Sustainability and Environmental Issues in Industrial Product Design

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ABSTRACT

The main purpose of this thesis is to examine the every aspect of industrial design from the view point of the sustainability. In traditional terms, the concern of the designer has ended with the launch of the product, but the environment-conscious designer should think about its complete life. To develop products in a sustainable way, the designer must be able to assess which design solution is better from the environmental point of view.

The basic aim of this study is to help designers to comprehend the features of 'Sustainable Product Design'. In other words, this thesis aims, together with considering environmental issues, to determine the basic changes occuring in design process and to lead the designer in the light of these principles.

One of the main purpose of chapter 2 is to examine the every aspects of industrial product design from the sustainable point of view.

In chapter 3, the changing design process is analysed by considering many specific examples which help us to comprehend the 'Sustainable Product Design Process'.

In chapter 4, the main environmental issues (such as global warming, water pollution, waste and noise etc...) are analysed to indicate that how industrial products affect the environment. In this chapter, there are three main sectors which are specific from the environmental point of view are selected to examine, such as electrical & electronic products, packaging and furniture products. All sectors are completely considered in specific examples to understand the relationship between the environmental issues and product design. Finally, the thesis include a case study in accordance with sustainable design context and using appropriate materials.

Keywords : Sustainability, sustainable design, product, environment, recycling.

ÖZ

Bu tezin ana amacı, endüstriyel ürün tasarımının, tüm yönleriyle ve sürdürülebilirlik bakış açısı içerinde ele alınmasıdır. Geleneksel süreçte, tasarımcının ürünle olan ilişkisi ürünün kullanım dışı kalmasıyla sona ermekte iken, çevre-bilinçli tasarımcı ürünün tüm yaşam döngüsü hakkında düşünmek zorundadır. Ürünlerin sürdürülebilirlik ilkeleri içerisinde geliştirilebilmesi için, tasarımcıların, hangi tasarımsal çözümlerin bu bakış açısı yönünden daha uygun olacağına karar verebilmeleri gerekmektedir.

Bu çalışmanın asıl hedefi, tasarımcılara, 'Sürdürülebilir Ürün Tasarımı' nın tüm ilkelerini kavramada yardımcı olmaktır. Bir başka deyişle, çevresel süreçlerin gözönüne alınmasıyla birlikte, tasarım sürecinde meydana gelmesi beklenen temel değişiklikleri saptamak ve tasarımcıya bu ilkeler doğrultusunda yol göstermektir.

Bölüm 2' nin ana amacı, endüstriyel ürün tasarımının temel ilkelerinin sürdürülebilirlik bağlamında ele alınmasıdır.

Bölüm 3'de, sürdürülebilirlik kavramıyla birlikte değişen tasarım süreci, birçok örnek gözönüne alınarak analiz edilmiştir.

Bölüm 4'de, endüstri ürünlerinin çevreye etkilerinin tespit edilebilmesi amacıyla, çevresel faktörler ve endüstri ilişkisi ayrıntılı biçimde analiz edilmiştir. Bu bölümde, çevresel bakış açısı içerisinde üç ana sektör ele alınmıştır.

Sonuç olarak, tez, sürdürülebilirlik ilkelerine bağlı kalınarak tasarlanmış ve bu kavrama uygun malzeme kullanılarak gerçekleştirilmiş mobilya tasarımını içermektedir.

Anahtar kelimeler: Sürdürülebilirlik, sürdürülebilir tasarım, ürün, çevre, geri dönüşüm.

LIST OF FIGURES

Chapter 2

Chapter 3

Chapter 4

LIST OF TABLES

TABLE OF CONTENTS

CHAPTER III

3. SUSTAINABLE PRODUCT DESIGN PROCESS

CHAPTER IV

4. ENVIRONMENTAL ISSUES AND PRODUCT DESIGN

CHAPTER I

INTRODUCTION

1.1. DEFINITION OF THE PROBLEM

The concept of sustainability is becoming increasingly important all over the world. Governments, communities and industries are all working to prevent pollution and over-consumption from ruining the planet and the natural resources we all rely on. There is an urgent need to make all industrial products and processes 'sustainable', and also good for people and planet.

Products are the source of all environmental problems. Major issues such as pollution, deforestation, species loss and global warming are all side-effects of the activities that provide consumers with endless consumer goods on the market today.

Designers have a crucial role to play in achieving a more sustainable economic and social order, and they must ensure that by providing solutions to one set of environmental problems they are not increasing others. Moreover, designers are masters of elegance, style and functionality. Traditionally issues considered in design have related only to function, appearance and financial concerns, but in recent years, designers and consumers have started to look beyond pure surface.

Sustainable design considers some of the harder questions collectively, such as need, equity, ethics, social impact and resource efficiency and thus, the role of design in achieving inter-generational equity. It is also intended to develop more environmentally benign products and processes. Unfortunately, in many past situations environmental effects were ignored during the design stage for new products and processes. However, change for any existing products is difficult.

Sustainable design seeks to convert global and regional socio-environmental concerns into products and services at the local level. Product design is an environmental focal point, because design decisions directly and indirectly determine levels of resource use and the composition of waste streams. Environmental regulations and consumer pressure are forcing manufacturers to become more responsible for the safe disposal and recycled of used products.

Design can have an impact upon the environment in many different ways; through the extraction of raw materials; through the design of the manufacturing process, how the product is used and distributed and what happens when the product reaches the end of its useful life.

Today, small numbers of products are becoming available that have a "total beauty" about them. So, from the cradle of raw materials production to their end of life has been designed to minimise environmental and social impact. Although designers have a crucial role to create a sustainable products and solutions for the earth, radical changes in behaviour and reductions in consumption will be essential. Consumption will always continue, and it is, therefore, legitimate to attempt to make its impact as minimal as possible. Consumer demand can be a key driving force for the development of more environment-friendly products.

The consumers of the future must be extremely concerned about environmental issues and they are supposed to be far more knowledgeable than many of their elders. In this case, the development of environmental labelling aimed at changing behaviour will also encourage consumers to look increasingly for sustainable products in the future.

Another crucial point is sustainable marketing. Market pressure is playing a major role in encouraging changes in industrial behaviour. Many marketers now know that having the environmental innovation brings competitive advantage in the market place. Designing for sustainable markets does not invalidate the traditional criteria for good design, but it leads to some demands in which new considerations are also taken into account.

Considering environmental issues, designer's responsibilities will become more difficult and more important than before. Designer was in a powerful position, able to help create a better world by considering environmental issues and creating environmental process and products. Designers already have to consider a wide range of criteria as part of the design process; marketing, production, financial and technical considerations have to be included. Compared with these, environment considerations could be even more complex. Because, it is difficult to be aware of all the environmental issues which surround design decisions. In addition, it is difficult to find detailed information on the environment performance of alternative materials and processes.

Finally, when considering environmental issues in industrial design, the area of the designer's responsibilities are more extensive, than before. Thus, designers should aim to create a better design in a better way for the environment.

1.2. AIMS OF THE STUDY

The main purpose of this study is to examine the every aspects of industrial design from the view point of the sustainability. In traditional terms, the concern of the designer has ended with the launch of the product, but the environment-conscious designer should think about its complete life.

A well-designed product performs its function succesfully and is manufactured efficiently through the use of appropriate materials and techniques. In addition to these criteria, it is practical, is safe, and it offers good price and looks attractive. The relative importance of these criteria will vary from product to product.

New definitions of good design will include an environmental consideration. In this case, the vital problem is whether the product is designed to minimise the impact it has on the environment during the whole of its life cycle, or not. If we want to minimise the extent of environment problems, design and design process will have to change, because users and consumers of design and industry will have to change.

However, environmental issues are complex and can seem hard to deal with. Most environmental problems are caused by unintentional side-effects of the manufacture, use and disposal of products. Looking at products closely highlights the environmental problems they cause.

Environmental problems become an increasingly important aspect of the designer's work to minimise the risks arising from the failure of a product or process. Because of the rapid technological development, environmental problems increase every day. On the other hand, new technologies often tend to be less polluting and dangerous than what they replace, and hence designers may find themselves in the forefront of identifying problems which must be addressed by technology. Sometimes, existing technologies may not be able to provide the solution, and the designer may have to influence the development of a new technological approach. Designers must also follow technological developments in order to be sure of incorporating the most environmentally advanced technologies.

Designers can make a significant difference to the effect of a product because they are responsible for influencing the key decisions. These determine the choice of material; how long the product will last; how effectively it uses energy; and how easily it may be reclaimed and re-used. The aims of environment-conscious designer are to use the minimum resources throughout, to get the maximum possible use and value out of the least quantity of materials and energy, and to minimise pollution created during the manufacture and life of the product.

Designers have to balance these competing demands, and ensure that the product is both demandable and also environmentally acceptable. In addition, a designer must understand the basic relation between a product and the environment. To develop products in a sustainable way, the designer must be able to assess which design solution is better from the environmental point of view.

1.3. METHOD OF THE STUDY

Environmental product development requires some fundamental changes in approach by designers. Consciously or not, the design of products and processes is the main determinant of environmental impact. Design is the key intervention point for making radical improvements in the environmental performance of products. Designers must create a capability that goes far beyond visual appearance.

To develop products in a sustainable way, the designer must be able to assess which design solution is better from an environmental point of view. In this case, designer's responsibilities will become more difficult than before. The main purpose of this thesis is to help designers to comprehend the features of 'Sustainable Product Design'. In other words, this thesis aims, together with considering environmental issues, to determine the basic changes occuring in design process and to lead the designer in the light of these principles.

These are some features which are crucial to create a sustainable products and processes that are completely considered in this study. One of the main purpose of chapter 2 is to examine the every aspects of industrial product design from the sustainable point of view. First of all, the concept of sustainability is analyzed from the designers point of view. Because, product design is an important environmental focal point and design can have an impact upon the environment in many different ways. Traditionally issues considered in design have related only to function, appearance and financial concerns. As the decisions made by designers have a direct effect on the amount of raw material used, the amount of energy consumed and pollution produced by a product during its lifetime it is important that designers are given the right information and tools to enable them to minimise the effect their products on the environment.

Another significant point is, the consumption behaviours of the consumers. With a small effort, people can make a contribution to minimise damage. Radical changes in behaviour and reductions in consumption will be essential. Consumption will always continue, but it is possible to make its impact as minimal as possible. Market pressure is playing a major role in encouraging changes in industrial behaviour. The changes

required to make and market environmentally sensitive products in improved customer relations.

Many marketers now grow their businesses by addressing the specific environmental issues which are most relevant to their consumers. Not only the marketers, but also the designers use these strategies to create profitable new sustainable products to balance consumers needs with environmental consideration.

In chapter 3, the changing design process is analyzed by considering many specific examples which help us to comprehend the ‘ Sustainable Product Design Process’ . The inclusion of environment criteria as a main part of the design process will be one of the most important developments in the history of design. Thus, this will not only create new themes for design, but also give a new and more central role to the designer. Compared with traditional design, environmental considerations could be even more complex. There are also, some difficulties, for example; there are no clear answers, or information is hard to find. Designer must therefore expect to take considerable responsibility for asking the right questions, and raising the relevant issues. Designers are necessarily team workers, so they have never been able to work in isolation. There is an important need to consider environmental issues at an early stage in the design process which means a close partnerships with other disciplines. Designers must create a capability that goes far beyond visual appearance.

In this case, the answer of this question is important. “ Is the product designed to minimise the impact it has on the environment, during the whole of its life cycle? ” Environmental impacts occur at all stages of a product’s life-cycle. Different types of products have impacts at different stages of the life-cycle. Many products which used to be designed to last for years are now intended to have only a short lifespan. Disposability has been presented as a consumer benefit. Product life may be limited by changes in technology which make it obsolescent, or by changes in fashion or style. However, extending the life of a product is an obvious way of reducing waste. There are many different ways of achieving this, such as improving reliability and durability so that it lasts longer, and making it recyclable so that the materials used to create it can have an additional life in another form.

It is not always easy to see how individual decisions by designers affect global environmental problems. In chapter 4, the main environmental issues (such as global warming, water pollution, waste and noise etc.) are analysed to indicate that how industrial products affect the environment. In this chapter, there are three main sectors which are specific from the environmental point of view are selected to examine, such as electrical & electronic products, packaging and furniture products. All sectors are completely considered in specific examples to understand the relationship between the environmental issues and product design. Finally, the thesis include a case study in accordance with sustainable design context and using appropriate materials.

CHAPTER 2

SUSTAINABILITY AND PRODUCT DESIGN

2.1. The Concept of Sustainability

Sustainable Product Design, is intended to develop more environmentally conscious products and processes. The application of sustainable product design involves a particular framework for considering environmental issues and a challenge to traditional procedures for design and manufacturing. Unfortunately, in many past situations, environmental effects were ignored during the design stage for new products and processes.

The challenge of sustainable design is to alter conventional design and manufacturing procedures to incorporate environmental considerations effectively. So, this requires change in these existing procedures. However, change for any existing products and process is difficult.

Consequently we can advance general goals for a sustainable future:

- reduce or minimize the use of non-renewable resources
- manage renewable resources to insure sustainability;

reduce, with the ultimate goal of eliminating, toxic and otherwise harmful emissions to the environment, including emissions contributing to global warming.

"Sustainable design considers collectively some of the harder questions, such as need, equity, ethics, social impact and total resource efficiency and thus the role of design in achieving inter-generational equity. More specifically, sustainable design seeks to

translate and embody global and regional socio-environmental concerns into products and services at the local level. When a designer is immersed in the design process, trying to meet a client's expectations and to satisfy consumer desires, terminology can become peripheral." (Lewis, 2001)

Figure 2. 1. The Earth

The following is a palette of terms that in some way define or refer to **sustainable design**,

Design for environment
Ecological design
Environmental design
Environmentally oriented design
Ecologically oriented design
Environmentally responsible design
Socially responsible design
Environmentally sensitive product design
Sustainable product development
Green design
Life-cycle design
Dematerialisation
Eco-efficiency
Biodesign

A sustainable product or process can not be defined in any absolute sense, but only in comparison with other alternatives of similar function. For example, a product could be entirely made of renewable materials, use renewable energy, and decay completely at the end of its life. However, this product would not be green if, a similar product uses fewer resources during production and use, or results in the release of fewer hazardous materials.

"Developing and marketing sustainable products is a concrete step towards sensible resource use and environmental protection and towards sustainable economic development. Green products imply more efficient resource use, reduced emissions, and reduced waste, lowering the social cost of pollution control and environmental protection. Greener products promise greater profits to companies by reducing costs (reduced material requirements, reduced disposal fees, and reduced environmental cleanup fees), and raising revenues through greater sales and exports. Designing greener products offers much to the current generation, as well as providing future generations with a planet that will enable them to survive and prosper."
(www.ce.cmu.edu/greendesign)

2.1.1. The Features of Sustainable Design

The basic principle for a green world is, in a word sustainability. Designers have a crucial role to play in creating a more sustainable economic and social order, and they must ensure that by providing solutions to one set of environmental problems they are not creating or increasing others. This concept is vital to designers, who often have a critical influence over every aspect of a product's life, from manufacture and use to repair and disposal, and from the choice of materials and the efficiency with which energy is used to the length of the product's life and the effects of its disposal.

Designers are creators of elegance, style and functionality. But much of this elegance is only skin deep. Recent years, designers and consumers are starting to look beyond pure surface. For example, recognising that products for example may look beautiful, however can it really represent the creativity if these are made using polluting methods and materials?

Figure 2. 2. Nike shoe box needs no glue

Governments, communities and industry are all working to prevent pollution and overconsumption from ruining the planet and the natural resources we all rely on. To support this, there is an urgent need to make all industrial products and processes 'sustainable', good for people and the planet. Small numbers of new products are becoming available that have a 'total beauty' about them. So, their total life, from the cradle of raw materials production to their end of life has been designed to minimise environmental and social impact.

For every sustainable product there are thousands of products that have no environmental improvement. Most manufacturers eventually comply with the few laws that cover environment, taking the lead out of paint or make their packaging more recyclable. But this is only a little part of what needs to be done.

The goal of sustainable design is to make all products 100% cyclic, safe and renewable. So, the design of Sustainable Products is not conceptually difficult.

These are some principles that refer to **'Sustainable product design'** ;

- **Cyclic:** The product becomes more cyclic by making use of recycled paper, metal, glass or plastic, by becoming more recyclable, or both, and then by making use of grown materials such as wood, leather and wool, by becoming more compostable, or both.

Figure 2. 3. Bamboo bike

- **Alternative Energy in Use:** The product becomes more solar by using a renewable energy in use, sometimes by using solar-generated electricity.

Figure 2. 4. Clockwork toothbrush

- **Alternative Energy in Manufacture:** The product becomes more solar by using a renewable energy source for its manufacturing process.

Figure 2. 5. Urtekram shampoo made in wind-powered factory

- **Substitute Materials:** The product becomes safer as a result of toxic materials or components being substituted for safer ones.
  Example: Tungsten bullets (lead free)

- **Stewardship Sourcing:** The product becomes safer in the habitat preservation sense and also more social by getting raw materials from fairly-traded sources or low impact sources.
  Example: Dolphin and Albatross- friendly Tuna

- **Utility:** The product becomes more efficient by providing greater utility for the user, such as multifunction products or rented products.

Figure 2. 6. Black & Decker Quattro Drill / sander/saw/screwdriver

- **Durability:** The product becomes more efficient in materials usage as its lasts longer.

Figure 2. 7. Spacepen Millenium II
contains a lifetime's worth of ink

- **Efficiency:** The product becomes more efficient in its use of energy, water and materials, both in manufacture and use.

Figure 2. 8. SoftAir Inflatable Chair

- **Bio-everything:** The product becomes more cyclic, safe and renewable as a result of using living organisms or biomimcry techniques.

Figure 2. 9. Foxfibre naturally coloured cotton

- **Communication:** The product communicates information that leads to a better environmental performance, usually by changing the behaviour of users.

Figure 2. 10. Plastic labelling to aid recycling

Product design is an important environmental focal point, because design decisions directly and indirectly determine levels of resource use and the composition of waste etc. Because product design encompasses the most crucial decision making activities of companies, the consideration of environmental objectives by designers could have important competitive implications. So, design can have an impact upon the environment in many different ways: through the extraction of raw materials; through the design of the manufacturing process; in how the product is used and distributed, and in what happens when the product reaches the end of its useful life.

Figure 2. 11. Picnic table made from old recycline toothbrushes

2.1.2. Design for the Environment

In recent years the information on 'Design for the Environment' has greatly increased allowing designers to gain some understanding of the subject. In this case, these are some aspects which should be included in design for the environment;

- manufacture without producing hazardous waste
- use of clean technologies
- reduce product chemical emissions
- reduce product energy consumption
- use of non-hazardous recyclable materials
- use of recycled material and reused components
- design for ease of disassembly
- product reuse and recycling at end of life
- Encourage the user to minimise environmental damage when using the product
- Facilitate long life by simplifying repair and upgrading

(www.co-design.co.uk/design.htm)

Figure 2. 12. Cardboard school in England

Figure 2. 13. VEG Tuning convert vehicles to run on vegetable oil

These aspects can involve in the design analysis. Design for the Environment can therefore be divided into main parameters for design;

- **Process design** : Process design focuses on the reduction of energy consumption and the minimisation of wastes and pollution processes.

- **Material design** : Material design is concerned with the selection and use of raw materials to minimise; hazardous wastes, amount an type of pollution emitted, and total amount of materials required.

- **Energy consumption design** : Energy consumption design is the selection of materials and processes which results in a reduction of the product's energy requirement when been manufactured or used. In recent years, many designers and companies are introducing the 'Design for the Environment' principles into their product designs.

Design for the Environment

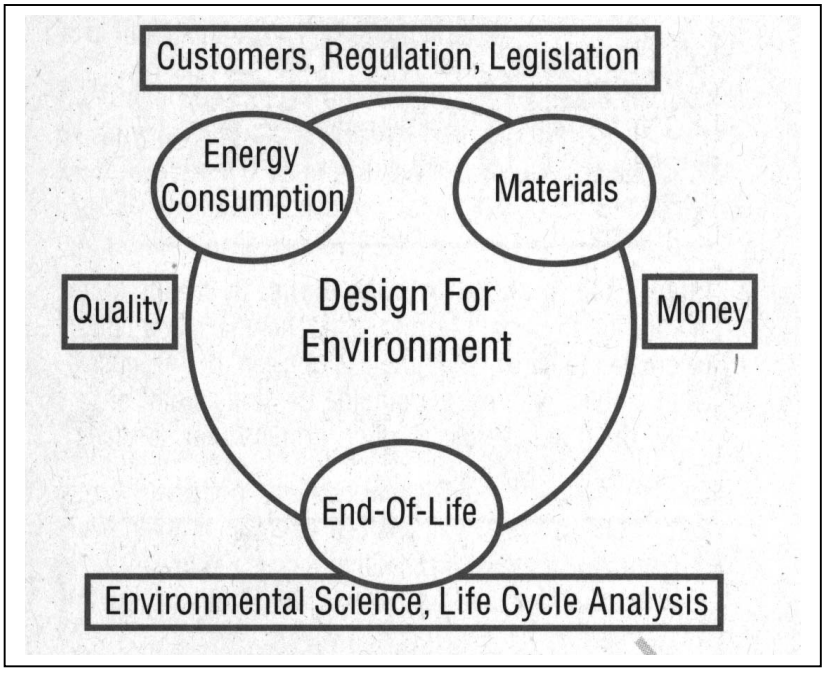


Table 2.1. Design for the Environment (Delft Green Back, May 1996)

Environmental regulations and consumer pressure are forcing manufacturers to become more responsible for the safe disposal and recycled of used products. This requires a new approach to product design, one which results in a product designed for all stages of its life cycle. Traditionally issues considered in design have related only to function, appearance and financial concerns. As the decisions made by designers have a direct effect on the amount of raw material used, the amount of energy consumed and pollution produced by a product during its lifetime it is important that designers are given the right information and tools to enable them to minimise the effect their products on the environment.

2.2. The Role and Responsibility of the Designer

The idea that designers should take into consideration the environment impact of their work is not new. Designer was in a powerful position, able to help create a better world by considering environmental issues and creating environmental process and products. In addition to that, rising public concern is being translated into action in many countries. For example, people are demonstrating their feelings through their preferences, by changing their behaviour to accommodate recycling or energy efficiency, and by using environment criteria in their purchasing decisions as consumers.

Figure 2. 14. BMW R1 roofed scooter makes it easier for people to get onto two wheels..no helmet required

In this case, we need to know the answer of some questions, for example; ‘ Are designers equipped to respond to the new demands which will arise from these changes?’ Unfortunately, the answer is no, as it must be for almost all professionals educated without reference to the environment impact of their activities. In most places, design has not been taught in the context of its social and ecological impact. So, many designers assume that their area of responsibility is limited to function and appearance. But, there is an opportunity for designers to show imagination and leadership, pioneering the way forward and solving real problems.

For many years, designers have been asserting their influence and demonstrating the power of design. The new demands of designing for minimum ecological impact will provide an ideal platform from which designers acknowledge their responsibilities. So, there is a crucial question that why should so much responsibility fall to the designer? Because, design is one part of a whole process, which involves a wide range of other skills. However, design is a pivotal part of the process.

Many environmental problems are caused by the pollution which results from the production and use of products and services, especially mass-produced products. Most products and services use natural resources, many of which are irreplaceable. The method by which raw materials are extracted from the earth can cause local environmental problems. The manufacturing process itself uses energy, creates waste, and may result in harmful by-products. Many products have a significant effect on the environment when in use, and finally ,the product may be disposed of, causing another set of problems.

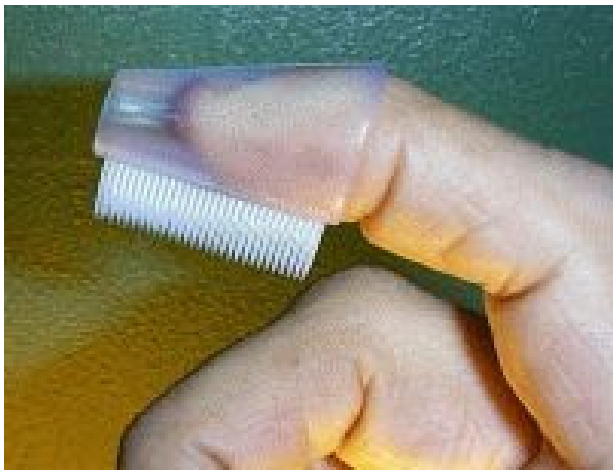


Figure 2. 15. The World's Most Minimal Toothbrush

The designer has a direct influence on the amount of damage which will occur at each stage in the process. For example, what materials will be used, and from where will these be obtained ? How will the product be manufactured ? How will the product be used and disposed of ? Is it designed to be easy to repair, or to be thrown away ? If it is to be disposed of, can parts of it be reused or recycled? So, designers are in a position to determine many of these issues. In this case, designers also influence environment impact indirectly through their role.

The role of designers as the link between the manufacturing process and the customer, between technical and marketing requirements, has given them a central position in many companies in area such as new product development.

Designers must demonstrate an ability to take on the complex and challenging issues which surround designing for minimum environment impact. This will require a willingness to undertake thorough research before starting the design process, and an understanding of environment issues and the ability to know where to look for guidance. In addition to that, some technical understanding of the production process and of the properties of materials will also be essential for the environment-conscious designer.

Figure 2. 16. Definity phones by AT&T designed for disassembly

Environmental impacts occur at all stages of a product's life-cycle. Different types of products have impacts at different stages of the life-cycle. For example, for furniture the raw materials and final disposal include most of the environmental impacts, and for energy-consuming products such as household appliances the use of the product includes most of the environmental impact. However, no matter where in the product life-cycle the impact lies ,most of the impact is locked into the product at the design stage when materials are selected and product performance is determined.

Figure 2. 17. Metamorf chair from recycled plastic

Working alone, the designer's environmental role is limited; in combination with other disciplines, the designer emerges as a critical player in ensuring that a diverse and sometimes conflicting range of issues and considerations are succesfully built into a product. It is completely the designer who creates the interface between the consumer and the technology underlying the shell or surface of a manufactured product.

We simply need to look around us, wherever we are, and note the almost infinite extend to which designers shape our physical and virtual worlds. It is ultimately the designer who gives form and meaning to objects that not only offer utility, function and convenience but also entertainment and visual pleasure. However, although a growing number of designers are acknowledging that they wish to be a part of the solution that is sustainable development, many designers and others involved in product development seem to feel restrained from having a positive environmental effect on the design process.

Recognising that the designer or the product development team can take practical action to shape, and model ideas and concepts into sustainable products, it must also be acknowledged that the goal is not to transform designers into environmental scientists.

Figure 2. 18. Dynamo and Solar Radio

Figure 2. 19. Eco flush ...set the flush level each time.

Usual definitions of good design already include criteria such as succesful performance, ease of use, safety, simplicity of maintenance, appropriate materials, efficiency of manufacture, attractive appearance and good for money. Designing for sustainable markets does not ignore the traditional criteria for good design, but it does demand that some are given different weightings and that new considerations are also taken into account. For example; the designer can no longer develop a product in isolation from the effects that the materials and production processes may have on the environment, or without thinking through the implications of eventual disposal.

2.2.1. The Basic Principles of Environmental Design

There are some basic principles which the environmentally aware designer should aim to:

- increase efficiency in use of materials, energy and other resources
- minimize damage or pollution from chosen materials
- reduce to a minimum any long-term harm to the environment caused by use of the product
- ensure the planned life of the product is the most appropriate in environmental terms, and if necessary that the product functions efficiently for its full life
- take full account of the effects of the end disposal of the product
- ensure the packaging, instructions and overall appearance of the product encourage efficient and environment-friendly use.
- minimize nuisances such as noise or smell
- analyse and minimize potential safety hazards

(Burall P., 1991)

Environmental product development requires some fundamental changes in approach by designers. Most important is the concept of product stewardship. Traditionally, designers have restricted their work to considerations affecting just a part of the lifecycle of a product: meeting the needs of the user and ensuring that a product can be manufactured efficiently have been the key aims.

The materials chosen by designer and manufacturer are crucial. For example, mining metal for cars creates atmospheric pollution, and uses oil and petrol, thus wasting natural resources that cannot be replaced. The designer's decision to use foam plastics to make cheap, throw-away food containers damages the ozone layer.

Figure 2. 20. Smart car easy upgrade

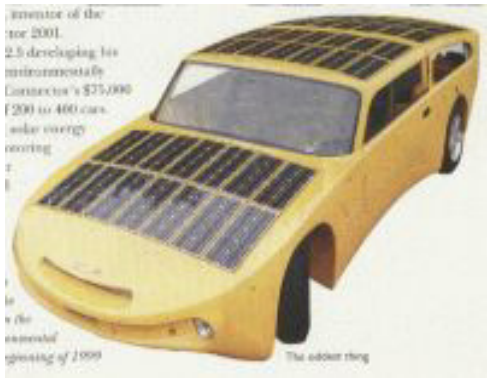


Figure 2. 21. Swedish solar car and

" The manufacturing processes of products is crucial. The questions facing the designer are: Is there anything in the manufacturing process itself that might endanger the workplace or the workers, such as toxic fumes and radio-active materials ? Further ecological choices face the designer when developing the package in which the product is transported, marketed and distributed. For example, foam plastics which pose acute dangers to the ecological balance, are used by designers as a protection for fragile products. Considerations of materials and methods are therefore crucial in the packaging phase of ecologically aware design. " (Papanek V, 1995)

Figure 2. 22. Recycline Toothbrush

Environmental product development extends these considerations to the whole life of the product, from the effects of the acquisition of the raw materials to what happens to the product when its useful life ends. Many products can have negative consequences after the useful product life is over. The designer's responsibilities are extended in another dimension too. Designers have long had a responsibility for the direct health and safety consequences of their work. So, those responsibilities are extended to the benefit of the global ecology.

Figure 2. 23. Birdy high performance folding bicycle

In the United States, the Industrial Designers Society of America has approved some Principles of Ecological Design that call for designers to reduce the use of natural resources; select ecologically appropriate materials; choose environmentally safe processes; and design for the life of the product. (Product development and the environment p:147)

Products are the source of all environmental problems. Major issues such as pollution, deforestation, and global warming are all side-effects of the activities that provide consumers endless consumer goods on the market today. Today, ecological and social issues are becoming more important than ever before, and a vital new role is opening up for design. Many good-looking products have an ugliness that is hidden to the consumer and is often invisible to the designer as well.

Sustainable products are those that are the best for people, profits and the planet. One issue is that most designers focus on improving form and function but they pay less attention to how products are made. Fabrication is where many of the environmental and social impacts lie, with damage being caused by the extraction of raw materials and by pollution rising from manufacturing process. Then there is the notion of producer responsibility. Products don't disappear after being sold. All products die when they come to the end of their useful life. In this case, there is an important question that 'Where do they go to then?'

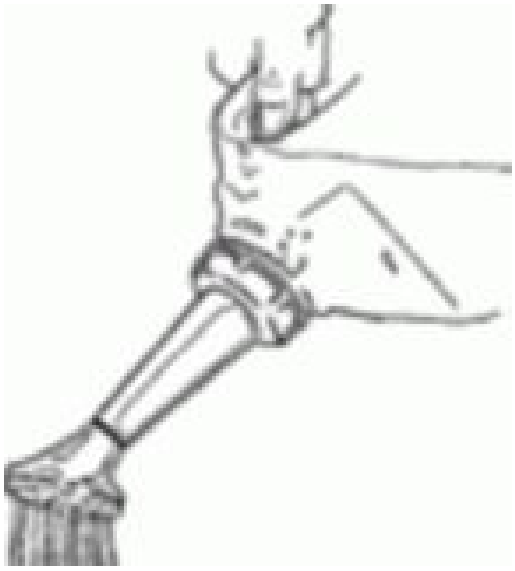


Figure 2. 24. Turn old bottles into watering cans

Environmental issues are complex and most environmental problems are caused by the manufacture, use and disposal of products. Looking at products closely highlights the environmental problems they cause. There has been a lot of improvement already. Every year, huge amount of money are being spent on cleaning up industry and environmental laws are getting stricter every day. Unfortunately, these measures are not enough, as the environment is still in a mess.

So while there have been some considerable improvements in the environmental performance of the 'usual suspects' like recycled paper etc., and we must start to look at everything. Consciously or not, the design of products and processes is the main determinant of environmental impact. Design is the key intervention point for making radical improvements in the environmental performance of products.

"The relationship between design and ecology is a very close one, and makes for some unexpected complexities. Product Life Cycle Assessment is the evaluation incorporating all of them, from the acquisition of raw materials, through the manufacturing process and assembly, the purchase of the complete product which also includes shipping, packaging, advertising and the printing of instruction manuals, the use, the collection of the product after use, and finally the re-use or recycling and final disposal." (Papanek V, 1995)

Figure 2. 25. Seiko kinetic watch with sleep function

Figure 2. 26 . Eco kettle

Although, all new products need to be designed in a sustainable way, existing designs also need to be revised. In this case, there are a lot of responsibilities should be considered by designers. There are some important areas of concern for the environment-conscious designer. For example; all designers should take a look at all their own activities and establish how they can limit environmental damage from day to day. Environmentally responsible design requires a clear policy, a structured approach and reliable information. The other need is training. Only cooperation between industry and the design professions can produce the combination of objectives and resources to fill this vital gap.

2.3. Consumption of Sustainable Products

"The willingness of consumers in many countries to regard environmental benefit as purchasing criterion has resulted in the emergence of new products, new selling platforms and new advertising themes. Many books and magazines has appeared, advising readers on how to be a green consumer, and providing extensive and varied guidance on what to buy and what to do." (Mackenzie D., 1991)

Actually, people have been concerned about environmental problems for many years, but levels of interest began to climb in many countries when increasing evidence emerged of the problems. Growing affluence in the developed world has afforded many people the luxury of being able to be interested in the quality of their lives, rather than simply in survival through the acquisition of basic necessities.

Environmental and quality of life benefits become 'added value' benefits, for which affluent people are prepared to pay. Individuals who feel concerned about environmental issues tend to want to try to do their bit to help address the problems . One of the simplest and least painful ways of feeling involved is by buying 'sustainable products'. With a small effort, people can make a contribution to minimising damage. Radical changes in behaviour and reductions in consumption will be essential. So, environment-conscious consumerism can be a starting point for more fundamental changes. Consumption will always continue, and it is therefore legitimate to attempt to make its impact as minimal as possible.

Figure 2. 27. Varta, Europe's largest battery manufacturer, produce mercury and cadmium-free batteries as part of their minimum environment impact initiative.

Many products have already been modified to incorporate better environment performance. For example, recycled paper, recycled plastic have all been presented as straightforward product improvements, designed to add an attractive competitive benefit to the product. Concern about environment issues is widespread across all income groups but higher among the better-educated consumers.

So, what do people expect of sustainable products? Some of the earliest products which offered environment benefits were significantly different from their conventional counterparts in terms of their performance. For many consumers, a reduction in functional performance was hard to accept, especially when combined with a higher price. Expectations can be modified, particularly when these relate mainly to appearance, during the initial stages the more succesful products have been those which perform very similarly to conventional products. The production of less environmentally harmful products which can compete directly on performance with traditional products is a major challenge.

Figure 2. 28. Dekoset natural cosmetics

Consumer demand can be a key for the development of more environment-friendly products. Among the public, there is a big evidence that consumers are, in principle, concerned about the environmental impact of their purchasing decisions. While consumer pressure is not yet the most powerful driving force for the development of the products with reduced environmental impacts, its importance is likely to grow. The

consumers of the future are extremely concerned about environmental issues and are far more knowledgeable than many of their elders.

Figure 2. 29. Ecobin

It is reasonable to assume that a customer who has been influenced to buy a product partly on its environmental performance will take such considerations into account when considering a repeat purchase. So, a manufacturer hoping to sell again to that customer must make sure that the environmental advantages are delivered in use.

Figure 2. 30. Amana washing machine, slightly above average energy and water performance

The notion of a environment-conscious consumer continues to be difficult to find, and hard to define demographically. However, research into recent buyers of sustainable products suggests that the consumers most receptive to environmentally oriented marketing appeals are educated women. (see, table 2.2)

They are motivated by a desire to make sure their children's future is secure. That women are in the leading position of sustainable product purchasing. They do most of the shopping and they may naturally exhibit a maternal consideration for the health and welfare of the next generation. In this case, women place a higher importance on environmental and social purchasing criteria than men.

In conventional marketing, demographics are often a key determinant of intent to buy specific products. But in sustainable marketing, what seems to determine willingness to purchase environmentally conscious product, more than demographics or even levels of concern for a specific environmental issue, are the consumers' feelings of being able to act on these issues, or empowerment.

Demographic Profile of Sustainable Product Purchasers

	Yes, in past 2 months	Yes, but not in past 2 months	No, have not bought	Don't know
Sex				
Total	26	19	49	6
M	22	18	53	7
F	29	20	46	5
Age				
18–29	23	19	51	6
30–44	31	18	47	3
45–59	27	21	46	6
60+	18	18	55	8
Household Income				
Under $15,000	19	13	61	7
$15,000–$30,000	21	17	55	6
$30,000–$50,000	28	22	45	5
$50,000 +	35	22	40	4
$75,000+	34	25	38	3
Education				
Non–High School Grad	14	18	60	8
High School Grad	24	17	55	5
Some College	31	25	41	4
College Grad	33	18	42	8
Occupation				
Exec./Professional	38	16	42	4
White Collar	28	23	43	6
Blue Collar	22	22	51	5
Other Demo				
Parent of Kids 0–17	31	19	46	4
Household with Personal Computer	36	21	40	4

Source: Roper Starch Worldwide, Green Gauge, 1996. Used with permission

Table 2.2. Demographic profile of Sustainable Product Purchasers (Ottman A.J., 1998, Green Marketing, p:21)

Although they express their environmental concerns in individual ways, green consumers are motivated by universal needs. These needs translate into new purchasing strategies with implications for the way products are developed and marketed.

Environment-Conscious Consumer Psychology and Buying Strategies

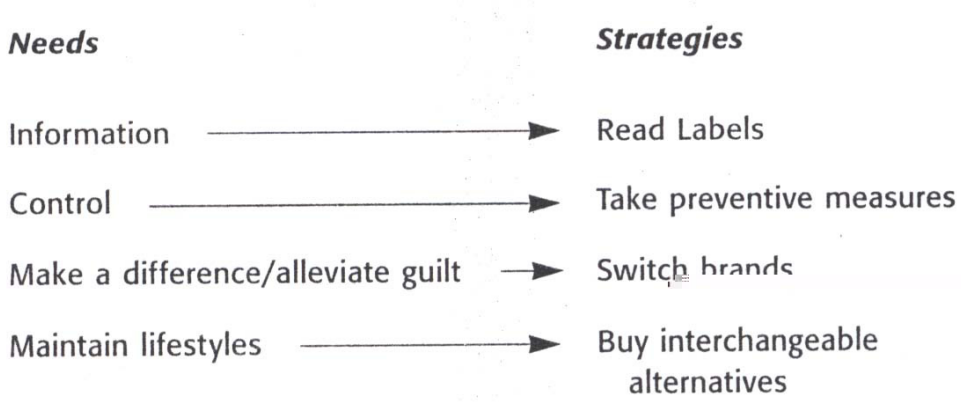


Table 2.3. Environment-Conscious Consumer Psychology and Buying Strategies (J. Ottman Consulting, Inc. , Green Marketing p:31)

The easiest way to save resources and energy and to cut down on waste is to use less. This statement is so simple as to sound banal, yet it can serve as a guide to action. Also implied is the idea of consuming less, buying less, making do with what we have already, even at times ridding ourselves of all the unnecessary gadgets and duplicates that so hideously clutter up our lives.

Nonetheless, we know what stunted lives people lead trying to buy more, to own more, to consume in ever greater excess and to make more money in order to continue this relentless cycle. Even if we bought goods merely to replace what had been used up, or worn out, or grown out of, the problems of over-consumption would noy go away, there are so many people now living in the world and using continuously shrinking resources.

With the geometric progression of world population,we can no longer afford to escalate production, consumption, waste.

Green consumers put familiar products under a magnifying glass of environmental scrutiny ,and their buzzwords signifying environmental compatibility abound. The broad scope of these buzzwords suggests that green consumers scrutinize products at every phase of their life cycle, from raw material procurement, manufacturing, and production straight through to product reuse, repair, recycling, or eventual disposal. While in-use attributes continue to be of primary importance, environmental shopping agendas now increasingly encompass factors consumers can't feel or see. They want to know how raw materials are procured and where they come from, how food is grown, and what their potential impact is on the environment once they land in the trash bin. (Ottman A.J ., 1997)

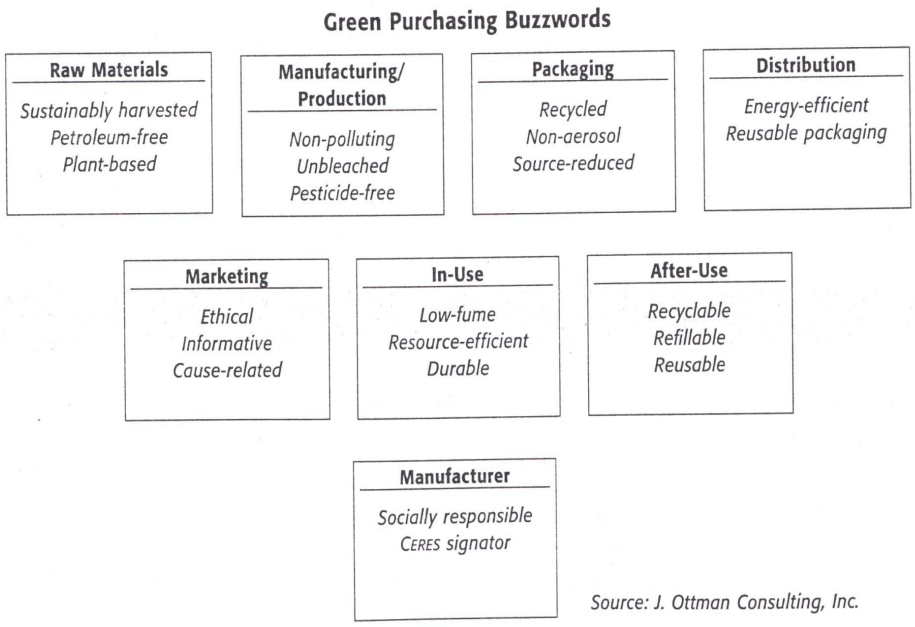


Table 2.4. Green Purchasing Buzzwords (Ottman A.J., 1998, Green Marketing, p:33)

What is needed is to re-establish our connections with nature and with our own roots. Societies that provide leisure time for activities that are not profit-directed or purely materialistic, and give ample opportunities to establish strong human relationships, tend

to be less wasteful and more deeply in tune with human needs. Having established a frame of reference from which to examine our wasteful and environmentally destructive patterns, we can now begin to think what can be done.

2.3.1. Questions Before Designing

- *Does the consumer really need it?*

Before making a purchasing decision, the first question should be: do I really need it? Have I been persuaded to buy it because it offers some real advantages over what I use now?

- *Can the consumer borrow it?*

If the object you need will only be used infrequently, or just once or twice, can it be borrowed? If it is possible, there is no need to buy.

- *Can the consumers own it as a group?*

Sharing to cut down on waste, to make things more affordable or just to reduce the amount of raw materials locked up in goods can operate on many different levels.

For example; sharing the expensive international professional magazines, more than one person can use (profit) it, and so it cuts down on the wastefulness of paper and printing inks as well as transport.

- *Can the consumer built it himself/ herself ?*

The average person, anywhere in the world, is better informed and more aware of his or her needs than any designer. It is therefore plain that the design needs of most people can best be served by the users themselves working in close collaboration with a designer. The next step is to suggest that people should be empowered to design their own solutions to their own specific requirements.

Having considered all these possibilities, we must now ask the vital questions:

- *Will it harm the environment?*

- *Does it use composite materials?*
- *Does it waste energy?*
- *Does it recyclable or reusable ?*

The materials chosen by designer and manufacturer are crucial. For example: the designer's decision to use foam plastic to make cheap, throw-away food containers damages the ozone layer. This is not a prescription for doing nothing at all, but an attempt to make designers aware that every choice in their work can have far-reaching and long-term ecological consequences. These are the crucial questions that we have to consider, before we decided to purchase. Considering these questions, it is certainly possible to make intelligent choices as to whether to buy or not to buy.

2.4. Sustainability and Marketing

Market pressure is playing a major role in encouraging changes in industrial behaviour. Environment pressures do not just create problems and commercial risks, however; they also bring about major new market opportunities. Improved environment performance provides an attractive new benefit in many sectors, and has led to significant competitive advantage for many companies.

Producing eco-efficient products creates less waste, uses fewer raw materials, and saves energy, too. The changes required to make and market environmentally sensitive products in improved customer relations and overall returns on investment. Many marketers now know that being the first with an environmental innovation brings competitive advantage. Today, conventional marketing is out, Sustainability in Marketing is in. Addressing the needs of consumers with a raised environmental consciousness cannot be achieved with the same assumptions that guided consumer marketing.

Figure 2. 31. Compact flourescent bulbs using replaceable parts to avoid throwing away the electronics each time

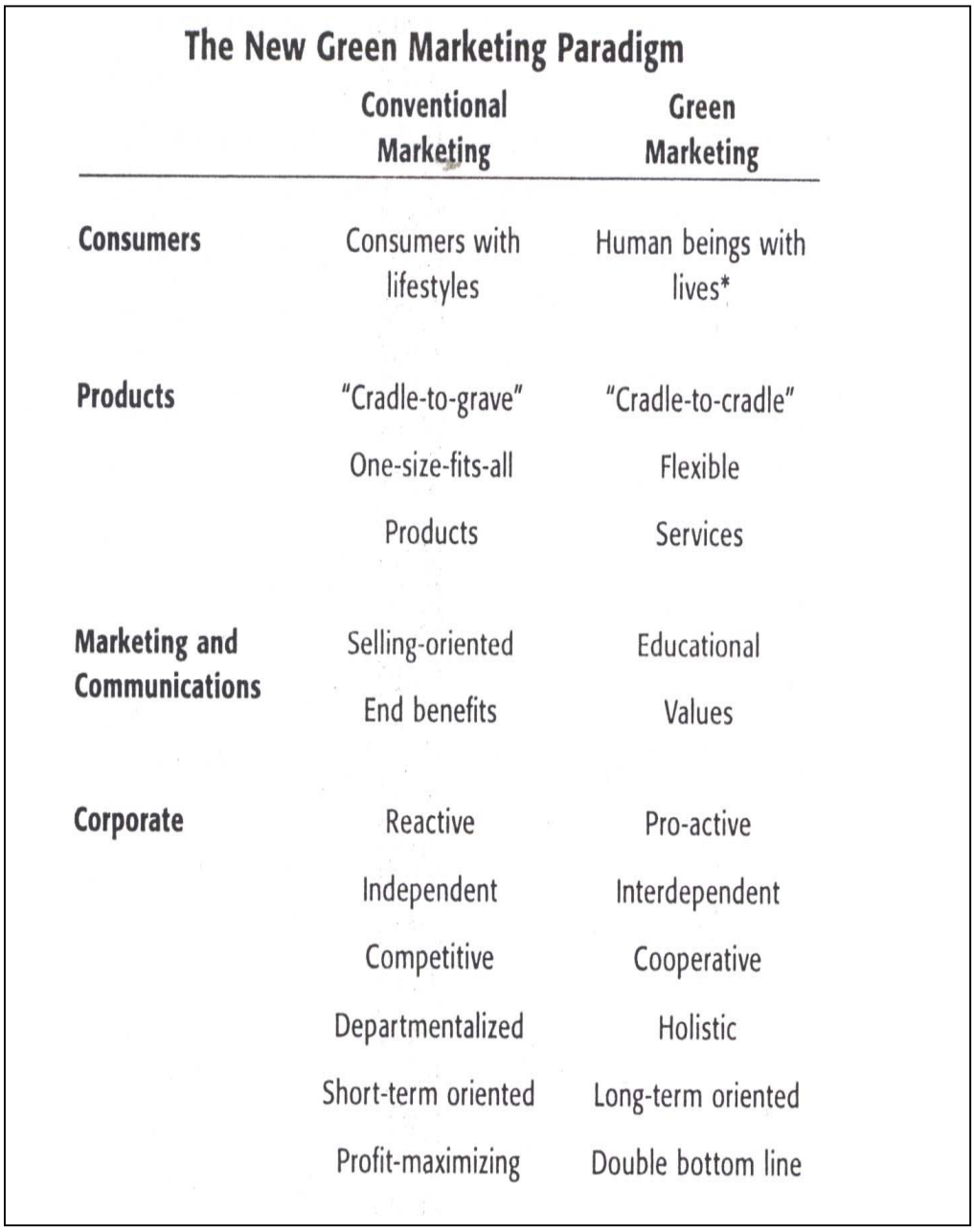
Conventional marketing requires developing products that meet consumers' needs at affordable prices and then communicating the benefits of those products in a compelling way. Environmental marketing is more complex. It serves two key objectives:

- to develop products that balance consumers' needs for quality, performance, affordable pricing, and convenience with environmental compatibility, that is, minimal impact on the environment

- to project an image of high quality, including environmental sensitivity, relating to both a product's attributes and its manufacturer's track record for environmental achievement (Ottman J, 1997, p: 45)

Figure 2. 32. Skoot folding bicycle UK

Marketers in the age of environmental consumerism face tough new standards. Meeting the challenges of environmental consumerism presents its own rules for corporate processes, product quality and promotion. Products are no longer designed with no regard for the long-term impact on society of their eventual disposal or no appreciation for the value of natural resources they represent.



The New Green Marketing Paradigm

	Conventional Marketing	Green Marketing
Consumers	Consumers with lifestyles	Human beings with lives*
Products	"Cradle-to-grave"	"Cradle-to-cradle"
	One-size-fits-all	Flexible
	Products	Services
Marketing and Communications	Selling-oriented	Educational
	End benefits	Values
Corporate	Reactive	Pro-active
	Independent	Interdependent
	Competitive	Cooperative
	Departmentalized	Holistic
	Short-term oriented	Long-term oriented
	Profit-maximizing	Double bottom line

Table 2.5. The new green marketing paradigm (Roper Starch Worldwide, Green Gauge, 1996. , Green Marketing p:48)

2.4.1. Strategies of Sustainability in Marketing

Using these strategies, its possible to create a 'Sustainable Marketing' for the sustainable world.

- Do your homework. Understand the full range of environmental, economic, political, and social issues that affect your consumer and your products and services now and over the long term.

- Create new products and services that balance consumers' desires for high quality, convenience, and affordable pricing with minimal environmental impact over the entire life of your products.

- Empower consumers with solutions. Help them understand the issues that affect your business as well as the benefits of your environmentally preferable technology, materials, and designs.

- Establish credibility for your marketing efforts.

- Build coalitions with corporate environmental stakeholders.

- Communicate your corporate commitment and project your values.

- Don't quit. Continuously strive for "zero" environmental impact of your products and processes; learn from your mistakes. (Source : J. Ottman Consulting, Inc., Green Marketing, p: 49)

Obviously, these are the key principles for environmental designers and companies which refer varied and complex issues of the environmental products.

2.4.1.1. Sustainable Product Development Issues

Raw Materials Acquisition and Processing

- Conservation of natural resources
- Protection of natural habitats
- Waste minimization and pollution prevention
- Transportation
- Use of renewable resources; sustainable use of resources
- Use of recycled materials
- Energy consumption

Manufacturing and Distribution Issues

- Minimal use of materials
- Waste generation and handling
- Energy consumption
- Water use
- Emissions to air, land, and water

Product Design, Use and Packaging Issues

- Energy efficiency
- Conservation of natural resources
- Designing eco-friendly products and processes
- Consumer health and environmental safety

After-Use/ Disposal Issues

- Recyclability; ease of reuse, remanufacture, and repair
- Durability
- Biodegradability/ compostability
- Safety when incinerated or landfilled

(Source: Martin Wolf, Giessen Wolf, Green Marketing)

Many marketers now grow their businesses by addressing the specific environmental issues most relevant to their consumers. Not only marketers, but also designers use these strategies to create profitable new or improved sustainable products and packages that balance consumers' needs with environmental consideration.

2.4.2. Economics of Sustainable Product Design

A complaint about improving environment performance, and one of the main reasons given for failing to adopt high standards, is the assumption that higher costs are always involved. The cost of safely disposing of products at the end of their life can also be high. Concerns are expressed about passing this higher cost on to the customer, particularly in markets facing competition from companies or countries which do not adopt higher environmental standards and can therefore keep prices lower.

On the other hand, the savings that can be made from minimising waste, increasing energy efficiency and not over-specifying the quality of materials needed are frequently under estimated. Customers would prefer to have good-quality products, offering good environmental performance at no extra cost, so this is the new challenge for designers. Can products be re-thought so that they deliver the same benefit to the user, in a way that is environmentally better; without extra cost.

In some sectors, the customer may be required to pay a higher price for the product, but the trade-off may be a longer-lived, more reliable product, or one that consumes less energy in use, thus leading to savings in the longer term. But some companies viewed the development of consumer interest in the environment as a short term marketing opportunity. Sometimes the apparent greenness of the product has camouflaged a poor environment performance in other aspects of the company's activities. So, for the designer, the ability to understand the environment impact of design decisions will no longer be an optional extra, but rather an essential part of design skills.

2.4.2.1. Design for Disassembly

Around 1990 a new direction in industrial design was introduced called 'Design for Disassembly', or take-apart technology. It takes the environment into account by designing the whole object in such a way that it can easily be disassembled and recycled once its useful life is over. Designing products in order to minimise their impact on the environment is becoming increasingly important. Many designers are beginning to recognise this fact and are therefore demanding tools and techniques which enable them to design more responsibly.

Design for Disassembly enables the product and its parts to be easily reused, remanufactured or recycled at end of life. Consequently, designers encouraged to consider product disassembly early in the product's design stage.

Figure 2. 33. Pile of electronic rubbish!

IBM Environmentally Conscious Products

The IBM Corporation has a strong environmental, health, and safety foundation, with policies in these areas dating back to the early 1970s. As these programs and the information technology industry matured, the corporation looked beyond its traditional roles for ways of expressing its corporate stewardship towards the global environment.

Working from a stewardship perspective, IBM decided that another step forward was needed, and responsibility and commitment for long-term environmental aspects of products was added to the corporation's environmental affairs policy. In 1990 IBM issued a corporate policy letter stating its commitment to 'develop, manufacture and market products that are safe for their intended use, efficient in their use of energy, protective of the environment and that can be recycled or disposed of safely.'

IBM continuously improve products and processes to ensure the protection of the environment. The design goals were:

- Product contents must be capable of being recycled or reused at the end of product life.
- Products must use materials that have a recycled content and reutilized components.
- Products must be designed using ease-of-disassembly techniques.
- Product energy consumption must be reduced.

(Fiksel J., 1996)

Figure 2. 34. Epro 2 by IBM ...the CPI Unit only has casing of recycled plastic

IBM finds new profit in recycling old computers, as leasing increases, company boosts earnings by giving second life to used PCs, selling returned items on the Web or stripping them for their parts. IBM Corporation is wringing new profit from old goods by refurbishing leased computers or cannibalizing them for parts when they're turned

in. Truckloads of used personal computers, laptops and servers pour onto conveyor belts and forklifts. The swift, automated process resembles manufacturing in reverse, the aim being to extract value rather than build it in. The refurbished machines and used parts are sold on auction web sites and to brokers.

IBM, the biggest computer maker, wants to extend the income-producing life of its products and increase its lease program's share of total sales. According to IBM Global Financing, the recycling business has a wider profit margin than the leasing side. IBM has been promoting leasing in more of its sales pitches, if a potential client balks at prices for new or leased units, the company can strike a bargain on refurbished equipment to keep the customer away from rivals. Besides computers, the gear includes monitors, printers, data-storage devices and network routers and switches.

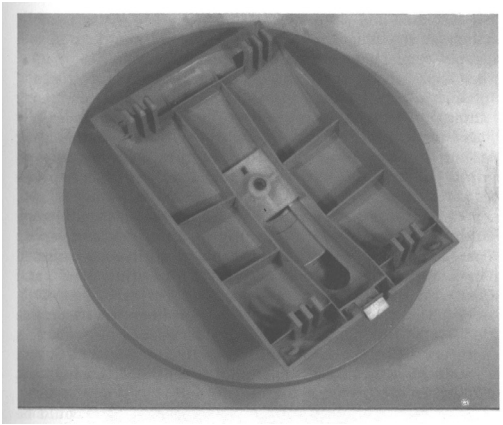


Figure 2. 35. Photograph of a monitor pedestal base, highlighting the molded-in material identification

As long as used computers can run the software required, they can be attractive to companies eager to squeeze as much as they can from their assets or those unable to make big capital expenditures. Tons of outdated computers sit idle in the U.S.,and many companies store them rather than face the complex task of environmentally safe disposal. IBM also may benefit if computer recycling becomes mandatory PC recycling law takes effect this year. IBM saves tens of millions of dollars a year by plucking used spare parts for its computers and tries to keep the turnaround time and labor costs of refurbishing used computers low. Software is used to confirm a computer's internal

configuration, erase all old data and test refurbished units. Later in the process, ‘optimization’ software helps IBM decide at what price to sell used machines and parts, based on market conditions and the products conditions. After stripping usable parts and recycling glass, metals and plastics, IBM discards about 4% of what it collects.
(www.lats.com)

CHAPTER 3

SUSTAINABLE PRODUCT DESIGN PROCESS

3.1. The Changing Design Process

If we want to minimise the extend of environment problems, design and design process will have to change, because users and consumers of design, and industry will have to change. Changing customer priorities and industrial competition will make the pressure for change inevitable. The changes that will be necessary, the inclusion of environment criteria as a main part of the design process will be one of the most important developments in the history of design. So, this will not only create new themes for design, but also give a new and crucial role to the designer.

Figure 3. 1. Zappy electric scooter

Because of demanding changes in attitude, the designer's responsibilities will become more difficult and more important than before. Designers already have to consider a wide range of criteria as part of the design process; marketing, production, financial and

technical considerations have to be included. Compared with these, environment considerations could be even more complex. There are some difficulties for example; there are no clear answers or information is hard to find.

Day by day , companies are assessing their environment performance, recognising that good environment performance does not come simply. For example, the development of a product which is environmentally safer in use or disposal may well be desirable, but if its production consumes much energy, the net result may be less beneficial. Designer must therefore expect to take considerable responsibility for asking the right questions, and raising the relevant issues. However, it is difficult to be aware of all the environment issues which surround design decisions. Unfortunately, it is difficult to find detailed information on the environment performance of alternative materials or processes.

In this case, designers cannot be expected to have the time or specialists knowledge to be able to gather all the information they will need. Although some designers may wish to spend their time devoted to background information collection; others will resist spending too much time away from the creative process. Designers can be a part of research, so they can ensure that research is built in to the design process. Increasingly, environmental researchers working closely with designers, advising them on material specification, or they review works at concept stage to identify any potential problems.

Figure 3. 2. Cardboard Chair

Figure 3. 3. Solar Charger

Many environment issues will relate to aspects of execution, for example; the materials used, the production process used, how a product will be disposed of etc. These questions have to be addressed during the development of the design concept itself. The crucial point is that designers are necessarily team workers, so they have never been able to work in isolation. There is an important need to consider environment issues at an early stage in the design process will mean that close partnerships with other disciplines. Designers must create a capability that goes far beyond visual appearance.

Environment problems become an increasingly important aspect of the designer's work to minimise the risks coming from the failure of a product or process. Because of the rapid technological development, environment problems increase every day. On the other hand, new technologies often tend to be less polluting and dangerous than what they replace. So, designers may find themselves in the forefront of identifying problems which must be addressed by technology. Sometimes existing technologies may not be able to provide the solution, and the designer may have to influence the development of a new technological approach. Designers must also follow technological developments, to be sure of incorporating the most environmentally advanced technologies.

Figure 3. 4. Electric Lotus Elise prototype

Environment-conscious design is not only related to style, so it must not be seen as a styling exercise. However, some obvious new styles may well emerge, based on a desire to embody in the look of a product the high importance given to environment

considerations during its design and development. Environment is not only a practical issue; but also a moral one. So, the idea that designers should aim to minimise the environment impact of their work has been accepted in many cases.

Designers have been persuaded to take responsibility for sustainability, because of the central role they play in influencing the environment performance of so many things. So many other moral issues are now emerging as possible influences on public purchasing and behaviour. The central position of the designer provides a real opportunity to affect change. Designers have always striven for a better way of doing things, now that better way can include environmental, ethical and social issues, too.

Figure 3. 5. Recycled PET garments

Figure 3. 6. Shoe from vegetable tanned leather and wood

Unfortunately, many designers and design courses continue to ignore environment issues, however it is essential to include information about environment issues and their relationship to the design process in the core curriculum. In order to anticipate problems and devise inspired solutions, designers must be equipped with an understanding of subjects which stretch far beyond the boundaries of traditional design teaching. Life sciences, behavioural sciences, ecology, anthropology and many other areas may come to be seen as a necessary part of the design curriculum, alongside computer programming and marketing. Designers have an opportunity to exert considerable influence, if they choose to do so. But this influence will have to be supported by

knowledge, open-minded-ness and flexibility, and an ability to go on learning. Designers can now prove that they are an essential tool in planning a sustainable future. (Mackenzie D., 1991)

Figure 3. 7. *Solar Car from Kyocera*

Figure 3. 8. *Fuel Cell bicycle*

3.1.1. Sustainable Design Tools

A designer must understand the basic relation between a product and the environment. To develop products in a sustainable way, the designer must be able to evaluate which design solution is better from an environmental point of view. These are some rules which are crucial to create a sustainable products and processes are given below;

- Do not design not only sustainable products, try to design sustainable product life cycle. Designers have to consider all design process, from the concept of design to manufacturing process, and finally use and disposal of product.

- In the sustainability, materials present the designer with some of the difficult problems. Material selection is one of the crucial point that environment-conscious designer should take into account. Designers and manufacturers should be increasingly aware of the possibility of using recycled materials.

- Today, many designers focus their attention on material selection. However, this is not enough by itself. People normally ignore the environmental impacts of

energy. For example, recycling paper can reduce by half energy consumption compared with manufacture from trees etc.

- Increase product life time is another way to create sustainable products. Designers can influence the product life time in several ways, such as, make it more durable from a technical point of view, make it upgradeable. More important, try to design the product in a such way people feel attached to it. Many products are not thrown away because they are broken, but because people got bored with them.

- People do not always want a product. Actually, they want a solution for a certain problem. Sometimes a service can be the best solution, like the launderette, instead of many individual washing machines.

- Minimum usage of material, may seem obvious, but it is more complex than designer think. Minimising materials requires careful attention to production processes as well as to the design itself. This is especially true in transport equipment, where less weight means less fuel consumption.

- Designers do not only make their product recyclable, but they have to use recycled material. If every designer only makes products recyclable, there will never be a demand for recycled materials in the future. In general, materials that have come from a recycled source are more environment-friendly than those from virgin sources.

- Finally, make your product recyclable. Most products could be recycled, but only few will. Only products that are disassembled easily and have a high enough yield will be chosen for recycling. A designer can increase the chance that the product is recycled by optimizing its design.

By considering these basic criterias, we can make a huge improvements in the environmental performance of products.

3.1.2. Specific Examples

The e.light

Figure 3. 9. The e.light

The e.light has many environmental advantages. All the components are designed to be disassembled, and can be recycled. Most fluorescent tubes contain mercury, which is extremely poisonous. Compared with normal fluorescent lamps, however, the e.light contains 93% less mercury. It is also very durable, as each e.light bulb lasts 2-3 times longer than average. This means that less bulbs need to be made, and also means that there is even less mercury pollution per hour of light provided. Having “task lighting”, as it is known, is much more energy efficient than lighting the whole office floor and this particular lamp is even more efficient. Because the e.light uses only so little power, it is cool to the touch, so there is no risk of burning for children or if you have it very close to you on your desk. This coolness also eliminates the need for reflective and heat resistant materials. (www.biothinking.com)

The Tripp Trapp Chair

Figure 3. 10. The Tripp Trapp Chair

The Tripp Trapp Chair grows with the child, meaning you don't end up with a baby chair you can't use anymore. This long-lived product is also made from low cost and recycled material.

'Steel Stud' Furniture

Figure 3. 11. Steel Stud furniture

This is a definition of innovation : to see something old in a new light. With the 'Stud Series' designers have innovated a new way of recycling steel, one of the most plentiful waste products of the last century, and at the same time they have innovated a new concept in low-cost and extremely practical furniture. (www.designresource.org)

Envirolet

Figure 3. 12. Envirolet

Get back into being part of the cycle with a compost toilet like this Envirolet. It has high, medium and low settings, allowing you to set the appropriate flush volume for the task at hand, cutting water use in half.

'The Th!nk City' Electric Car

Figure 3. 13. The Think City electric car

The Th!nk City electric car feels like a "real" car and is very low maintenance, and it costs only 50 cents to recharge the battery -- equivalent to 30 cents a gallon ... (www.designresource.org)

The Compostable Keyboard

Figure 3. 14. 'The Compostable Keyboard' computer keyboard made of carrot pulp, keys of spinach and celery.

Each year millions of computers and accessories are manufactured throughout the world. Highly toxic pollutants used in computer production are released into the environment. As obsolete computers and their accessories are retired to make way for new ones, they add the already high levels of toxic waste in the landfills. In nature, all waste converts to food.

The concept that commercial production and product consumption cycles could evolve to be as efficient as nature is one of the many ideals of sustainable design. Using this concept, 'The Compostable Keyboard' is designed that reduces the amount of harmful toxins released into our biosphere.
(www.designresource.org)

Hot Cup System

Figure 3. 15. Hot Cup System

Materials List: Expanded polystyrene, recycled paper, and aluminum.

Design Concept: With the large number of recyclable cups used and thrown away everyday, designer feel a deep concern to do something about it. Recycling container have designed, made of recycled polystyrene, for the collection of single-use polystyrene cups and lids. The intention of the recycling container is to not only collect disposable cups but also to create awareness for the possibility of recycling and the benefits of using polystyrene as a viable alternative to paper products, such as paper cups. The recycling container organizes cups in a specific way. It allows cups, of any size, to be stacked. There is a separate area for lids and a place to pour leftover liquids. The removable racks that hold the stacked cups and lids would be collected by the recycling company, and the containers that hold the excess liquid is removable for emptying. There is also an area for garbage in the outer case unit that holds the rack. The recycling container is entirely moveable and lightweight, and has taken into account the possibility of spilt liquids and ease of use by consumers.

(www. designresource.org)

‘Green’ Bus Shelter

Figure 3. 16. ‘Green’ Bus Shelter

Materials List: Steel for shelter frame, HDPE #2 recycled plastic for sheltered panels and bench, and recycled porcelain earrings for mosaic artwork.

Design Concept: Designers need to examine the natural ecologies and design for composting, non-toxic. They need to redesign the world to regain the Earth. Seeing is believing. Touching is feeling. Designers want people to be able to see, touch, feel, and as a result, believe in recycling. Finally, they hope to raise the public’s awareness of sustainable design and environmental concepts with this "green" bus shelter.

(www.designresource.org)

Chair

Figure 3. 17. Disassembled chair

Materials List: Gridcore, solid wood (cherry), fabric by Design Tex, upholstery foam, and knock-down fasteners.

Design Concept: The design of the chair is fun and would not look out of place with other furniture. Designers tried to create a design that would not require a compromise in quality comfort, or aesthetics even though it is made of a recycled material and can be disassembled. The chair knocks down. It can be shipped flat and assembled by the purchaser. Designers see it as a catalog item for people who don't want to spend time shopping and don't want to handle a large, heavy piece of furniture when it is delivered. It would be especially appropriate for people without cars, people who move frequently, and people who live in apartments where large, heavy pieces of furniture are difficult to get up stairs or through narrow halls. The chair would also be appropriate for a cash and carry store. It would be important in marketing to highlight the recycled nature of the construction materials to appeal to buyers who are sensitive to ecological concerns.

(www.designresource.org)

Great Fun

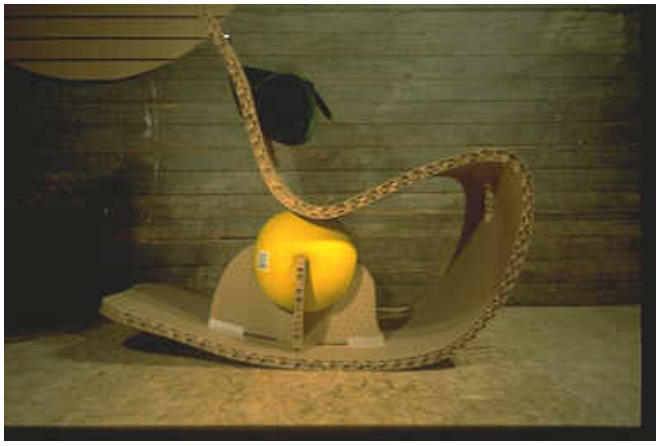


Figure 3. 18. Great Fun

Materials: Gridcore (recycled mixed waste paper), kick ball

Great fun and flexibility...

Small home office – ready to assemble

Figure 3. 19. Small home office

Materials: Gridcore, paper twist, corrugated paper

It will be easy to move or carry out of the apartment ...this product is strongly focused on recyclability.

(www.designresource.org)

‘Bob Pen’

Figure 3. 20. Bob Pen

"Bob Pen" a reusable, refillable child's art marker

Children are tomorrow’s consumers, and unfortunately they are taught from an early age that products are disposable. With an environmentally friendly marker pen, they would be made aware of environmental issues….The pen is non-disposable and is refillable. It is made with an minimum number of parts, materials are recyclable. The pen has child safe qualities. (non-toxic inks)
(www.designresource.org)

Backpack

Figure 3. 21. Backpack

"Backpack", recyled HDPE detergent bottles, clear apple juice containers, aluminum can bottoms and a used bicycle inner tube. The concept of this project is to create a product from post-consumer waste with a sense of whimsy and style. The pack is made entirely by hand without the use of any power equipment or chemical additives.

"PK Chair" , used milk cartons

Figure 3. 22. PK Chair

The use of milk packages in this chair is designed for consumers who show a greater concern for the environment throughout the entire life cycle of the product. Designer chose milk packages because they are daily used by millions of people throughout the world. By producing this chair designer increase the milk packages life cycle and help reduce and abolish waste by offering home furnishing article of good design and functionality at low prices. (www.designresource.org)

The E- Cloth

Figure 3. 23. The E- Cloth

The E-Cloth is a microfibre cloth that allows you to do clean household surfaces without cleaning fluids -- just water and elbow grease.

Bagless Vacuum Cleaners

Figure 3. 24. Bagless vacuum cleaners

Bagless vacuum cleaners use no bags but that saves only the equivalent of a Sunday newspaper a year. Good old carpet sweepers like this Hoky are quick and handy, have no motor and need no electricity. (www.biothinking.com)

Sodasan Soap

Figure 3. 25. Sodasan soap

Sodasan soap from organic and fairtrade veg oils. Natural body soap, environmentally friendly products...

'Just shake it' torch

Figure 3. 26. Nightstar 'just shake it' torch

Nature and technology can co-exist...Nightstar 'just shake it torch', no need for battery, easy to use, to carry...(www.biothinking.com)

Deep Eco Shoes

Figure 3. 27. Deep Eco Shoes

Deep E Co Shoes are made from organically-grown leather and wild natural rubber.

The Keeper

Figure 3. 28. The Keeper

The Keeper is a small, bell-shaped, natural gum rubber menstrual cap that is worn internally. It is a comfortable, hygienic, sanitary, safe alternative to tampons and pads. It's very easy to use, and one cap will last at least ten years. (www.biothinking.com)

Superwindows

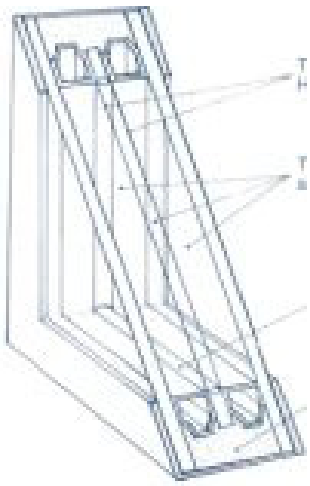


Figure 3. 29. Superwindows

Superwindows use low-e coatings, gas fill, good edge seals, insulated frames, and airtight construction, and then go one better: They have one or two sheets of transparent polyester film suspended between the glass panes. The result is windows that insulate twice as well as the same thickness of fibreglass.

Dry Cleaning System

Figure 3. 30. 'Hangers' Dry Cleaning

Most traditional dry cleaning systems clean clothes in a chlorinated solvent called perchloroethylene, which is carcinogenic and must be disposed of as hazardous waste. The Hangers franchise cleans instead with liquid carbon dioxide, more than 98% of which is recovered from the process for reuse. (www.biothinking.com)

3.1.3. Labelling

Information about the environment impact of product which may have to surround ingredients, manufacturing method, use and disposal instructions will be included on packaging. Consumers wish to obtain an immediate impression of the environment characteristics of their intended purchase; they also require usage instructions and disposal instructions which make the right behaviour appear simple and desirable. The growth of products which are sold in many different countries will pose the challenge of how complex information can be communicated by the use of visual symbols.

Figure 3. 31. Blue Angel ecolabel

How is the consumer to know whether or not a product is environmentally acceptable? The first response of many advertising and marketing people to the sudden popularity of environmental issues was to introduce the words ‘environment-friendly’ at every opportunity. The second response was to invent a labelling scheme.

Official eco-labelling systems will be one aspect of information provision, but these will not cover all categories, and will necessarily be a summarised version of more detailed information which may well have to be communicated in some other form elsewhere. There is also a considerable risk from labels such as the rapidly-spreading recycling logo, the use of which is uncontrolled and can therefore be meaningless, although some

helpful, unofficial schemes, aiming to provide the facts and publish the criteria by which they are used, do exist.

In some countries labelling schemes backed by law have been introduced. Significantly, some of these schemes place as much emphasis on improwing the awareness of the public about the relationship between the environment and the products they buy as on the labelling scheme itself. (Mackenzie D., 1991)

Figure 3. 32. The EU ecolabel

Figure 3. 33. TCO Electronics Label

What is not in doubt is the impact on designers and manufacturers of the labelling schemes and controls on advertising. Designers have become used to having to include all kinds of health information on packaging. Such constraints are likely to increase in the future to take account of environmental impact information. Designers should not see their role solely as one of responding to sustainable rules and pressures, for they have a positive role to play in promoting environmentally sympathetic behaviour too.

3.2. Product Life

Traditionally, the concern of the designer has ended with the launch of the product, but the environment-conscious designer should think about its complete life. The traditional definition of a well designed product is that performs its function succesfully; is manufactured efficiently by using suitable materials and techniques. In addition to these criterias, it is easy to use, is safe, offers good price, and looks attractive. The relative importance of these criteria will vary from product to product. New definitions of good product design will include an environmental consideration. In this case, the answer of this question is crucial. Is the product designed to minimise the impact it has on the environment, during the whole of its life cycle?

Figure 3. 34. 'The Tripp Trapp Chair' grows with the child, meaning you don't end up with a baby chair you can't use anymore.

Environmental impacts occur at all stages of a product's life-cycle. Different types of products have impacts at different stages of the life-cycle. For example, for furniture the raw materials and final disposal include most of the environmental impacts, and for energy-consuming products such as household appliances the use of the product

includes most of the environmental impact. However, most of the impact is locked into the product at the design stage when materials are selected and product performance is determined.

Designers can make a significant difference to the effect of a product because they are responsible for influencing the key definitions. These determine the choice of materials; how long the product will last; how effectively it uses energy, and how easily it may be re-used. The aims of the environment-conscious designer are to use the minimum resources throughout, to get the maximum possible use and value out of the least quantity of materials or energy, and to minimise pollution created during the manufacture and life of the product.

Many products which used to be designed to last for years are now intended to have only a short lifetime. Disposability has been presented as a consumer benefit. Disposable products have been made possible by advanged technology reducing manufacturing costs and there is often little incentive for the consumer to look after a product to ensure that it lasts, as it can so easily be replaced. Product life may be limited by changes in technology which make it obsolescent; or by changes in fashion which make it old-fashioned and unattractive.

Figure 3. 35. Terradent toothbrush

Figure 3. 36. Highlighter refills

Extending the life of a product is an obvious way of reducing waste. There are many different ways of achieving this, from improving reliability and durability so that it lasts longer, to making it recyclable so that the materials used to create it can have an additional life in another form.

One way of extending a product's life is therefore simply to design it so that it can easily be maintained and serviced, by making those parts accessible and replaceable, and ensuring that the product is easy to disassemble and reassemble. With advanced products, repairs and replacements tend to have to be carried out by specialists, which means that product servicing becomes an important part of the total product offer. Durability can also be achieved through the use of different technologies.

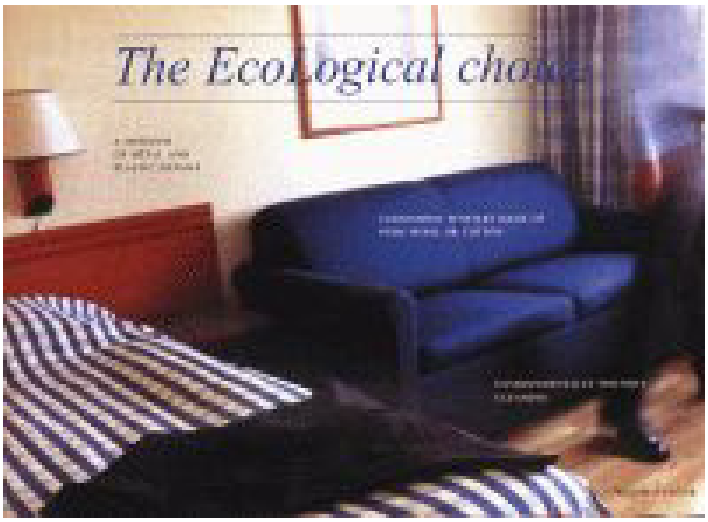


Figure 3. 37. Scandic Hotels - the 92% recyclable hotel room

3.2.1. Product Life Cycle Assesment

Life cycle assesment is about minimizing environmental troubles throughout the life cycle of a product. The life cycle includes all activities that go into designing, making, using, transporting and disposing of a product. The life cycle concept is a 'cradle to grave' approach to thinking about products, processes and services. It recognizes that all product life-cycle stages have environmental and economic impacts.

In business use, a product life cycle begins with the first phases of design and proceeds through the end of production. Research, marketing and service to support products are also included in the life cycle. However, retirement and disposal of products are generally not considered.

- **Business life cycle:** The product life cycle is a sequence of activity phases including the creation of a product concept, its development, launch, production, maintenance, maturity, reevaluation, and renewal in the form of a next-generation product. Similarly, the process life cycle is a sequence of activity phases including the development of facility and process designs.

- **Physical life cycle:** The product life cycle is a sequence of transformations in materials and energy that includes extraction and processing of materials, product manufacture and assembly, distribution, use, and recovery or recycling of product materials. Similarly, the process life cycle is a sequence of transformations in materials and energy that includes extraction and processing of materials used for process equipment and supplies, and waste disposal or recovery.

The life cycle framework is a system for assessing the full environmental, economic and social consequences of design. So, in its most complete form, life cycle design evaluates total inputs, outputs, and effects for all stages of the life cycle. Products sold to customers are consumed or used for one or more functions. Throughout their use, products and processing equipment may be serviced to repair defects or maintain performance. Users eventually decide to retire a product. After retirement, a product can be re-used or remanufactured.

Material and energy can also be recovered through recycling, composting etc. Materials can be recycled into the same product many times (closed loop), or used to form other products before eventual discard (open loop). (Joseph F. , 1996)

Figure 3. 38. Cardboard Coffin from recycled newspaper

Life cycle design relies on an expanded definition of a product in which all activities needed to make, use, and retire products are considered a single unit. Design addresses the entire product system so, this is the most logical way to reduce total environmental impacts.

Product LifeCycle Design

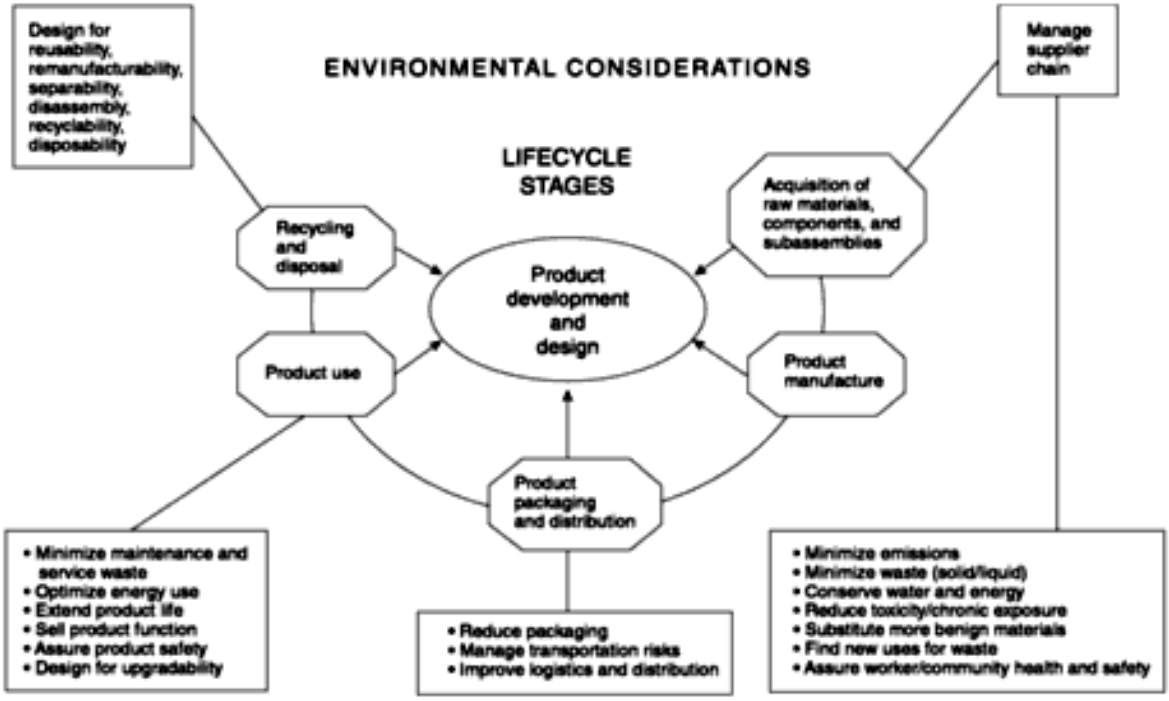


Table 3.1. Product Life Cycle Design (Richards and Frosch, 1994, The Industrial Green Game, p:17)

Product

The product component consist of all materials in the final product. Every form of these inputs in each life cycle stage is included. The product component of a complex product such as an automobile consists of a wide range of materials, these may be a mix of primary (virgin) and secondary (recycled) materials. The material in new or used replacement parts are also included in the product component.

Figure 3. 39. Future cars!

Process

Processing transforms materials and energy into a variety of intermediate and final products. The process component includes direct and indirect materials used to make a product.

Figure 3. 40. Swedish Cardboard Chair

Distribution

Distribution consist of packaging systems and transportation networks used to contain, protect, and transport products and process materials. Storage facilities, are necessary for distribution. In addition to that, selling a product is also considered part of distribution. This includes both wholesale and retail activities.

Figure 3. 41. Sony speaker cabinets from Tectan recycled drink cartons

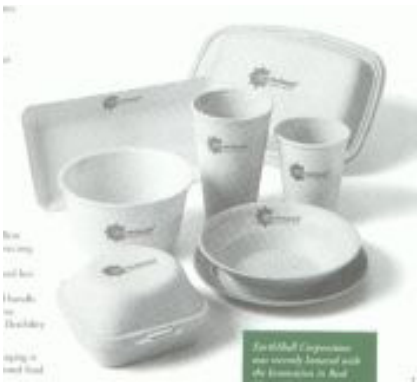


Figure 3. 42. Earthshell Packaging

Management

Management responsibilities include administrative services, financial management, personnel, purchasing, marketing, customer services, legal services, and training and education programs. The management component also develops information and provides it to others in the life cycle. Information is a key element of life cycle design. Reducing environmental impacts and risks depends on developing and using accurate information. The need for information extends throughout design. Marketing, labelling and similar activities are included in information provision. (Gregory A. K., Menerey D., 1994)

Figure 3. 43. Ecotopia educational handling box

As a result, the main environmental objective of life cycle design is to reduce the total impacts caused by product design, development, use and disposal. Environmental concerns have extended rather than altered fundamentally decisions about materials, efficiency and cost however, lifecycle decisions are different. Traditionally, the concern of the designer has ended with the launch of the product, but the environment-conscious designer should think about complete life of a product.

In addition to future improvements in technical or safety standards, and new materials, design for ease of maintenance and repair is also important for a sustainable product. Today, many products are a combination of high and low technology, so this can create a new approach to design for extended product life. Products which have reached the end of their useful lives will in most cases contain components or assemblies that are far from outdated. If the product has been properly designed with a concern to minimize environmental damage, the these units should be easily removable either for use as straight replacements for new parts or for remanufacture and re-use.

3.2.2. Product Life Extension

Extending the life of a product can directly reduce environmental impacts. In many cases, longer lived products save resources and generate less waste. Retirement is the defining event of useful life. For example; a product may be retired for fashion or technical reasons, eventhough it continues to perform its design functions well.

Generally, clothing and furniture are often retired prematurely when fashions change. By the way, technical obsolescence is common for electronic devices. Users may also be forced to retire a product for functional reasons. Repeated use can also cause structural deformation that finally result in loss of function. Understanding why products are retired helps designers extend product life.

Durable

Some design actions may make a product more durable without the use of additional resources. For example; modular construction allows easy upgrading of fast-changing components without replacing the entire product. In addition, materials should be as durable as needed. Some materials that increase product life by resisting decay may increase waste and other impacts on disposal.

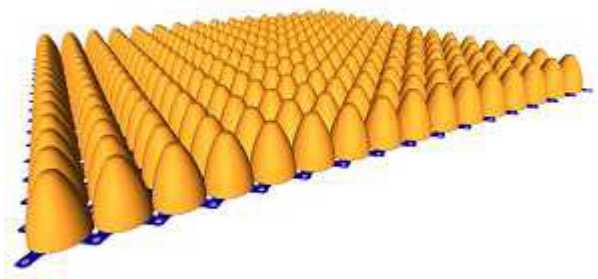


Figure 3. 44. The **'module'** concept are available for playgrounds, relaxation, amusement environments, swimming pools, seating surfaces.....

Adaptable

Adaptable designs either allow continual updating or they perform several different functions. Modular components allow single-function products to improve as needed. Adaptability can extend the useful life of products that quickly become obsolete. To reduce overall environmental impacts, a sufficient portion of the existing product must usually remain after obsolete parts are replaced.

Figure 3. 45. Child's school desk good reuse of material and recycling**...multifunctional** !

Serviceable

Many complex products designed to have a long useful life require service and support. Service activities can be seperated into two major categories: maintainability and repairability. Designers wishing to create products that are easy to maintain. Repairability is another crucial point to extend product life. Because, easy -to-repair products life are longer than the others.

Figure 3. 46. Folding bikes ...easy-to-repair

Reusable

Reuse is the additional use of an item after it is retired from a clearly defined duty. When applied to products, reuse is a purely comparative term. The environmental profile of a reusable product does not always depend on the number of expected uses. If the major impacts occur in manufacturing and earlier stages, increasing the number of uses will reduce total environmental impacts. Single-use products often cost more per use than reusable products.

Figure 3. 47. 'Bob Pen' a reusable, refillable child's art marker.

3.3. Material Selection

Material selection is a fundamental part of design, it offers many opportunities for reducing environmental impacts. In the sustainable design context, materials present the designer with some of the most difficult problems. The life of a product begins with the acquisition of materials. For designers, the choice of materials is crucial. The material used has a major impact on the environmental performance of a product, influencing its energy efficiency in manufacture and use, how easily it can be recycled, or whether it represents a hazard when eventually disposed of. Consideration of materials should begin at the earliest stage of the design process, with selection made in the context of how the product will be used, whether recycling is possible, and what performance characteristics are demanded.

Figure 3. 48. Emeco super-durable recycled aluminium chair

Designer should aim to use a material which is appropriate for the way in which the product will be used. Sometimes high-quality materials are specified because of their attractive appearance, but innovative design can create unusual and appealing images through the use of low grade material which may be more appropriate to the product life cycle. Against this must be set the danger that lower quality materials will simply encourage disposability.

There is considerable confusion about whether some materials are inherently less damaging to the environment than others. Some may consume more energy or nonrenewable materials in their production, but perhaps have a longer life span. Some are easier to recycle, while others are believed to degrade easily and harmlessly. When disposed of by incineration, some materials are valuable because their energy content can be reclaimed, but there may be concerns about the substances released into the atmosphere during the incineration process. No one type of material can claim overall environmental superiority. Material selection has to be considered, therefore, as part of the total manufacturing and design process, taking into account the entire life cycle of the product.

There are main criterias that environment-conscious designer should consider to 'design for material conservation':

- **Design multifunctional products**: Products which have multiple uses are by nature eco-efficient, in that the same amount of material achieves a higher level of functionality. There are essentially two types of multiple functionality:

    1. ***Parallel functions,*** in which the same product may simultaneously serve several different purposes.

    2. ***Sequential functions,*** in which a product is retired from its primary use and then applied to a secondary use.

- **Specify recycled materials**: An important aspect of sustainable development is the conservation of nonrenewable resources. Recently, many designers have begun to encourage the use of more 'environmentally conscious' materials.

- **Specify renewable materials**: Instead of recycling nonrenewable materials, an alternative approach to sustainable development is substitution of renewable materials. For example, materials developed through agriculture are renewable. Examples of products that use renewable materials include soy inks and wood products.

- **Use remanufactured components**: Product manufactured with refurbished components can potentially have the same level of quality as ones manufactured with brand new components.

- **Design for product longevity**: From a consumer point of view, longer-lived products are generally more desirable because of convenience and cost savings. Apart from the life extension for the product as a whole, another way to achieve longevity is to extend the life of product components. There are at least two ways to accomplish this:

    1. Design upgradeable components
    2. Design a reusable platform

- **Design for closed-loop recycling**: Where possible, closed-loop recovery of materials and components enhances the value of strategies such as using recycled materials and remanufactured components.

- **Design for packaging recovery**: In the field of industrial packaging, great strides have been made in developing methods and technologies for the recovery, recycling, and reuse of packaging materials.

- **Design reusable containers**: Disposal of used containers is a major source of solid waste. Industrial suppliers can redesign the shipping containers in which they deliver materials and components so that they can be recycled and used repeatedly. In this case, consumers have a crucial role. For example, consumers can learn to purchase concentrated refills for their spray bottles and detergents etc. (Gregory A.K., 1994)

Much of the effort in materials development recently has been towards the creation of new materials which have unique properties. Designers should not specify any substance without first considering whether it has any dangers in use, such as a possible health risk, or it could create dangers in disposal. It is not always possible to identify

easily the harmful side-effects of products, especially when these occur at the disposal stage of the product's life, rather than in use.

3.3.1. Minimum Use of Material

For all designers, one of the first rules should be to minimize the quantity of any material chosen wherever possible. The benefits of this, can be seen at the product's life, from the conservation of resources, through the reduction of energy and pollution in manufacture and use, to the minimization of the problems of disposal. Minimizing materials demands careful attention to production processes as well as to the design itself. A reduction in the amount of material used is desirable because of cost savings, in addition to the environment benefits of saving resources. In addition, weight reduction is a key objective.

Using less material obviously saves direct costs as well as minimising the environmental burden. Reducing materials usage should go beyond simply minimising a particular design. For some products, weight reduction brings significant benefits during later stages of a product's life. This is especially true of items such as packaging, where lower weight cuts transports costs and can ease handling. In this case, designers should be consider some crucial points:

- Ensure that the choice of materials is appropriate to the expected life of the product.
- Use renewable materials from a sustainable source where this is appropriate.
- Use recycled materials if possible.
- Avoid or minimise materials containing toxic chemicals.
- Minimise materials use both by the choice of design approach and through detailed design.
- Consider the energy implications of materials choice over the lifetime of the product.

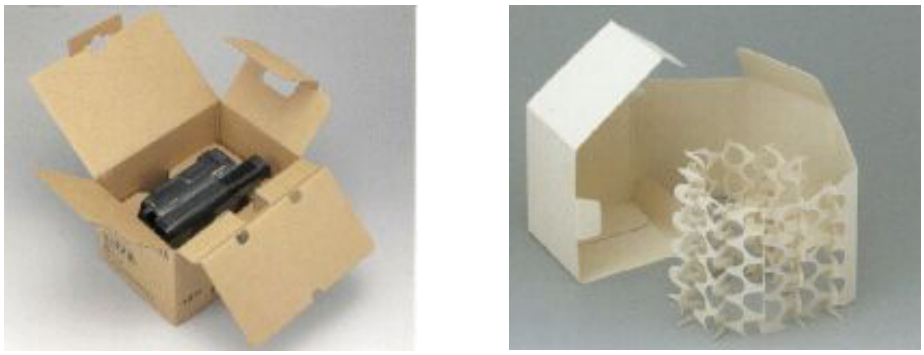


Figure 3. 49. Inventive cardboard packaging from Japan

3.3.2. Using recycled materials

Designers and manufacturers should be increasingly aware of the possibility of using recycled materials. In general, materials that have come from a recycled source are more environment-friendly than those from virgin sources. Not only does recycling reduce the waste, it is often far more energy efficient. There is an important point that, depending on processing methods and final use, recycled materials may sometimes be less environment-friendly than they seem, but any recycled material should be investigated as a possible resource.

Figure 3. 50. Kodak film with lens ..excellent recycling

Materials which are difficult to recycle may have other benefits, such as greater energy efficiency. The replacement in the automobile industry of easily recyclable steel and iron by hard-to-recycle plastics helped improve fuel consumption because of the savings that could be achieved in the weight of the car.

However, the inclusion of higher quantities of plastic made it more difficult for scrap merchants to retrieve the metal parts, thus increasing their costs and diminishing the value the metal recycling process. Efforts now being made to develop plastic components which are easy to dismantle and separate, and which be recycled themselves, may reduce this problem. (Mackenzie D.,1991)

Figure 3. 51. Wheel recycling at Ford

3.3.3. Biodegradable Materials

Biodegradable materials are another possible resource which demands careful consideration. Natural substances such as wood and cotton are inherently biodegradable, and may therefore be preferable in many applications to plastics, which will not biodegrade. The development of biodegradable plastics may be useful for items which have to be disposed of after limited use. They might also be used for products which are regarded by consumers as disposable, especially for those which end

up in the sewage system, although a better alternative might be to encourage re-usable products instead.

Figure 3. 52. Shampoo bottles made from biodegradable plastic

3.4. Energy Efficiency

One of the main contributions designers can make to improving the environment performance of products in the area of energy use. They can design products which use energy efficiently, and which use as little energy as possible, and they can explore opportunities to use energy from renewable resources. The prime objective of environmentally conscious design is to use resources efficiently, thus minimising their use and avoiding waste. These objectives also lead to reduced costs for the manufacturer and the user.

Sometimes, energy wastage may continue completely unnoticed. Televisions with standby features consume electricity even when they are not being used. Timing controls allow appliances to be used during the night, when energy needs can be supplied more easily.

Figure 3. 53. Television & remote control with standby features

The designer should always look to see if the choice of energy source is inevitable or if a better alternative is available. Energy efficiency is important during the manufacturing stage, too. Many materials are highly energy-intensive in production, but that energy cost may be justified by energy savings delivered in use, and by length of life through recycling. Considerable energy savings, can be achieved by allowing the end user of a product to assemble it. Assembling and transporting goods such as furniture and domestic appliances are costly; producing simple and easily assembled components would reduce manufacturing and transport costs.

Figure 3. 54. The FRIA cooling system, utilises cold air from outside to reduce energy costs in winter, giving a net energy saving of around half compared with a conventional refrigerator.

The contribution made to national power supplies by renewable forms of energy such as solar and wind power is likely to increase steadily in many countries. For most powered products, mains electricity or gas is likely to be the most practical source of energy, but there may be opportunities to use solar or wind power directly. Solar power is particularly valuable in areas where no other form of energy is readily available.

Figure 3. 55. Cousteau's partly-wind powered boat

Figure 3. 56. NASA Solar-powered airplane

There is, one important difference between designing for the ordinary consumer and designing for a commercial user. In general, the direct recovery and re-use of waste energy or other resources lost in use is unlikely to be economic for most domestic products. But the capture and re-use of resources can be of considerable interest to a commercial user, both in meeting environmental requirements and in saving money. Such systems range from incorporating regenerative braking into electric vehicles so that energy is returned to the batteries to utilising a centrifuge to decontaminate cutting fluids so that they can be re-used.

In this case, designers should be consider that;

- Minimise the use of energy and other resources required by a product to perform its function.

- Design both the product and accompanying instruction manuals to encourage its most efficient use.

- Consider how waste energy and other resources can be recycled and utilised.

(Burall P.,1996)

Figure 3. 57. Old model solar camera from Canon

3.4.1. Minimising Pollution

Mechanical changes to products can reduce the amount of water they use. By increasing mechanical pressure, and ensuring that water is directed to where it is needed, it has been possible to develop a washing machine which uses significantly less water. Air, water and noise pollution can be reduced and prevented by designers carefully considering the selection of product materials, and by looking for alternatives to conventional approaches.

Figure 3. 58. Brox human power delivery vehicle

The automobile is one of the worst polluters. One way of addressing this problem is to try to produce cleaner cars by using power from electricity, or other cleaner fuel sources and by developing new types of engine. But, a more fundamental solution is to develop efficient alternatives to car usage, in the form of public transport systems.

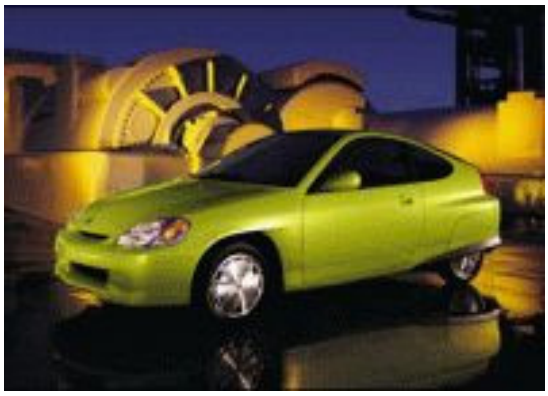


Figure 3. 59. Honda Insight Hybrid

New technologies can make more effective use of resources. Of course, any new technology brings with it some uncertainty, because the long-term consequences of its use are unknown. However, it seems clear that the incorporation of appropriate advanged technology into products and processes can make a significant contribution to improving their environment performance. It is up to the designer to be well informed about the possibilities of new development.

CHAPTER 4

ENVIRONMENTAL ISSUES AND PRODUCT DESIGN

4.1. The Background to Environmental Issues

It is not always easy to see how individual decisions by designers, affect global environment problems. However, design can have a crucial impact on the environment in many different ways, such as; the extraction of raw materials, the design of the manufacturing process, how product is used and distributed, and in what happens when the product reaches the end of its useful life.

4.1.1. Global Warming & Air Pollution

Gases in the atmosphere insulate the earth, preventing some of the sun's heat, reflected from the earth's surface, from escaping into space. This is a natural effect without which the world would be frozen. But, industrialisation and agricultural development have resulted in increases in the concentration of some gases in the atmosphere, trapping more heat.

Figure 4.1. Wind power represents a relatively cheap, clean and simple form of alternative power

Discussions of ways to avert global warming have focused on the need to reduce emissions of carbon dioxide, for example by extracting it from power stations, on the importance of developing alternatives to fossil fuels; on the need to preserve the earth's forests, which absorb carbon dioxide; and on reducing the amount of energy produced in the first place, through improved energy conservation and efficiency. (Mackenzie, D., 1991)

Figure 4.2. Solarex solar- powered solar panel factory

The energy efficiency is important, too. In this case, designers can play a crucial role in conserving energy in several different ways;

- By designing products with improved energy efficiency.
- By designing products for recyclability. The energy required to manufacture a material originally is almost always greater than that required to recycle it.
- By specifying materials which have been produced efficiently.
- By redesigning machinery and processes to reduce energy loss and to save production costs at the same time.
- By encouraging more people to use public transport.

Figure 4.3. Taxibike, very common in London now ..

Another global environmental concern is the depletion of the stratospheric ozone layer. If the ozone layer thins, more ultraviolet rays will reach the earth's surface, causing damage to living substances, such as skin cancer in humans. Ozone is broken down naturally by UV rays, but this process is accelerated by the presence of chlorine, which destroys ozone molecules. Chlorine is released into the atmosphere by the breakdown of chlorofluorocarbons. CFCs are used for plastic foams such as packaging materials, as propellants in aerosol sprays, and as solvents for cleaning electronic components.

4.1.2. Water Pollution

The increasing use of water for industrial purposes also creates a serious problem for the environment. In addition to possible dangerous effects on the drinking water supply, water pollution is also creates major problems for wildlife, animals and plants. Because of this growing danger, pressure is increasing for industry to aim for sustainable waste management systems.

Designers may play a significant role in the redesign of industrial processes to reduce the need for harmful emissions and can help to reduce water pollution;

Figure 4.4. Hoover Quattro EU Ecolabel washing machine

- Saving water is as important as saving energy. So, designers should aim to design household appliances, etc... which use far less water.

- The record of suppliers of raw materials and components should be examined to ensure that their manufacturing processes are not unnecessarily polluting.

- The processes by which specific ingredients are manufactured should be questioned. For example; titanium dioxide, used in a wide variety of products including paints etc. can be produced in different ways, with varying degrees of polluting effect.

Figure 4.5. Biofa natural paints

4.1.3. Waste

Another problem is the disposal of trash, garbage, and industrial wastes. Unfortunately, the developed countries produce a billion tonnes of industrial waste each year, some is incinerated and some is simply dumped at sea. Each of these primary disposal methods has serious drawbacks, besides being a waste of valuable and often irreplaceable natural resources. Burning rubbish can generate energy.

Because of the mixed nature of waste, and the types of materials included in it, incineration can release toxic gases into the air unless a very high temperature is reached. Incineration also leaves behind a residue which can contain dangerous metal pollutants. On the other hand; depositing rubbish out at sea may solve an immediate problem, but it causes damage to marine life. (Mackenzie D., 1991)

Figure 4.6. Barbour jackets never die...they are repaired and recoated in large numbers

The most effective way of addressing the waste disposal problem is to produce less waste. In this case, designers have a crucial role to play. Good design can make a difference for example; products can be made more durable, or easy-to-repair, etc.

However, products last only for a specified period of time because of the rapid advance of new technology which quickly make them obsolete. In packaging areas, re-use will becoming increasingly important, with the development of returnable packs and refill systems.

Figure 4.7. Greenpak , re-use system for cardboard cartons

In some applications, safety requirements may make the use of virgin materials necessary, but there are many applications where recycled material would be fine. Designing for recyclability needs some requirements such as ;

- Make the components easy to disassemble
- Reduce the number of different types of materials used
- Avoid using combinations of materials which are not mutually compatible
- Avoid composite materials where possible
- Consider how materials can be identified
- Ensure that is possible to remove easily any components which would contaminate the recycling process

Figure 4.8. Biffa collect and dispose of flourescent tubes

Designing to minimise waste will require a good knowledge of the life cycle of the product, and good information about the performance of different materials within the re-use or recycling chain.

4.1.4. Noise

Noise pollution is an increasing source of discomfort to people. Major improvements have been made in the reduction of the noise levels of many industrial machines, but noise can still be a real health hazard in some industries. Noise from motor or air traffic is a serious problem for those living near to busy routes, and even the noise from domestic machines can cause considerable irritation and a real impairment of the quality of life. Sometimes the use of lightweight materials can reduce noise output, improvements in environment performance, noise output may also be improved as a side effect.

Figure 4.9. Carradale electric bicycle, silent way for transportation

As a result, the conservation of natural resources and the responsible management of renewable resources lie at the heart of the concept of sustainable development, which will become an essential theme for politics and industry. We should aim to meet today's needs without harming the ability of future generations. Using up non-renewable resources is an obvious concern, but simply increasing consumption of renewable resources may not be the solution.

In this case, designers have crucial impacts. Materials may be recycled or virgin, renewable or nonrenewable. Materials which occur near to their point of use have the advantage that they require less energy to transport. In addition, materials made from non-renewable resources should be re-usable or recyclable wherever possible. Another way how the designer can make a major impact on resource consumption is in considerations about the energy used throughout the chain of extraction, manufacture, transit, use and disposal. Finally, designers could be to design multi-purpose, highly functional products to reduce the number of objects and their environmental effects.

4.1.5. Biodiversity

The other issue of global extent is the loss of diversity of plant and animal species, with particular emphasis on depletion in tropical forests and coastal marine regions where diversity is particularly rich. The care for biodiversity stems in part from practical concerns regarding the potential worth to humans of individual species and ecosystems for medicines and crop varieties, and for services.

Nature provides such as nutrient recycling and water purification. It also stems from ethics which intrinsically value all species and ecosystems. Still, data on species loss are poor; much of what is lost, associated with the destruction of ecosystems in areas that have been largely unstudied. Uncertainty also makes it difficult to verify species loss. A major contributor is loss of habitat, such as wetlands. Biodiversity in coastal marine regions remains under great pressure as the result of increased population and development, associated changes in water quality, increased marine debris and pollution, and destruction of habitat, etc.

4.1.6. Deforestation

The effects of deforestation include the destruction of species, since rainforests contain a wide diversity of animal and plant life; the disruption of local climates, possibly leading to desertification due to changes in rainfall patterns; desertification, and the loss of habitat for local people. The destruction of vast areas of forest is also considered to be a significant contributory factor in the greenhouse effect and brings about global climate change.

Figure 4.10. The rainforests

Tropical hardwoods tend to be associated with high-value-end-uses, such as furniture, and durable boards for protection of buildings. However, is used in other areas where other woods, or different materials altogether, would be appropriate.

4.2. Electrical & Electronic Products

Each year, people purchase millions of electrical and electronic products such as refrigerators, televisions and computers etc. The benefits gained from electrical & electronic products often come at a cost to the environment, such as, vast amounts of energy, water and detergents are consumed, as well as millions of tonnes of non-renewable resources.

In addition, a potential revenue stream may be missed by not recovering and recycling materials. A substantial amount of those materials end up in landfill at the end of the product's life. As components may contain hazardous materials are inappropriately disposed of.

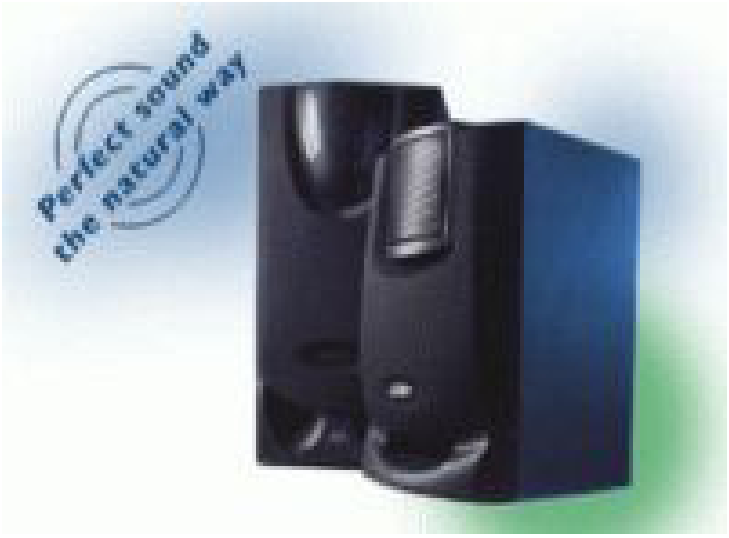


Figure 4.11. Philips biocomposite speakers

The environmental impacts of electrical & electronic products are not isolated to any single stage of the product life cycle. In addition to that, the major environmental impacts associated with electrical & electronic products occur during their use and operation. The life-cycle impacts of electrical & electronic products also vary according to the specific product. We need to be cautious in generalising about the nature of environmental impacts, but, full life-cycle environmental assesments show energy consumption is the main environmental impact.

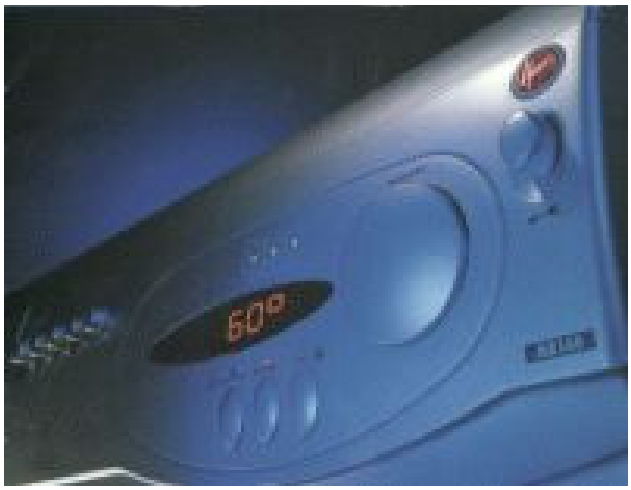


Figure 4.12. Hoover Quattro EU Ecolabel Washing Machine

4.2.1. Design Strategies

4.2.1.1. Design for minimal energy consumption

- minimise standby power consumption
- minimise warm-up time
- power down as far as possible, as fast as possible, after use
- minimise operational power requirements
- use efficient power supplies
- for equipment that uses paper, provide double-sided copying and printing
- ensure controls for energy-saving features are easy to use
- incorporate lightweight moving components
- optimise system efficiency under the likely range of usage, including standby energy
- where water is heated, minimise volume and heat losses and recover waste heat
- where heat must be transferred, optimise the process

4.2.1.2. Design for water efficiency

Many of the principles listed above also apply to water efficiency. The aim should be to minimise water usage in production, use and re-use. Water should be recovered and re-used. Consumer use of a product is also critical. Environmentally conscious products and labels can encourage consumers to buy the most efficient product but consumer education is also required to ensure that the product is used in the most efficient way.

Figure 4.13. Fax and scanner in one uniot from HP

4.2.1.3. Design for durability

The designer should specify durable materials. Products should also be designed to allow for future upgrades, especially of electronic products, such as computers, audio-visual equipment, washing machines and other household appliances.

Figure 4.14. Second time around 'STAR' refurbished computer

4.2.1.4. Design for disassembly and recycling

Complex products will need to be disassembled so that different materials can be seperated for recycling. Design for disassembly can also make a product easier to repair or re-manufacture. Design for recycling means that the materials used to manufacture a product could have a secondary use, either for the same product or for a different product. Design for disassembly, reducing the diversity of materials, and labelling polymers are important in improving the potential for recycling electrical & electronic products.

Figure 4.15. Ricoh copier disassembly

4.2.1.5. Design for remanufacture

Remanufacturing is an important strategy in avoiding waste. Re-manufacturing involves collection of used products, disassembly, replacement of damaged components, assembly and resale. Increasingly there is considerable discussion about product-service strategies and how the total volume of manufactured products might be reduced through dematerialisation and maximising materials efficiency. It's therefore important to carefully understand the functional aspects of conventional products and explore the potential for designing new, sustainable services as opposed to simply redesigning existing products. (Centre for design at RMIT University)

Specific Example

Reducing the amount of electricity used in washing machines, the most used household appliances, can make a significant contribution to energy conservation. The German company AEG, which consistently aim to improve the environment impact of their products, have developed to new Lavamat to achieve low energy and water consumption.

Figure 4.16. AEG washing machine

The build-up of soap suds in the machine is monitored, and excess suds are avoided throughout the wash by partially reducing the spin speed. Because the level of suds is controlled, less water is required to rinse the clothes. A load sensor automatically relates the amount of water required to the type and size of load, again ensuring that only the minimum amount of water and energy is used. This is particularly important when the machine is not loaded to its full capacity, although the manufacturers encourage users to fill machines whenever possible.

Reliability and long life are also important. One additional benefit of the electronically controlled transmission system, and the amount of insulation, is that the machine is very quiet in operation. These features of increased intelligence, lower energy consumption and better water economy will no doubt be the objectives of future product development in this sector.

4.3. Design for Packaging

Packaging plays a critical role in sustainable design process. Well designed packaging fulfils a diverge range of functions from dispensing content, through to preventing breakage, leakage, spoilage and contamination of contents. In addition to that, packaging can extend the life of contents and ensure that products are safely stored while in transit.

Packaging is also a key factor in marketing a product and capturing the interest of consumers in a highly competitive market place, especially when it comes to household items such as food, beverages, detergents and many other consumables.

Figure 4.17. Duracell packaging no PVC blister needed

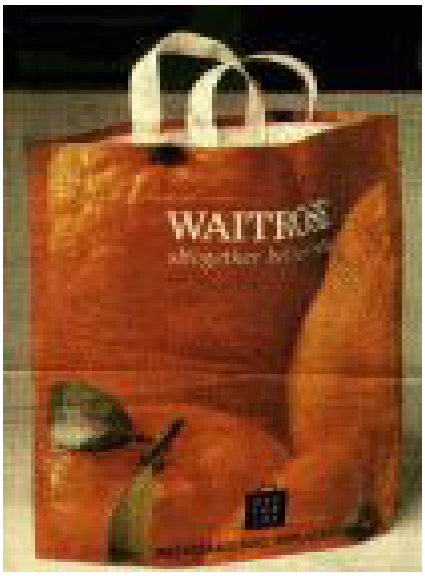


Figure 4.18. Waitrose bag for life

Increasingly, packaging delivers important information to consumers about issues such as specific content and instructions for use etc. It becomes clear that well designed packaging can perform many useful functions, however it is also obvious that packaging that is not supported by effective recovery and recycling systems represents an in-efficient use of resources / materials . As a result, packaging can contribute to solid waste and other impacts associated with landfilling.

Figure 4.19. Sainsbury's packaging eliminated card boxand saved 80 % on materials

4.3.1. Design Strategies

These strategies should be viewed for the development of design techniques appropriate to each situation.

4.3.1.1. Waste management

Recently there has been a great deal of emphasis on recycling to reduce waste, even though the waste management hierarchy favours source reduction and reuse above recycling.

The waste management hierarchy:

1. source reduction
2. reuse
3. recycling
4. safe disposal

Although the hierarchy is a generalisation and each step may not apply in every case, source reduction should be considered first because of the benefits it brings throughout a product's life cycle. In other words :

- less material is extracted or harvested
- less raw material and energy is needed in manufacture
- less energy is used in transport because of reduced weight
- less waste for disposal or recycling

Figure 4. 20. More cardboard packaging from Japan

4.3.1.2. Source reduction

- Minimise the material required to contain, protect and deliver products safely to the consumer
- Reduce package wall thickness through redesign
- Minimise the weight of the package
- Package products in a concentrated form
- Package products in bulk
- Keep the number of packaging layers to a minimum

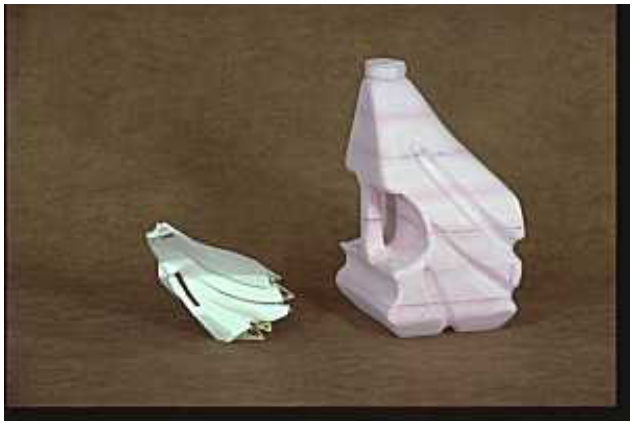


Figure 4.21. Collapsible bottle from post consumer PETE

4.3.1.3. Reuse

- Use durable materials to prevent damage during handling
- Use in-mould labels rather than paper or plastic labels, which can be washed off
- Establish an efficient return system, which takes advantage of existing networks and minimises the need for transport
- Use lightweight refill packages to enable reuse of bottles, within the home
- Consider loaning packages to the customer rather than selling them

Reuse occurs around the home often without people being aware of the environmental benefits.

Figure 4. 22. Reusable crates from Sainsburys

4.3.1.4. Recycling

- Although a material might be physically recyclable, it cannot be called recyclable if there is no infrastructure and market in place to process it
- Try to use a single compatible material, for simple recycling
- Avoid non-recyclable laminates or multi-material films
- Use materials that can be economically recycled
- Use materials that have an existing collection and recycling system
- Avoid using labels, adhesives, coatings and finishes which may contaminate recycling
- Use in-mould labels made from the same material
- Use water-soluble adhesives for labels
- Ensure that inks are compatible with recycling
- Ensure the consumer is clear about the product's recyclability

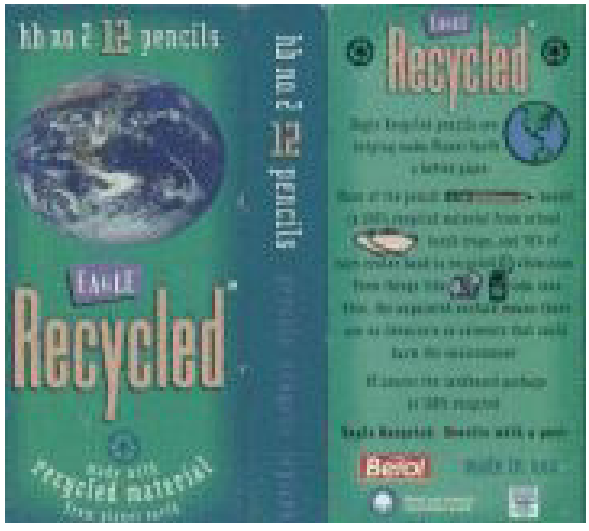


Figure 4. 23. Eagle pencils & packages from recycled dinner trays

4.3.1.5. Energy efficiency

- Avoid unnecessary packaging components
- Use lightweight materials
- Maximise energy efficiency of production processes
- Avoid or minimise the need for refrigeration
- Design efficient collection programs for reuse or recycling, to minimise transport impacts
- Perform a life cycle energy audit through extraction, processing, transport, storage, recycling and disposal, to a certain areas of concern

Figure 4.24. Ecomental packaging design for re-use

4.3.1.6. Safe Disposal

- Use any source-reduction techniques appropriate.
- Minimise the incidence of toxic waste by careful selection of components.
- Use companies that will process toxic materials or recycle them.
- Label toxic material packages with instructions for safe disposal.

- Avoid use of inks, dyes, pigments, stabilisers and adhesives where possible, for example, use in-mould labelling.

Figure 4.25. Recycled paper products

It's therefore important to carefully understand the functional aspects of conventional products and explore the potential for designing new, sustainable services opposed to simply redesigning existing products. (Centre for design at RMIT University)

Figure 4. 26. Dunlop golf ball wrapped in bioplastic film from CDP

Specific Example

The Body Shop is a company with over four hundred outlets worldwide selling a wide range of toiletry products. The company adopts a non-exploitative approach to the environment, emphasising natural ingredients; simple, recyclable and refillable packaging, and no testing of products on animals.

Figure 4.27. The Body Shop products

Minimal packaging includes cylindrical plastic bottles, plastic is used because it provides an effective barrier, and is robust, durable and light for distribution. It is also regarded as safer than glass, because of the potential danger if glass were to shatter into tiny particles. But the virtues which make plastic so useful,its strength and durability, also create problems when it comes to disposal. The Body Shop considers that plastic packaging should be re-used wherever possible, and encourages its customers to bring bottles back for refilling. Recycling is the next priority, with disposal considered as the last resort.

Figure 4.28. The Body Shop products

To ease recycling, The Body Shop has minimised the number of different materials used for packaging, within the constraints of the need for compatibility between product and packaging. The clear bottles are made of PET (polyethylene terephthalate), and the opaque ones from HDPE (high-density polyethlylene)both are recyclable materials. The Body Shop aims to recycle as much waste as possible, recovering materials such as cardboard and plastic film from the distribution system.

4.4. Furniture Products

Unlike other manufactured goods, such as appliances which impact on the environment through the energy/water used during operation; furnitures can result in environmental problems throughout their life cycle from manufacture to distribution and construction and finally disposal of the product.

Figure 4.29. Trannon Furniture

4.4.1. Design Strategies

Environmental impacts of a product and its packaging can be reduced through a variety of design strategies.

- **Minimalization**

  minimise the use of different materials, simplifying the internal process maximises the opportunities for recycling waste from production and re-using the components at end of life.

- **Optimization**

  optimise the number of components and assemblies; maximise material specifications and minimise waste.

- **Integration**

integrate several functions in one component or assembly, or design one component to serve more than one purpose, thereby reducing material use and making savings in tooling and energy.

- **Specification**

specify low-impact materials and processes, for instance, avoid processes that use toxic materials.

Figure 4.30. Little Beaver chair made from corrugate cardboard, fiberboard

New product design should include the evaluation of end-of-life scenarios to minimise or eliminate waste at the end of the product's life.

- Design for durability. This can be achieved by identifying and eliminating potential weak points in the design; particularly for operational components and parts.

- Design for ease care and maintenance to extend the product life.

- Design for re-use and re-manufacture. Furnitures should be designed for re-use or refit, so, damaged components should be replaceable. The objective is to extend the first life of the product as long as possible.

- Modular design can also reduce premature obsolescence and unnecessary disposal.

- Design for disassembly. This is a crucial point that ensure that the overall design can be disassembled for re-use. This strategy facilitates easier repair and maintenance. Replacing a single component is preferable to a whole assembly or product.

- Design for recycling. This means that the materials used to manufacture a product could have a secondary use, either as the same product or as a different product. Consider using single materials and materials that are compatible with recycling. Consider using single materials for assemblies and sub-assemblies where possible. Evaluate construction methods and try to avoid adhesives and incompatible materials.

- Design for safe disposal. Ensure that all materials that have a toxic content , products and components that use adhesives and surface coatings, are correctly labelled. Impacts will vary according to the individual product design, its functional life-span, and its ultimate disposal path. However, when evaluated critically, it becomes obvious that the manufacture and disposal of furniture contributes to an extensive range of impacts that affect environmental quality.

Figure 4. 31. Phenix biocomposite material

4.4.2. A Case Study of Sustainable Furniture Design

The concept of sustainability is becoming increasingly important. In this case, products are the source of all environmental problems. From the traditional view, design is related only to function and appearance, but in recent years, designers and consumers have started to look beyond pure surface.

Design can have an impact upon the environment in many different ways. Considering environmental issues in industrial design, the area of the designer's responsibilities are more extensive than before. Thus, designer should aim to create a better design in a better way for the environment.

The aim of this study is to create furniture by considering sustainable design strategies and using appropriate materials which are available to the concept of sustainability. Unlike other manufactured goods, furniture can result in environmental problems throughout their life cycle from manufacture to distribution and construction and finally disposal of the product. Considering this, first of all, design strategies are determined clearly (see, page 117-119) Then, a case study has been designed in accordance with sustainable design context and using appropriate material.

4.4.2.1. The Features of Design

"Yekpan" children furniture have been designed from the view point of sustainability;

- safe (ergonomic design, rigid construction, no sharp corners)
- fun to use (bright colours, like a puzzle without the use of tools or hardware)
- useful (adjustable, multifunctional, modular design)
- easy to assemble x disassemble (no extra tools required)
- durable (all "Yekpan" construction and non-toxic paint.)
- safe disposal (no waste, fully recyclable)
- grows your child' s "creativity"

(It's recommended for children ages 3 to 8)

4.4.2.2. Materials and Manufacture

The material is Yekpan, a colourful, water-resistant, durable chipboard from shredded beverage cartons. Yekpan board is composed of paper (75%), polyethylene (20%) and aluminium (5%)- the components of the beverage carton. The cartons are sorted, shredded, heated and cut into 5 mm particles. The material is then spread into sheets, compressed, heated and pressed between two plates and a special foil which is later comparable to a lacquered surface. The polyethylene content in the material melts acting as a glue to bond the board and making it durable. The board is then cooled in a cooling press and pressed once again to strengthen it. The finished board can be processed as required.

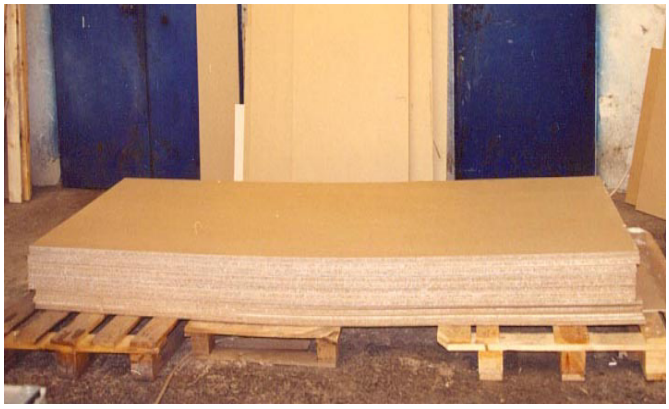


Figure 4.32. 'Yekpan' panel board

Manufacturing Process of Yekpan

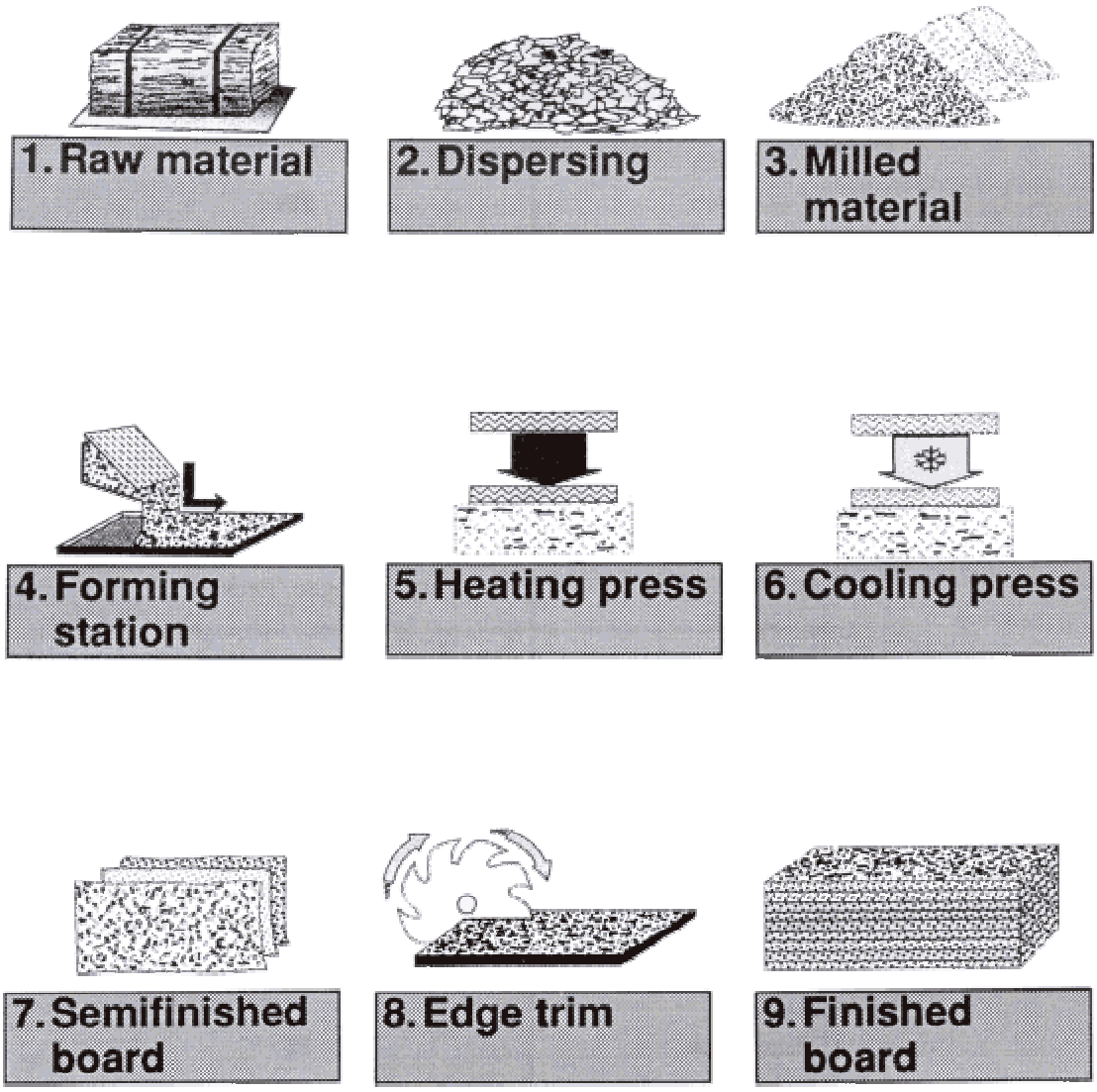


Figure 4.33. Manufacturing process of **'Yekpan'**

4.4.2.3. Conclusion of Case Study

“Yekpan” children furniture have been created by considering sustainable design strategies such as design for durability, design for disassembly, modular design, design for recycling and design for safe disposal etc., and by using appropriate materials.

“Yekpan” children furniture are designed to be:

- safe
- fun to use
- useful
- easy to assemble x disassemble
- durable
- safe disposal

Modular design of “Yekpan” children furniture allows you to have alternative usages. It is possible to create different modules and to obtain functions by using the same components. It is also available to design alternative furniture by using similar combinations such as bedroom furniture, garden furniture etc.

CHAPTER V

CONCLUSION

Today, the concept of sustainability has become more important. The challenge of sustainable design is to alter conventional design and manufacturing procedures to incorporate environmental considerations systematically and effectively. So, this requires a change in these existing procedures.

Designers' taking the environmental impacts of their works into consideration is not a new approach. Designer was in a powerful position, able to help create a better world by considering environmental issues and creating environmental process and products. At that point, the question is whether the designers are equipped to respond to the new demands which will arise from these changes, or not. Unfortunately, the answer is disappointing. In most places, design has not been taught in the context of its social and ecological impact. Many designers assume that their area of responsibility is limited to function and appearance. But, there is an opportunity for designers to show imagination and leadership aiming at solving real problems.

Many environmental problems are caused by the pollution which results from the production and use of products and services. Most products and services use natural resources, many of which are irreplaceable. The manufacturing process itself uses energy, creates waste, and may result in harmful by-products. Many products have a significant effect on the environment when in use, and finally, the product may be disposed of, causing another set of problems.

Designers have a direct influence on the amount of damage which will occur at each stage in the process. For example; what materials will be used, how will the product be manufactured, how will the product be used and disposed of ? Is it designed to be easy to repair ? Is it reused or recycled ?

Designers must demonstrate an ability to take on the complex and challenging issues, which surround designing for minimum environmental impact. It is ultimately the designer who creates the interface between the consumer and the technology underlying the shell or surface of a manufactured product and who gives form and meaning to objects that not only offer utility, function and convenience but also desire and visual pleasure.

Usual definitions of good design already include criteria such as succesful performance, ease of use, safety, simplicity of maintenance, appropriate materials, efficiency of manufacture, attractive appearance and value for money. Designing for sustainable markets does not invalidate the traditional criteria for good design, but it does demand that some are given different weightings and that new considerations are also taken into account.

Consciously or not, the design of products and processes is the main determinant of environmental impact. Design is the key intervention point for making radical improvements in the environmental performance of products. The relationship between design and ecology is a very close one, and makes for some unexpected complexities such as the acquisition of raw materials, through the manufacturing process and assembly, the purchase of the complete product which also includes packaging and advertising, the use, the collection of the product after use, and finally the re-use or recycling and final disposal.

Environment is not simply a practical issue; it is also a moral one. The idea that designers should aim to minimise the environmental impact of their work which has been accepted in many cases. Designers have the central role they play in influencing the environment performance of so many things. Designers have always striven for a better way of doing things, now that better way can embrace environmental, ethical and social issues, too.

The main purpose of this thesis is to analyze the ‘Sustainable Product Design’ from every aspect which is completely considered and has given specific examples to make them easy to comprehend.

In Chapter 2, first of all, the concept of sustainability is defined clearly. Then, the role and responsibility of the designer is emphasized which is crucial for sustainable product design. Consumption and marketing of sustainable products have some differences from conventional product design and all these differences have been considered in this study.

In Chapter 3, the changing design process is analysed with every aspect such as labelling, product life, material selection and energy efficiency.

In Chapter 4, environmental issues are introduced such as global warming, water pollution, waste and noise...etc. Then the relationship between environmental issues and product design is emphasized by considering specific sectors (electrical & electronic products, packaging and furniture products).

Finally, this thesis is completed with a case study of sustainable furniture design. The aim of this study is to create furniture by considering sustainable design strategies and using appropriate materials which are available to the concept of sustainability.

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