Chapter 7
Design: From Repair to a Fresh Start

Und bei diesem strebend Sinn
zu immer kleineren Gütern hin,
bis einmal einst, was heut noch Ware,
zerrinnt in Geist als dann das Wahre.
Schließlich dann materielos
bestimmt das ES dann unser Los?
Karl-Heinz Walter

Designs for meeting service needs

If a sustainable economy is to manifest itself in ways outlined in the preceding chapters, we will need fundamentally new products on the market. If we do not succeed in effecting important changes in product design and in the qualities of these products, then in a few decades, five billion *more* people will be surrounded by infrastructures and products resembling those we have today. We must therefore conceptualize other ways of organizing goods and services in order to bring about the necessary productivity revolution. We must consider their design.

Design determines the ecologically relevant characteristics of products at all stages, from production all the way to landfilling. A product which has been designed according to ecological principles from the beginning will always have less of an impact on the environment than a technology which is concerned with an ex-post removal of pollution. An automobile which uses significantly less environment than one produced today is ecologically superior to one that carries a catalytic converter. A consumer good which is built according to ecological design criteria consists of selected materials. It is laid out for separability, reparability, and other criteria which we will examine in detail.

Products designed and produced today, if they are optimized according to ecological principles, are much too frequently optimized for energy use or emission control during the use-phase, or according to other criteria that are important only during the product's service life. As long as ecological design has not yet gained a foothold, this shouldn't be a surprise. Even design is a reaction to the presently debated issues of environmental and health risks, and to the "pollutant of the week." Designers have to create products that have a market. Therefore it makes sense to develop products that have advantages the customer can see and experience.

Many other qualities are ecologically relevant, however. To take them all into consideration in the design could become very complicated and confusing, unless one were to come up with superordinate assessment criteria. Dematerialization certainly is one such criteria. A logically consistent reduction of the material and energy intensity of products, facilities and services automatically reduces the waste flows, including the flows of toxic and eco-toxic emissions. Virtually all ecologically relevant qualities of products are captured by MIPS in one way or another. We wish to illustrate this with the help of a list of ecologically relevant product characteristics. The list is divided into three parts: production, use and the phase after the first use has occurred, in accordance with the manufacturer's intent; i.e. the phase manifesting any of the following: garbage, recycling, reuse of parts, or second use. All qualities that relate in any way to material intensity are marked with a *.

Ecologically relevant product characteristics

Manufacture

- *Material intensity of raw materials, processes, structures, facilities.
- *Energy intensity of raw materials, processes, structures, facilities.
- *Use of renewable materials. This is advisable only if the total material intensity is lower than if the materials were non-renewable.
- *Amount of useful products produced. This includes linked products, as, for example, in the chemical industry: those chemicals that are by-products, but that can be used anyway.
- *Waste intensity. Emissions into the air and water are included here.
- *Scrapping rate. This is determined by the quality control as well as by process

management.
- *Transport intensity.
- *Packaging intensity.
- Dangerous materials (either materials entering the product itself or as waste materials; see section on "use").
- Surface appropriation.

Use

- *Material throughput, i.e. the amount of detergent required by the operation of the washing machine, fuels, cleaning agents or lubricants.
- *Energy input.
- *Energy output (in the case of facilities, those that yield energy in a useable form, such as power plants and waste incinerators).
- *Weight. This can be an important decision making criteria for the purchaser, as it is one (albeit a rough) estimate of the amount of material that is contained within a product (see also the chapter on "Market Signals").
- *Self-regulation and self-optimization. This category would include the electronic regulation of the flow of consumables (energy, detergent, ...), the "intelligent house" or the "screen saver" option on computers.
- *Multifunctionality. A touring bicycle that can be used both for recreation and commuting is preferred to a highly specialized (racing) bicycle, in an ecological sense. Buildings, for instance, can be constructed in such a way that different use-patterns can be accomodated.
- *Second-hand option. Second-hand clothing stores do an excellent job of organizing this concern, as do all other second-hand retailers.
- *Option of joint use. All products that are used only rarely could qualify here. Electric drills, washing machines and other household appliances, video cameras, lawn mowers or even yachts.
- Size and surface appropriation. This would include the requisite access roads and parking lots.
- *Durability. This is a collective term for a list of characteristics. These include:

-- timeless design, or a design that remains outside the world of fashion and obsolescence--retaining its appeal over time;
-- corrosion resistance;
-- likelihood of material fatigue (especially in the case of plastics);
-- reparability;
-- partibility/separability (for maintenance and repair);
-- resilience and reliability;
-- adaptability to technical progress. Products should be put together in such a way that individual parts can be exchanged for newer, improved ones (car engines or refrigeration units). This holds true not only for durable goods, but also for goods that can change very quickly such as computers.

After the end of the first intended use

- *Durability is also a relevant criterion in this phase of the product. Included in this list are:

-- Material composition and complexity. This determines how easily the product can be reused, or parted out.

-- All forms of continued use; reusability of parts for the same purpose or for other purposes; reuse of raw materials for the same purpose and for new and different purposes.
-- The option of collecting, sorting and transporting the product after its initial use without great material effort.

•*Flammability, or the ability to capture some of the energy content through burning the product.
• Compostability.
• Effects on the environment after the final storage or dispersion into air, soil or water

The contribution of design to ecological transformation

What does a designer do? In what ways can he or she affect the ecological quality of goods? Conversations with renowned industrial and communications designers have convinced us that the design profession can contribute to a more ecologically benign product palette, albeit within certain limits.

It is the job of the industrial designer to design products. In so doing, he does not only pay attention to functionality, but also to aesthetic qualities. The design of a product in industrial practice always has two goals: to make the product usable as well as to improve its chances of selling. A designer's success is measured in the profits of her employer. This has generally meant that more products had to be sold. But this does not have to be this way. It could instead mean that the product simply becomes more expensive, either because it was made from expensive materials, or because it has been endowed with particular aesthetic qualities (as with name brand products). The customer is willing to pay more for a "designer chair," perhaps because he thinks it more comfortable, but probably first and foremost because he is willing to pay for an immaterial value: the quality of the design. Particularly ecological or healthful qualities could provide the rationale for a product that costs a bit more than the competition.

Whether a product is produced at all is generally not the responsibility of the industrial designer (this is true for employed as well as self-employed designers), and in the choice of materials he is often tied to the employer's product spectrum. But he can take an advising role and point out more ecologically sound alternatives.

The job of a communications designer is somewhat different. Her "product" is either advertising or consulting. In an advertisement she can emphasize ecologically preferable products, assuming her employer is open to such emphasis. In consulting for an ad campaign, for instance, she can alert the customer to ecologically harmful qualities. This can affect the design of the product, especially if it is somehow linked to either health or the environment. In both cases, she needs to have access to reliable information about the ecological quality of products and materials--information that is not readily available to date.

A further difference is also important. The work of a communications designer does not in all cases result in the production of a product. The result of consulting could, in principle, be a decision to do without a product, or to change the way the product that is supposed to render the service is produced.

While the designer can design a product that is durable, easily maintained and energy conserving, he cannot normally influence the consumer's attitude toward its use. The consumer may not want it at all, or may buy it because it is fashionable and then throw it away. The exception to this are products which are designed in such a way that they can be used over and over again, possibly even for different purposes. An example would be the interior of a store--the counters--which can be reused as the furnishing for a student's apartment, or for storage in the basement. For this to work, the designer must consider the issue of separability and transportability.

Once the designer has succeeded in dematerializing the product, arranged it so that fewer materials or materials obtained by less ecologically damaging means are used, he may inadvertently achieve a side-effect that can undermine all gains: the new, optimized design may lower the production costs. The product sells better, which is a definite advantage as far as the client is concerned. But ecologically, the result is not necessarily positive. Although the individual product is made with less material, so many more are produced and sold than before, that the total material flows increase. This is called the rebound effect. Dematerializing a product in its design can apparently produce ecologically undesirable consequences along with the desirable ones.

Laser printers for computers are one such example. A few years ago they were big and heavy. They incorporated much more material than other computer printers, and their material intensity was very high. (Disparities still exist, as Figure 30 shows) But these machines cost several thousand dollars, and were only sold in small quantities. In the meantime, they have joined the general boom in computer hardware, and are sold alongside all other printers in large quantities. Their design was optimized (while employing some very ecologically problematic materials). The result has been that the smaller, lighter laser printers of today are so cheap that in some areas they have almost completely displaced other printing techniques. Computers, thanks to their drop in prices, are also rapidly taking over, becoming as essential to an office as the desk and chair. Every employee is now often entitled to his or her own computer, and the groups jointly using one printer are growing smaller and smaller. The result is that, these days, more laser printers are sold in a few weeks than were sold over the course of several years a while back.

Copy machines have fared similarly. When Xerox introduced a dry copier in 1959, their business consultant estimated the U.S. market to be at roughly 5,000. Approximately twenty-five years later, in 1986, businesses bought 200,000 copying machines in the U.S. alone, in one year![1]

How can we deal with the rebound effect?

These examples are not chosen randomly. The market for office equipment, especially with respect to computers and their accessories, belongs to one of the fastest growing segments of the economy. Such markets are particularly vulnerable to these effects: every little effort to save material is subsequently swamped by the quantitative expansion. The chances for success are quite different for products in areas that have already reached capacity. The market for refrigerators, for instance, as well as for several other appliances, is pretty well saturated--each household has at least one. The car market is almost to that point in the industrialized world. If these products were dematerialized, it would have a positive effect overall, as the purchases would be replacement purchases, rather than additions to the pool.

The second reason for rapid product or model turnover is that we only have very few examples of timeless design. This means that a design becomes "obsolete"; new products are desired only because a different design is considered more pleasing. Clothing furnishes the best example of that. Fashion dictates when and what to throw out. (Although sometimes it is worth keeping them around for a while and they come back in style). Other products like cars also become obsolete, aesthetically, but the used-car market deals quite ably with that phenomenon. A third category of products does not become aesthetically obsolete at all; tools such as hammers and screwdrivers are in this camp. No, or very few, aesthetic demands are made of these products, and they are generally not even dealt with by designers.

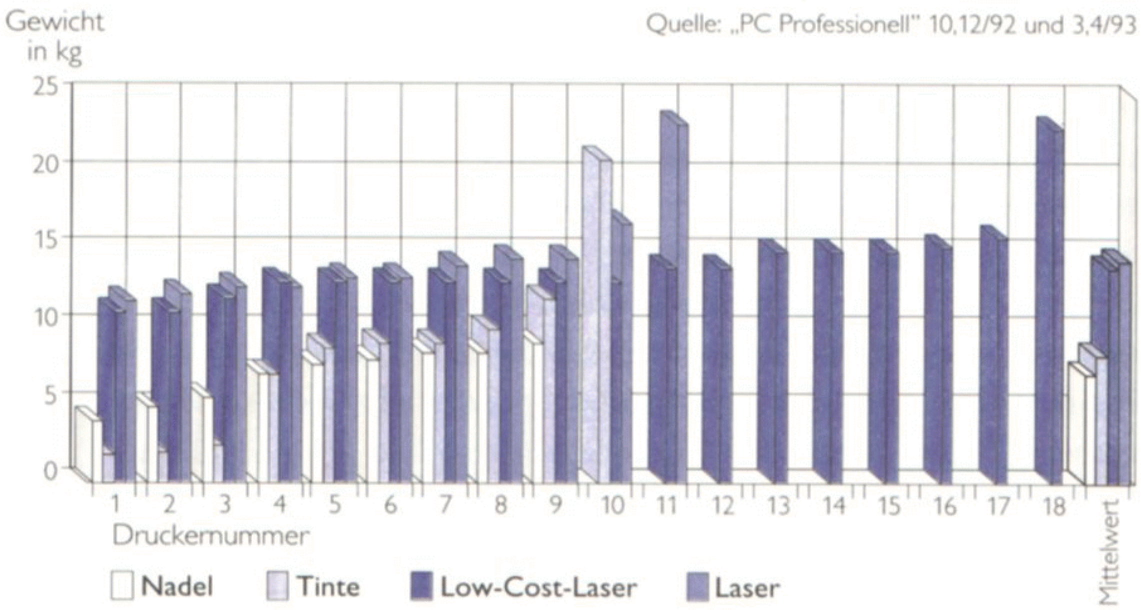

Fig 30: Computerdrucker gibt es als Laserdrucker, Tintenstrahldrucker und Nadeldrucker. Die unterschiedlichen Techniken führen zu großen Unterschieden im Gewicht der Geräte. Tintenstrahldrucker sind im Durchschnitt deutlich leichter als Laserdrucker, weil in ihnen weniger schwere Materialien verbaut werden. Aber auch innerhalb der Geräteklassen sind die Unterschiede groß, was zum Teil auf unterschiedlichen Bedienungskomfort zurückzuführen ist. Einzig die Gewichte der Nadeldrucker bewegen sich in einem engen Band; hier scheint eine Angleichung von Technik und Komfort stattgefunden zu haben. Das Gerätegewicht allein sagt selbstverständlich nichts über Ökotoxizität und ökologische Rucksäcke der verwendeneten Stoffe aus! (Auf Produktnamen ist in der Grafik verzichtet. An ihrer Stelle steht die "Druckernummer")

As timeless design is so rare, the aspirations for constructing modular goods that are easily repaired and reused are necessarily limited. Products exist that can be used virtually forever, if one replaces the parts that wear out, but this concept, as ecologically promising as it may be, is not necessarily easily transferred to other types of products. Examples of exceptionally durable goods are some investment goods, like street cars, bicycles (as long as they do not succumb to fashion trends), or the vehicles used by parcel services that are often built for long service lives.

A sensitivity to ecological pros and cons is not foreign to industry. If a designer can show with reasonable certainty that a particular material is ecologically preferable to others, he stands a good chance of getting the material accepted. These days, however, such information is noticeably absent. This book is concerned with precisely this deficiency, and it is also one of the major issues the people at the Wuppertal Institute are working on. No definitive criteria exist, according to which materials could be judged. Instead, a multitude of perspectives are discussed, often contradicting each other. It is thus very difficult, if not impossible, to invoke the ecology-card, to argue for the ecologically benign characteristics of a product, if one does not want to become embroiled in an ideological battle.

Criteria for ecological design

It is highly unlikely that an independent category of ecological design will emerge if one limits oneself to "ecologizing" current products, because these products were created, optimized and used under "un ecological" conditions. Design should therefore not try to "ecologize," but should bring forth new ecologically optimized concepts. A deliberate strategy in this direction could proceed according to the following steps:

Step 1: detailed description of the service needs

The first step toward dematerialized products, systems and services of the future must be a clear definition of what is needed or desired. At this stage, the question should absolutely *not* be how to technically improve existing systems according to ecological criteria, as this often leads to the invention of "outboard motors for dinosaurs," such as filters, catalytic converters and devices which automatically turn off the car engine while waiting at stoplights or railroad crossings. Besides obscuring the actual goal, such mechanical wizardry requires additional material displacement.

Step 2: the search for the most dematerialized solutions--concept, planning, draft

Here we are looking for ways to meet those service needs. New and unconventional ideas are what we are seeking. What must be kept in mind is that while people buy goods because they are under the impression that doing so will meet their service needs, they might also have very different reasons. Aesthetics and status considerations figure in to the purchase of many an object.

Step 3: First evaluation of the results

In the first round, unrealistic suggestions are thrown out. In this phase the first test takes place. Can these ideas that emerged during the brainstorming phase as environmentally friendly actually be turned into environmentally friendly products? Mass production must be possible, for instance, and the production costs should remain within a realistic range.

Step 4: Detailed inspection of the selected options

In this step the remaining suggestions are assessed with the help of the above list of criteria for ecological design--step by step. At the conclusion it should be clear how each suggestion fares with respect to all criteria.

Step 5: Assessment of the remaining suggestions

In a further assessment procedure, the prototypes are compared with the above list of criteria, the goal being to find which entrant has met the terms best and with the least impact on the environment. The first criteria are the MIPS, and, as far as they are known, the human- and eco-toxicity. Additionally, traditional design criteria are brought into the picture at this stage, such as safety, healthfulness, and, last but not least, aesthetics.

Step 6: Implementation of the selected optimal solution--or a return to step 2

If a winner emerges, the solution is now implemented; the draft process is completed and the product is produced. If no winner emerges, the option of returning to step two, to the brainstorming, exists. If that is neither desired nor sensible, other criteria within the existing list must be emphasized more heavily.

If no solution was found, it could mean that no ecologically appropriate good exists for the job. The result might be to stick with existing products, or to do without the service provision entirely. A business that is subject to innovation pressures and competition will in all likelihood find doing without to be a difficult step.

Without a doubt, the price has to play an important role in the assessment of the chosen solution. But as long as prices refuse to "tell the ecological truth," this criterion can lead to ecologically devastating results.

The procedure just introduced for selecting an ecological design is not just stodgy theory. Ursula Tischner of the Wuppertal Institute has followed this path in her Master's Thesis, working on a new concept for the service "keeping produce cool in the household." We introduce her results under the heading "Does a refrigerator have to travel?" Precisely this question was the key that opened the door in step two to a new solution in line with our goal of dematerialization as it is demanded in this book.

[1.1] Robert Herman, Siamek A. Ardekani and Jesse H. Ausubel, Dematerialization. in: *Technology and Environment*. Washington D.C., 1989.

Does a refrigerator have to travel?

How does one find a material-saving alternative to a conventional product? The designer Ursula Tischner worked this out in a concrete example*. She implemented the rules for ecological design outlined in this book for the refrigerator. What she came up with is not simply a new refrigerator, but a new concept for storing temperature-sensitive groceries in a household. She calls the first refrigerator in the world designed according to MIPS criteria "Fria."

The fact that she chose a refrigerator is not entirely coincidental. The type of appliance we commonly find in kitchens and college dorm rooms contributes in no small manner to the waste flow and to changes in the earth's atmosphere. Somewhere between 20,000 and 30,000 tons of CFCs leak out of refrigeration and freezer equipment into the atmosphere each year. They contribute to the destruction of the ozone layer and exacerbate the greenhouse effect. Roughly three percent of all CFCs are built into household refrigerators, some as coolant and some as insulating foam.

Besides that, numerous other materials are used: steel, aluminum, plastics, glass, rubber, formica, and more. Recycling has so far extended to the metal and not much further. All told, a 160-liter refrigerator weighs about 35 kilograms.

Such a refrigerator uses about 0.85 kilowatt hours of energy, which is 310.25 kWh per year. That's not much when compared to central heating and hot water heaters, but if we disregard those two for a moment, the refrigerator uses an average thirty percent of all the rest of the energy used in households. According to the producers, such a refrigerator is in use for about fifteen years. But they often seem to show up at the landfill after a mere five to eight years.

In the Western part of Germany, 34 million refrigerators are in use. That means 1.44 for each of the 23.5 million households. Nine percent, or three million refrigerators, are thrown on the scrap heap each year. That adds up to 105,000 tons of refrigerator, or three to five million tons of requisite "environment" each year. While ninety percent of all refrigerators are now being collected separate from other garbage, estimates indicate that the CFCs are removed from only about three percent of refrigerators before they are shredded. Most recently, and only in a few facilities, up to ninety-nine percent of the CFCs in the insulation foam and in the compressor oil are being removed.

The first step in the planning, "description of the service needs," indicates an area where new solutions are to be found. The question: "what could a more ecologically benign refrigerator look like?" is already the wrong question, as this asks about the appliance and not the service needs. Some of the services provided by a refrigerator are the following: produce or groceries should be kept cool and dark so that they will not spoil; the storage space should be located in immediate proximity to where food is prepared; it should be hygienic, able to accomodate the usual containers, as well as meet the reigning aesthetic standards, and it should be easily accessible.

The last point is not well addressed in contemporary refrigerators, as one is forced to squat to get anything in or out of them. Furthermore, they have a characteristic they do not really need. They possess a sturdy exterior box that permits them to be taken along when one moves. Why? Do we take along the bathtub when we move? Hardly. Why then the refrigerator?

The fundamental service requirement of a refrigerator is ecologically sensible. Storage in a cool dark space permits shopping in bulk, and prevents produce from spoiling quickly.

The critique of the conventional concept well illustrates our point: why should a refrigerator not be a part of the house similar to our grandmother's root cellar or pantry? If it were integrated into the outside wall of the house--preferably at a convenient height--then the appliance could shut itself off in winter and suck in cold air from outside--fully automated, no different than our central heating works today. We could do away with CFC foams as insulating material, replacing them with scraps from cork production or recycled paper. The doors, seals, control technology, as well as the separately incorporated refrigeration unit, should be exchangeable. It might even be preferable not to purchase the thing at all, but to pay a regular fee to have either the whole structure, or just the refrigeration unit, regularly maintained by a service company, who would then have every interest in keeping the device in the best operating condition and at the cutting edge of technology so as to minimize its maintenance costs. Regular and diligent maintenance will be required in any case, if the appliance is to last as long as the house.

How then should the built-in refrigerator look? Ursula Tischner has thought through the idea and built a model. She planned a cold-storage room with a variable volume of between 110 and 220 liters, built into a corner abutting an exterior wall of the kitchen. The cold-store does not have just one door as most conventional refrigerators do, but several, so that the loss of cold air through opening the door is minimized. Each drawer is cooled to a different temperature. The freezer compartment is cooled to zero degrees Fahrenheit, the "cold-store" compartment to between thirty-four and forty-four degrees, and the "basement" compartment to between fifty and sixty degrees. All materials used in the construction are high quality, to ensure durability. As few plastics as possible are used, and no composite materials, as they are difficult to recycle. The metals used are rust-proof, and cork, solid foams and gas-aerated concrete sheets were used for insulation.

The cold-storage idea is preferable in many respects. Durability and the fact that the appliance is not transported, but produced on the spot (by the installing craftspeople), reduces the material demands enormously. As the cold-storage room is to be used for the life of the house, the wearing parts must be easily exchanged, another plus for the environment.

The most important question to be put to the final draft is, How high is the material intensity per unit of service, the MIPS? First with respect to energy consumption: The cold-store, as Ursula Tischner has developed it, can be run on 0.4 kWh per day with its connected load of 110 watts. Conventional refrigerators with the same performance require 0.85 kWh, or more than twice as much. Let us assume that the electricity is produced entirely in a lignite power plant. To produce one Megawatt hour, (1,000 kWh) of electricity requires about 1.2 tons of lignite coal. To obtain this much, 9.5 tons of overburden must be displaced. As the 0.4 kWh per day for the cold-store add up to 146 kWh over the course of one year, the material flows associated with the energy requirements are already 1.5 tons per year. (This, incidentally, does not include the amount of ground water pumped off). An equivalent number for a conventional refrigerator would be 3.3 tons per annum. The above calculations also do not include the fact that an optimally installed cold-store is supplied with cold air from outside for several weeks out of the year, saving more energy.

The balance of material flows for the production looks very different, though. The box or housing of the appliance is virtually eliminated, and only few plastics are still used. The cooling technology remains essentially the same, although a ventilator is added, and the insulation volume is increased noticeably. Altogether, 36.68 kilograms of material are required for the manufacture, in addition to several kilograms of replacement parts over the course of perhaps one hundred years. This is more than the 35.2 kilograms for a conventional refrigerator, keeping in mind, however, that this last number does not include repairs. The decisive difference is that the cold-storage uses these materials for up to a century, whereas the 35.2 kilograms for a conventional refrigerator are required all over again every ten years. All told, the material intensity of a conventional refrigerator can be reduced by a factor of about seven in the case of this cold-storage room.

This calculation does not yet include the "ecological rucksacks" of the materials used: glass, sheet metal, rubber, copper. To date we have almost no information on the associated material flows of any of these source materials. Before we can actually compute the material intensity from cradle to cradle, such a database must be created. Researchers at the Wuppertal Institute are working on compiling a "materials atlas" of the most important source materials used in industry.

If the cold-storage room has such advantages, why does it not exist in the private sector yet? Quite a few reasons can be listed. One is certainly convention or habit: we perceive it as unusual not to own the refrigerator we are using. Additionally, the network of craftsmen is not in place who could be responsible for installation, maintenance and repair. And yet again we bump into the obstacle of a price structure that does not reflect the ecological truth. To help bring about the necessary infrastructure, a governmentally funded initiative would probably be needed that would mandate the installation of such appliances in new construction and renovations. Such an initiative would not be breaking new ground, either. Building codes abound, and energy-saving window and exterior wall insulation has been, and is currently, funded with public money. Instead of the isolated choice of a "refrigerator" we must come up with a "system solution," that consists of more than just the manufacture of an appliance by a producer.

[*.*] Ursula Tischner, Die Kühlkammer--Ein umweltfreundliches Kühlkonzept für den Haushalt. Diplomarbeit an der Bergischen Universität Gesamthochschule Wuppertal, Fachbereich 5 "Industrie Design", in Zusammenarbeit mit dem Wuppertal Institut für Klima, Umwelt und Energie, 1993.