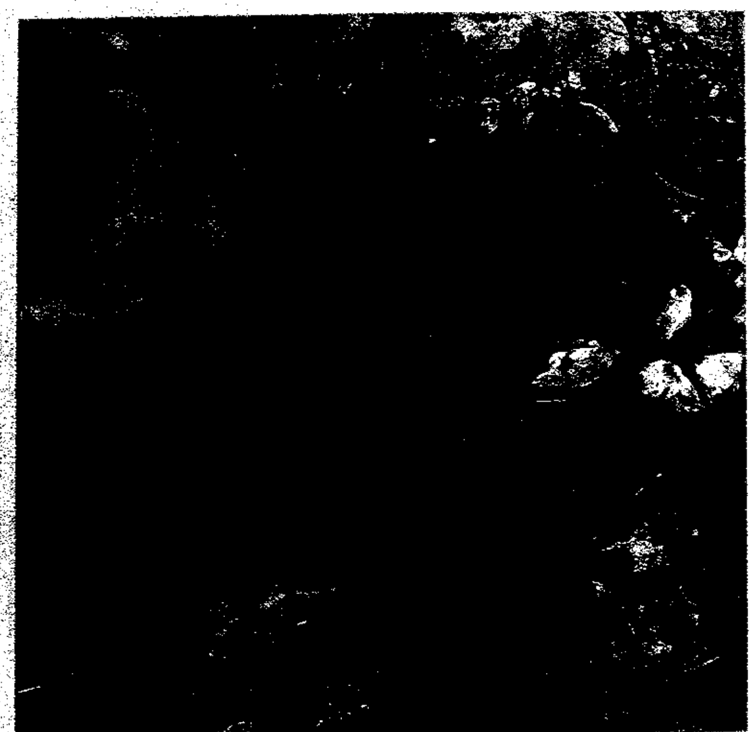
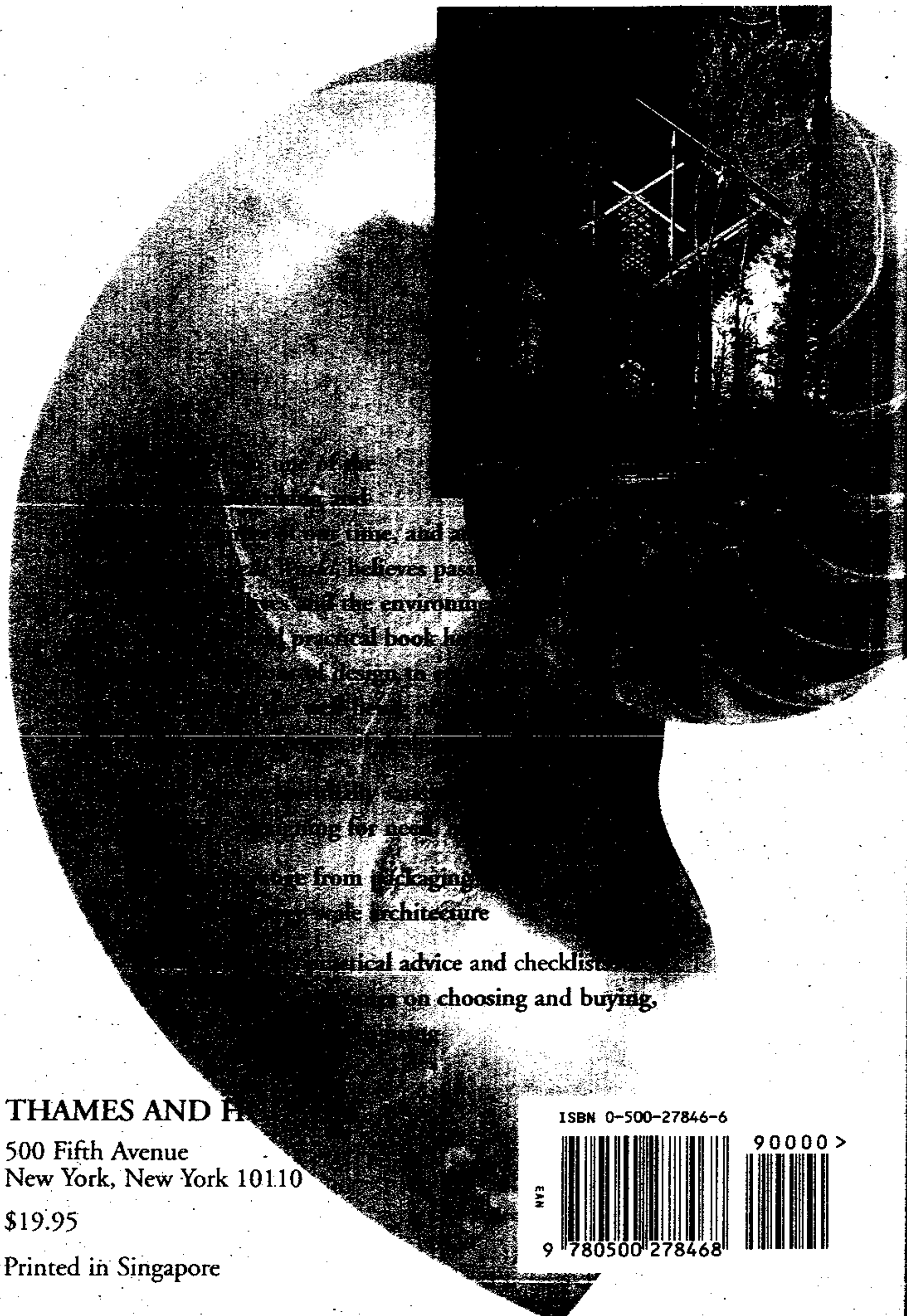
THE GREEN IMPERATIVE



NATURAL DESIGN FOR THE REAL WORLD

VICTOR PAPANEK



THAMES AND H

500 Fifth Avenue
New York, New York 10110

$19.95

Printed in Singapore

ISBN 0-500-27846-6

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CHAPTER 1

Here Today, Gone Tomorrow?

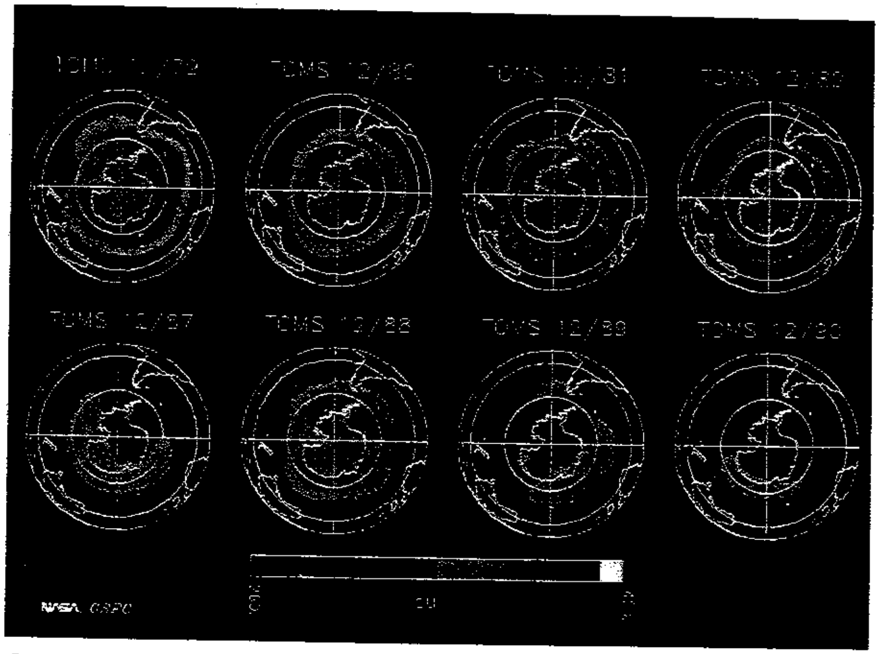
All thinking worthy of the name must now be ecological.
Lewis Mumford

THERE CAN be little doubt that the environment and the ecological balance of the planet are no longer sustainable. Unless we learn to preserve and conserve Earth's resources, and change our most basic patterns of consumption, manufacture and recycling, we may have no future.

We are all, every one of us, involved with issues of ecology, and we seem to adopt one of two ways in approaching the problems posed by a deteriorating environment. The first is try to do something on an individual or family level. We use less water to flush our toilets, we separate and recycle our garbage, we buy cars that run more economically, we insulate and retro-fit our houses, and generally practise conservation and preservation whenever possible. We join consumer initiatives to campaign against toxic chemicals in agriculture, to keep trees from being cut down or to save the whales. The second way is mentally to shrug our shoulders and decide to 'leave it to the experts'. This amounts to shirking our moral accountability and leaving ethical responsibilities to an ill-defined group of scientists and activists.

I would suggest that we add a third way. We must examine *what each of us can contribute from our own specific role in society.* We must ask the question: 'What can I do as a professor, construction worker, taxi-driver, school teacher, prostitute, lawyer, pianist, housewife, student, manager, politician or farmer? What is the impact of *my* work on the environment?'

There is an ecological and environmental dimension to all human activities. Whatever the subject he or she teaches, a professor can make a personal contribution by cutting down on the immense waste of paper, using computers to store data and reducing the amount of photocopying for classes. The construction worker or taxi-driver must examine how his or her work touches the environment; switching off instead of idling the engine of the cab or the construction machinery, waiting rather than cruising for fares, these seemingly minor interventions can help. Simple acts can empower the individual by providing a feeling of doing *something* to help. Managers, politicians and lawyers are in positions of power; they must sharpen their understanding of the precise balance between ecology and economics – a relationship that is frequently falsely portrayed as confrontational, whereas recent studies show that ecological awareness can have



Ozone concentrations above Antartica (recorded by satellite as red and yellow) during the 1980s.

positive economic consequences. The question of ecological intervention will be explored throughout the whole of this book.

OUR DAMAGED PLANET

Between 1981 and the end of 1994 major climatic changes have occurred all over the world. The summers from 1990 to 1994 were among the hottest ever recorded in northern Europe, with the autumn of 1994 in Sweden the warmest for two hundred and fifty years. During this same thirteen-year period, winters in North America and Europe were generally much warmer, yet interrupted by brief cold snaps with the temperature descending as low as -37°F (-37°C). Australia was plagued by huge firestorms caused by prolonged droughts. Summers in northern Argentina and north-eastern Brazil were also much hotter than usual, and the winters there since 1987 warmer than ever previously recorded. In May 1994, we learned that the warming of the Earth and the holes in the ozone layer were increasing at nearly twice the speed predicted in 1987.

During the summer of 1993, enormous floods in the Midwest of the United States wreaked havoc through nine states, and for nearly three months the Mississippi river was six times wider than normal. The Sahel, the sub-Saharan part of Africa, has seen a dry, desert-like climate moving southwards starting in the late 1970s, and these continuing droughts have devastated Niger, Chad,

Senegal and the Ivory Coast. The incidence of major typhoons in south-east Asia doubled between 1990 and 1994. Bangladesh suffered the two worst floods in its history in 1982 and 1983; during the second an incredible 81% of the land surface was under six feet (2m) of water for several days.

The most devastating hurricane to strike Florida occurred in 1992, and major hurricanes continue to batter the east coast of the USA. El Niño, the recurrent warming of the westward ocean currents heading towards South America, led to heavy rains that resulted in killer landslides in Colombia, Ecuador and Venezuela.

The completely unpredictable temperature and weather patterns of the last few years suggest that we are living through a time of massive environmental change. In June 1993, when this chapter was written in southern Spain, which normally has a desert-like climate, the ambient temperature was distinctly chilly and a heavy rain was falling. At the same time a colleague arriving from Helsinki reported that for the previous few weeks there had been a heatwave there that would have been considered tropical in August.

THE HISTORICAL VIEW

Yet humanity has withstood ecological, environmental and energy crises before. I have been working with a historian, helping to turn her scholarly interests towards ecological and environmental studies, and learning a great deal in the process about the effects of climatic changes in the past.

The first great energy crises came long before the OPEC oil embargo of 1973. Twelve thousand years ago agriculture (the transformation of wild annual grasses into domesticated cereals) began in the southern Levant under the simultaneous pressure of drought, high temperatures, over-population and over-exploitation of natural resources. This forced foray into plant genetics brought about massive changes in nutrition, trade and settlement patterns.

The 'Little Ice Age' in western Europe lasted roughly from 1550 to 1700 and helped to shape ways of living, farming, and, as a consequence, artistic expression.[1] More time spent indoors during the longer winters led to a flowering of the crafts that made life more comfortable, such as quilt-making, blanket and carpet-weaving, and pottery. Mirrors and crystals were used in experiments to enhance candlelight, and interest grew in choral singing and in decoration for home and church. Conditions during the 'Little Ice Age' must have been very like those in the isolated, dark and snow-bound farms in Finland during the 18th and 19th centuries. This home-centred mode of living nourished all kinds of artistic expression, especially in music and literature which sprang from story-telling and narrative poetry. One of the most obvious results of the colder climate in England was the disappearance of much of the common land (due to the increase in sheep farming) leading to great changes in land ownership, travel and class structure.

The depletion of forests occurred not once, but many times and in a great many different places. An energy crisis was developing in England by the 16th century, forcing people to burn coal or peat – foul-smelling, inconvenient and dirty – to keep off the chill during the winter months. Yet in a landscape drastically deforested and turned into sheep pastures in the northern Midlands and Scotland, a roaring log fire was no longer practical.[2] Coal-mining not only changed the structure of settlements through the building of mining towns and row upon row of working-class cottages, but also ushered in the 'dark Satanic mills' and the beginning of pollution through the use of fossil fuels. The precipitation of soot and coal-dust could soon be measured by the changes in the appearance of the peppered moth (whose wings turned from silvery-white speckled with dark spots for camouflage against birch bark, to a uniform dark brown, matching the birch trees now blackened by soot).

In China the overcutting of forests caused a fuel shortage that lasted from 1400 to 1800, a vivid dress rehearsal for the oil embargoes of the 20th century. The Chinese were forced to burn straw and – by learning to build with bamboo – developed a bamboo-based structural technology equalled only by that of Latin America before the conquest.[3] Historian-ecologists now have much data on China and are preparing to study the possible relationship between rainfall and drought cycles in the development of treeless terrain and the subsequent expansion of the Central Asian steppe peoples.[4] The inhabitants of India, Pakistan, Sri Lanka and Bangladesh, lands where forests have been destroyed, burn dried cowdung, lacking other fuels.

It is salutary to remember that almost all the deserts in the world – with the exception of the central Australian outback – are human-made. Recent studies suggest the influence of climate and eco-catastrophes on the shifting fortunes of the Mayan civilization of Central America.

The historical view also makes clear the alarming increase in the speed of change in the last few decades. I now live in Kansas and learned that in the western part of the state, one June day in 1860, it was as dark as night – the light of the sun had been blotted out by a flight of between three and five thousand million passenger pigeons, breaking trees when they came down to roost.[5] Now, a little over a hundred years later, there is only one passenger pigeon left – it is stuffed and stands in my university's museum of natural history.

The sooty coloration of the peppered moth c.1850–1970 indicates the period of worst pollution.

THE ACCELERATION OF DISASTER

Our present concern with the biosphere is the result of a whole series of recent catastrophes. One of the first indications of the potential hazards to human existence posed by industry started in Japan in 1932 and lasted through the 1950s. Mercury was pumped as waste into the Bay of Minamata, poisoning thousands of local fishermen and their families in the Chizo Prefecture of Japan. It was not until 1953 that there was scientific proof that this had been causing great genetic damage and had led to the birth of many severely handicapped children.

This was followed by large-scale dioxin poisoning in Sardinia and other parts of Italy, which started in 1949. Since then we have had, among hundreds of smaller nuclear accidents, the thermonuclear-reactor near-meltdown at Three Mile Island in Pennsylvania in 1982; the Chernobyl disaster in the Ukraine in 1986; we have had the poisoning of thousands by a US chemical corporation in Bhopal in India in 1984; in 1986 a Swiss pharmaceutical factory accidentally released large amounts of toxic chemicals into the Rhine, poisoning the river from its sources in Switzerland throughout its course in Germany, France, Belgium and the Netherlands, eliminating fish-life for more than five years.

We have had *an average of one major oceanic oil spill every second day for the last eighteen years.* The *Exxon Valdez* oil-tanker spill in 1990 affected wildlife and the Alaskan coastline and fishing grounds, and will continue to do so into the next century, putting into jeopardy the cultural life and very existence of the native peoples of Alaska who subsist from hunting and fishing. In August 1994 the US courts found the Exxon Corporation guilty of criminal negligence and it was ordered to pay five thousand million dollars to the native peoples and fishermen of Alaska, in addition to almost two thousand million dollars already awarded as direct damages.

The explosion of the Siberian oil pipeline of June 5, 1989, in Russia, also derailed two trains killing hundreds of people. *On an average of three times a day, towns or villages have to be evacuated somewhere in the world because of the spillage of toxic chemicals from train wrecks or truck crashes.*[6]

People often seem to be far ahead of their governments in concern for ecology. The second greatest man-made ecological tragedy in the 20th century was the burning of over five hundred oil wells in Kuwait at the end of the Gulf War. By far the most terrible ecological disaster in our time was the systematic destruction and defoliation of the south Asian forests in Vietnam, Laos and Cambodia from 1968 to 1971 through the use of Agent Orange and other chemical and biological 'goodies'.

There are other disasters, no less devastating for their more insidious development. The slow death of northern European and North American forests and lakes is largely caused by effluvia from factory smoke stacks which turns rain acid;

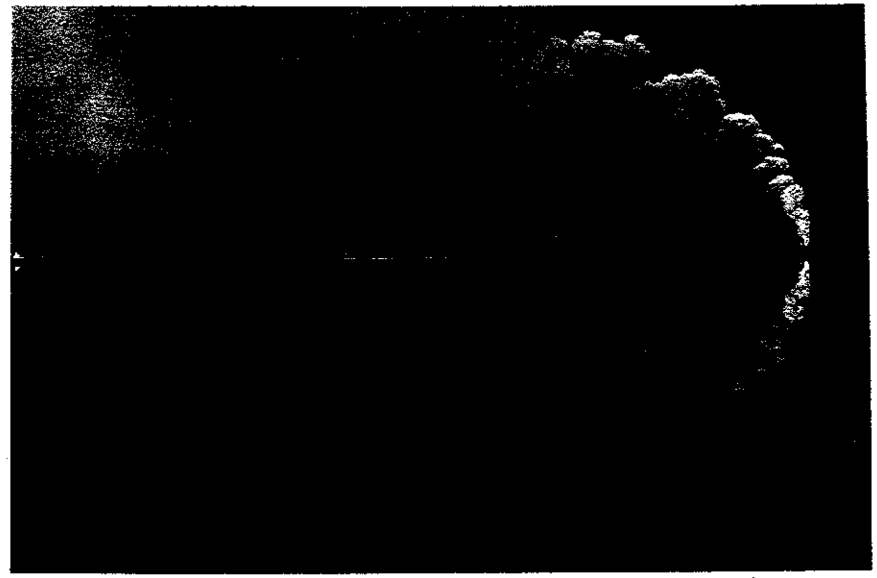
Sealions on oil-covered rocks in Alaska after the Exxon Valdez oil spills in 1990.

the gases given off by factories in the American Midwest cause acid-rain damage in Canada; factories in the Ruhr district of Germany and the Czech republic are affecting Sweden and Denmark.

There is the terrible threat of the increase in 'greenhouse' gases. Some of the heat from the sun is radiated back from the surface of the earth and much is trapped by several naturally occurring gases in the atmosphere, such as carbon dioxide, nitrous oxide and methane, which act like the glass in a greenhouse. Clouds also work as magnifiers: cirrus clouds let in sunlight, yet trap rising heat. This effect is necessary for the existence of life as we know it, for without it our planet would be considerably colder. On the other hand, human activity, compounded by the explosive rise in the population, has increased the production of greenhouse gases so alarmingly that scientists predict a wholescale global warming, which may already be apparent in the recent climatic changes.

Through sample drillings in rock, Arctic ice and soil it has been established that the carbon-dioxide content in the air *never rose above 280 parts per million during the last twelve million years. By 1958 it had risen to 315 parts; to 340 parts by 1988, and to 350 in 1993.*[7] This is the result of the burning of fossil fuels (coal, oil and gas) and the diminishing of tropical rainforests which absorb large amounts of carbon dioxide as well as producing oxygen.

Nitrous oxide is also produced by fossil-fuel burning, and more comes from the increase in the use of fertilizers in agriculture. Enormous amounts of methane are generated by cattle (now bred in increasing numbers by a fast-growing human



Burning oil wells in Kuwait in 1991 emitted 200 million tons of carbon dioxide.

population, particularly for the meat and dairy products of a Western-style diet), by waterlogged soils such as rice paddies, oil and gas production, and by landfill.

CFCs (chlorofluorocarbons), not invented until 1930, are responsible for the holes in the ozone layer, increasing the risk of skin-cancer, leukaemia and birth abnormalities all over the world as we lose protection from the sun's ultraviolet rays, and – more ominously – contributing to the radical warming of the Earth's climate. CFCs are being phased out because of their threat to the ozone layer, but are being replaced as refrigerants, solvents, blowing agents for foam plastics, by related gases, the HCFCs and HFCs, which, though less powerful ozone-depletors, are long-lasting greenhouse gases.

Our best computer-modelling tells us that we may expect a rise of temperature of 1° to 1.5°F (0.6° to 0.8°C) by the year 2000, and a consequent rise in sea levels of about three feet (one metre). This doesn't sound too threatening until one stops to calculate that on a sloping beach, such a rise could bring the ocean as much as 295 feet (90m), above its current tideline.

The razing of tropical rainforests has to be halted now. Sadly some of these natural green lungs of Earth have already been eliminated within the last few years. The destruction of the huge rainforest areas in Sarawak, which started at the beginning of 1991, had eliminated *all* rainforests in northern Borneo by mid-September of that same year. The Amazonian and other rainforests are still with us; besides their great importance to the Earth's atmosphere, they contain millions of species, many still unknown to us, some of which are in danger of being eliminated forever. The rosy periwinkle, native to the shrinking rainforest of Madagascar, yields two compounds that are successful in treating two cancers – lymphocytic leukaemia and Hodgkin's disease.

Even in the United States there are examples of previously unknown beneficial plants, such as the Pacific yew whose bark and needles have proved to be helpful in the treatment of ovarian and cervical cancers and some breast cancers. Hoping to cure or at least control AIDs, pharmaceutical companies continue to study plants, lichen, spores, moss and other botanical specimens as well as various rare soils. Among the many experimental drugs released for laboratory study in 1993, one contained constituents from a tree mushroom in the Brazilian rainforest.

Even such seemingly trivial changes in the environment as the enormous increase of tsetse flies and malaria-bearing mosquitoes, can be directly traced to human activity. There are approximately three thousand million car and truck tyres in dumps in the United States alone. Tyres collect stagnant water and provide a perfect breeding-place for these insects.

These accelerating man-made catastrophes make it vital for the survival of the world as we know it that industrial designers, graphic designers and architects, contributing from their particular areas of knowledge and influence, and joining with other disciplines, should involve themselves in environmental issues.

HEALING ON A HUMAN SCALE

There is a secondary problem. It is the problem of human scale, the threat of bigness. My primary conviction as a human being, a designer and an ecologist is: *Nothing Big Works – Ever!* One only has to look at General Motors, General Dynamics, General Electric, or General Westmoreland and all his armies for that matter, to see the truth of this proposition. It is equally true of those large countries made impotent by their own ungovernable size, such as the former Soviet Union, the United States, China, India and – to a lesser degree – Brazil, Indonesia and Nigeria. This curse of bigness holds true of large corporations, huge school systems, mushrooming bureaucracies and other megastructures. *Nothing Big Works – Ever* is a simple natural fact, elegantly stated by the biologist D'Arcy Thompson: 'The elephant and hippopotamus have grown clumsy as well as big, the elk is of necessity less graceful than the gazelle.'[8]

Hope for the future springs from witnessing small reversals of the damage we have caused. Animal species have, through the good works of individuals, been brought back from near-extinction. The Lincoln sheep from Lincolnshire provides a virtually cholesterol-free milk and an extremely fine wool. The Devon cow is, to my knowledge, the only species providing very low cholesterol meat. Collectors of Navajo carpets are aware that the best Navajo rugs were made before 1870 or after 1960. The reason is that before 1870 saddle blankets and rugs were made from the wool of Churro sheep – a breed of sheep that simultaneously yields four different kinds of wool, some of it extremely fine and silky, other parts tough and long-wearing. Nearly a century later Churro sheep were bred back from the edge of extinction, and their wool is again used for weaving by Native Americans.

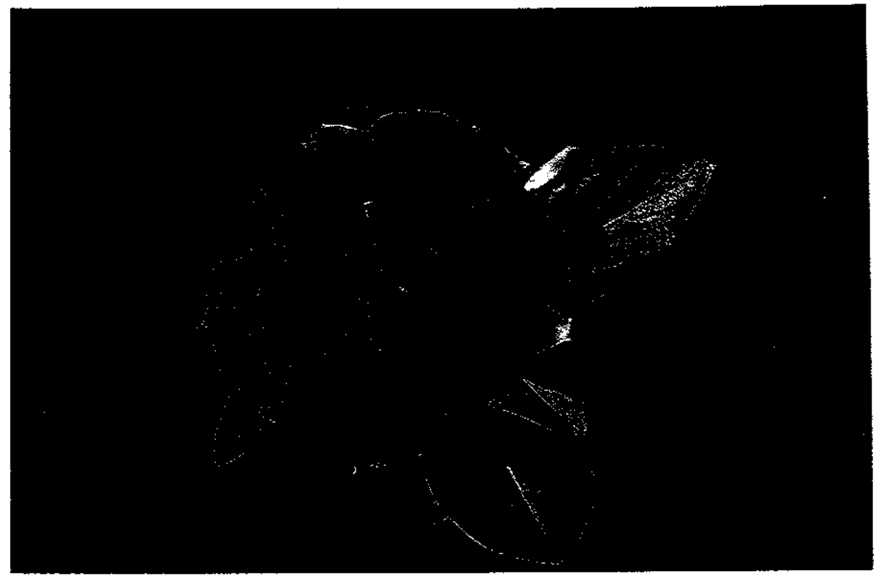
These dangerous times for Earth call not just for passion, imagination, intelligence and hard work, but – more profoundly – a sense of optimism that is willing to act without a full understanding, but with a faith in the effect of small individual actions on the global picture. The actions of the city council of Irvine in California, reported in the *New Yorker*, vividly illustrates this point. Laws were passed in 1989 restricting the sale and use of chlorofluorocarbons inside the city limits. This would affect local businesses and raise local prices, but any improvements to the atmosphere would be so tiny as to be almost unnoticeable; any benefits would be global not local, for future generations and not now.

> It's idealistic, even quixotic, for little Irvine to take responsibility for the sky. And yet on an emotional level the action seems exactly right. As global problems become overwhelming, the idea of locality assumes a new political importance.... It may be that authority – the power to take responsibility – can at this point be recovered only on a local level, and that this is why local politics has acquired new significance.... Irvine's step does not come anywhere near solving the problem of ozone depletion, but the Irvine City Council did not claim that it would: so large is the sky and so small is Irvine that the relationship of the city to the problem is automatically acknowledged as that of tiny beings to something utterly beyond their control. In this acknowledgment, true scale is recovered, and, with it, effectiveness. The problems of the environment are beyond the power of Irvine to solve, but because the city took responsibility where it could, it is no longer helpless. It examined its own contribution to the destruction of the ozone, asked, 'If not us, who?' and heard the answer, 'No one.'[9]

The problems may be world-wide, yet they will yield only to decentralized, human-scale and local intervention. This is partly due to the fact that we are still unable to assess the impact of what we do as designers and as consumers – only if our intrusions are modest in scale are the chances of major miscalculations reassuringly remote.

Most architects and designers – especially younger industrial designers – feel that high technology is bound to disturb the ecological balance even more profoundly. They express this concern through a nostalgic longing for the past, in an attempt to return to a seemingly simpler, more primitive way of life. Yet one cannot turn back the clock, however good the reason may seem. Others – equally concerned with the environment – are convinced that the problems of high technology require a 'techno-fix', that is, the use of even more technology to solve the technology-based problems that we face on the planet.

Tropical rainforests help to maintain the atmosphere of the planet.



The rosy periwinkle, a rainforest plant, is valuable for the treatment of certain cancers.

Both viewpoints are wrong. Useful answers to many of these problems will frequently come from areas we normally associate with high technology, such as electronics, computers, and microchips. The importance of computer modelling in exploring the growth of ozone depletion cannot be overstated. Remote sensing from space satellites has given us a profound understanding of how far pollution, desertification and droughts have already changed the land, the oceans and the climate of the Earth. But equally informative clues to the true nature of the difficulties we face will come from the life-sciences, as well as anthropology, cultural geography and geology. Still deeper insights will be derived from biological, botanical and biomorphic sources, as well as the study of history, ethnography and the so-called 'old technology'. We are all in it together and we need all the information we can get.

IS TIME ON OUR SIDE?

Most people agree that these ecological catastrophes pose enormous dangers, but we tend to shrug them off with the assumption that changes in nature occur slowly through many periods lasting millions of years – the Cambrian, the Triassic, the Cretaceous, and so forth. For nearly two hundred years, writers dealing with nature have tried to understand the almost incomprehensible length of what the anthropologist Loren Eisley, called 'the immense journey'.[10] The age of the trilobites began six hundred million years ago. The dinosaurs flourished for about one hundred and fifty million years. Since we have trouble imagining even a million years, we feel that nothing happens speedily, any change takes unfathomable, 'geological' time.

Yet this concept of time is misleading. The time-span of the world we know, in which human beings first formed into some sort of civilization, can be quite easily comprehended. Peoples began to assemble in prototypical social groupings in the north of Mesopotamia approximately twelve thousand years ago. If we assume twenty-five years to be the length of a generation, that means that civilization began only 480 generations ago. As I write this, I can think back some five generations, and through my teachers a common bond is formed, reaching from Frank Lloyd Wright back to Louis Sullivan, to George G. Elmslie and the sculptor-theorist Horatio Greenough in 1789.

I have family photographs of five generations, from the late 1840s to the present, which means I can actively think myself back one ninety-sixth of the way to the start of human settlements. Furthermore, my family's records can be traced to the year 1280, so I have a concept of my own family going back one thirty-third of the way to the beginnings of civilization. Plays, books, historical accounts, and the works of archaeologists give me some sense of daily life at least as long ago as the Pharaohs in Egypt, which is nearly half way. About three hundred and twenty generations ago, Jericho was a walled city with three thousand inhabitants. Of course, three hundred and twenty is a large number, but not quite as incomprehensible as six hundred million. Yet even within these last twelve thousand years from Mesopotamia to the present, our sense of time is not particularly uniform. The world we understand goes back only to the Renaissance. The world as we *really* know it dates back to the Industrial Revolution, and the world we feel comfortable with probably began – depending on our age and feeling for history – sometime between 1945 and 1973.[11]

Thus our view of an unlimited future is a chimera. During a lifetime, a decade, a year, or even a day, profound and impersonal dramatic changes take place. We have come to understand the concept that continents can drift over the course of aeons, and that continents could perish in one thermonuclear second. But we feel that 'normal time' is isolated from such great changes. Yet most of the ecological and possibly irreversible damage has occurred only during the last thirty years. Time is running out.

CHAPTER 2

Designing for a Safer Future

The epidemic psychosis of our time is the lie of believing we have no ethical obligation to our planetary home.
Theodore Roszak

ECOLOGY AND the environmental equilibrium are the basic underpinnings of all human life on earth; there can be neither life nor human culture without it. Design is concerned with the development of products, tools, machines, artefacts and other devices, and this activity has a profound and direct influence on ecology. The design response must be positive and *unifying*. Design must be the bridge between human needs, culture and ecology.

This can be clearly demonstrated. The creation and manufacture of *any* product – both during its period of active use and its existence afterwards – fall into at least six separate cycles, each of which has the potential for ecological harm.

When we speak of pollution as related to products, we usually think of end results: the exhaust fumes from automobiles, the smoke from factory chimneys, chemical fertilizers or truck tyres in a dump poisoning the ground-water. But pollution falls into several phases.

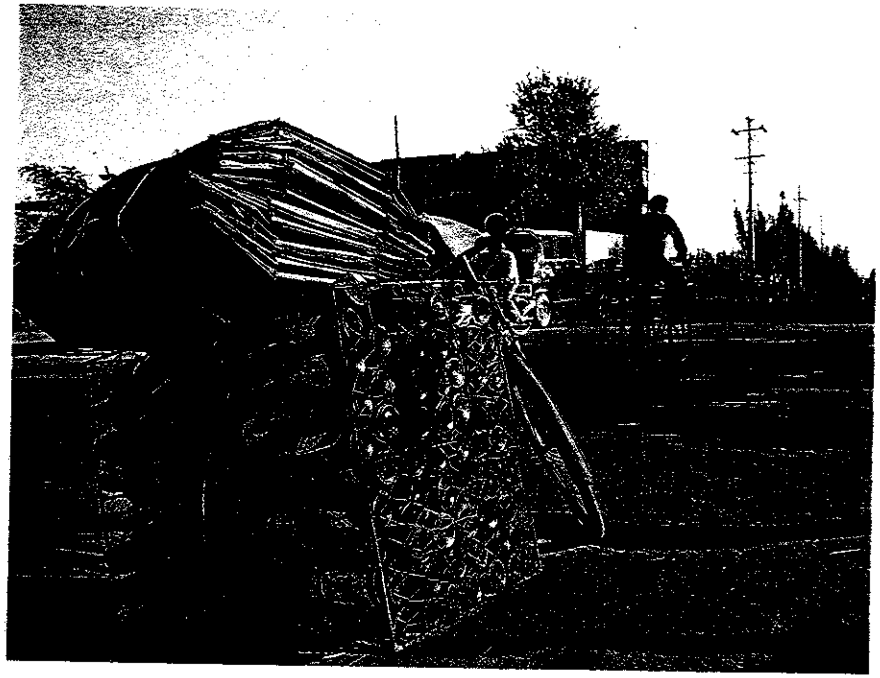
PRODUCTION AND POLLUTION

1. The choice of materials

The materials chosen by designer and manufacturer are crucial. 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. This is *not* a prescription for doing nothing at all, but an attempt to make designers aware that every choice and dilemma in their work can have far-reaching and long-term ecological consequences.

2. The manufacturing processes

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 or radio-active materials? Are there air-pollutants from factory smoke-stacks, such as the gases that cause acid rain. Are liquid wastes from the factory leaking into the ground and destroying agricultural land or – worse still – entering the water supply?



Scarcity of materials for many Third World countries has made recycling a necessity and a way of life for generations. When life is hard, nothing is wasted. Bottles and card are collected in China for recycling (above) and old tyres are made into water carriers in Nigeria (opposite).

3. Packaging the product

Further ecological choices face the designer when developing the package in which the product is transported, marketed and distributed. Foam plastics, which pose acute dangers to the ecological balance, are used by designers as a protection for fragile products. It is now known that propellants (such as CFCs) for lacquer sprays and other products are directly implicated in the depletion of the ozone layer. Considerations of materials and methods are therefore crucial in the packaging phase of ecologically aware design.

4. The finished product

There are too many different versions of the same item available in many cases. Since the manufacture of most industrial or consumer products uses up irreplaceable raw materials, the profusion of objects in the market-place constitutes a profound ecological threat. To give a typical example: in western Europe, Canada, Japan and the USA there are now more than 250 different video cameras available to consumers; the differences between them are minimal – in some cases they are identical but for the name-plate. The choice of consumer products in the West is highly artificial.

Other products threaten the ecological balance even more directly. Snowmobiles, which are largely sold as winter-sports and recreation equipment, are so noisy that when they go into roadless terrain they destroy breeding grounds and habitats. Yet, at the same time, they have assumed an important role in hunting and herding cycles and are now important tools for survival among the Inuit of Canada and Alaska. 'Off-road' vehicles and 'mountain bikes' affect the precious layer of topsoil and humus that can grow crops. 'Dune buggies' harm the sand-dune layers at the critical edge between ocean and land.

5. Transporting the product

The transporting of materials and products further contributes to pollution by the burning of fossil fuels, and by the necessity for a whole complex of roads, rails, airports and depots. There is transportation from the mill to the factory, the factory to the distribution centre, from there to the shops and, eventually, to the end-user.

6. Waste

Many products can have negative consequences *after the useful product life is over.* One only has to see the huge automobile graveyards in many countries to understand that these vast amounts of rusting metals, decaying paints and shellacs, deteriorating plastic upholstery, leaking oils and petrol are leaching directly into the ground, poisoning the soil, the water-supply and the wildlife, besides visually destroying the landscape. It has been estimated that the average family in the technologically developed countries throws away some 16 to 20 tons of garbage and waste a year. This is not only an environmental hazard, but is also an enormous waste of materials that could be recycled responsibly. This is one area in which the so-called Third World countries are leading the way – because of material scarcities, recycling is an accepted way of life there and has been for generations.

PRODUCT ASSESSMENT

The relationship between design and ecology is a very close one,[1] and makes for some unexpected complexities. The designed product goes, as shown, through at least *six* potentially ecologically dangerous phases. Product Life Cycle Assessment is the evaluation incorporating all of them, from the original 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. It can best be understood through the hexagonal diagram, the six-sided 'Function Matrix' (p.34). At the moment Life Cycle Assessment is very new, and can be profoundly complicated, demanding a great deal of study, testing and experimentation.

The vast Smokey Mountain rubbish tip in Manila in the Philippines provides home and livelihood for the very poor.

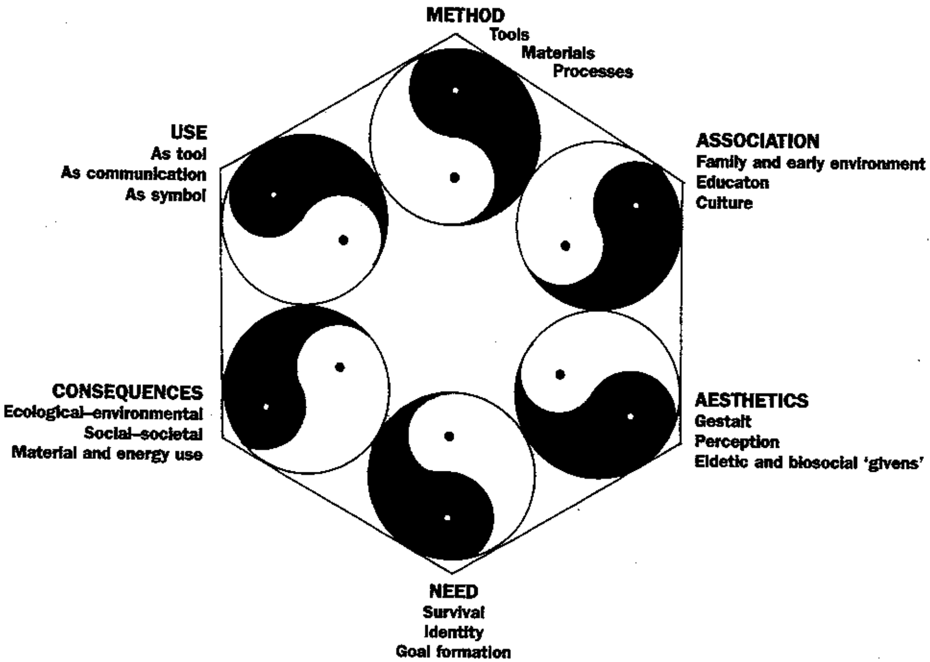
Environmental issues in Life Cycle Assessment

- The exhaustion of scarce or finite resources
- The production of greenhouse gases
- The production of chlorofluorocarbons leading to ozone depletion
- The production of acid rain
- Habitat destruction and species extinction
- Materials or processes that harm plants, animals and humans
- Air, soil and water pollution
- Noise pollution with its deleterious effect on the human psyche
- Visual pollution

PACKAGING AND SHROUDING

Most goods need to be packaged. The package protects the contents in transit and in store from spoilage, vermin, moisture and damage. It can serve as a powerful marketing tool through design, colour and texture. Furthermore, as explored in Chapter 7, it will frequently signify not only the contents, but also lend identity to the product-line. In terms of goods that are nearly identical – washing-up powders, breakfast cereals or cigarettes – it can be said that *the package is the product.*

SIX-SIDED FUNCTION MATRIX



It is clear that we routinely over-package things. In some cases this is to lend a visual charisma to luxury goods such as perfumes that sell at enormously inflated prices. But the less luxurious package can be equally destructive of the environment. Fast-food suppliers have for decades used small coffins made of a plastic known as styrofoam in North America in which to serve their cheeseburgers and Big Macs. Some years ago, McDonald outlets in the American Midwest proudly proclaimed on an automatically changing neon sign: '*Seventy billion* sold so far' (italics supplied). More recently the McDonald corporation has been convinced of the ecological soundness of switching to paper containers.

Foam plastic is a very useful packing material, yet profoundly damaging to the environment. After it has been discarded, it is doubtful whether it is possible to re-use it, and it continues to be an environmental and toxic hazard in spite of the optimistic assurances of the manufacturers relayed to the public by their public relations people. The advantages of foam plastic are that it makes an extremely lightweight protection for precision parts, is easily formed around delicate optical instruments or electronic assemblies, and is quite inexpensive. But there are alternative and organic ways of packaging.

It is a valuable concept that there is really nothing new in the world that needs to be packed and shipped. The immediate objection will be that this is sheer nonsense. After all, there were no computers, CD players or camcorders in the distant

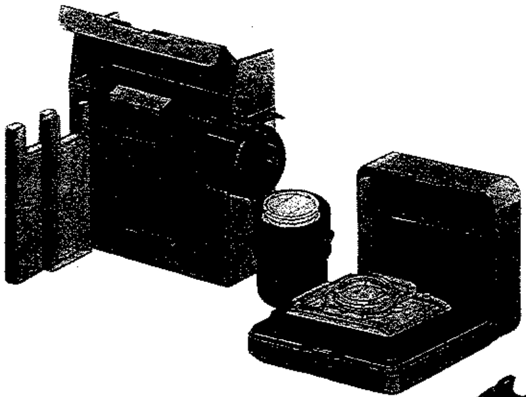
past. Yet Van Leuwenhoek had to ship his microscopes from the Netherlands to Padua in the 16th century, Galileo needed to send telescopes to the Danish astronomer Tycho Brahe on the island of Hven off southern Sweden, and forward 'philosophical instruments' and optics to various other parts of Europe. More recently, during the Civil War in the United States, delicate surgical instruments had to be shipped from northern factories to the front. The materials used to pack such early precision instruments were Spanish moss, other dried mosses, sand, sawdust, crushed and dried leaves or dried grasses, thin cotton bags filled with down or feathers, wood chips, and much else. The one thing that these materials have in common is that they can be recycled; they are all organic and will return to the natural environment.

My earliest introduction to this way of packing was my first job as a young boy in New York. I worked in the basement of the Museum of Modern Art packing small sculptures or ceramics to send to members of the museum who were renting art objects for a few months at a time. I remember that, in addition to shipping-boxes (which were made of wood or cardboard), we had two gigantic popcorn machines, and made popcorn – unsalted and without cheese, I may add – in which to pack the sculpture pieces; polystyrene 'worms' did not then exist. It was an intelligent and decent way of packing which in 1992, to my delight, began to be revived by some mail-order firms as an ecologically responsible way of dealing with fragile objects.

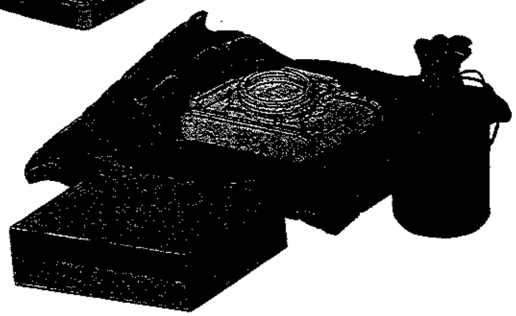
In 1989 I was hired by a Japanese corporation, specializing in computers, cameras, and other high-tech products, and spent three years conducting research and feasibility studies in the use of organic packaging materials. Research eventually concentrated on plants that, when maturing, surround their seeds with an enormous protective cradle of fluffy material. The specific seed we researched expands its bulk to more than forty times the original volume.

The package was for a professional precision 35mm camera and its lenses. Normally, expensive small cameras are cradled in a shaped foam-plastic cushion that has been covered with an equally plastic fake-velveteen fabric. This in turn is topped by another velvet-like foam-plastic lid on top, and both are bedded in a sarcophagus-like box, made of high-impact polystyrene. The box is held, or suspended, by two foam-plastic spacers within an outer (again plastic) case. Lenses are normally placed in plastic tubes that are upholstered with foam on the inside, and covered with a leather-like vinyl, called 'leatherette' (the very word makes one's flesh crawl), or a plastic called 'naughahide' on the exterior. A hideous example of over-packaging and transparent make-believe.

Eventually we created a small quilt, about 15 inches (37cm) square. The 'shell' of the quilt is made of rice-paper, filled with fluffy plant fibres and then sewn into quilt squares with a hemp-derived thread. The quilt is wrapped around the



The organic packaging (below) was designed 1989–92 to replace the plastic packaging of a Japanese 35 mm camera (left). The rice-paper quilt is filled with fluffy plant fibres from seed-heads, and sewn with hemp thread. The lens pouch is made from cotton and eiderdown.



camera body and inserted into a cardboard sleeve. Quilted pouches, made of 'green' cotton and filled with eiderdown, protect the lenses. In Japan this method of softly cradling precision parts is already in experimental use, and will probably soon be used for export models. The great advantages of this package are obvious. Reliance on oil-based plastics and the hazards of their manufacture are entirely eliminated. The new package is wholly organic, and will return to the soil. To exaggerate somewhat, theoretically it may be possible in a year or two for someone to buy a camera or CD player and literally dump the wrapping in the back garden where the recyclable, organic components of the package – augmented by trace amounts of nitrate boosters – will actually help the garden grow.

At the moment, packaging generally involves the use of plastics (discussed in detail later in this chapter), metal, wood, cardboard and paper. The use of paper has two major effects on the ecology. One of these is the cutting-down of trees and forests, the other the pollution that occurs in the paper production itself. Nine-tenths of paper products come from forests in northern temperate zones – Canada, the United States, and northern Europe. It is now widely known how to manage such forests commercially so that they can continue to function as renewable resources, but the timber industry generally refuses to engage in selective harvesting from multi-species mature forests, and continues to plant monocultural forests and to employ the clear-cutting of established woodlands.

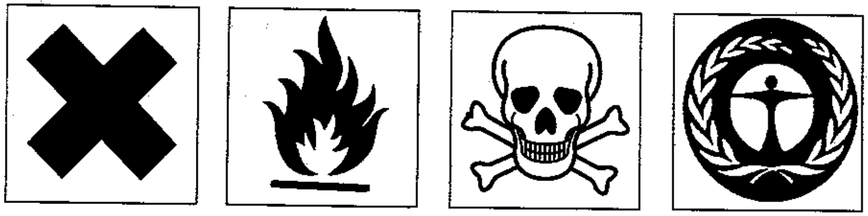
Chlorines used in paper production as a bleach for wood fibres also pose an ecological hazard. Chlorine creates dioxins that are mutagenic, that is to say, they create genetic changes by bonding to the DNA structure of living cells. Furthermore the runoff of water tainted with dioxin and chlorine has endangered aquatic life (such as salmon in the Pacific north west of North America), as well as poisoning ground-water.

There are packaging items that are inherently impossible to recycle. Manufacturers can easily avoid using high-gloss papers, highly coated or plastic-coated papers, glues that are not water-soluble and plastic windows on envelopes. Instead designers could specify non-bleached papers or those whitened with new, bleach-free methods. More than three-quarters of all paper types can be recycled, but usually a percentage of new fibres are added. Recycling waste paper can be 50% more energy efficient than the use of virgin pulp. It is good practice to use paper with the highest percentage of recycled material. The Simpson Paper Company of San Francisco has emerged as one of the leaders in this field.

Lead, mercury, arsenic, chromium, cadmium, beryllium and vanadium are all carcinogenic and neurotoxic. They are frequently used in the composition of printing inks on packages, and pose a severe threat when they leach into the water supply from landfills. De-inking is difficult and costly. Vegetable-based inks, made from soya for instance, can be used effectively, and here again the Simpson Paper Company has led the way.

There are other materials that are dangerously poisonous to human beings and the environment. Some countries have already restricted polyvinyl chloride (PVC)

Recycling plants do not have to be a blot on the landscape. This trash recycling plant near Lund in Sweden is unobtrusive and uncluttered.



Three hazard symbols for harmful, flammable and toxic materials respectively, and (on the right) the Blue Angel symbol for safe materials, introduced in West Germany in 1977.

since, unless it is burnt in special handling ovens, it releases dioxins and hydrochloric acids into the air. It has also been established that the making of PVC is directly linked to kidney cancers in workers. There are many other substances, such as cadmium-based pigments, certain flame-retardants and chlorinated solvents, that are still unrestricted in the United States and the United Kingdom, yet pose major health threats. A series of labels and symbols have been developed and accepted internationally, and more specific national or regional markers also exist.

Terms for hazardous materials, products or processes

- **Carcinogenic:** can cause cancer either in manufacture or in use
- **Mutagenic:** can cause genetic mutations in human beings or other organisms
- **Neurotoxic:** can attack the nervous system of human beings or other animals
- **Biocidal:** destructive to the environment and ecology

In January 1993 a comprehensive set of laws was introduced in Germany to deal with the reduction of packaging waste. These include requirements that producers and suppliers take back all sales and transport packaging. Manufacturers are also obliged to remove wrapping when selling to the end-users, and to inform them where and how to return the rest of the package. Furthermore, the law states specifically that manufacturers must take back, sort and recycle the following:

> Electrical or electronic appliances in the sense of this ordinance are household goods, entertainment electronics appliances and appliances and installations for office, information and communications technology, banking machines, electrical tools, measuring, steering and lighting technology, toys, clocks which contain electrical or electronic component parts...component categories such as casing, screens, keyboards or plates.[2]

Furthermore, these laws decree that packages are merely for the protection of the contents and are not be used for advertising messages or point-of-sale graphics.

Packages come in various guises. With complex mechanisms and electronic parts forming a machine or device, the package in industrial design frequently turns into a 'shroud', that is, an external cover or shell that keeps dust from the working parts, protects them, and cuts down the visual confusion of a complicated working arrangement that can no longer be understood by the end-user.

THE PROBLEM WITH PLASTICS

Virtually all plastics in common use today are based on fossil fuels. Their manufacture therefore contributes to the greenhouse effect, as well as utilizing irreplaceable resources. Although many plastics can be recycled in one form or another, there must be an upper limit to the number of dark grey, rough-textured counter-tops that can be usefully employed. Plastics that contain similar molecular structures can be co-recycled, but it is better procedure to keep plastic materials separate.

There is a continuing need for plastics in medicine, optics, animal husbandry, research into and storage of food and chemicals, where nothing else will do the task as effectively. Plastic is, at the moment, the best material we have for replacement heart-valves, heart pacemakers and artificial joints, filtration and liquid storage devices. But as vast quantities of indestructible plastic waste are washed up on the shoreline and lie unmouldering in our rubbish dumps, we must analyse the whole question of how we use it and how we throw it away.

The 'environmentally friendly' recycling initiative started by the plastics industry should be welcomed with great caution. American householders are encouraged to separate plastics from the rest of their houshold trash, but it seems that thousands of tons of both household and industrial plastic waste, instead of being recycled in the United States, are being shipped to less industrialized countries, particularly in Asia, where the waste is reprocessed under much less stringent rules for health and environmental safety, or is merely dumped in landfills there. Although waste imports are banned by law in the Philippines, over 7500 tons of plastic waste were shipped there from the USA in 1991. Indonesia was receiving thousands of tons until November 1992, when the Indonesian government banned imports of plastic waste; since then, however, illegal container shipments of plastics from the Netherlands, Japan, Korea and the USA have been accumulating in Indonesian ports. By far the largest importer of US plastic waste is Hong Kong, from where much of it goes to China.[3]

One of the main difficulties then lies with the fact that plastics just won't go away. It has been estimated that a discarded plastic bottle will be around for between two to four hundred years. Approximately 25% of all trash in the United States consists of plastics – some ten million tons every year. Landfills can no longer absorb such enormous quantities.

California, Minnesota, Wisconsin and scores of cities and towns are considering banning non-degradable plastics, and are advocating paper for packaging. This approach sounds reasonable at first, until it is realized that this would require a hundred and seventy million acres of extra forest land for paper production, an area the size of the United Kingdom. This alone would add fifty-five thousand million pounds (twenty-five thousand million kg) of trash a year world wide, and would also raise annual energy consumption by more than 225% each year. Researchers are therefore currently attempting to develop plastic materials that can be biologically degraded, either into many inert, minute fragments, or, ideally, into carbon dioxide and water.

Not only designers but also recyclers and users of products need to know what kind of plastic or elastomer (an elastic rubber-like material) they are dealing with. Thermoplastics and elastomers are easy to recycle. Thermoplastics melt at a specific high temperature and therefore can be compared to glass. Thermosetting polymers – a loaf of bread could serve as a metaphor – do not liquefy and are consequently extremely difficult to recycle. Thermosetting materials can be ground up and used as a 'filler' in newer thermosetting materials, but less than a third of the newly constituted material can be recycled filler. Thermosetting plastics, such as melamine, phenolic, epoxies, urea, unsaturated polyester (UPE), or thermosetting polyester (PE) are extremely difficult to re-use.

The use of such terms as 'biodegradable' and 'biodegradation' lacks precision and is too simplistic. Even within the plastics industry and scientific circles, these terms need clarification. The table opposite gives a short explanation of the meaning of various terms in relation to the different categories of plastics and the alternatives presented to the product designer.

At present the designer has a choice of at least seven strategies that employ plastic materials in an ecologically benign way – a repertoire that is sure to expand greatly over the next few years. Yet there are many other possible materials available, and the designer should bring about innovative new ways of utilizing what we already have. In May 1990 an industrial design student at the Gerrit Rietveld Akademie in Amsterdam, on a short-term Eco-design course with me, demonstrated that layers of paper no heavier than ordinary typing paper could be laminated into an all-paper armchair with organic glue so that the entire structure could be recycled or – better yet – abandoned to return to the earth.

The necessity for choosing materials with extreme care is emphasized by the problem of landfills – dumping sites where unsorted rubbish is buried in the ground. Frequently such landfills are then used as building sites. Recent research excavations of older landfills have shown that, if closely packed, even organic waste and waste considered biodegradable can last from twenty to forty years without significant changes.

CATEGORIES OF PLASTICS
Permanent For products for which there will be no secondary use. Applications in medicine and related fields for products in direct contact with organic parts, e.g. parts of an implanted hip-joint, shell of heart pacemaker, artificial veins, blood-storage bags. Material characteristics and lasting quality performance of primary importance, e.g. **nylon 66.** Quantity used negligible.
Re-usable Product can be used over and over again unchanged, e.g. plastic bucket. Complex tools or appliances can be repaired, upgraded in whole or in part, for resale. Enormous numbers of items involved. Wood, tin, enamel, glass, ceramics ecologically and aesthetically preferable.
Recyclable **Thermoplastics** and **elastomers** melt at a specific high temperature like glass and are easy to recycle. **Thermosetting polymers** do not liquefy and are very difficult to recycle; research is continuing into better methods.
Co-recyclable Compatible materials can be recycled together to form a useful new material.
Biodisintegratable Attempts have been made to embed a biodegradable trait into synthetic polymers so that they turn into mulch. These compounds perform badly in landfills through lack of moisture, slightly better when composted. Radical improvements have produced plastics, now commercially available, that degrade 100% less than 2 months after being discarded. Research continues into further control of the start of degradation.
Biodegradable 100% biodegradable rather than biodisintegratable. PHA **(polyhydroxyalkanoate)**, a member of the polyester family discovered in 1925, is 'manufactured' directly by micro-organisms. Since then scores of bacteria that produce this organic polymer have been found, including **PHBs (polyhydroxybutyrates)**, one of the first to be commercially available. PHA plastics can be moulded, melted and shaped like petroleum-based plastics, and have the same flexibility and strength. The same production methods can be used, e.g. melt-casting, injection-moulding, blow-moulding, spinning and extrusion. Manufactured under the name Biopol in Europe by ICI and PHBV in the United States. Too expensive for routine use for soft-drink bottles or grocery bags, but the cost should drop with full-scale production.
Bioregenerative Union Carbide researchers have produced a type of **polycaprolactone film** that completely biodegrades within 3 months, leaving no residues. Research into paper products laminated with layers of corn-based cellulose materials prove they can resist water for 6 to 8 hours and could serve as containers for drinks and fast-food items.
Bioenhancing Carry additives to stimulate plant growth, or, as with the artificial burrs designed in the 1970s to prevent erosion in arid climates, carry plant seeds and seedlings embedded in growth stimulants.

MILLIONS OF TYRES

My own particular concern is scrap tyres. In the United States alone there are presently more than three thousand million tyres in landfills, illegal dumps and stockpiles, increasing by another thousand million every four years. The largest pile of tyres in the world is in Westley, California, where thirty-four million scrap tyres cover nearly 200 acres, sometimes forming seven-storey high mountains. Apart from providing ideal breeding conditions for disease-carrying insects, tyres are also profound pollutants of the atmosphere when they burn, producing spectacular clouds of stinking oily smoke; these fires can last for years. In landfills tyres can capture explosive methane gas and 'float' upwards – sometimes shooting to the surface with enormous force. In 1984 seven million tyres began burning in Winchester, Virginia. The fire lasted for more than nine months and nearly seven hundred thousand gallons (two and a half million litres) of oil oozed out.

Less than 20% of tyres are re-used in the United States; most are exported. All tyres, from a child's tricycle to the monsters on earth-moving machinery, are made of near-identical ingredients. There are several types of natural and synthetic rubber, fabric, steel and carbon black, and each must be recycled separately, further complicated by the fact that tyre rubber is vulcanized, that is, the sulphur and carbon in the rubber are bonded inseparably – the rubber is 'thermosetting' rather than 'thermoplastic' and, like a loaf of bread, it cannot be remoulded.

Tyres can be made into a new product called rubber-modified asphalt; a mile of road uses sixteen thousand chopped-up tyres. American laws now require that at least 5% of asphalt laid in any American state must contain recycled rubber; this will rise to 20% by 1997. A tyre road lasts twice as long as a normal asphalt one according to the National Solid Wastes Management Association.

Pyrolysis is a costly process that can vaporize tyres at 1000°F (538°C). A new process has been developed that can do this at 450°F (232°F), yielding light oil and also methane gas which is used to power the machinery.[4] Experiments are proceeding with dissolving tyre scraps in oil at 700°F (371°C)[5] which produces a light oil that can be refined into diesel gas, heating fuel and other chemicals and also smaller amounts of heavy fuel oil. It has been estimated that *presently there are over twelve thousand million gallons (forty-five thousand million litres) of oil locked up in tyre dumps around the world.* Our resources lie deeply embedded in recyclable scrap – the mines and reservoirs of the future are the rubbish tips of today.

GREEN DESIGN

Design for Disassembly (DFD) is a profoundly important new development in design, take-apart technology which facilitates recycling. There is also Design Diversification, the imaginative discovery of new applications for superfluous components. There is also the use of manufacturing waste and production fall-offs which has not yet been sufficiently investigated; it is a brand-new approach to benign recycling. All these developments will be examined later in the book.

The exploitation of solar power seems to be going in two different directions. American scientists are attempting to improve the efficiency of solar cells, whereas Japanese engineers are reducing their cost through mass-production methods. Yukinori Kuwano, general manager of research and development at Sanyo, began to make solar cells of amorphous silicone after the energy crisis of 1973. Sanyo has since become the world's leading manufacturer of amorphous-silicone cells which are now used – essentially as free give-aways – in calculators, wristwatches, cameras and other small consumer goods. Yukinori Kuwano is quoted as saying that within seven and a half years the *entire* energy needs of the world could be supplied by 323 square miles of solar panels covering 4% of the world's deserts. Super-conducting cables would carry the power to areas with less sunlight.[6]

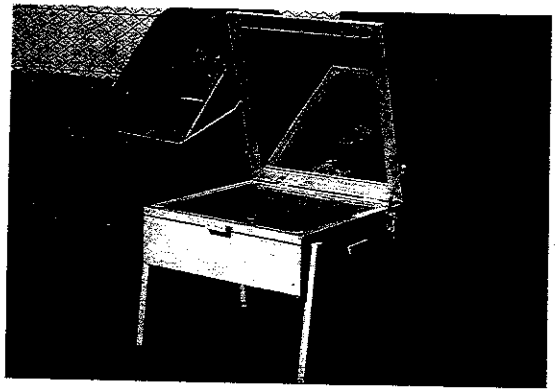
Commercially viable small-scale solar devices should be more readily accepted following ideas for suburban and garden pathway lighting with self-sufficient solar lamp standards, as well as my own concept for amorphous silicone roof tiles.

In 1981 I was commissioned by the United Nations to develop a non-electric refrigerator to be used in developing countries for storing medicines and bulk food. The design is based on a classic experiment by Michael Faraday in England over one and a half centuries ago. Faraday coupled two glass retorts together, one containing silver nitrate crystals, the other ammonia. When a bunsen burner heated the glass vessel, the resulting mixture made the other retort extremely cold.

Early in the 20th century, the Crosley Radio Corporation in America produced a refrigerator based on Faraday's experiment which was widely marketed under the name of the 'Crosley Icy-Ball'. This fridge worked well for years, since the chemical mixture was contained in a closed system and did not need to be renewed. It was much more convenient than the old-fashioned ice-chests. With the introduction of electric or gas-driven refrigerators, however, the Crosley Icy-Ball lost the advantage of greater convenience, and quickly faded into disuse.

My design research team re-defined the unit, which is now powered by a parabolic solar mirror, with lithium bromide substituted for the earlier chemical charge. The unit is produced in a number of Third World countries, primarily for the storage of medical supplies. It has proved itself effective in more than ten tropical countries. My team considered it for re-design in technologically highly developed, or overdeveloped countries, but this has been overtaken by the introduction of CFC-free refrigerants, such as Suva MP-39, and the production of environmentally safe coolers by Siemens A.G. in Germany among others.

There are hundreds of ways in which industrial designers can participate in helping the environment and forestalling further ecological damage. I shall



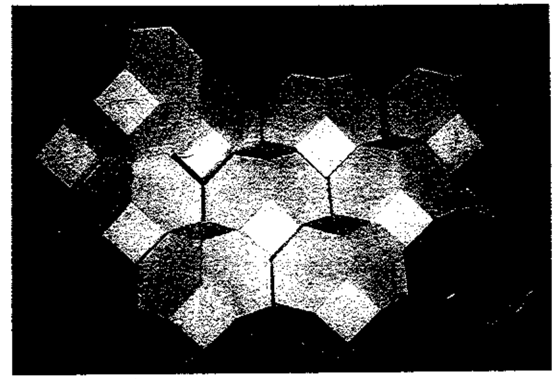
This solar cooking stove was developed through UNESCO for India and Pakistan where millions are now in daily use.

confine myself to a few solutions explored by my colleagues, my graduate students and myself. Only a selection from scores of important topics will be covered in the hope that these kaleidoscopic fragments will form a meaningful pattern. These design interventions may seem trivial – they *are* trivial as they are the first small attempts to reverse the ongoing trend of 'bigger is better', and to challenge the received wisdom of design 'progress'.

A portable solar cell, about the size of two sheets of typing paper, has been developed and is now on the market to provide power for charging batteries on boats, automobiles and some small tools. A simple solar cooking stove has been developed through UNESCO for India and Pakistan, and some 40–80 million units are now in daily use. This stove will cook meals over a five-hour period using only sunlight, and the unit can be self-built on a village level of technology. (It must be pointed out that this lends itself only to the preparation of traditional Indian foods and is not suitable for quick cooking methods.)

Studies in preventing future oil spills have resulted in the design of modular oil-storage containers. These hollow, tetrakaidekahedral-shaped units[7] measure some 36 feet (12m) in diameter and can be assembled into transportation floats that will bring oil to the surface from submarine drilling, transport it across the ocean surface and to onshore refineries. The containers are virtually impervious to puncture – should something go wrong however, the spill would be restricted in size and therefore limited in its destructive effect.

In 1981 I was able to start a user-initiative for ecological controls in Papua New Guinea, which had only recently achieved independence and was still emerging from a virtual Stone Age culture. Nonetheless it proved feasible to organize clean-up squads, and to mount parades and rallies that focused attention on recycling, litter control, the use of biomass conversion, geothermal power, and so forth. The press in Papua New Guinea took up our initiative and continues to push for sane



Design study for tetrakaidekahedral modular units for the safer transportation of oil.

environmental controls. Through a simple organization and the development of a consumer movement, Papua New Guinea was fifteen years ahead of many technologically developed societies in ecological awareness.

It is in the soft-energy technologies that the excitement of Green Design can be found. The Egyptians, the Greeks, the Romans and others used passive solar power. In downtown Los Angeles one can still see solar mirror panels – or rather the remains of them – that date back to 1905 and that provided light and some power to offices, a fact that young students today find startling. Now solar furnaces at Mount Louis in the USA and Odeillo in France and vast solar mirror concentrations in Colorado and California are providing power.

The first geothermal power station was built at Ladarello in 1904; both volcanic as well as hot-water geothermals have been used in Iceland for more than three centuries, and in New Zealand for generations, to warm buildings and provide power. Tidal power has been harnessed in France at St Malo, Garonne, the Loire, and has been studied intensively since 1989 in the Bay of Fundy in Canada.

Wind farms (consisting of large clusters of wind-turbines) have been in use in North America and Israel since 1978. Methane digestion has been in use in Gothenburg and other Swedish towns since the 1960s. When working in Chad (in North Equatorial Africa) in 1972, we researched the exploitation of the great differential in desert regions between night-time and daytime temperatures; such systems, using pipes filled with water, alcohol and other liquids, are now used as power generators in Libya, Egypt, Morocco, Iran and Saudi Arabia.

Biomass conversion, that is, the conversion of dead plant-material, has been used in Brazil since 1973 to make an alternative fuel for cars from banana leaves and cane sugars. Maize is used as a propellant in the USA, and Austria has pioneered the use of 'raps' (a combination of rapeweed and turnip) as an automobile fuel, and this is (in 1994) available in filling stations in Vienna.

Before the re-unification of Germany, serious research was being carried on in East Germany on 'co-generation', which is the use of industrial waste to generate electricity as well as the re-use of heat generated in the manufacturing process. Forest waste is being turned into liquid fuel in eastern Colombia and Venezuela; and in the Alps near Mt Blanc French scientists are studying the possible use of glacier movement for power generation. In Indonesia and Malaysia research goes on to study tropical downpours of rain as an energy source.

Some years ago the first trans-Australian solar-powered automobile race was held; since then, in subsequent trials, vehicles have improved enormously. The *Gossamer Albatross*, a solar and muscle-powered aircraft, has crossed the English Channel, and Commander Cousteau's research vessel *Alcyone* has covered most of the oceans and rivers of the world, relying entirely on its vertical wind-turbines.

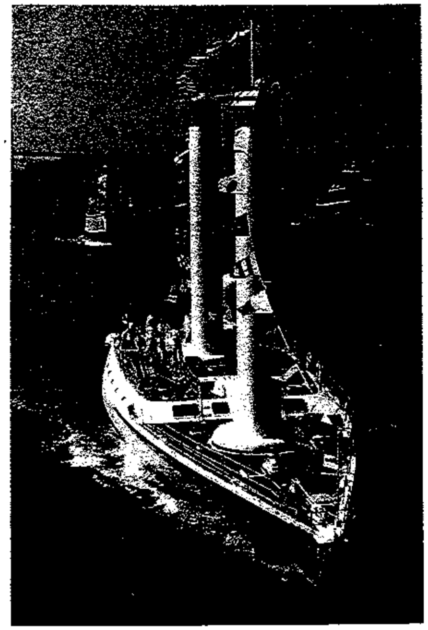
Even though few of these experimental devices will find immediate applications, these and other benign techniques provide exciting challenges for industrial designers to explore new technologies that will do less harm to the environment.

Whenever high technology achieves greater speed at greater financial and energy cost, it would be useful if a slow but cheap alternative way could be developed. The time may have come for serious consideration of the re-introduction of abandoned railtrack, canal boats and transoceanic sailing ships as an alternative to speedy but costly air shipment. Sailing ships were phased out largely because a large crew was needed to swarm up the rigging and re-set the sails. Because of modern computer-controlled rigging and servo-mechanisms, 'tall ships' now cruising the Caribbean frequently have a crew of only twelve handling the sails, working in three shifts. In previous books I have suggested the re-introduction of Zeppelin-like aircraft for leisurely transcontinental travel, as well as for the direct silo-to-population transfer of emergency food and aid to various parts of the world.[8]

PROFIT AND POLITICS

Industrialists, primarily in Germany, Japan and Sweden, have recognized the current environmental and ecological hazards for what they really are: vast new challenges for humankind that must be solved, and *vast possibilities for future earnings, since few governments or industrial powers yet take these threats seriously.*

The beneficial connection between economics and ecology has been systematically misrepresented by industrial and governmental apologists. When the Pacific Electric Company distributes thousands of low-wattage and therefore energy-saving fluorescent light bulbs (that retail at $16.95 each), at no cost to its domestic customers, and insulates private houses for free, this may be done out of altruistic concern for a benign environment, but it also saves 185 million dollars otherwise needed to build a new power-generating station.[9]



Jacques Cousteau's research vessel 'Alcyone', powered by vertical wind-turbines.

The slogan 'Re-use, recycle and dispose responsibly' is a familiar one. 'Use less', however, should should be our over-riding maxim. Manufacturers and their designers are frightened by the idea of using less. It implies that less will be bought and that profits will shrink. Yet if we disengage ourselves from this linear way of thinking, we see that quite the reverse may happen. In a world in which less is used and less is bought, products that are designed to last longer and are more carefully crafted and assembled will obviously need to cost more.

Most designers today don't seem to feel comfortable with a term like 'social responsibility' in reference to the built or designed environment. The Post-Modern condition can be characterized as a vacuum of conscience in which such socially responsible notions as fair housing, a clean environment, health care or access to services are considered somewhat of an embarrassment. Product culture has been allowed to run wild, and has substituted trendy objects for community values, many of them provided by industry and their captive industrial designers, designers and architects.

The richer countries of the world should feel guilty for a statistic that has often been cited since 1970: 6% of the world's population consumes more than 35% of its resources. A riveting fact is that individual sentiments of guilt or shame have done little to alter collective or governmental or professional accountability. Each new insight into the environmental crisis has led to a normalization of a Green Apocalypse – global warming, acid rain, soil and water depletion and the toxification of the land – all these have become accepted penalties for our high-entropy way of life. The consequences which seemed far off and uncertain, are now with us, and yet are treated with the same inattention as the weather.

The great threats which have contributed to this crisis – mechanized agriculture, dirty industry, and rapid urbanization – are well-known. Roughly 70% of the energy used in the United States (which produces more than 25% of the planet's greenhouse trace gases) is attributable to urbanization: this includes transportation, heating, lighting and power, and the generation of that power itself.

Yet it is stupidly optimistic to imagine what *might* happen if we don't know *how* it will happen. This is why concern for the ecology involves ethics and social responsibility. Using less, preserving for the future, conservation and softer energy sources are only drops in the bucket unless these activities are linked to a greater social process that can influence industrial design, industry and policy.

The question of ecology as a socially-based priority asks that design and planning consider sustainability and social justice as reciprocal conditions – that saving the planet and saving the community become one – inseparable.

DESIGN IN THE 21ST CENTURY

As we move towards the 21st century, there will be an increasing need for *some – a few* – designers who are specialists in ecological design. However, in my opinion, *all* design education must be based on ecological methods and ideas. This will include studies in the scientific method, as well as in biology, anthropology, cultural geography and related fields. Social and human ecology and philosophy and ethics will form an integral part of this training.

The future of design is bound up with the key role of *synthesis* between the various disciplines that make up the socio-economic-political matrix within which design operates. I list some examples of how an ecological world-view could change design:

1. There will be a greater emphasis on quality, permanence and craftsmanship in designed products, as people and designers come to understand that obsolescence or bad workmanship waste natural resources that can't be replaced, and contribute to shortages on a global scale. The style of the future will be based on products that age gracefully, and will be more timeless than the quickly changing fads, trends and fashions of the late 20th century.
2. Designers and manufacturers will need to question the ultimate consequences of a new product being introduced. Questions of profit balances and production quotas are not enough.
3. New product ranges will appear, especially in areas such as catalytic converters, afterburners, scrubbers for factories, air, water and soil-quality monitors.
4. It will be understood that no design stands on its own: all design has social, ecological and environmental consequences that need to be evaluated and discussed in a common forum.
5. There must be a greater concern for and a deeper understanding of nature, and this will be a preserving and healing force for the global environment.[10]