the firms through, for example, standards associated with product 'take back.' When you do that, you begin to ossify technology. So you run into a dilemma. On the one hand we are saying that we need to have rapid technological evolution; on the other hand we are saying we need bigger industrial structures to match the scale and the scope of their environmental impacts, which slows down technological change. I confess I don't have the answer to this problem.

The other issue which needs to be looked at more seriously is the whole question of technological evolution. What are the real barriers, constraints, incentives and processes involved in the technological evolution? There's no really robust theory of it and I think part of it is that the predominant economic models tend to have a fairly static approach built into them. They don't always interpret and reflect technology in its practical sense. And I think that's a problem. We need to learn a lot more about how technology really diffuses in the economy. For example, the technology to design an environmentally-friendlier car exists, or could be relatively easily developed. What doesn't exist is any relatively feasible way of implementing it into a real economy. Because if you did that, for example, you'd begin to obsolete a lot of the investments in the petroleum sector and you'd never get away with it. So we need to think about technological evolution in its full context, not just the product, but also the cultural, economic and technological matrix within which it is embedded. Only by understanding that, can you realistically identify opportunities for improvement. •

The technology to design an environmentally-friendlier car exists, or could be relatively easily developed. What doesn't exist is any relatively feasible way of implementing it into a real economy.


## Solar Mower

**Husqvarna, Sweden**

Husqvarna, a subsidiary of Electrolux, has developed the 'Solar Mower', which not only eliminates the need for fossil fuel in use, but also eliminates the need for the conventional human component of lawn mowing – that is, no pushing and no riding is necessary – the mower works completely independently.

The 'Solar Mower' is a radical departure from anything that looks like a traditional lawn mower and, according to Husqvarna, the designers found their inspiration in one of our earliest lawn trimming machines – the sheep. Powered by the sun using photovoltaic cells, the mower starts at sunrise and continues through to sunset, working slowly, continuously and quietly. Napping neighbours won't be bothered by noise and the atmosphere won't have to absorb any greenhouse gases. The super-efficient machine requires a 20 watt output, whereas traditional electric mowers require between 1000–1500 watts. An on-board computer functions as the 'brain.' The mower can sense obstacles and manoeuvre around them. When the mower encounters shady areas, it calculates the capacity of its batteries and returns to a sunny spot in time to recharge. An added benefit is that by shredding grass into small bits which return nutrients to the soil, the machine reduces the need for fertilisers.

However, at US$3000 the 'Solar Mower' is extremely unlikely to displace conventional mowers in the near future. But Husqvarna claim it is vigorously investigating ways to use clean technologies to develop a more affordable version of the product, as well as diversifying into other product areas.

*Text by Connie Backer, The Netherlands Design Institute, the Netherlands.*


## ThinkPad

**IBM**

The IBM ThinkPad range incorporates a variety of environmentally conscious features. Generic requirements are that all materials used are capable of being recycled, all plastic parts greater than 25gm are identified in accordance with ISO 11469 and the IBM Corporate Standard and are designed with snap-fits for easy assembly/disassembly. Specific features include the PC 700 models which are powered by lithium-ion or nickel metal hydride batteries, in preference to those containing lead or cadnium, and the housing of the 730TE which is made of 100% recycled magnesium alloy.

## Teletangram

**Nicole van Nes, Delft University, the Netherlands**

A graduation project which builds on an innovative product development initiative from Philips Sound & Vision, focusing on minimising the environmental impacts of products by considering extending their useful life. The Teletangram is a product family, consisting of a mother module, an intelligent telephone and several extension modules, such as an answering machine and facsimile. By using 'smartcards' (PCMCIA) different functions can be added and upgraded. This product's flexibility encourages the owner to keep the product longer because it can adapt and alter with the users changing needs. This prototype concept is used within Philips to show the benefits and opportunities available by adopting such a product development approach.

## Space and water saving toilet and washbasin combination

**Huib van Glabeek, the Netherlands**

This combined toilet and washbasin product design was first conceived for installation into social housing project developments, where limited space is an important factor. The toilet is diagonally positioned to the washbasin, creating a comfortable position for the toilet user and optimising space. This product also conserves water by using the wastewater from the washbasin to flush the toilet. The wastewater is stored in a reservoir housed in the duel purpose basin stand/toilet cistern. 30% of the water consumed by a household is used to flush the toilet. Furthermore, the re-design of the conventional toilet cistern mechanism was accompanied by an attempt to produce a more 'contemporary' form, which would have a classic, long-lasting appeal. Huib van Glabeek developed an elegant, durable shape to meet this need. The product is also designed for ease of installation, maintenance and repair.

*Photograph: Hans van der Mars/ Henk Visser*

## Energy efficient bicycle and road signpost lighting

**n|p|k industrial design, the Netherlands**

The Royal Dutch Touring Club (ANWB) invited the design company n|p|k to re-design the signposting system for bicycles and cars that can be found at every crossroads in the Netherlands. The design, created by designer Thomas Linders placed within the design brief energy conservation as a key objective. By placing the light source in a more central position the light was more efficiently utilised. Previously the system used high power continously, especially in inclement weather conditions, as neon lights are less efficient at low temperatures. A sensor was thus installed to give extra power in low temperatures. The above design improvements resulted in 40% less energy being required to operate the new signposting system.

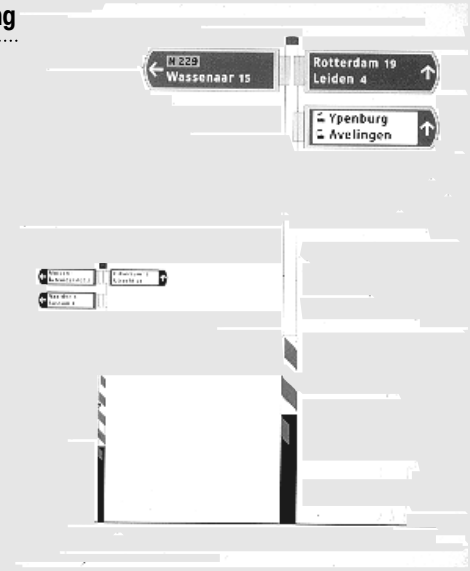


*Illustration: n|p|k industrial design, the Netherlands*

## Jute geotextile

**Claudia van Riet, Delft University, the Netherlands**

This graduation project was undertaken in Indian jute mills in Calcutta. The manufacturer had the problem of a diminishing world market for the jute products it produced, due to competition from synthetic materials. Jute has an old fashioned image associated with shopping bags and door mats. However, jute is a renewable resource with low environmental impact during cultivation and is biodegradable. In addition, jute has various positive characteristics such as moisture retention, high strength and stiffness. On the basis of these characteristics a geotextile was developed, which would be used to protect fallow land against wind and water erosion, until new plants had taken root. The product slowly biodegraded with the moisture retained within the geotextile assisting the feeding of the new plants. Furthermore, no toxic trace elements are left in the soil. The product is at present being market tested.

# Managing the eco-design process

**Martin Charter**

Joint Coordinator, The Centre for Sustainable Design, UK

**The article provides an overview of the key issues involved in the management of eco-design. Planning and implementation issues are addressed, with particular reference to those involved in product development and design. There is a focus on IBM's and Electrolux's approach to eco-design, particularly illustrating that corporate approaches to eco-design differ by product, market sector and geographical region. Eco-design is in its early stages, and the business case will evolve as drivers strengthen.**

## Drivers

There are a range of pressures that are starting to focus business on the environmental performance of products/services:

- customers (consumer, intermediary and 'business to business)
- environmental regulations
- product stewardship
- risk management
- sustainable development
- eco-labelling
- voluntary standards eg. ISO14001 and Eco-management and audit scheme (EMAS)
- shift to cleaner technologies
- competitive advantage
- increased profitability.

Drivers differ by product, market sector and geographical region and the complexity is illustrated by eco-labelling. There are different eco-labels in different countries for different products eg. recycled paper, alongside more generic eco-labels for certain products. For example, in some organisations the US the Energy Star label has become an accepted requirement in the purchasing of computers.

## Planning for eco-design

Eco-design or 'Design for Environment' is a strategy that aims to incorporate environmental considerations into product development and design, throughout the life cycle of a product or service. It is essential to have some organisational commitment to environmental issues and a clear goal and business case for eco-design before a programme is developed and launched.

This should include a clear understanding of the strategic, tactical and operational implications of eco-design activities in relation to business and marketing plans. Key elements of the programme should include the links to the technology strategy and the development of an effective organisational approach to make eco-design happen. Technology considerations include issues such as reducing materials volume and type, energy use, recycling and remanufacturing.

Each firm has a different organisational culture, and mix of businesses and products/services. Therefore the 'shape' of the eco-design strategy and programme will need to reflect this and it should be adaptable to different organisational approaches ie. centralised versus decentralised decision-making. At present eco-design is generally not integrated into mainstream product development and design, with the environmental management function tending to 'own' eco-design rather than research and development (R&D), design or marketing departments. The approach to eco-design tends to reflect the firm's overall attitude to environmental management ie. is the firm 'compliance-driven', 'technically-focused' or 'opportunity orientated'. The extent of the commitment to reduce the environmental impact of products/ services will be indicated by:

- environmental objectives
- environmental policy
- level of accountability
- level of responsibility
- availability of training
- environmental performance evaluation.

## Product development

The management of eco-design is usually established as a specialist discipline or project, but ultimately it should be integrated into the mainstream product development process at each stage:

- incubation
- concept review
- market assessment
- development
- product launch
- product management.

It is important to address environmental issues early in the product development cycle, to ensure problems and opportunities are determined before development and design decisions are made.

For eco-design to progress it is essential that it becomes more strategic and moves beyond the existing operational focus ie. re-design of existing products, for existing markets.

A key success factor is the ability to sell eco-design into the different business functions involved in the product development process. The key issue is to avoid 'hitting the green wall' ie. eco-design issues must be translated into the language and business benefits for those involved in the product development process:

- marketing
- design
- R&D
- production
- quality
- finance
- purchasing
- environmental.

Another key element of successful eco-design is cross-functional working, learning from concurrent engineering and Integrated Product Development (IPD) approaches.

Internal barriers to eco-design do exist, and need to be overcome to implement programmes successfully:

- limited resources
- poor communications
- organisational inertia
- individual inertia
- lack of expertise
- hidden costs
- perceived costs
- lack of time.

## Implementation

When planning and then implementing eco-design there are a range of key considerations:

- analysis of strategic/tactical/operational issues
- establishing eco-design objectives
- developing appropriate organisational structures
- undertaking training
- establishing information and support systems.

The development of quantified objectives for eco-design is still in its early stages, and so therefore is measurement. However, performance metrics are a useful mechanism to monitor the effectiveness of eco-design. Metrics can be relative, absolute, source or impact-related. For example, developing ratios that highlight energy usage, water usage and materials burden per product or product group.

There are a range of eco-design strategies that can be employed relating to different stages in the life cycle of the product or service. The use of these approaches is dependent on the organisational culture, product/market issues, and the relative environmental impacts of products/services. There are a range of analysis methods available to determine and understand the environmental impacts of products/services, including: checklists; matrices; Life Cycle Assessment (LCA); and, customised product-related environmental impact analyses.

An important element of eco-design is to develop information systems to support both management and product designers. This should be in the form of a structured systems incorporating paper-based information, software, internet, online databases and expert advice.

## Case histories: IBM and Electrolux

A number of leading-edge companies are finding that the implementation of eco-design programmes is leading to innovative solutions and competitive advantage.

### IBM: environmentally conscious product development

- IBM is a worldwide manufacturer of advanced information technology, with sales of US$75.9 billion (1996) and a workforce of 225,000 employees.
- In 1971, IBM established its

corporate environmental policy (CEP).
- It has developed a worldwide environmental management structure, with national focal points.
- In 1990, the CEP was widened to acknowledge 'producer responsibility', including the development of 'Environmentally Conscious Products' (ECP).
- IBM see a range of benefits from ECP. These include:
  - tangible: lower costs
  - intangible: good PR, more responsive to legislative developments, etc.
- Within the environmental management structure, eco-design expertise is focused in the Engineering Centre for Environmentally Conscious Products (ECECP) in the US. In each operating unit there is an ECP strategy owner, with responsibility for developing eco-design targets. This extends to all products.
- IBM's eco-design focus is on five key areas:
  - materials reduction
  - recycled content
  - plastics labelling
  - reduced energy consumption
  - ease of disassembly.
- The company uses three main eco-design tools:
  - Life cycle inventory (LCI)
  - Product environmental profile (PEP)
  - Corporate Standard – Environmentally Conscious Design.
- Eco-design performance measures are in the early stages of development. At present, the method used examines attributes, each supported by design guidelines or targets. Each attribute is scored using a formulae based on:
  - part-count ie. the percentage of parts in the product meeting specification requirements
  - character-count ie. percentage of features used in the design of products this is also being used as a mechanism to work with suppliers.
- IBM has developed eco-design approaches to the re-design of existing products and the development of new products:
  - re-design: PCs have a small 'window of opportunity' to make eco-driven re-designs due to short development timescales, compared to mainframes that require less frequent changes
  - new product design: the PEP is used throughout the product development and design cycle.
- IBM have faced three prime obstacles in progressing eco-design:
  - economic: cost/benefit justification of eco-design
  - education: lack of awareness and understanding of environmental issues amongst the marketing function and customers
  - technical: 'trade off' of real and perceived costs; quality issues relating to recycled materials.

**Electrolux: the integration of environmentally-sound technologies in product design**

- Electrolux are a major producer of household products, commercial appliances and forestry/garden products. The company employs 112,000 staff worldwide and had a turnover of SEK 110 million in 1996.
- In 1992, Electrolux developed an environmental vision statement. This incorporated a reference to product development:
  *'We are going to meet our customer's expectations for safe, environmentally-sound products, and we will actively distribute information aimed at stimulating demand for these products.'*
- The environmental strategy is a business strategy. It has lead to competitive advantage, market opportunities and resource efficiency. In production terms, it means cost efficiency.
- The company has set a plan to have all 150 factories accredited to the international environmental management standard, ISO14001 by 2000. Additionally, European companies within the group may register for EMAS.
- There is a clear environmental management structure driven from the top. The Senior Vice President for Environmental Affairs acts in an advisory capacity on environmental strategy issues to the Group CEO. Environmental Affairs (EA) operational activities are channelled through the household products Business Unit. To operationalise the environmental policy within the group a worldwide network of 70 coordinators has been developed, positioned within each of the 20 product lines.
- Environment-related targets for products are set within each

product line. Measurement is the responsibility of Environmental Affairs and a series of tools have been developed, including:
  - assessment of environmental leadership of the product
  - assessment of profitability of the product
  - annual improvement of product range
  - recycling properties of products.
- Key issues include recognising and managing life cycle impacts and 'adding value' through the supply chain. Within each product line, Research and Development (R&D) has a key role to determine potential and existing environmental problems and generate new solutions.
- Product line purchasing departments are responsible for assessing suppliers. From 1996, supplier environment assessment has become a prerequisite for all business areas.
- At the start of the product development cycle, new product concepts are assessed against business and environmental strategies before they are progressed.
- Electrolux perceive levels of eco-innovation:
  - continuous improvement eg. higher energy efficiency
  - new technologies eg. catalytic converters of chainsaws
  - new product concepts eg. solar powered lawn mowers.
- The company has now incorporated eco-design into an Integrated Product Development (IPD) process. Tools have been developed to aid this process:
  - design guidelines
  - eco-design checklists
  - check points in the development process.
- A key issue for the development of eco-design and environmental business strategies is differing levels of environmental awareness and concern around the world. In addition, the uncertainty surrounding 'green' legislative trends poses problems in product design and development.
- A range of improvements has resulted from applying eco-design to the business areas:
  - Household products
    - significant improvements in the life cycle 'use' phase
    - products well received in more environmentally-aware markets
  - Commercial appliances
    - improvements in resource efficiency
    - development of competitive-edge
  - Forestry/gardening products
    - improved ergonomics
    - reduced emissions.

## Conclusion

There are growing range of drivers for eco-design, However, corporate eco-design programmes are in their early stages of development. Success will depend on the firm having a clear vision of what it wants to achieve, the degree of integration into mainstream product development, supplier partnerships, and the receptiveness of the organisation to environmental opportunities.

There is a key need for senior level commitment and motivation, as well as, well organised structures and systems to plan, coordinate and implement eco-design, particularly within multi-product/multi-market based transnationals. There are a growing number of approaches to eco-design, particularly in the electronics sector. A range of business benefits are starting to emerge and examples are likely to grow as the eco-design evolves, and becomes more accepted. •

*Many of the issues discussed in this article are more fully explored in 'Managing eco-design: a training solution', recently produced by The Centre for Sustainable Design.*

# The sustainability cycle: a new tool for product development and design

**Peter James**

Director, Sustainable Business Centre, UK

Peter James previously worked at Ashridge Management Centre, the University of Stirling and the University of Warwick business schools, UK. He was also Professor of Management at Limerick University, UK. The Sustainable Business Centre is a UK based organisation which provides research-based information and advice on how companies can become more sustainable. Its main areas of work are performance measurement, organisational change for sustainability, environmental accounting and incorporation of sustainability issues into research and product development. He worked with Claude Fussler on the book 'Eco-innovation: driving eco-efficiency' (Pitman Publishing, London, UK, 1996). He is recognised as a leading consultant and researcher on sustainable business issues.

## The next green wave

Like nature, environmental concern is cyclical. It rises during economic booms, which create impacts such as congestion and increased pollution and reduce worries about other issues such as unemployment. And it falls during recession, when impacts are less obvious and issues such as employment and crime become more prominent. However, each turn of 'the cycle' tends to leave concern – and action in the form of legislation and other measures – at a higher level so that the impact on business is constantly increasing.

The last 'green wave' peaked around the end of the 1980s and then fell away as recession hit most Organisation of Economic Cooperation and Development (OECD) economies. Now, increased growth rates – and growing concern about issues such as global warming and 'gender bending' chemicals – are building another 'green wave' which is already effecting some businesses and will increase as we move towards the millennium.

The drivers of this next 'green wave' are growth in population and living standards. Our planet will have around 50% more people within 40 years. And, for the foreseeable future, most of its people will want higher living standards – equivalent to around 3% per annum real growth according to most forecasts. This means greater use of resources, more emissions and increased congestion (even allowing for improvements in efficiency). Whilst the precise environmental consequences of this are hard to judge – and easily exaggerated by zealous 'greens' – most scientists would accept that, in aggregate, these trends will cause serious risks to human well-being and natural systems and that more radical action is needed to ameliorate them.

Leading environmental thinkers and a growing number of policy-makers and businesses believe that meeting this challenge will require a 'factor four' improvement – ie. reducing the amounts of resources needed and pollution generated to deliver goods and services to consumers by at least 300% over the next 20–30 years. Some – such as Germany's Wuppertal Institute – believe that this is just a medium-term

target and that in the long-term we will need a 'factor ten' improvement. There is no theoretical reason why these can't be achieved – and in some cases have already been. The environmental impacts of providing a given amount of computing power are a fraction of that required only a decade ago.

But targets such as this are certainly a challenge. Even more so when the other elements of the sustainable development agenda are taken into account – such as meeting the basic needs of the world's poor and reducing global inequalities.

Business responses to this challenge are increasingly based on the concept of eco-efficiency. This has been developed by the World Business Council for Sustainable Development (WBCSD), which represents leading multinationals and has been chaired by the CEO of BP and – the current incumbent – 3M. Its focus is to create more stakeholder and customer value with less environmental impact by:

- increasing resource productivity so that more is obtained from less energy and raw material inputs
- creating new goods and services which maintain or increase customer value but use fewer resources or create less pollution.

Sustainable product design (SPD) must meet both these objectives. Fussler with James (Fussler and James, 1996) have outlined the opportunities for this and stressed the need for 'eco-innovation', ie. new products and processes which provide customer and business value but significantly decrease environmental impacts. For example, by working with pest controllers to reconfigure delivery services, Dow Elanco succeeded in reducing the amount of material needed to provide termite protection to buildings by 99%.

## Evaluating product environmental impacts

SPD needs tools and techniques to establish which products are sustainable. One challenge is to translate complex Life Cycle Assessment (LCA) data into simple concepts and criteria which can be used by product designers and developers. Two well-known product evaluation schemes which do this are 'Eco-points' and the 'Eco-compass'.

### Eco-points

A number of eco-points schemes have been developed, of which the best known are those used by Volvo and Philips (now available as a commercial package called Eco-scan). They are similar in that they cover all life cycle stages – production, distribution, use and 'end of life'. For each stage, the user selects appropriate materials, processes, usage, and transportation details from the options provided in the software. The package then calculates an 'eco-score' for each of these elements, based on a number of points for a given quantity or usage.

The value of eco-points schemes is that they can provide quick analyses of the overall environmental effect of products and how different elements of the design contribute to this. Their main disadvantage is that they are ultimately dependent on subjective weightings of different environmental effects and that these are not always transparent to users. Hence, they are particularly well suited to identifying areas for attention and exploring (rather than making) choices between different alternatives. They are not at all helpful for communication, as eco-points are meaningless in themselves and some customers and stakeholders will challenge the assumptions they rest upon.

### Eco-compass

The eco-compass has been developed by Dow Chemical to provide a simple, visual summary of life cycle analysis data. It is based on the indicators of eco-efficiency developed by WBCSD, with some minor amendments. The eco-compass has six 'poles':

- energy intensity
- mass intensity
- environmental and health risk potential
- sustainability of resource usage
- extent of revalorization (reuse, remanufacturing and recycling)
- service intensity.

All of these are measured across the entire life cycle.

The eco-compass provides a holistic, visual, overview of products using dimensions which have been subject to considerable discussion and development by the international business community. It is very useful in comparing and making choices

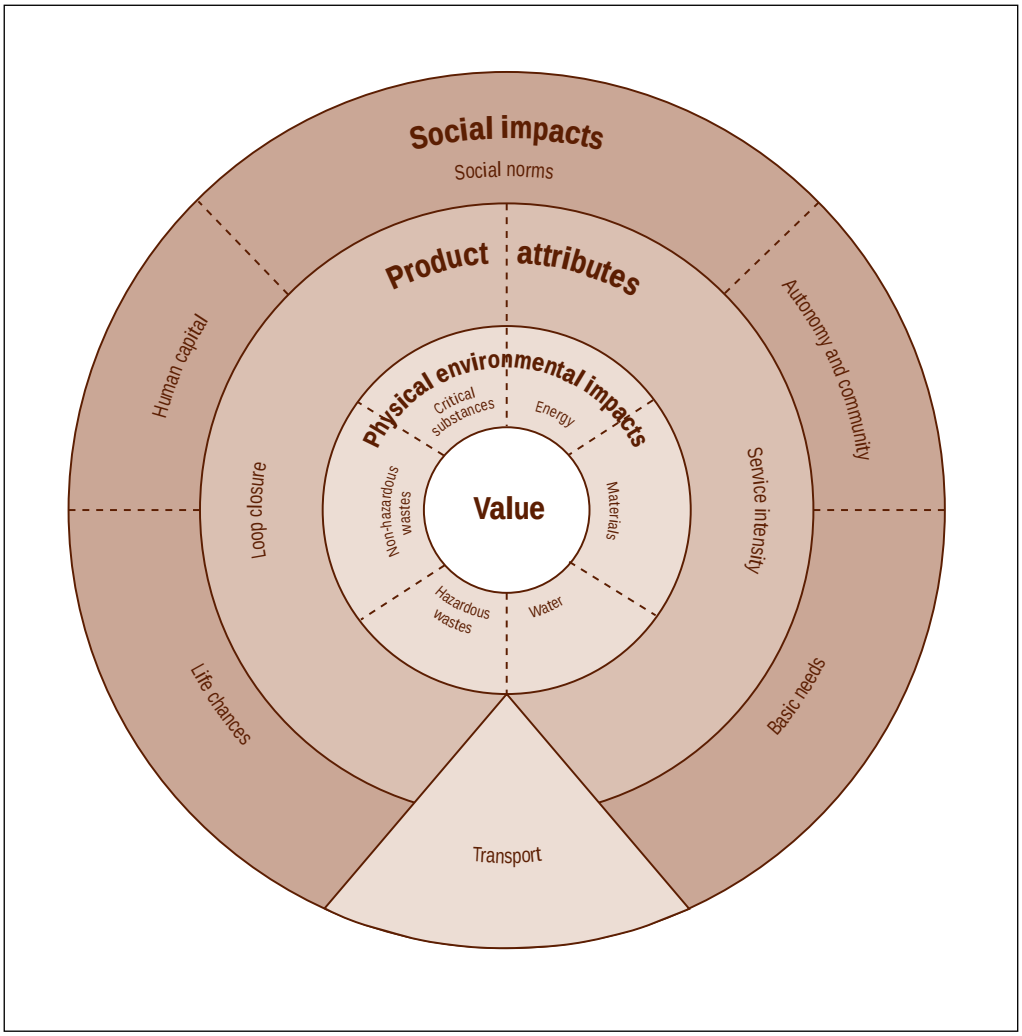


Figure 1: The Sustainability Circle

between different products or product variants and, with some explanation, in communicating environmental effects to customers and other interested parties. It can also – when used as part of a workshop process – generate ideas for attention in the product design and development process. However, one problem is that it requires reasonably complete LCA data and also that scoring some of the dimensions which have qualitative elements can be difficult.

## The Sustainability Circle

The implication of the previous discussion is that we need environmental evaluation tools which can encompass – but have clear transparency between – both quantitative and qualitative information. There is also a need for what might be called 'traffic light' assessments which present information in terms of a few states rather than in highly complex forms or ones which are summarised into a single number (see Figure 1).

We also need tools to take into account the social dimensions of sustainability, which neither eco-points or eco-compass do.

This section presents such a model, which synthesises and builds on the approaches discussed above, and particularly those of WBCSD and Dow. It is structured into four rings, covering:

- customer value
- physical environmental impacts
- product attributes
- social impacts.

Each of the rings has a number of elements within it.

**Customer value**

Customer value is at the centre of the circle as it the central aim of all product development. Often environmental product evaluation will take value creation as given and find ways of reducing the environmental impacts needed to deliver this value. However, as Claude Fussler and others have argued, there are often opportunities to develop new sources of customer value through eco-innovation processes and it is important to consider opportunities to do this when all the elements of the wheel are being considered.

**Physical environmental impacts**

The second layer is that of primary or physical environmental impacts – ie. those which can be quantified through the use of LCA techniques. Three of these relate to inputs – energy, materials and water – and three to outputs – hazardous substances and radiation, non-hazardous wastes and environmentally critical substances such as chloroflurocarbons (CFCs) or carbon dioxide ($CO_2$).

One option within this layer is to use eco-points to provide an aggregate measure of impacts. However, care must be taken that issues not addressed in most eco-points schemes – such as depletion of resources or land-take – are not ignored.

**Product attributes**

The third layer is the attributes of products which are major determinants of the physical environmental impacts of the product itself and/or society as a whole. Although their effects will usually – although not inevitably – show up in life cycle data, their importance is such that they are worth considering in their own right.

Three broad kinds of product attributes can be identified:

- transport – the total use of transportation over the life cycle
- revalorization or loop closure – the extent to which the product can itself be recycled, reused or remanufactured or can use recycled, reused or remanufactured inputs or components
- service intensity – the provision of additional service to customers in ways which potentially reduce environmental impacts.

Service intensity is an all-embracing category and there are in fact six significant ways of achieving it, for example:

- product substitution – eg. 'video by wire', in which a provider of an entertainment service delivers films by wire to final consumers rather than through cassettes.
- use intensity – increased use of a single product, and when two or more people share use of a single vehicle. This can be facilitated by introducing new features, such as meters which monitor levels of individual usage.
- life extension – for example, by making artefacts more durable or using modular design so that key components can be replaced. This can facilitate leasing of products rather than their sale.
- product augmentation – which involves addition of new features to facilitate a service. An example is installation of on-board computerised monitoring to vehicles to provide more data to providers of maintenance services.
- multi-functionality – so that they meet several different needs simultaneously.
- product integration – products meeting different functional needs can be integrated with each other to optimise their environmental and, sometimes, functional performance. In the case of buildings, for example, integration of heating, insulation, ventilation and other systems can reduce energy and materials consumption by avoiding over-sized equipment or preventing conflict between them – as when heating systems roar into action because excessive ventilation is occurring.

However, none of these measures automatically generate environmental improvement so judgements need to be validated by some kind of LCA. Making vehicles last longer, for example, reduces the energy and material requirements needed to build replacements but also foregoes the much lower levels of emissions which new models tend to have.

**Social impacts**

The fourth layer is attributes of the product which have significant social impacts. The Brundtland Commission defined sustainable development as being about social equity as well as environmental protection, on the grounds that the latter can't be achieved without the former. The detailed blueprint for achieving it is Agenda 21, which came out of the 1992 Rio Earth Summit. There's still much discussion about what exactly it involves but its broad parameters are clear:

- economic development will continue but will have to be based on sustainable production and consumption – which in turn requires new kinds of goods and services
- a considerable reduction in the environmental impacts of human activity
- a more equal world, with less of a disparity between rich and poor countries or men and women
- meeting the basic needs of the quarter of the world's population who lack adequate food, health care, clean water, sanitation and shelter
- building strong local communities.

Dealing with these and other social issues at the design level is difficult. There is often a lack of knowledge about social impacts, which will be complex and often occur only some time in the future. For this reason, quantified data may be difficult or impossible to obtain. In addition, products are designed for specific contexts and it may be inappropriate or futile to assess them against universal criteria. In many cases, assessment can only be about whether there are gross violations of the social conditions for sustainability. Finally, the social arena contains many different points of view and there will be seldom be consensus. This often means that there is no single 'right answer' and that the main objective is simply to recognise that there are different points of view and to violate as few as possible.

Nevertheless, the centrality of social issues to sustainable development and public concerns – and the risk of making serious mistakes in the field – is such that they have to be addressed. Condensing these social considerations into a few key issues is difficult but practical experience suggests that five elements cover most aspects:

- basic needs
- life chances
- social norms
- human capital
- autonomy and community.

As transport also has major social implications, this element is also incorporated into level four.

**Basic needs**

The people with the world's poorest life chances are the one billion plus who have inadequate food, shelter and other bare necessities of life. Their situation is so critical – and so central to successful sustainable development – that it needs to be considered explicitly. The reality of product development – which is undertaken primarily in and for richer countries – means that little can be said in many cases. However, at least gross problems can be identified and addressed and experience shows that innovative actions are sometimes possible.

**Life chances**

Equality is one of the more controversial aspects of sustainable development. However, it is generally interpreted as focusing more on equality of opportunity than of outcome and the creation of a situation where the poorer have greater 'life chances' – of employment, education etc. The same argument also applies to other groups which some have felt are disadvantaged – such as women and minorities. There will seldom be consensus about this but the key question is whether a product will accentuate existing disparities of life chances and, if so, what is being done to address it.

**Social norms**

New products or product-related actions can create emotional reactions and acquire a 'symbolic loading' through providing a tangible manifestation of broad trends or debates in society which challenge or impinge upon established or majority norms.

Hence, the disposal of Brent Spar resulted in a debate not only about the environmental impacts of the platform itself but also about the 'end of life' of all oil facilities and the broader acceptability of any kind of marine waste disposal. Advance consideration of the ways in which products might challenge or change societal norms – particularly those relevant to sustainability – is therefore essential.

**Human capital**

One controversial attribute of many new products and processes is that they require less human labour to operate than previous versions. Given the central – and problematic – nature of employment in most societies this is socially negative. However, experience shows that the additional wealth created by increased inefficiency creates employment elsewhere in the economy and also that in the medium-long term, new products can create new forms of employment to exploit and maintain them. Hence, whilst immediate labour effects are important, the key indicator is the overall effects of a product on knowledge, skills and other dimensions of human capital.

**Autonomy and community**

There is a widespread belief that many modern products and technologies threaten individual freedom and local community (which are themselves not always in harmony). Hence, it is important to check the effects of products on this. At an aggregate level, for example, BT recognises that through national and global connections, telecommunications could potentially undermine locally-based communities and therefore has a Community Networks section to identify ways in which this can be prevented.

## Scoring the elements

The purpose of evaluation is then to colour code each of the elements, based on a modified traffic light system. Five colours can be used:

- white – to denote an absence of information but no indications of serious sustainability problems
- red – to indicate serious sustainability problems
- amber – to denote question marks, caused by lack of crucial data and/or conflicting interpretations on questions which have environmental significance
- light green – some modest sustainability advantages
- dark green – major sustainability advantages, compatible with 'factor four' rates of improvement.

Such a scoring scheme provides clear and readily understandable distinctions even in the absence of full quantitative data. In particular, it quickly differentiates products with major problems or question marks (large arrays of red and amber) – on which more work needs to be done – from those without them, ie. largely green in colour.

One point to note is that level two – physical environmental impacts – would be expected to be green and, in some cases, white. Hence, any ambers or still more reds would be alarming. Another is that the Sustainability Circle allows for lack of consensus – such as over the elements of level four, on social impacts – to be taken into account by giving them an amber colour.

## Conclusions

Environmental product evaluation is always a 'trade off' between simplicity and complexity and all schemes therefore have inherent limitations. However, the Sustainability Circle can at least draw attention to key trends and issues with regard to both the environmental and social side of sustainability and provide a simple, but effective, means of assessing them which takes many of the strategic issues of sustainable product design into account. It can therefore complement more quantitative approaches such as the 'Eco-compass' or 'Eco-points'. •

## Footnote

This article is based on a longer Sustainable Business Centre working paper entitled 'Sustainable Product Evaluation'.

## References

Fussler C. and P. James, 'Driving Eco-Innovation' (London, UK: Financial Times Pitman, 1996).

# Special feature: O2 Netherlands

**Edited by Iris van de graaf de Keijser**

Co-founder of O2 Global Network and owner of KIVA Product Ecology, the Netherlands

**The Journal of Sustainable Product Design has developed a partnership with the O2 Global Network to further disseminate information and ideas on eco-design and sustainable product design. O2 Global Network is an international network of ecological designers. The O2 Global Network is organised into national O2 groups which work together to provide various services such as: O2 Broadcasts, which report live from O2 events using email and the Worldwide Web (WWW); O2 Text meetings, a meeting place on the Web; the O2 WWW pages, which provides an overview of activities; O2 Gallery, an exhibition of eco-products on the Web; and, an O2 mailing list.**

**For further information on the above activities and the O2 Global Network contact:**
**O2 Global Network**
**Tourslaan 39**
**5627 KW Eindhoven**
**The Netherlands**
**email: O2global@knoware.nl**
**tel/fax: +31 40 2428 483**
**internet: http:www.wmin.ac.uk/media/O2/O2_Home.html**

**'O2 News' will update readers of the Journal on the latest eco-design issues from around the world and on O2's national activities. In this issue O2's activities in the Netherlands are highlighted.**

## Eco-design update: news on eco-design projects from around the world

### Environmental product development at Delft University

In September 1992 the Faculty of Industrial Design Engineering at Delft University of Technology, the Netherlands, created a department of Environmental Product Development (EPD). EPD now includes twelve people working on education and research to stimulate and enhance environmental awareness in industrial product development. The EPD's major research areas are environmental design and product management; environmental load and use of consumer products; the development of systems and tools for re-use, re-manufacture and recycling.

*For further information contact:*
*Linda Roos*
*& +31 15 278 2738*
*email: L.Roos@TUDelft.NL*
*internet: http//www.io.tudelft.nl/research/mpo/index.html*

### UNEP Working Group on Sustainable Product Development (UNEP-WG-SPD)

UNEP-WG-SPD operates within the framework of the United

Nations Environmental Programme (UNEP). Its goal is to develop and implement the concept of Sustainable Product Development worldwide with special attention to developing countries. The centre has organised workshops, brokerage meetings, set up international co-operation and produced various publications. The network has more than 600 contacts in 55 countries.

*For further information*
*contact Hans van Weenan*
*& +31 20 525 6268*
*email: unep@unep.frw.uva.nl*
*internet: http://unep.frw.uva.nl*

**PROMISE manual: 'Ecodesign; a promising approach to sustainable production and consumption'**

The original Dutch 'Eco-design manual' has been revised and translated into English. The manual gives a practical seven-phase method to conduct eco-design. Furthermore, it includes information on eco-design strategies, optimisation of 'end of life' systems, Life Cycle Assessment (LCA) and, life cycle costing methods, green marketing, environmental problem description, environmental policies, information providers and literature references. The manual is illustrated with international eco-design examples and is published by UNEP. The cost of the manual is US$150 (ISBN 92-807-1631-X) and can be ordered from:

*SMI Distribution Services Ltd*
*PO Box 119*
*Stevenage*
*Hertfordshire SG1 4TP*
*fax: +44 1438 748844*
*email: anthony@SMIBooks.Com*

**Life cycle assessment (LCA) tools**

Four new LCA tools have recently been launched, which provide quick and efficient guidance on how to calculate environmental impacts:

- *Ecoscan 1.0* calculates impacts and costs.
  Prices: between DFL 845,- and DFL 995,-
  *Contact: Turtle Bay*
  *& +31 10 165 1178*
- *ECO-it 1.0* calculates environmental impacts based on the Eco-indicator 95 method, a one score rating system for products, materials and processes.
  Introduction price: DFL 360,-
  *Contact: Pre Consultants*
  *& +31 33 455 502222*
- *DfE* helps designers to construct for 'end of life' scenarios.
  Price: given on request
  *Contact: TNO industry*
  *& +31 15 260 8806*
- *EcoOffice* helps environmental coordinators calculate environmental impacts of office equipment, electricity, paper usage, transportation and other office issues.
  Price: DFL 500,-
  & +31 24 360 6600

**Dutch government programme 'Economy, Ecology and Technology' (ETT)**

The ETT programme aims to encourage technological innovations while still fulfilling the following economic, ecological and technological objectives of reducing industrial wastes, wastewater, emissions and energy from traffic systems; the integration of environmental considerations into the product development process; the use of renewable and sustainable energy. The call for proposals is open until Autumn 1997. Financial support is being provided by the Dutch government.

*For further information contact:*
*Mrs Smulders, ETT programme office*
*& +31 30 239 3683*

**Environment Awards for Industry 1997 & 1998**

Until 31 August 1997 European companies can apply for the National Environment Award for Industry 1997. This award scheme has individual awards for each European Union country. The national award winners can then be nominated for the European Better Award for Industry 1998, which will be presented June 1998, in Leeuwarden, The Netherlands. The European Award is organised by the European Commission's environment programme. The following categories are covered: ecological product design and development; clean technology; reuse or application of waste; environmental management systems in companies; and, partnerships in sustainable development.

*For further information contact:*
*Petra de Boer*
*t& +31 70 3837705.*

**White paper on 'Environment and Economy', the Dutch Ministry of Environment, June 1997**

In this White paper the Dutch Ministry of Environment focuses on technological development, balancing both environmental issues and economic profits. The paper will be followed by the third National Environmental Policy Plan (NEPP) from the Dutch Government.

Price: DFL 20,-
Code number: 14532/176 (Dutch language)
22566/210 (English language summary)

*For further information contact:*
*Distribution Centre*
*& +31 70 344 9449*

## O2 Focus: The Netherlands

*Diana de Graaf, member of the Board, O2 Netherlands*

Inspired by other European O2 groups O2 Netherlands was founded in 1993. O2 Netherlands has over 150 members and is continuing to grow. Evening lectures and workshops are held monthly on subjects ranging from 'Utopia and the environment' and 'Sustainable design and the third world' to 'New regulations on packaging' and 'LCA tools'. O2 Company, a section within O2 Netherlands, organises in-house company meetings to stimulate the involvement of designers. The O2 Expert Working Group invites O2 members, relevant specialists and policy-makers to develop and discuss new ideas on the topic of sustainable design and related concepts. For example, at a monthly meeting in May 1997 three O2 members presented various eco-design, R&D and design projects: a wind-up toothbrush; innovative uses for thermoplastic wood; and, an energy efficient crossroads signposting system (see Gallery section). Finally, O2 Magazine appears three times a year (only in Dutch) with articles which include technical information on environmental aspects of materials, as well as product examples and commentaries.

*For further information contact:*
*O2 Global Network*
*PO Box 519*
*3000 AM Rotterdam*
*The Netherlands*
*& +31 10 411 8102*
*fax: +31 10 4049495.*

# Books

**Green Design**
**Design for the Environment**
(second edition)
Dorothy Mackenzie
Laurence King, UK 1997
ISBN 1-85669-096-2
176 pages
Price: £19.95

This attractive book is a revised version of a 1991 edition, and clearly shows that the design world has changed immeasurably in that short time. There can be few major manufacturers who do not now recognise their need to improve the environmental performance of their wares, even if they are not (yet!) bound by regulations requiring it. Major corporations are competing with one another to out-green their rivals with resource-efficient, environmentally sensitive buildings and target-setting corporate environmental reports.

To support this 'green' trend a new breed of designers is needed. They must have an understanding of the impacts of their work, and know how to address the issues raised. They must be able to defend their decisions on raw materials, energy consumption, durability and disposal. Design is no longer simply a way to improve product appearance and performance: now designers must care for the environment as well.

After the book's introductory chapter on the role and responsibility of the designer, a scene-setting chapter provides the background to environmental issues. In just thirteen pages, the author has attempted to summarise some of the most difficult facets of the designer's decisions vis-a-vis the environment. There are inherent conflicts between, for example, designing to minimise resource use and design for recycling. If environmental protection is to be the driving force, it is short-sighted to pander to a public's espousal of recycling (despite the fact that many never *actually* recycle) in product design without assessing whether that confers greater benefit than using less materials, even though the chosen materials may not ultimately be recyclable. Balancing such conflicts can be simplified – if not resolved – by the cradle-to-grave, or life cycle approach, which is briefly described.

The book is then divided into five sections which cover architecture and interior design; product design; packaging; print and graphic design; and textiles. Each of the five sections ends with a selection of case studies derived from all over the world, offering practical real-life examples of good design saving resources and reducing environmental impact.

Rather than taking the high moral ground, this excellent book adopts a pragmatic and businesslike approach as the following quote demonstrates:

'There is little point in producing environmentally sensitive solutions if they are too expensive, inconvenient or unattractive for any one to want to buy and use them. There is no reason why designing for minimal environmental impacts should produce drab, poor-quality results which give satisfaction only through guilt reduction.'

An invaluable starting point for young or aspiring designers, the book will equally inspire many established designers, while anyone who commissions design would have a better understanding of the breadth of the designer's role having read it. Nor should owners of the first edition be deterred from purchasing this one, as the text has been extensively revised and updated and there are a number of new case studies.

*Maggie Thurgood is a freelance writer and editor specialising in environmental issues. She is a consultant to the World Health Organisation and a member of the International Energy Agency's Integrated Solid Waste Management Group, UK.*

**A Manager's Introduction to Product Design and the Environment**
Larissa Barrett and Edwin Datsenefski (eds.)
The Environment Council & Centre for Environmental Strategy/ The Environment Council, UK, 1997
ISBN 0 903158, 77 9
17 pages, £20.00

Called 'A Manager's Introduction to Product Design and the Environment' and authored by a University of Surrey team (including the Professor Roland Clift) this concise seventeen pager, published by The Environment Council encourages designers and developers to think using the generally accepted Life Cycle Assessment (LCA) approach (which considers the environmental impacts of products, materials and services, from raw materials extraction through manufacture and use to final disposal).

The team of authors call this approach 'Design for Environment' or 'DfE' for short.

DfE aims to show that paying attention to the environmental dimension, during the design of products and services, can help companies improve resource management, increase productivity, enhance environmental performance and still win competitive advantage.

The publication's contents are focused under five principal headings:

- Design for Environment (DfE)
- DfE in action
- Strategies for DfE
- Implementing DfE
- Integrating DfE into the business.

Under the first heading the authors thankfully avoid the common environmentalist's mistake of believing that designing a greener product means that the world will beat a path to its creator's door. Instead they correctly focus on satisfying consumer needs, but challenge develops to meet these with less environmental cost.

'DfE in action' stresses that environmental protection (I would have preferred to call this environmental quality) does not have to cost money but often delivers real business benefit. A number of product and service related examples are given of how companies have reduced materials use, substituted better materials, improved recyclability, functionality and manufacturing processes – often with multi-million pound savings.

'Strategies' discusses how DfE can help extend product or material life, reduce material use, improve energy efficiency, minimise pollution and maintain ecosystems. As these are often key to the consumer in making value judgements, this focus is consistent with better meeting needs.

'Implementing DfE' looks at the design process, product strategy, development and specification and describes a number of analytical and environmental management tools (with emphasis on the Materials, Energy and Toxic Emissions matrix) which can be brought to bear, particularly at the design stage.

Finally, while 'Integrating' suggests that life cycle thinking can be successfully brought into corporate strategy it realistically acknowledges that value judgements will also need be taken to balance environmental wants against commercial objectives.

The Environment Council sees the DfE approach as an important first step in widening the appeal of its major reference resource 'The Business and the Environment Programme' handbook and say feedback on the publication has been excellent. I agree. As the environmental agenda progresses, the need for key managers to be environmentally literate and responsible grows steadily.

Mild criticism of DfE is that it is perhaps too laid back in its approach; perhaps failing to suggest sufficient confrontation. Let me explain. Designers and developers have a difficult job in trying to satisfy consumer needs while meeting client marketing, manufacturing, financial and timing pressures – and can push environmental considerations to one side, unless they are forcefully positioned.

Persuasion is sometimes not enough and the development paradigm may need be energetically challenged through questions like 'Can we design 1 million tonnes of waste out of our manufacturing processes?, 'What would it mean to our competitive positioning if we used 90% less of the packaging per sales unit compared to major competition?', 'Could we get the consumer to more readily accept this design change if we explained its environmental benefits?' or even 'Will this meet regulatory and consumer needs towards the end of the product's marketing life?'

Companies face two choices, 'business as usual' or embrace innovation and entrepreneurship to outsmart competition. DfE is certainly not 'business as usual'.

*Paul Rutherford, Environmental Quality Manager, Proctor & Gamble Technical Centres Ltd., UK.*

**Managing eco-design online conference, Textiles, design and environment online conference, Sustainable Product Design online conference**

‰ The Centre for Sustainable Design
The Surrey Institute of Art & Design
Falkner Road
Farnham
Surrey GU9 7DS
UK
& +44 (0)1252 732229
fax +44 (0)1252 732274
email: cfsd@surrart.ac.uk

6-8 August 1997

**Green engineering for a difference**
Pennsylvania, US

‰ Akhelsh Lakhtakia
The Pennsylvania State University
227 Hammond Building
University Park
PA 16802-1401
US
& +1 814 863-4319
fax +1 814 863 7967
email: ax14@psu.edu

13 August 1997

**The 1997 packaging waste regulations: what must companies do and how can they do it**
Oakham, UK

‰ Jackie Epps
Commerical Seminars
The White House
17 Burley Road
Oakham
Rutland LE15 6DH
UK
& +44 (0) 1572 757751
fax +44 (0) 1572 757752

19–21 August 1997

**11th ICED – International conference on engineering design**
Tampere, Finland

‰ Tampere University of Technology
PO Box 300
FIN 3T101
Finland
& +358 3 365 2441
fax +358 3 65 2164
email: iced.info@ruuvi.me.tut.fi

24–27 August 1997

**The Humane Village – 20th Congress of the ECSID**
Toronto, Canada

‰ Design Exchange
Humane Village Congress Secretariat
PO Box 18
234 Bay Street
Toronto Dominion Centre
Toronto
Ontario M5K 1B2
Canada
& +1 416 216 2124
fax +1 416 368 0684

25–29 August 1997

**Course on cleaner production and sustainable product development**
Amsterdam, The Netherlands

‰ The Amsterdam-Maastricht
Summer University
PO Box 53066
1007 RB Amsterdam
The Netherlands
& 31 20 620 0225
fax 31 20 624 9368
e-mail: asu@gn.apc.org

28 August 1997

**Results of the O2 expert working group**
Rotterdam, The Netherlands

‰ O2 Netherlands
PO Box 519
3000 AM Rotterdam
The Netherlands
& +31 10411 8102
fax +31 1040 9495

September 1997

**Environmental polices in Europe: towards sustainability?**
Manchester, UK

‰ Elaine White
ERP Environment
PO Box 75, Shipley
West Yorkshire BD17 6EZ
UK
& +44 (0)1274 530408
fax +44 (0) 1274 530409

10–16 September 1997

**ENVASE '97 – 5th international packaging exhibition**
Buenos Aires, Argentina

& +54 1957 0350/0940/2576
fax +54 1 9561368

18–19 September 1997

**Business strategy & the environment conference**
Leeds, UK

‰ Elaine White
ERP Environment
PO Box 75, Shipley
West Yorkshire BD17 6EZ
UK
& +44 (0) 1274 530408
fax +44 (0) 1274 530409

18–21 September 1997

**ECOTECH II conference**
California, US

‰ Janice Whitacre
email: jwhitacre@acotech.org

23–26 September

**ECOMEX '97/Enviro pro expo – international trade fair for environmental technology & recycling**
Mexico City, Mexico
& +49) 89 5107 196
fax +49) 89 5107 341
email: info@messe-muenchen.de

25 September 1997

**Graphic design & environment**
Rotterdam, The Netherlands

‰ O2 Netherlands
PO Box 519
3000 AM Rotterdam
The Netherlands
& +31 10411 8102
fax +31 10404 9495

29 September – 3 October 1997

**ISWA '97 Conference – towards sustainability: opportunities & challenges**
Wellington, New Zealand

& +64 4 801 3751
fax +64 4 801 3003
e-mail: auty_v@wcc.govt.nz

14–16 October 1997

**Partnerships in power for the next millenium – Asia-Pacific initiative conference & exhibition for renewable energy & energy efficiency**

Jakarta, Indonesia

& +852 2574 9133
fax +852 2574 1997
e-mail: office@adal.comm

15–17 October 1997

**Design for the environment short course 'managing change in product development'**

Guildford, UK

‰ S Hodgson
Centre for Environmental Strategy
University of Surrey
Guildford GU2 5XK
UK
& +44 (0) 1483 259047/ 259043
fax +44 (0) 483 259521/ 259394
email: s.hodgson@surrey.ac.uk

19–29 October 1997

**Cleaner production international workshop on approach, methodology & practice**

Cali, Colombia, South America

‰ Professor Guspavo Bolanos
Department of Chemical Processes
Bel Valle Universitab
P.O. Box 25 C60
Cali, Colombia, South America
& +57 2339 1235
fax +57 2339 2335
e-mail: cleaprod@mafalda.univalle.edu.co

30 October 1997

**Products & environmental management systems**

Rotterdam, The Netherlands

‰ O2 Netherlands
PO Box 519
3000 AM Rotterdam
The Netherlands
& +31 10 411 8102
fax +31 10 404 9495

31 October 1997

**Managing eco-design: 2nd International conference**

London, UK

‰ Martin Charter
The Centre for Sustainable Design
The Surrey Institute of Art & Design
Falkner Road
Farnham
Surrey GU9 7DS
UK
& +44 (0)1252 732229
fax +44 (0)1252 732274
email: cfsd@surrart.ac.uk

27 November 1997

**Wave of factors: reduction factors for sustainability**

Rotterdam, The Netherlands

‰ O2 Netherlands
PO Box 519
3000 AM Rotterdam
The Netherlands
& +31 10411 8102
fax +31 10404 9495

27 November 1997 and March 1998

**What will new packaging legislation mean to your business: packaging waste alert seminars**

Surrey, UK

‰ Jackie Warton
Training Group
Pira International
Randalls Road
Leatherhead
Surrey KT22 7RU
UK
& +44 (0) 1372 802047
fax +44 (0) 1372 802243
email: training-service@pira.co.uk

5–8 December 1997

**The Design and Environment Conference**

Canberra, Australia

‰ Catalyst '97 Conference
University of Canberra
PO Box 1
Belconnen ACT
2616
Australia
& +61 6 201 5754/61 6+ 201 2178
fax +61 6 201 2279/61 6+ 201 5034
email: cat97@design.canberra.edu.au.

# Contributor guidelines

*The Journal of Sustainable Product Design is targeted at Environmental directors, managers, Design managers, Product designers, Academics and Environmental coordinators in local and central government worldwide.*

## Submissions

Three copies and a 3½" Macintosh – or IBM compatible disk should be sent to:
Martin Charter or Anne Chick
The Journal of Sustainable Product Design
The Centre for Sustainable Design
Faculty of Design
The Surrey Institute of Art & Design
Falkner Road
Farnham
Surrey GU9 7DS
UK.
Email submissions should be sent to: cfsd@surrart.ac.uk.

A black and white photograph of the author(s) should be supplied.

## Presentation

Articles submitted to the Analysis section (peer reviewed) should be between 2,500–5,000 words. Shorter articles of 1,000–1,500 words are also requested for for the Case Study and Innovation sections. Manuscripts should be typed in journal style, double spaced (including footnotes and references) with wide margins, on one side only of good quality A4-size paper.

Manuscripts should be arranged in the following order of presentation.

**First sheet:** Title, subtitle (if any), author's name, affiliation, full postal address and telephone, fax number and email. Respective affiliations and addresses of co-authors should be clearly indicated. Please also include approximately 100 words of biographical information on all authors.

**Second sheet:** A self-contained abstract of up to 150 words summarising the paper and its conclusions.

**Subsequent sheets:** Main body of text, footnotes, list of references, appendices, tables (on separate sheets), and illustrations.

Authors are urged to write as concisely as possible. The main title of the article should be kept short, but may be accompanied by a subtitle. Descriptive or explanatory passages, necessary as information but which tend to break the flow of the main text, should be expressed as footnotes or appendices.

**Bibliographic references:** All bibliographical references should be complete and comprising of authors and initials, full title and subtitle, place of publication, publisher, date, and page references. References to journal articles must include the volume and number of the journal. The layout must adhere to the following convention:

Author, A., and B. Author, 'Title of book: Subtitle' (Place of publication: publisher, date), pp.xx–xx. or

Author, A., and B. Author, 'Title of Journal Article: Subtitle', in Journal, Vol.x No. x (January 19xx), pp. xx–xx.

These should be listed, alphabetically by author surname, at the end of the article.

If referring to works in the main body of the article, please use the 'short title' method in parentheses.

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### Copy deadlines

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