Chapter 8
The Market and its Signals

Because the markets cannot by themselves internalize environmental cost, it is necessary to establish appropriate environmental laws, institutions and policies to do so.
Joint declaration by the IMF and the OECD, 1991

Federal and state economic and fiscal policies should take into consideration the overall economic balance. Policy measures are to be selected in such a way that while remaining within the parameters of a market economic order, they simultaneously contribute to price stability, a high level of employment, trade balance and steady economic growth.
The German Law for the Promotion of Economic Growth and Stability, June 8, 1967, § 1

We are systematically destroying cultures in order to erect economies. This is one of the greatest curtailments of the human spirit. I cannot imagine destroying anything greater or more valuable.
If culture is no longer our concern, if it has become secondary, if it has become unimportant, how can we speak about nature? How can we say that we should concern ourselves with improving our relationship to nature? That is nonsense. Why is it nonsense? Because the only arguments accepted today are economic ones. I must come up with an economic reason why nature should not be destroyed. This means I must have an economic argument to intervene in the destruction of life. It is an ontological barbarity that the economy stands above life, instead of life above the economy. We live in a society today in which people are servants of the economy instead of the economy serving the people.
Professor Manfred Max-Neef, Universidad Bolivariana/Development Alternatives Center CEPAUR, Santiago de Chile (from a tape transcription at the Protestant Akademie Bad Boll in Germany)

Where we stand today

Humans are faced with an enormous problem. The biosphere is showing signs of exhaustion and partial collapse. The reasons for this are sufficiently well known, and no longer surprising from a scientific perspective. Humanity has gotten used to the fact that it continues to grow, and with it the production of goods and services as well as resource consumption. This worked for centuries and no one needed to seriously concern themselves about whether this could indeed be maintained indefinitely: perpetual growth on an apparently finite, non-growing planet.

But the time has come. Thanks to scientific discoveries we even know how urgent any ameliorative action on our part is, even if science cannot provide an exact date on which the collapse of the biosphere will occur with a large bang. This date will never occur, and no one will hear the great bang either. Symptoms will accumulate, one after another, sometimes slowly and sometimes with great speed. We will simply get used to some of these symptoms, with the phenomenal ability of the human mind to forget bygone occurrences and observances, and become accustomed to, and perceive as normal, the environment into which we were born. In the context of a study about early recognition of environmental changes, we asked shepherds in the vicinity of Munich in 1986 about any changes in nature they had noticed throughout their working lives. Their answers were all essentially without relevance. Popular literature has been dealing with the dangerously incremental nature of catastrophes for two decades now. John Brunner's horror scenario "Sheep look up" was published alongside space adventures in a science fiction series[1].

This invisibility associated with slowness will not last. We, humans, will start feeling the reactions of the biosphere. It will probably first hit the people of the South, who are, as yet, not even the main culprits in the biospheric changes. The rising number of environmental- and poverty-stricken refugees who are demanding admittance to the wealthy countries is clear proof that we do not have to wait for this time to come--it is already here. But all predictions gauging the extent of present environmental changes indicate that we in the wealthy countries of the North will not miss out on the effects--even if, at present, these consequences are limited to a stream of refugees.

Our rapid ascendancy to the currently available manifestations of material wealth fills many people with pride and satisfaction. At the same time they instinctively shy away from any changes that might require them to leave their familiar territory. The technical milieu cannot help but continue to change in the future. What we can hope is that this takes place within the ecological guard rails.

In this situation we now hear the good news from the systems analysts: from both a chemical and a technical perspective a dematerialization of present infrastructures, goods and services by a factor of ten or more is possible. It would be technically possible to reduce the metabolism we carry on with our environment by enough to restabilize the biosphere significantly, if not decisively.

Naturally, enormous and very focussed innovation and development efforts would be required to achieve this both in the private and the public sectors. The emphasis of techno-scientific research must be shifted away from the analysis of environmental stress toward an analysis of the consumption of the environment. Dematerialized technical

solutions are in demand. Naturally this means that the service delivery machines would end up looking and functioning very differently than our present equipment. In all likelihood they would even be better and more elegant than today's models. It is fairly certain that another consequence would be to accelerate the trend toward increased economic significance of the service sector. This is because we can assume that all efforts to increase the service life of goods through repair and maintenance will gain in importance, in light of the increasing need to circulate the materials within the technosphere for as long as possible before they are eventually expelled.

A systemic change does not occur in the real world just because it becomes technically possible. Many peoole would want to emphasize the beneficial aspects of this phenomenon. Systemic changes must become politically feasible as well as societally desired before they can ever become reality.

From an economic perspective, one of the main reasons why we persist in carrying on un-ecological behavior is that neither the prices nor any other economic signals are encouraging the economy to move in a more sustainable direction. The market itself is simply unable to internalize the externalities--the "costs" of unintentioned environmental changes--it cannot, in and of itself, include them in its price structures. Governments are therefore called upon to carefully adapt their economic and fiscal policies in such a way that ecological management will become more attractive.

This is not a new task for parliament and governments. Such adaptations are quite normal in modern societies, and they find their institutional form in ministries of labor, health, research, science and economics etc. We should note, however, that virtually all adaptations have so far been of a social nature. To carry out the necessary adjustments to achieve an ecologically sensible and sustainable economy is a bit different, as it is not merely people's well-being or the well-being of their society that is at stake, but the preservation of the biosphere as the only home and reliable resource base humans and their descendents have. Do these words sound familiar? We've heard this before? You bet.

More prosperity through less consumption of the environment!

But eco-politics must go well beyond a "detoxification" of the economy and the environment. Next to the old question about "clean" production, the truly important issue becomes how to satisfy the production and consumption needs with one-tenth the amount of environment. In other words, How do we produce more prosperity while using up less environment? Eco-politics must concentrate on the beginning of the economic process, rather than on solid waste removal. It must render possible the production of wealth by entirely new economic and technical means. The German Minister of the Environment, Klaus Töpfer, also lacks the authority to effect the necessary economic and fiscal policies required for preserving some sort of ecological equilibrium. As the Minister of Economic Affairs is compelled to devote his efforts to increasing national wealth, in step with the aforementioned "Law for the Promotion of Economic Growth and Stability," there is a *de facto* stalemate. It will continue until we understand that we have to quit satisfying our desire for material wealth by displacing enormous amounts of energy and materials and appropriating vast areas, and have instead adopted these tenets into our economic policies. No such thing as ecologically neutral extraction of material exists,

just as no ecologically neutral garbage exists. Only a fundamentally new, ecologically oriented, economic policy can change this. Once we have achieved this, and no sooner, can we realistically speak of a market economy shaped by ecological and social concerns.

To date not a single country has a market economy organized around a concern for the environment. The Germans are no exception, and when compared to countries like the U.S.A., Canada and Australia, the German per-capita consumption of resources even turns out to be quite reasonable. Compared with virtually all countries of the "Third World" (as there is no more Second; we should probably now refer to it as the "Second World" in this strange neo-colonialist way of counting), we may consider ourselves members of the exclusive Club of Super-Environment-Wasters (Fig. 31). Raimund Bleischwitz and Helmut Schütz of the Wuppertal Institute have amassed some numbers on this[2].

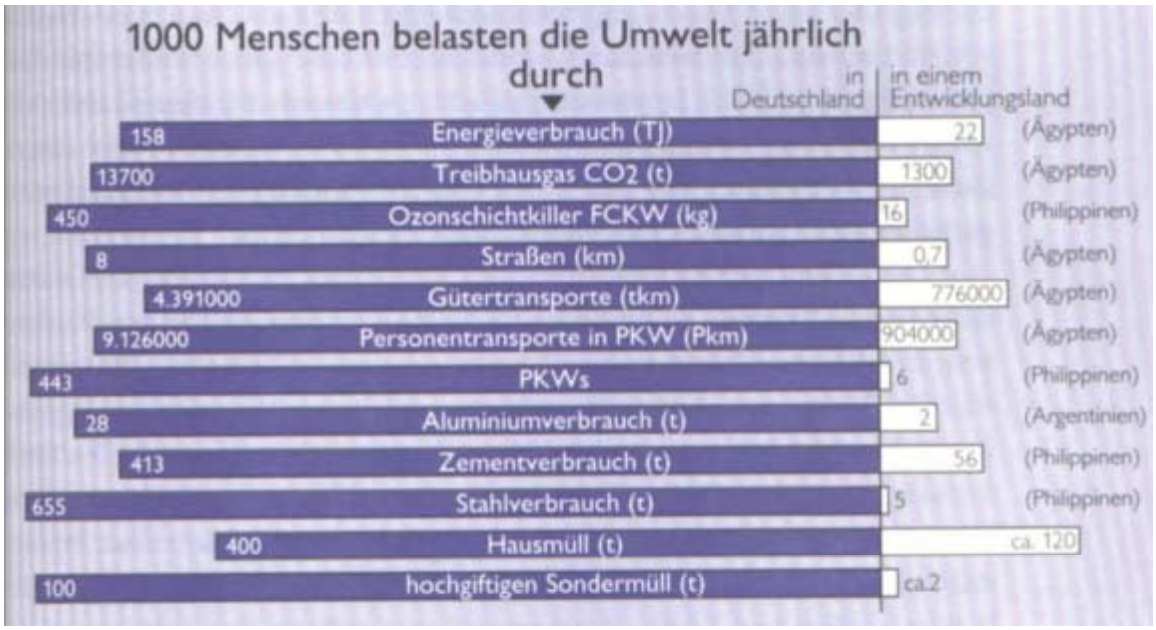

Fig 31: In dieser Abbildung werden die verschiedenen Aspekte des Ressourcenverbrauchs in Deutschland mit dem weniger industrialisiertenm Ländern verglichen.

As our earth is neither divisible nor expandable, our ecological view should confirm that all economic decisions of all nations are of interest to all nations. The ecological meaning of a decision is determined in important ways by both the population level in the deciding country, and by its economic power. If a small, rich country engages in ecological nonsense, it could be worse than if a populous, poor nation continues in the wrong direction.

Gross domestic product--the incomplete balance sheet

Robert Repetto, economist at the World Resources Institute in Washington, D.C., illustrates the ridiculousness of present national income accounting with a fairly drastic example[3].

If a farmer cuts wood in his forest and subsequently sells the wood in order to make enough money to build a barn, then he can enter both an asset and a debit item on his balance sheet. The asset item is the barn, which he has acquired as productive, income-generating capital. The debit item is his loss of the trees. He traded in this manner because he calculated in an economically clever way: the barn is more important for his economic future than the forest.

The farmer's decision enters the national income accounting of his country later that year. It is registered in an internationally accepted measure, the gross domestic product. The gross domestic product (GDP) is the monetary value of all goods and services generated by the people of that country. Our farmer has increased this GDP figure in two ways. First of all, he invested--he built a barn and in so doing increased the country's capital stock. Secondly, he engaged in a productive actitivity--he cut down a forest. He took a raw material from nature, thereby entering it into the economic sphere. Both aspects of the farmer's activities were positive.

Only positive? Wasn't a forest there before, where none remains? Didn't the economy begin to deplete a small portion of its capital, the raw material timber, through the activity of the farmer? Shouldn't the country, like the farmer, add a debit item to the two asset items in its calculation to take account of the loss of forest? Indeed it should. At least that is the opinion of a growing number of economists. But it doesn't. The consumption or loss of natural raw materials is not registered anywhere in the GDP figures. On the contrary, if a country loses all its forest and must consequently invest huge sums of money to curb erosion and compensate for ground water subsidence, these investments raise the GDP even further, even though they are investments in repair activities and are not really creating anything of value.

Repetto, and Meadows et al. in their book Beyond the Limits,[4] illustrate this point with the example of Costa Rica. This nation lost thirty percent of its forests over the course of twenty years. In many instances the often valuable tropical hardwoods were not even sold, but simply burned to make room for farms. The result, in this hilly country with high annual precipitation, was unprecedented erosion. The World Resources Institute estimates the loss of topsoil to have been about 2.2 billion tons over the course of two decades--mathematically speaking, a layer of soil twelve meters thick over the capital of San José. The associated siltation, combined with overfishing in the coastal waters severely damaged both the fisheries and the coral reefs.

The net result: in the year 1989 alone, marketable timber with a value of about four hundred million dollars were simply destroyed. Repetto writes: "This amount works out to about sixty-nine dollars per capita for the population of Costa Rica, and exceeded the interest payments on the foreign debt by thirty-six percent." The loss of nutrients due to erosion works out to about fourteen percent of the annual cattle revenue and seventeen percent of the crop revenue. The income of the fishermen sank below the poverty level. Within twenty years, the calculated loss of value in forests, soils and fisheries summed to more than four billion dollars in 1984 prices--a loss greater than Costa Rica's annual GDP figure. This is as if Costa Rica had produced nothing for a whole year and lived entirely off its capital. In Repetto's words, "compared to the size of the economy, the loss is as great as if the entire defense budget of the United States were to disappear without a trace every year."

None of these losses appear anywhere in the national income accounting of the country. Naturally, the country got into financial trouble. The International Monetary Fund (IMF) jumped in, the foreign debt was calculated precisely and programs were implemented to stabilize the currency, but no one seemed to be interested in the loss of resource capital.

As we have portrayed national income accounts, they appear as a gargantuan and absurd undertaking. It would seem as if we had merely to present the example of Costa Rica or of the farmer to an economist of moderate intelligence, to see him so ashamed of the obvious shortcomings in his balance procedures that he would wish himself swallowed up by the ground beneath his feet. But the situation is not quite that simple. The classical procedure of national income accounting has its history and its achievements.

The roots of the presently accepted procedure are found in the last century, the century of industrialization and of exploding international trade in raw materials and products. This century, as well as the beginning of our own, the twentieth century, were marked by phases of unprecedented economic successes as well as tragic recessions, of crass differences between the poor and the rich within otherwise wealthy industrialized nations. The more dramatically this boom and bust cycle proceeded, the less politicians, business executives and economists were willing to put up with not being able to make sense of these fluctuations. They sought for causes and for indicators that could be used as early warning signals.

After the stock market crash of 1929, the British economist John Maynard Keynes proposed a model that became the basis for the currently practised national income accounting. Roughly fifty years ago, the United Nations made it a standard. In this system, a few key characteristics are carefully summed up. The result is considered an indicator, a single number, that gives information about whether the economy is doing better or worse--even when our day-to-day lives give no indication of either imminent euphoria or impending doom. This indicator is the GDP. In the meantime it is used almost everywhere in the world, although not always in the exact way the UN had once intended.

Even Robert Repetto, a critic of the seemingly universal measure of GDP, credits the procedure with some accomplishments. "National income accounting" he writes, "belongs--despite its shortcomings and despite the fact that the general public understands very little of it--undeniably to the most important social achievements of our century." It took long enough for the sciences to figure out how economies can be steered. In the political day-to-day, at least in the industrialized countries, the GDP is considered one of *the* most important economic statistics. Governments are held responsible for every movement of this number. If the number drops, it can mean the end of a Minister or of an entire government. If it remains stable, or rather if it grows steadily, it is considered a sign of political quality, and, ignoring the visible ecological consequences for the moment, this convention has been perceived as a resoundingly positive one for the last several decades.

For citizens of the wealthy countries such as the U.S.A., Japan or Germany, it is still positive, as these countries can afford to devote considerable percentages of their GDP purely to repair-investments. Every traffic accident, every visit to the hospital, every cleanup of Superfund sites, the Green Dot, and every pollution filter are registered

as positive contributions in the GDP calculations. It is true that, indirectly, a hospital contributes to the productivity of a country, by allowing sick people--unproductive people--to work again; and in one sense, cleaning up Superfund sites can be considered productive, by restoring land to productive uses. But a business willing to incur incidental expenses of this nature would probably soon vanish from the market. And it would be completely absurd if a business were to buy raw materials at high prices and then sell them cheaply or transform them into products in a less than optimal manner.

With that, we are back to the topic of this book and to the farmer who trades his forest for a barn. When John Maynard Keynes set up his macro-economic model, upon which subsequent calculations of the GDP are based, there was no reason to concern oneself with the fact that raw materials might have characteristics commonly referred to today as "limits," or that their use might be responsible for ecologically destructive consequences. International trade flourished, raw materials flowed from countries of the South to Europe and North America as a matter of course, and these countries' share of the price of the final goods remained minimal.

Let us recall that Keynes was interested in the economic laws of the ups and downs of the world economy. Naturally he too was aware that the value of a good was composed of human labor, investment capital and natural resources. But the prices of the majority, and certainly of the most important, of these natural resources were so low that their exclusion made little difference to the overall computation. Thus the entry "natural resources" faded away quietly (and not at all secretly) in the economic accounts. To date they have not celebrated a comeback.

Narrow-chested resource productivity

Humans now know that each time we take a ladleful of something from the environment soup, we precipitate ecological changes. Whatever we do with the material flows, whether we forget about them after having gotten them out of our way, or whether we make cities, cars, shredders, concrete dwarves or mouse traps out of them, the biosphere does not forget the ladling. Encouraged by ever better machines of the dinosaur brand, forced by increasing population pressure and seemingly caught in the frenzy to provide ever more material wealth for all, humans continue to increase the speed with which resources are extracted. We have left the geologic rate of change far behind and are running the risk of getting ahead of things by turning ourselves and numerous other species into fossils. We are calling into question our own survival on the only planet we have.

We are faced with the decisive question as to how we are going to deal sustainably with the resources available to us. The question is really two questions: first of all, how much wealth do we need, and secondly, how much wealth can we get out of a given amount of resources? These are expressly not the conventional questions of how much labor and capital we need to satisfy our material desires, and which materials are best suited to the task.

The new question is concerned with resource productivity. This smells a bit of thrift, of eco-thrift, and that is as it should be. What is truly exciting about it, though, is the tremendous challenge it provides to human ingenuity and skill to develop new models of wealth, and to create the requisite technologies.

This is especially a challenge to the industrialized countries, whose phenomenal economic successes of the last two centuries were made possible by virtually unfettered access to the planet's natural resources. These successes naturally appeal to the less wealthy countries, and--along with our methods of achieving them--appear exemplary.

What does the reality look like today? If one believes the political stump speeches and campaign pledges of politicians in many countries, but especially of those in the industrialized nations, guaranteeing (preferably ecologically mindful) access to "essential" resources belongs to the most important tasks of economic policy. A focussed revisioning of the efficiency with which we use resources is not on the current list of priorities. Federally funded research fares similarly. Improved supply of resources, including renewable ones, is still given far greater prominence than, for example, the research into resource-saving technologies.

Even military efforts are understood as investments in the supply of resources: the war over oil in Kuwait in the spring of 1991, to which almost the whole world contributed in some way or another, cost several tens of billions. Germany, although it was not involved militarily, contributed about one-third of that sum. Independent of whether one wishes to list other reasons for fighting in Kuwait and Iraq, the fact remains that in the very recent past, oil was subsidized quite heavily through tax funds, instead of making it more expensive as a feature of ecological structural change. Those who have read Al Gore's book Earth in the Balance[5] will look in vain for a call to decisively improve resource productivity. And this book has been praised extensively for its relevance to environmental politics.

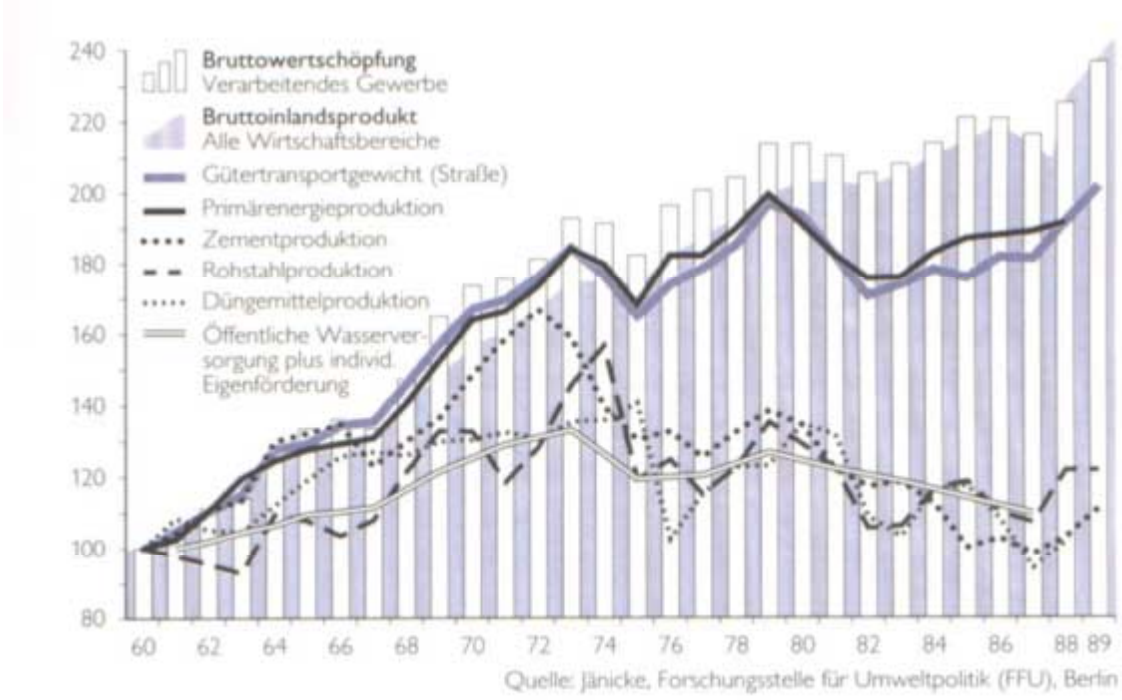

Fig 32: Wirtschaftlicher Strukturwandel in der Bundesrepublik Deutschland (Index 1960 = 100)

Looking at the temporal development of some important industry indicators in the former West Germany shows a mixed, but in some sense also an encouraging, picture. Martin Jänicke has put forth some interesting numbers in this context[6]. Between 1960 and 1989 the production of traditional goods such as fertilizers, steel, cement, and even water supply has become de-linked from economic growth, as measured in the GDP (Fig. 32). The structural environmental stress due to these goods is declining. The use of primary energy and the total weight of transported goods have remained constant since about 1979. While this is not a direct indication of a rise in resource productivity in the production of these goods, it nevertheless charts an increasing independence in Germany of the net value-added from the production of these goods (including the amount of water procured).

On the other hand, the production of certain other goods grew disproportionately over the same time period in Germany. These include electricity, chlorine, aluminum, insecticides and paper. Figure 33 shows the trends.

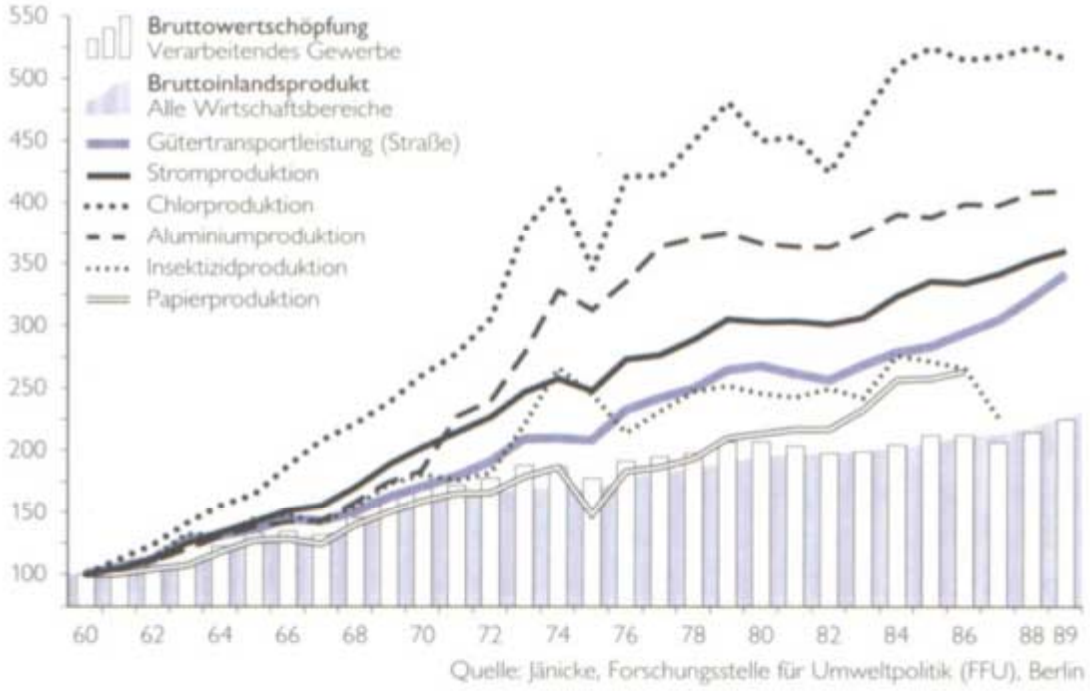

Fig 33: Wirtschaftlicher Strukturwandel in der Bundesrepublik Deutschland (Index 1960 = 100)

In an international comparison, Jänicke's results show that especially Japan, Luxembourg and Sweden have succeeded in de-linking a growing GDP from environmental stress, measured in terms of freight transport, energy and water consumption, along with seven other indicators in the field of heavy industry. At the other end of the scale are the Southern European countries, just behind the Eastern European countries. Germany is somewhere in the middle. Countries of Africa, South America and large parts of Asia were not included in the analysis.

One can appreciate that raw materials are far from being in short supply and that the economies have no fears of this changing any time soon, by looking at the trends in their world market prices. In many cases, the prices have fluctuated a fair amount over the last two hundred years, but overall they have dropped, decade by decade. Their prices are so low today, that they rarely sway economic calculations one way or another. But even in the most extreme cases, the cost of raw materials doesn't amount to more than two to five percent of the price, while labor intensity and labor productivity often account for more than eighty percent of the production cost.

We are concerned with economic policies that permit the greatest possible latitude for developing and increasing wealth within the parameters imposed by nature.

In industrialized nations, the per capita costs of a workday are, roughly speaking, worth one ton of raw material. Sand, gravel, water, grain and soil are even much cheaper. What today's prices reflect are the more or less carefully calculated economic truths of the utilized capital and labor costs for providing the material, and the requisite percentage for profit. Ladling from the environment soup is simply not included in the price formation. This is especially true for transport costs. In Germany it is economically rewarding for a firm to ship everyday goods thousands of kilometers during their production in order to save labor costs. Cotton fabric is regularly sent to Kiev in the Ukraine, and back for dying and for other refinement processes, and then sent to Poland and back for similar treatments. The belief that opening the European borders to the East will bring jobs to countries within the European Union is hardly defensible over the long term with transport prices like these. We already discussed the work of Stefanie Böge of the Wuppertal Institute earlier. She charted the breathtaking transport distances of a simple glass of yogurt. Aluminum from the Rhineland, strawberries from Poland, bacteria cultures from Schleswig Holstein and ultimately produced in Stuttgart. Transportation of this sort makes no sense economically, and even less ecologically. It is a typical example of a completely misguided subsidy policy.

We have figured out that resource productivity lags far behind labor- and capital productivity. In part, this is because only in the last few decades have we begun to be concerned with the risky ecological effects of resource use. It is also attributable to the fact that to date only few people take seriously the risks involved in anthropogenic environmental change.

We have put forth the argument that Western economies must dematerialize their activities by a factor of ten if they wish to make substantive progress toward a sustainable economy. The required increase in resource productivity will likely be in the same order of magnitude.

So far it is entirely unknown how the different productivities are related to one another. Labor productivity and resource productivity are almost certainly related and interdependent; they might therefore also not be maximized independently. An increase in resource productivity would be felt in the world of labor. This might lead to an expansion of the service sector.

For clarification, we are not talking here about resource efficiency, but about productivity. For the sake of comparison: as labor costs were becoming the deciding factor of success in economic competition, the truly significant breakthroughs did not

come about by improving efficiency of existing processes, but by inventing new machines and quality control systems that delivered markedly better results than had hitherto been possible. The shoemaker did not learn how to make ten times as many shoes in the same time, but instead entirely new methods for producing shoes were introduced. Productivity improvements by a factor of ten, twenty and more were more the rule than the exception. In extreme cases, as for instance in mining, factors of ten thousand and more were realized.

Incorrect prices--incorrect market decisions

Let us accompany someone shopping. Let us say they are buying a variety of items: two wall-hooks, an electric can-opener, a washing machine, some apples and tomatoes, and two pounds of roast beef. The consumer is environmentally conscious. She wants answers to two questions: first of all, Which products are in and of themselves more "ecologically expensive" than others; and secondly, How do I recognize if a competing product is ecologically preferable, and if so, by how much?

What is certain is that the price of an industrial product today has little, if anything, to do with its environmental impact. Even the labelling as a so-called green product only refers to the criteria selected by the producer--for instance--the avoidance of pesticides. Such a declaration says absolutely nothing about water consumption or energy use. Awarding the "Blue Angel" was based from its inception on cleverly selected and transparent criteria--but these criteria are simply limited.

The consumer's first question includes the question of the "zero-option." Does a true demand exist for owning or consuming this product? Even if it is "ecologically expensive"? Do I really need an electric can opener? Does cousin Caroline need one for her birthday? How often would I be using the washing machine? Might it not be cheaper, worth the chat, space-saving, and in the end even more convenient, to go to the laundromat once a week or to use the communal machine in the basement? Should I really always eat so much meat even though the doctor keeps telling me to cut back?

Zero-options in consumption are always ecologically preferable to even the most refined environmentally compatible technical solution.

These days, a confusing flood of advertising containing partial ecological information is printed on ecologically expensive paper and glued to many products. And then we have the Green Dot on top of that. But how much environment do these things really cost, including packaging and disposal? From cradle to cradle, that is. How is a consumer to determine these things in the store? We need easily grasped, expressive information, something like the price, a single number, a mark on a scale, better-worse--something to hold on to, even if, in the final analysis, the information is not precise. Material intensity (MI) or MIPS might bring us closer.

The second question, about competing products, must be answered if the consumer wants to compare and eventually decide; if she wants her decision to be at least the better one. How is that with respect to the wall-hooks, and with the fruit and vegetables? Information exists here, too, some of it even correct information. As we have noticed, though, the environmental significance of the product includes everything

from cradle to cradle, which includes packaging and transportation. Buying apples from New Zealand and tomatoes from Portugal in far-away Germany cannot be ecologically sensible, even if they were grown "organically."

Only very few stores of the old kind still exist, where you can simply buy two hooks. Today you generally get ten, because they are packaged that way. It saves labor costs in the supermarket, it discourages theft and it makes the packaging industry happy. You naturally lay the eight extra hooks aside and forget about them, or use others the next time you need some. That's how the economy flourishes. That creates jobs! You think those are small potatoes? If each German bought hooks like that once a year, at one gram a piece, about 20,000 tons of environment would be unneccessarily displaced, not counting the packaging and transport efforts. MI or MIPS on the package would perhaps be more helpful than the Green Dot!

Besides, the best experts in the world could not have helped our consumer very much. As yet, we still lack an internationally agreed-upon method for estimating the life-cycle-wide environmental stress intensity of goods and services that meets the criteria already introduced earlier in the book. Years of research and a fairly large computer would have been required to give our customer even preliminary answers to her questions. Answers, by the way, that other experts would have contradicted.

A further "besides." A "green" Global Agreement on Tariffs and Trade or GATT is not possible, (especially no tariff equilibration for goods that take environmental aspects into account) without an international agreement on how the environmental compatibility from the cradle to the border should be measured. For this, too, MIPS provides a starting point. In fact, thinking about the question of international trade and the environment produced this idea[7].

Free trade with today's goods subsidizes the destruction of the environment.

In order for the market to function reliably, millions of buyers and sellers, those people participating in the market, must continually be making sensible decisions. The market must then react to the sum of these decisions. The market brings forth the products which the buyer demands, or for which the buyer's interest has been awakened. These kinds of products are successful. If a new, more reliable--or for some other reason superior--product is offered, the buyers' collective decisions change, and the sum of their decisions changes the market processes. The "invisible hand" directing the market is the community of buyers. The "invisible hand" is the most important decision making mechanism of the market. The ecological reform of the economy will either take place in the markets or it will not take place at all.

The international criterion for market decisions is the price. Distorted prices are not able to allocate resources in a sensible way. They steer the resource flows in the wrong direction, at the wrong time and in the wrong quantities. If the prices do not speak the ecological truth, if they are based on incorrect or missing estimates of the ecological carrying capacity, what then?

Without the "invisible hand" the market doesn't work, and without honest prices the "invisible hand" gropes in the dark. Unfortunately, it is not too likely that we will get ecologically truthful prices anytime soon. We will try to explain why that is later on. In the meantime, however, consumers need understandable and internationally reliable

information about the environmental significance of each process, facility, good and service--in addition to the price. Otherwise they cannot fulfill the role of the "invisible hand," delegated to them through the market. The MIPS approach provides a useable solution for this.

An example of world-historical dimension of the recent past illustrates the economic consequences of jettisoning the market framework: the planned economies of the socialist countries collapsed. A major contributing factor to this development were governmentally decreed prices, which did not even reflect the true *economic* costs.

As we have seen, the prices in our own economies are not correct either. They invite us to over-exploit the environment and help the consumer to undermine the stability of the biosphere. It is hard to believe that the majority of experienced economists harbor deeply held fears of entering into a serious debate over how we are to get ourselves and our economies out of this critical imbalance, and how we intend to effect ecological economic reform. This stands in striking contrast to their willingness, even eagerness, to be helpful to the formerly socialist economies in establishing a market economy.

If the governments of industrialized nations were far-sighted and wise, they would do their best to overcome the flagrant contradictions between the traditional goal of economic policy, increasing national wealth, and the requirements for maintaining global ecological stability. Should this fail, the loss of political credibility will continue. It will continue to erode until the legitimacy of governments and public institutions at the local, national and international levels is gone, bringing about changes not unlike those which are still rocking the formerly socialist world. One of the victims could be the market economy, another the liberal society.

How to bring about structural change?

Some preconditions

Some fundamental conditions should probably be considered before one can seriously begin with ecological structural change. The following are some of these conditions:

First of all, it is absolutely essential that a sound majority of people in many countries, and especially decision makers in both the private and public sectors, are convinced that business-as-usual will necessarily lead to ecological collapse. A collapse which will, in all probability, significantly restrict the viability of continued human life on earth, if it does not make it downright impossible. This scenario becomes more explosive every day, as the not-yet-industrialized countries know of no other model of development than our un-ecological economics which they are diligently imitating. It can be doubted that presently more than a small minority of Ministers of Economics, heads of state and CEOs take seriously the ecological risks. We have a bit of hard work to do here. The "missionaries" should concentrate on the "unconverted." Too many "greens" talk almost exclusively to other "greens."

Germany needs a new industrial culture, new approaches and a completely new predisposition toward risking new ideas. (Peter Mencke-Glückert)

Secondly, decision makers must be convinced that the possible collapse could happen within the next few decades. They must be convinced that decisions have to be made today in order to get technical innovations onto the market in time, so that market instruments (such as ecological taxes) can be introduced with the necessary time frame so that people have a reasonable chance of becoming acquainted with fundamental changes without having to rush things. Especially the high economic growth rates in the part of the world that has not yet industrialized, with the necessarily gigantic investments in transport, energy, and infrastructures, contribute in no small way to diminishing the chance that we will one day be able to restabilize the biosphere.

Thirdly, the ecological reform of the economy must work within societally and technically realistic time frames. Tax and fee increases must consider absolute limits, and should be reliably phased in over decades. They must reflect certain givens, for instance that new key technologies require a decade or two for the bugs to be worked out and to become diffused; that significant societal change takes a generation at the very least.

The *fourth* point warns against arbitrarily and prematurely tearing down and replacing long-term investments in technical fields that were planned prior to the implementation of such structural change with ecologically preferable solutions. Such Luddite behavior can be economically as well as ecologically counterproductive. It is extremely necessary to work out models for ecologically optimizing procedures and behavior. The MIPS approach also provides a suitable foundation for this.

As a *fifth* point, politics and economics must be able to rely on scientific analyses of the essential economic causes of the present ecological mess, in order that purposeful and sustainable "least-cost investments" can be made to improve the situation. The multiplicity of complicated environmental analyses which exist for every conceivable realm and are peddled by every expert group do not hold much promise here. Resilient, simple, cost-effective and directionally stable economic indicators must be developed in accordance with the necessary analyses in order to be used in the planning and execution of ecologically benign and lasting infrastructures, facilities, products and services. These indicators must permit international control of the success of such structural change as well as provide the conceptual framework from which to suggest changes in course. The MIPS approach tries to meet this need. Hardly any doubts should remain regarding the centrality of significant improvements in resource productivity (eco-efficiency) with respect to ecological structural change. As we have mentioned repeatedly, extensions of- and complementary procedures to MIPS are both possible and in some cases necessary. This is especially true for the evaluation of toxic material flows.

As a *sixth* point we find it necessary for the economy to have reliable guideposts for determining how far structural change will have to go in order for future developments to remain within the biospheric guard rails. As a first approximation we suggest the "ecological safety factor of ten" for the dematerialization of Western economies. Globally and with the present distribution of population this would work out to a mean reduction in anthropogenic material flows of fifty percent over the next several

decades. The economy also needs a new industrial culture which it must bring about itself. New approaches and a new predisposition toward risk are in order.

Seventh, any future attempt to legislate the specifics of a technically required solution must be avoided. It is the responsibility of the government to articulate the goal that is to be reached. If this precept is not abided by, it will be a far more effective means of obstructing ecological structural change than all the end-of-the-pipe technologies put together.

Eighth, it must be pointed out that steps toward ecological structural change on a national level can only go so far. All people need the earth as a store of resources, not to mention as a home. Over the long haul it will be of little use if only some countries transform their economies, especially if they find themselves economically penalized for doing so.

We note that for successful ecological structural change to occur, international cooperation of all countries must be improved. Here, too, we must append a "but." If large countries like Germany do not wish to lose their leadership role, then they have to muster the courage to point the way, with humor and imagination.

Without innovative ecological demonstation projects, Germany will lose its economic position. (Peter Mencke-Glückert)

Legislative measures

Over the past twenty years environmental protection has been primarily advanced through legislative regulations. In principle, this path is suited to removing specific or describable types of environmental pollution relatively quickly and efficiently, and for creating conditions for industry that preserve competition. In the case of clear and present danger, legislative measures are indispensable, as in the case of accidents involving toxic substances. It must be doubted, though, whether the regulatory path is the most cost-effective approach and whether it actually leads to desirable cost- and resource allocations. So far, this approach has not proven itself as a workable means to achieving ecologically informed prices. Besides, in most nations of the world the infrastructures necessary to enforce environmental protection of a legislated kind are absent. Nevertheless, such regulations will continue to have a place in future efforts to protect the environment. No one would opt for doing away with the *Chemikaliengesetz*, for instance. Legislative measures just might be the proper vehicle for carrying out clearly defined steps toward ecological structural change. With respect to future private transportation in cities, a ban on all but City-cars by the year 2005--if not sooner--might be conceivable as an example of an appropriate legislative act. The technology has existed for some time. It would be even better if the automobile producers would finally figure out that they can initiate and carry out ecologically sensible strategies on their own.

Legislative instruments have the tendency to prescribe technical, scientific and administrative regulations with great specificity. In doing so, they permit comprehensible evaluations of success, but also feelings of achievement on the part of the responsible bureaucrats, as well as at many other levels of administrative institutions. Legislative orders of this sort generate the following types of activities:

- the development and prescription of norms, standards, upper limits, testing guidelines etc.;
- granting of permits and prohibitions and the prescription of restrictions;
- inspection of compliance with legal requirements and regulations;
- monitoring and, if necessary, the punishment of violations of any regulations.

Institutional improvements

Alongside legislative measures, governments should purposefully alter and generously expand prevailing institutional conditions that might accompany citizens on their way to new consumption patterns and new conceptualizations of prosperity. Associations, churches, political parties, firms, universities, community colleges and other institutions can and should contribute importantly to the generation of new stimuli, for instance in some of the following areas:

- vocational and continuing education
- hearings and opportunities for participation
- adapting professional and job training requirements
- limiting or supporting advertising
- ease information access
- expand labelling efforts
- create new kinds of jobs (such as energy or material consultants, crop doctors and others)
- increase transparency of both state and business operations in light of the necessity for ecologically benign activity and improved products.

And finally we remind ourselves that governments often have a lot to gain by giving affected institutions generous space for developing innovative approaches under their own responsibility.

Taking advantage of market forces

What do we mean by economic instruments?

We have already clarified the decisive role of the market in realizing an ecological reform of the economy. By economic instruments we mean those instruments that help to ecologically strengthen the "invisible hand" without recourse to injunctions or prohibitions; that permit the millions of decisions made by market participants to become--on average--more ecologically sound.

The example of solid waste

The solid waste problem with which industrialized countries are currently preoccupied cannot be solved by shutting landfills and incinerators and recycling the stuff ever more frequently; while raw material prices remain in the basement and the input

gates, from biosphere to technosphere, are left wide open. First of all, continual recycling with no attendant waste or material and energy demand is impossible; secondly, the amount of material circulating in the technosphere--with no exit--necessarily increases over time. In the final analysis this would mean organizing ever greater stores of material within the technosphere, maintained at rising ecological costs. The material quality will eventually suffer through what is called down-cycling. The price for secondary raw materials then drops, and governmental subsidization runs its course.

A crass example of the international consequences of such policies is now taking place in Indonesia. Tens of thousands of people there have been living off what they could earn by collecting discarded plastics and selling them to recycling firms. Recently, however, and in no small part due to the Green Dot, the imports of plastic garbage from Europe and North America have risen considerably. Recycling firms in Indonesia profess to prefer this garbage, as it is allegedly of higher quality. New processing plants have shot up--and due to high subsidies in Europe, the plastic ends up being delivered free to the Indonesian processors. The result is a steady drop in the price paid to Indonesian plastic collectors; many can no longer support themselves. The German Association for Technical Cooperation (GTZ) is now involved in funding a retraining program for garbage collectors in Indonesia! German tax funds are being used to support a program that is supposed to mitigate the effects of highly subsidized garbage exports from industrialized countries including Germany[8].

Unhealthy, illegal and sometimes even criminal practices in the context of garbage cannot--realistically speaking--be brought under control (or if they can, then only with exceedingly high prosecution costs) as long as an ecologically and market economically coherent material input policy has not been articulated and put into practice. Reports of such incidences crop up every so often in the news media. The aforementioned plastics imports to Indonesia, for instance, contain--according to outraged local agencies--up to thirty percent non-recyclable material and up to ten percent toxic waste.

Over the long term, the waste problem can only be solved by reducing the inputs into the technosphere. This emaciation must be brought about by changes in market signals. More expensive raw materials lead to more marketable secondary materials.

The example of an energy tax

We will introduce here in outline form an example as a clarification of the functioning of economic instruments. We do not wish to provide an exhaustive analysis of the effects of a rise in the price of energy. Many reports and books have been written about this issue[9].

Let us imagine that the European Union has decided to levy an energy tax with the goal of slowly and incrementally increasing energy costs: over the course of forty years, the energy costs are to rise by five percent per year. This would mean that in forty years energy would have increased eightfold in price, not counting inflation and potential price increases of primary energy producers.

First of all, a general comment: Ernst Ulrich von Weizsäcker, one of the most convincing proponents of ecological taxes, has tirelessly pointed out that such taxes are not to be levied for the purpose of filling government coffers. This would weaken their

purpose as directive taxes for pointing the way toward a stabilization of the biosphere, as well as serving to undercut their political feasibility. He suggests simultaneously introducing a reduction in, for example, some other tax, such as the income tax, or in conjunction with the incidental wages costs, so that the total tax revenue does not increase.

Let us assume then, that we have an energy tax. How does a private consumer react? In response to an energy tax the reaction would very likely be that the consumer reduces his or her use of energy as much as possible to make up for the increased cost. Insofar as no actual loss of services (lighting, showering, washing, cooking, heating, etc.) occurs, this would be a private sector energy productivity increase of the first order. As we have pointed out, the "zero-option" almost always exists alongside the others: doing without certain services or eschewing the ownership of certain appliances or other goods. Zero-options are always ecologically correct, unless one squanders the benefit to the biosphere in some other way, for instance through increased driving or on vacations to faraway places.

Furthermore, industry will busy itself with developing more efficient technical means for living with less energy for private, institutional and industrial energy consumers. Industry will do its best to fill the new niche. (An example of this are the already available energy-saving light bulbs.) They make money, gain market advantages and even create new jobs. (Some old ones may fall by the wayside, too.)

This reaction from industry should be equated with an increase in energy productivity for two reasons: first of all, the private or institutional final consumer--for instance a school--saves more than they were already able to do on their own, and secondly, the energy use in producing virtually any good will drop in the case of those firms who invest in the new technology to save on their energy bills. But, these investments do cost money--they have to pay for themselves. To explain this to an investor can get so complicated that a new vocation might develop--an ecological purchase and use consultant (comparable, perhaps, to a tax consultant). This too could contribute to an increase in jobs.

With continually increasing energy prices, ever more competition is generated in industry as well as with other countries to produce better, more elegant and cheaper energy saving devices--the service delivery machines of the future. The transition to an ecologically inspired market economy will have been successful.

As the MIPS discussion has shown, we would have to ascertain first whether the increased energy productivity actually covers the entire life cycle of the product, and if it has not perhaps been achieved at the expense of material productivity. Otherwise the success may be deceiving. Estimates of this kind, with the help of MIPS, are indispensable. A further analysis should be performed as to whether or not more toxic materials were substituted in the new technologies. Whether these factors are relevant in the case of the aforementioned light bulbs remains to be seen.

It is entirely possible that more ecologically benign service delivery machines will be more expensive to purchase than conventional solutions; the efficient light bulbs are a case in point. Should this prove to be a general rule in the future, and some things point in that direction, then certain adjustments with respect to how ecological structural change would be financed are in order. An example of this need might be the concern over how poorer families would find themselves able to adapt to the changes. In other

words, the options in the area of renting and leasing would have to be reexamined and possibly extended to other product categories.

Energy price increases could very well precipitate price increases for industry and thus also for consumers, at least in the interim. This would register negatively in national and international competition. Industry has made a point of repeating this over and over again, and has so far blocked any energy price increases by so doing. This may be taken as an indication that those responsible in industry and government do not consider the ecological risks to be either imminent or very threatening.

In the context of an ecological reform of the economy, resource productivity would have to be improved considerably. This is true for geologic resources as also for water, soil and energy. An important question is whether an increase in price (taxation) of all these resources is sensible or not. The answer is yes--but. One can make steel so expensive that it would pay to steal the train tracks at night, or mailboxes. This can hardly be considered a sensible strategy. Stealing energy, on the other hand, is far more difficult. It is particularly hard to store, and when we are talking about commercially interesting quantities, it is downright impossible. Storing water is also a tricky thing--an expensive proposition--if for no other reason than that it is liquid. This means that one would have to sit down and think about which materials to make more expensive, by how much, and how to go about it, in order to improve resource productivity in specific target areas. It might make sense to increase the price of cement through a special energy tax if one is interested in improving the productivity of cement production. In this light, energy seems to be particularly suited to a "general tax," especially as all technical activities require energy in one form or another. But we must remind ourselves that the amount of energy used is not a reliable measure for the resulting environmental stress. Last but not least, we should take into account that federally implemented energy price increases within the European Union can and will have repercussions on the oil, gas and coal producers in other countries.

An interesting example of how one can turn conventional thinking in the electricity supply industry on its head is provided by electric utilities in the United States. By giving away hundreds of thousands of energy-saving light bulbs, they avoided having to build additional power plants. This turned out to be a commercial success, as well as doing the environment a good turn; the construction, operation and demolition of conventional power plants involves high MIPS all the way, even if the power plant in question is a nuclear one. Amory Lovins calls this the sale of "negawatts"[10]. We call it incentive reversal and will return to it shortly.

The example of subsidies

Subsidies are--as we have seen--fundamentally good at falsifying market prices and altering economic structures. In brief, they successfully weaken the efficiency of the "invisible hand." We will deal with a few examples of subsidies as they pertain to ecological structural change.

The subsidies that are afforded each year in Germany amount to about forty billion Marks. Many indirect subsidies are certainly not captured by this number, either. All presently existing subsidies are more or less un-ecological. As is generally well-known, rescinding subsidies is not an easy matter. Attempts in the areas of agriculture,

steel and coal have made this clear. Those who watch television know of the demonstrations of protest. Besides market distortions, personal and societal dependencies manifest themselves as well. Subsidies artificially freeze economically unstable situations.

It would be desirable if, in the future, the news media--in addition to providing extensive coverage of regions in which subsidies are being rescinded and the attendant difficulties experienced by those people, cities, and regions affected--would also illuminate the significance these changes have for effecting ecological structural change. This transformation will necessarily bring with it the demise of certain lines of business, as well as creating new ones. We can appreciate here how carefully and with what foresight the path toward a sustainable economy must be conceptualized, and how important it is to give people a reasonable chance to acquaint themselves with the changes that lie ahead. But we cannot butter our toast on both sides. We cannot hope to prevent an ecological collapse while simultaneously continuing to root around in the earth as we are at the moment. The industries which introduce raw materials into the economy, such as the sand, gravel, potassium and coal industries, must be relegated to the "sunset" sector.

The solid waste industries are well on their way to generating massive subsidy diversions in the medium term. Employment in this sector is skyrocketing (also because of the Green Dot.) Should our demands for a dematerialization of the economy be realized, and should the waste flows be reduced accordingly, the demand for continued employment will be heard there as well, as expensive capital equipment rapidly loses its value. In this way, an ameliorative sector can become harmful to the general cause.

Structural changes have always occurred, otherwise most of us would still be farmers. What distinguishes ecological structural change is that one can predict with some accuracy which lines of business will have the capability of making significant contributions to the dematerialization of the economy. To name only a few: communications, bio technology (if, in the future, it can make do with less water), micro- and nano-technology, chemicals, a new transport industry, construction, civil engineering as well as a decentralized low-voltage DC-current supply network.

Basically we have a fairly broad-based political consensus on the need for reducing subsidies, if not abolishing or transferring them. This sentiment could be channelled in a socially considerate manner in the direction of a sustainable economy. As a first step in this direction, a sound comparative analysis of the ecological character of major subsidies within Germany and the EU should be undertaken. The MIPS approach can be of some help here, too. In addition, an objective and comprehensive picture of direct and indirect subsidies, must be worked out before any sensible attempts to reduce and transform existing subsidies can be recommended.

New U.S. estimates of the direct and indirect subsidies of private automobile traffic in the United States are relevant in this context. They add up to an astronomical 300 billion dollars per annum! The use of streets for free parking in cities, the demand for health care resulting from the use of the automobile, as well as the investments in police, government bureaucracy, information and communications were included in the study. This figure is much too preliminary for us to draw any conclusions from it, but it does indicate that reliable analyses in this area can give valuable insight into market distortions on a large scale.

Various economic instruments

In the following, we wish to enumerate the most important kinds of economic instruments which the government can access on the path toward a sustainable economy. As in every situation, it will require an intelligent combination of measures to reach certain ecological goals. This applies both to the combination of instruments as well as to their temporal sequencing.

In the fiscal realm, governments can do the following:

- dismantle un-ecological subsidies
- levy resource consumption taxes; if necessary, in conjunction with reductions in other taxes
- require fees (solid waste, effluents)
- grant tax exemptions
- facilitate the use of write-offs
- enact user fees
- require deposits
- use its own purchasing power to influence product and service provision (fleet purchases, etc.)
- fund research and development programs
- offer direct financial assistance in the form of low-interest loans and other financing options
- permit tradeable emission and effluent licenses
- alter ownership and use rights
- influence insurance premiums
- set liability parameters.

Beginnings of ecological structural change

We now direct our attention to a difficult undertaking. We will make a first attempt to describe different ways of initiating ecological structural change as well as relating them to one another.

We have already mentioned an energy tax and have discussed several aspects related to the effects of subsidies. Measures in these areas will have great significance for ecological structural change. In both cases, however, it is the government that must act, and in Germany's case, the supra-national obligations within the EU must also be taken into consideration. This takes time. Because of this, we want to look at a few more alternatives that only require the government's intervention in a limited way, or not at all.

Figure 34 shows a type of phased plan for realizing some of the options along the way to a sustainable economy. It is a purely hypothetical construct and makes no claims of either completeness or realism. The only thing that is important is that we develop strategies for practical mastery of this extraordinarily complex task.

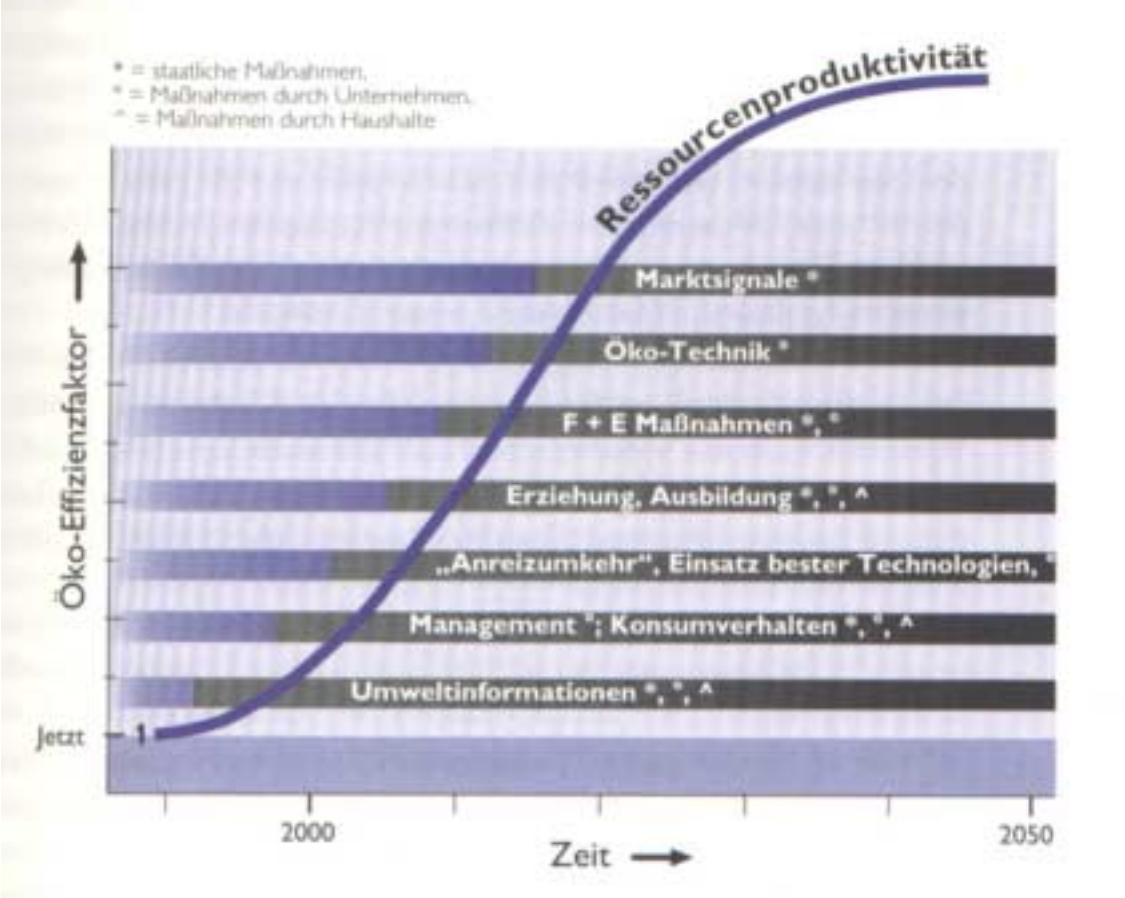

Fig 34: Die hypothetische Zunahme der Ressourcenproduktivität (Ökoeffizienz) durch verschiedene Maßnahmen im öffentlichen Sektor (*), in Unternehmen (°) und in privaten Haushalten (^) über die nächsten Jahrzehnte.

Incentive reversal

An example of reversed incentives: Architects today earn a percentage of the total cost of building the structure they design. That is how the fee scale operates. In this situation they are not left with much of an incentive to save on either materials or energy in the construction or operation of the building--the reverse is actually more likely.

We must not forget that a substantial portion of the material input in buildings is required by federal, state and local building codes as well as by other health and safety norms. This is not meant as a diatribe against safety, but an invitation to all involved to rethink such norms and codes in light of the idea of resource productivity and international experience. As has already been mentioned, if every German were to unnecessarily purchase ten grams of steel per year, 25,000 tons of environment would have been displaced for nought.

Back to the architects. One possible incentive reversal would be to agree upon remunerations based on the amount of material and energy saved. The basis for such an arrangement could be a comparison between a conventional solution and a highly conserving solution with comparable durability or service life. This would be a MIPS comparison, with the "S" in MIPS (the service) being equivalent in both cases. An

appropriately well-negotiated contract would yield many winners: clients, architects and especially the environment. There would be losers, too: the cement industry.

The example of hundreds of thousands of energy-saving light bulbs that were given away can also be an example of such a reverse incentive. The idea of Least Cost Planning, which aims to limit the amount of energy sold in a region by considering a plethora of different methods of conserving energy, belongs in this category as well. Peter Hennicke and his associates from the Wuppertal Institute are working intensively in this area.

This appears to us to be an area well worth more intensive work and thought. Options and practical experience in the areas of land use, material savings (including water), as well as a reduction in energy use should be collected and adapted. It is quite conceivable that a thoughtful compilation of approaches and case studies that also considers the potential for diffusion, could make a significant contribution to ecological structural change. All of this could in fact occur without significant loss of time, in many cases without substantial investment, and without any dependence on the actions of the state.

Management

Repeatedly, experience has shown that significant improvement potential still exists in the area of resource productivity, both in the private and public sectors, if people would improve their "housekeeping" and keep their eyes open. In discussions with engineering firms who perform audits for companies, the tenor is that, almost always, twenty percent or more energy and material can be saved without incurring costs for expensive technical equipment; or, if they do cost money, the payback period is usually between one and two years.

Often such savings are achieved through continued (and often tiring) watchfulness and reminding. At Dow Chemical, a system of rewards for energy-saving measures led to substantial savings. Such savings are not necessarily once and for all. They can require considerable time, and the total savings are always necessarily limited, one way or another. It would therefore be very helpful if it could be made easier to access affordable electronic monitoring and optimization equipment for residential and commercial structures.

Possible ecological savings through improved management could include getting rid of dead-end streets in cities and doing away with some of the traffic signals, or at least turning them off for most of the day. Having to stop and wait in a car is equivalent in fuel consumption to driving for several hundred meters. These strategies should be taken seriously, especially where City-cars are the only or primary users of inner-city roacs and streets.

Research and development

Alongside politics, science and technology are especially called upon to look for possibilities for reducing material inputs on a grand scale. Science and engineering research and technology programs, but also social science research institutes are included here.

As the situation stands, we need not hope for the private sector to come up with alternatives with which to improve resource productivity. Research and innovation are based on expectations over the very long-term, and from the perspective of industry it is far from clear that the transition to a sustainable economy is really gaining momentum. For this reason the state must come up with definitive commitments. The European Union can be considered a "state" in this context as well.

The most important economic competitors of Europe, Japan and the United States have made it abundantly clear that they intend to strengthen the degree to which their governments support and fund research in technology. Japan has developed plans for ecological structural change called "New Earth 21" along with a large scientific institute charged with developing environmental technologies. President Clinton announced a new program for developing technologies that combine increased environmental protection with high-income job opportunities.

In neither case is an increase in resource productivity or a comprehensive dematerialization of the economy for the purpose of stabilizing the biosphere explicitly mentioned. Either way, we see here a momentous chance for Europe to access future export markets. A prerequisite for this would obviously be to establish and carry out sufficiently funded research and development programs. The participation of the private sector within the usual framework of financial support can be assumed. Yet again, we wish to emphasize that parallel to the pursuit of technical solutions, questions of how new models of wealth and prosperity might look need to be answered as well.

The need for policy analysis is a real one, and is especially important in overcoming diagnostic hurdles in the political sphere. Such efforts furnish the crucial link between a more theoretical and abstract kind of research and the development of practical political strategies for dealing with societally important issues.

In the very general areas of technology and management, the potential contributions to be made by sub-fields such as nano-technology, micro-electronics, **Mikrosensorik**, bio technology, and automation and materials research (especially in chemistry) for materially *extensive* processes, goods and services, are to be examined. New approaches to product design should be examined with an eye toward sustainable solutions. Approaches which aim to use and reuse materials through cascading should be systematically supported, especially in those cases where carbon constitutes a high percentage of the material. If they are already in the technosphere, then we might as well use the products, their parts, and eventually the materials of which they in turn are composed, in as many incarnations as possible--from highest to lowest quality, concluding with a thermal usage at the very end. The Life Cycle Analysis methodology should be revamped and internationally harmonized. Norms and safety standards should be dissected with an eye to their potential for wasting energy and materials. Developing energy systems with low total consumption of material and energy should be made a priority. Models of gradually decentralizing production, distribution, and energy provisioning systems should also be developed. A database should be compiled of the most important basic materials of industry and mass-produced goods, that includes information about the material, energy, and surface-use intensity over the entire life cycle. International harmonization, constant updating and access possibilities for as many interested parties as possible should be considered in compiling such a database. A "green GATT" would, for instance, require this information. Management strategies

need to be developed for initiating and maintaining dematerialized product lines and service offerings. New transport and infrastructure systems that require a minimal amount of energy, material and surface area for their establishment, maintenance, operation and demolition should be examined with the help of case studies.

Overall, the development of technologies is and must continue to shift from an emphasis on mass and energy to intelligent solutions--from manufacturing of scale to manufacturing of scope. Intelligent solutions imply more information intensity, which requires a greater emphasis on the politics of research and development.

In the area of *environment*, we consider the following research, development, and policy themes to be a priority:

- development and examination of practical, economically relevant and internationally harmonizable indicators for measuring the environmental stress intensity of goods, services, regions and economies;
- development of methods for cost-effective and reproducable Life Cycle Analyses;
- development of ecological optimization principles for recycling, reuse and the inclusion of renewable materials;
- calculation of the material, energy- and surface-use intensities (the "ecological rucksacks") of the thirty to forty most important input materials for industrial processes;
- development of practical approaches for estimating the ecological carrying capacity of the earth;
- testing of our hypothesis that over the long term, OECD countries will have to reduce the material intensity of their economies by a factor of ten.

In the area of the *social sciences* we consider the following to be priorities:

- development of models for socially and politically acceptable approaches to significantly reducing the material and energy consumption of our economies;
- development of alternatives to the current inflation of demand; delimitation of the different aspects of sufficiency; development of options for dematerialized consumption;
- examination of the relationship between material ownership and the perception of status (with reference to ostentatiousness);
- development of measures for our perception of wealth;
- development of models for an improved cooperation between industrialized and non-industrialized nations in the implementation of measures toward sustainable development.

In the area of *economics* the following seem to be of primary concern:

- development of economically effective approaches toward a marked increase in resource productivity;
- development of models for financing ecological structural change;

- examination of the interdependencies between labor markets and structural change ("rationalize resources instead of labor") while considering an economically feasible time frame for structural change and the transition from producing economy to service economy;
- examination of the international ramifications of national and international efforts to increase the price of resources;
- inquiry into the order of magnitude of current direct and indirect subsidies in the countries of the EU, and the development of ecologically desirable changes;
- development of national balance sheets that combine the physical basis of the economy with appropriate indicators for economic success;
- development of political strategies for an ecologically defensible world trade (modification of GATT);
- examination of the effects of different incentive systems toward sustainable development (i.e. Least Cost Planning as applied to water and other materials, not just to energy);
- analysis of the conditions under which individual countries could be financially supported in light of their ecological predicament;
- examination of the possible effects of a rising resource productivity on the demand for goods and services;
- analysis of the economic effects on those countries which must take on the leading role in the move toward sustainable development.

Nature versus culture--the agricultural exception

If one wants to represent the effects of agriculture on the biosphere in the terms of Material Itensity Per unit of Service, one has to take certain peculiarities into account. Christiane Richard-Elsner of the Wuppertal Institute did just that in her comparative study of cotton plantations in Arizona and Uganda with respect to material inputs*.

Agriculture replaces existing biological circumstances with a new set of conditions. When the crop in question takes up water and nutrients from the soil, when it affects the carbon cycle, as well as influencing many other parameters, it is not simply a matter of counting up the water, nutrients, CO_2 and others things to get the material intensity. Before the agricultural conditions were in place, another form of ground cover existed, that also did all--or most--of the above. The latter scenario must provide the baseline.

A materials balance of agricultural activity must therefore resemble the procedure for a firm or factory. While in a factory situation raw materials are brought into the factory and subsequently sold again as intermediate or final products, capital exists there, too, which remains in place and changes only very gradually. Machines, buildings and other infrastructures are worn out, and this trend must be accounted for. Nature fares similarly, as it is "worn out" through agricultural practices: soil quality usually changes, and the hydrologic cycles are almost always altered in some way. The difficulty here is to obtain the data relating to the conditions prior to agricultural intervention--the material flow relationships in existence prior to the present use. If, as in Christiane Richard-Elsner's case, an adjacent piece of land with which to compare one's findings is available, the data can be considered all the more reliable.

Cotton is one of the most important export commodities in the world. Twenty-one million tons are produced each year. The results of this study show that humans displace between 6,000 and 10,000 kilograms of natural "environment" to produce one kilogram of cotton fibers, severely influencing natural cycles.

The differences between the various sites where cotton is grown are considerable. In Arizona, lots of irrigation and fertilizers are used, and machinery is employed for harvesting the fibers. In Uganda entire families manually work the fields, and because of the abundant rain, irrigation can be omitted almost entirely. Pesticides are used in both regions, however.

Although all of this points to an environmental advantage in favor of Uganda, the study shows the exact opposite. More than 10,000 kg of "environment" are displaced in Uganda for 1 kg of cotton, and in Arizona "only" slightly more than 6,000 kg are displaced. The material productivity could thus be improved in both regions.

In cotton agriculture the water productivity is especially low. Almost 100 percent of the material flows are water--both in Arizona and Uganda. Roughly 10,000 kg of water are displaced in the African country to produce 1 kg of cotton; in Arizona "only" slightly more than 6,000 kg of water are used. All other flows almost vanish by comparison: in the U.S. they add up to five kilograms; in Uganda it is fifty-four kilograms.

The low water productivity is ecologically fatal in both regions. In Arizona, cotton is grown in a virtual desert that must be irrigated. In Uganda the natural precipitation is utilized, but the cotton plants take up considerably more water than the

native plants, and between them the water takes away large quantities of soil. Forty-four kilograms of soil per kilogram of cotton are lost! Naturally one cannot count the precipitation as an effect of agriculture--it would rain even in the absence of cotton plantations. But due to the greater surface area demands of cotton agriculture in Uganda per kilogram of cotton fiber the rainfall adds up to such a staggering number.

The CO_2 balance is an example of the "before-after comparison." In Arizona's desert, the cotton plants take up more CO_2 than the natural vegetation--in Uganda it is exactly the reverse. The tropical vegetation fixes more carbon than the cotton that has replaced it.

The purely anthropogenic portion of the material inputs is comparatively simple to calculate. The amount of fuel per season was determined, and the weight of the machinery was divided over the number of harvests for which it can be used. In Arizona this amounts to one kg per kg cotton, in Uganda roughly one hundred grams per kg cotton.

This calculation does not include the figures for the steel, rubber and fossil fuels that were necessary to produce and operate the machines, and which in turn required large amounts of environment for *their* production. These "ecological rucksacks" of industrial raw materials are only partially known to date.

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