A Report by the

THE FACTOR 10 CLUB

Chapter *I*

Factor 10:

Making Sustainability Accountable

Putting Resource Productivity into Praxis

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Preface

1.

Because the ecosphere is a non-linear complex system, it is scientifically impossible to ascertain all environmental insults originating from technical and other human activities. This is even true for well-researched individual pollutants such as cadmium or CO_2.

Because of this we do not know - and will never comprehend - all environmental effects of our activities.

Thus we operate in conditions of high uncertainty and **permanent risk**. While we have to accept risks as part of our lives - imbedded as they are within the ecosphere -, common sense would nevertheless demand to minimize such risks through **precautionary policies**.

2.

Environmental changes are caused not only by **pollution** but also by the processes involved in **extracting resources**. In fact, resource extraction is the more significant cause, since (1) all technical interference with natural resources *in situ* have consequences with respect to the evolution of the ecosphere, and (2) all materials taken into the economy end up sooner or later as emissions and wastes.

Therefore the chances for moving toward sustainability depend critically upon the increase of the resource productivity of all economic activities.

MIPS, the Material (plus energy) Input per unit **service** (or utility) is a reliable measure for the eco-intelligent and economic use of natural resources. The inverse of MIPS, namely **S/MI,** is a measure for the **resource productivity.** The surface of the earth is another natural resource, which is limited and vastly overtaxed at this time in many parts of the world. Its productivity can be measured in **S/FI**, the utility per unit surface denatured (F = Fläche = surface in German), **FIPS** being the equivalent of **MIPS**. In industrialized countries, at least a tenfold increase (**Factor 10)** in resource productivity is necessary if sustainability is to be reached.

3.

- Real wealth is more than economic wealth. It includes everything that people value. It includes factors such as employment, education, and access to information, health, safety, and freedom from violence, freedom of choice, environmental quality, social security, participation, leisure, and equity. Wealth obviously depends as much upon historical developments and cultural preferences as on economic and geographic circumstances.

- The access to desired services is the underpinning of the **wealth of people**. The totality of accessible services within a country is a proxy of the **wealth of this nation.**

- The economy is a wealth-delivery-system, prominently (but by no means exclusively) acting through making services and the required goods available for <u>and</u> accessible to all people.

1. General Introduction

Within one generation, nations can achieve a tenfold increase in the efficiency with which they use energy, natural resources and other materials.

The Factor 10 Club - an international body of senior government, non-government, industry and academic leaders existing since 1994 - believes that such a goal is now within the reach of technology and, with appropriate policy and institutional changes, could become an economic reality (Factor 10 Club, 1994/1997). In fact if the entire socio-economic system is re-oriented in this direction, even higher factor changes are attainable. In the process, we should see a steady improvement in the quality of life of communities, new opportunities and improved competitiveness for business, expanded possibilities for employment, and an increased potential for wealth creation and its more equitable distribution.

The Factor 10 Club believes that environmental protection as practiced today in most countries is unsustainable. Both from an ecological and economic point of view, there is a need for more rational, focused, effective, systematic and quantifiable environmental policies. The key is to shift the balance of concern from the monitoring and control of pollutants and wastes to a new focus based on resource use.

Environmental damage is caused not only by pollution but also by the processes involved in extracting resources (Schmidt-Bleek, 1993/2). In fact, resource extraction is the more significant cause, since all materials taken into an economy end up sooner or later as emissions and wastes. Thus, reducing the costs of environmental damage requires both, bringing down emissions and reducing the flow of resources drawn from nature.

Sustainability requires that environment and development be made mutually supportive at the front end of the development cycle, when the goals and policies of society are being set, not at the tail-end after society and the economy have already incurred the damage costs of unsustainable developments.

Sustainability also requires that growing social instabilities caused by gross inequities in job opportunity, by widespread hunger, and by inadequate health care be reversed lest all techno-economic measures striving for sustainability be naught at the end of the day.

Most governments, corporations, and voters continue to assume that a healthy economy is one that uses increasing amounts of energy, materials, and resources to produce more goods, more jobs, and more income. This assumption is a holdover from the mass economy of a dying age, an age in that growth was marked by a steady expansion in the production of energy, the depletion of resources, and the degradation of the environment. Although passé, this assumption still dominates public policies in finance, energy, agriculture, forestry and other sectors, slowing and sometimes stopping and even reversing the transition to a new, efficient and more sustainable economy (Hawken, 1999).

Dominant fiscal production and consumption policies continue to block the transition to this new energy and resource efficient economy. In fact, the entire framework of all socio-economic activity in industrialized countries is anchored in the concept of a throughput economy, discharging and destroying enormous quantities of material goods continuously, replacing them with new gadgets. Even traditional environmental policies exert negative impacts, particularly when prescribing technical solutions to isolated problems, neglecting the systems character of the ecosphere - as well as that of the economy - and the need to administer cradle to grave considerations. The catalytic converter in present-day passenger cars is a typical example of such shortsighted solutions.

This must change.

But governments must also deploy policies to ensure that gains in resource productivity are not lost through a "boomerang" effect. Experience indicates that, with steady or falling prices - or with increasing disposable income - efficiency gains can be easily wiped out by yet higher levels of consumption.

Boomerang effects cannot and should not be controlled on the firm level. However, they can be measured on the macro level through national statistics in terms of Total Material Flows, as is now the case in Germany. And they can be controlled and avoided with the help of a bouquet of government actions, including tax reforms and the abolishment of counterproductive subsidies.

To a small extent, the new economy has already begun to emerge, one that is more efficient and potentially more sustainable. It is marked by people producing more goods, more jobs, and more income - while using less energy and resources for every unit of production and service. This new economy is the result of a complex combination of factors including new technologies and changes in historic relationships between capital, labor, and resources, including energy. It is most evident in those market economies open to change. It is led by world industry and is transforming it. Another reinforces the trend of the new economy: the structure of production is moving inexorably toward services. Even in industrialized countries, the share of manufacturing in GDP has already dwindled to some 20 - 25%.

But this new economy needs considerable encouragement and support by radical new fiscal policies in order to become pervasive.

Industry has long wanted to escape the growing burden of end-of-pipe environmental protection and certain advanced companies have long known how to do it. When pressed by the rising costs of energy, materials, and capital during the '70s and '80s, they found that they could invent lighter products that use fewer materials and require less energy to produce. They also found that they could redesign production processes to require less and more flexible capital plant and to recycle and reuse by-products internally - with benefit to their bottom line. In fact, they discovered that front-end investments to enhance energy, resource and environmental productivity, and front-end measures to design eco-efficient goods and services, are frequently less costly than taking care of unwanted emissions and wastes, and could be regained and transformed into new business, new markets and new profit centers.

Using current resource productivity as a benchmark, the Factor 10 Club has concluded that governments, industries and international and non-governmental organizations should adopt a tenfold increase in energy and resource productivity as a strategic goal for the new millennium in already-industrialized societies, in order to make environmental space available for developing countries while halving the global resource flows. Emerging countries, too, will need to strive for developments based on higher resource productivity levels in order to compete successfully for the earth’s resources and market shares.

As measure for resource productivity members of the Factor 10 Club have adopted S / MI, where MI is the total input in natural resources - from cradle to grave - in order to provide a unit of service or utility S. The MI could be looked upon as the "ecological price" of the product. "Service" in the MIPS- and Factor 10 concept corresponds to utility in traditional economics (Schmidt-Bleek, 1998).

Obviously, either lowering MI can improve the resource productivity for a given S , or by increasing S with a fixed quantity of resources, or both approaches at the same time. Both changes can be achieved through technological as well as managerial innovations. For example, by increasing the longevity of goods (in particular goods for end-users), by leasing rather than selling a product, and by sharing buildings, infrastructures, vehicles or machines can the total number of service units be improved dramatically, without a corresponding increase in the total input of natural raw materials.

These suggestions by the Factor 10 Club are important to all those who design, implement or support policy and institutional changes that will make transitions to a resource productivity paradigm attractive and profitable: Leaders in governmental and non-governmental organizations, opinion leaders in business and finance, professionals whose daily decisions commit resources use (engineers, designers, architects, planners, marketing managers, financiers, etc.) and academics who can influence the minds of future generations and facilitate transition processes. On the shop-floor level, practical experience already in hand can help to dematerialize processes, services and goods such as vehicles, buildings, machines, and infrastructures.

The Reports of the Factor 10 Club have already proven to be essential reading for concerned individuals and citizen groups whose views and behaviors - as employees, consumers and voters - will be central in reaching sustainability.

In putting forth its publications, the Factor 10 Club has five objectives: the first is to disseminate the basic message about resource productivity and factor 10. The second is to demonstrate the technical feasibility of achieving factor 10 and to exemplify best practice. The third is to prove the economic advantage of dematerializing the economy dramatically, the fourth is to explore the usefulness of factor 10 as a leitmotiv for comparing visions of alternative development trajectories and the sets of framework conditions that would support these. The fifth finally is to explore the opportunities that might exist for different stakeholders in helping to define and support a new paradigm based on resource productivity improvements.

These five objectives are important in respect to building the capacity for change within societies as well as building consensus across different stakeholder groups about the need for change and the key elements of change strategy.

On one level, the publications by members of the Factor 10 Club are written as a practical "how-to" manual. Illustrative examples of proven dematerialization strategies and approaches - spanning the full spectrum of economic sectors - are placed throughout.

At another level, the authors hope to excite and challenge stakeholders about the possibilities and opportunities that may be found in changing development trajectories.

We do not suggest that all the answers be known. There are problems to be faced. The question whether we have to democratize our democracies so that people can again exercise sufficient control over policies and economic developments is one example. The limits to open international competition with the present imperfect markets is another. Is a renewed and truly serious international debate on measures for providing wealth to people not overdue? Equally, the role of industry, and service sectors, including banking, with respect to its social and political responsibilities may have to be re-examined. Should we perhaps revive the concept of a long-term social contract for industrial enterprises? Should we radically revise conventional signals and preferences into the market mechanisms? What new forms of international accords or organizational structures are required to make a level playing field, globally, regionally, and at home?

Despite these uncertainties we remain convinced that if the process of dematerialization does not begin very soon, the stability of our economies as well as the social fabric of our societies and the global ecosystem are seriously at risk in the medium-term. Furthermore, by starting now, we would have the option of achieving a transition slowly by evolution rather than being forced to change suddenly through revolution.

2. Executive Summary for This Report

At least a tenfold leap in resource productivity must be achieved by industrial nations within the next few decades if sustainability is to be reached.

Sustainability will be achieved through the market mechanism, or it will not be reached at all. Only by making it attractive for both, manufacturers of products and the users of goods and services, to consume less materials, energy, and surface area, will improvements of resource productivity become a reality through the powers of the market. Therefore, it is reasonable to concentrate on the environmental stress potential of goods and services for end-users when developing strategies for reaching sustainability.

Today, up to 90 % of the biomass harvested as well as more than 90 % of the natural abiotic (non-renewable) materials disturbed in their natural settings by machines in their natural settings are wasted on average on the way to making products available to end-users.

The Factor 10 Club therefore believes that avoiding waste and designing radically dematerialized processes, products, and infrastructures - while providing continued end-use satisfaction - are among the major avenues toward sustainability. Considerable interest has grown in the private sector during the recent past in exploring opportunities for increasing the resource productivity through the creation of novel technical solutions and management policies (Lehner, 1999).

This interest springs from many considerations. Important among them is the fact that saving resources can pay and pave the way to occupying untapped market niches with innovative products. More and more industrial leaders also believe that the development of hitherto little industrialized countries can only be accomplished when less resource consuming technologies of high quality - in particular infrastructure systems - are made available. The ecological consequences of copying current western kind of wealth generation for 8 billion people or more would otherwise spawn uncontrollable ecological consequences. Managers seem to be more convinced than ever that commercial success will depend upon eco-efficient technologies and innovative approaches to their marketing.

Increasing the eco-efficiency by a factor of 10 or more in industrialized countries is essential for regaining the ecological stability. The Factor 10 must be regarded as an absolute goal for using less natural material on the input-side of industrialized economies. Less than a Factor 10 will simply not suffice to make enough environmental space available for the development of more than 150 countries within the confines of the sustainability goal of halving the yearly global translocation of natural resources.

Factor 10 is strategically important since it implies that system solutions must be sought, and in many cases entirely new technical approaches be developed in order to provide current services with comparable quality to the end-markets. In most instances, neither "good housekeeping" nor mere "ecological adjustment" or "cleaning" of present-day technologies - and most certainly not any end-of-the-pipe solutions - will suffice to reach a tenfold increase in resource productivity

This Report by the Factor 10 Club attempts to meet the growing need for explaining how dematerialization of technical artifacts can be accomplished in day to day practice. It summarizes several step process that have already been extensively tested with excellent results in small and medium sized companies in Austria and Germany (Schmidt-Bleek, 1998/2). This report also addresses sustainable purchasing and marketing.

The Report explains how MIPS (Material Inputs Per unit Service) is assessed, S / MI being the measure for resource productivity. The meaning of S is explored to some degree in chapter 7.6. The Report notes that grave errors can result when only energy consumption is taken as an indicator for the environmental impact potential of processes, goods, or whole economies (Schmidt-Bleek, 1998/3).

By applying the MIPS-concept, comparing the respective resource intensity of goods becomes feasible. Progress toward sustainability thus becomes accountable, not only for goods and services, but also for economies as a whole.

This Report demonstrates how ecological rucksacks are computed for end-use products and why rucksack factors of base materials (like metals, glass, plastics or cement) should be known and considered as novel properties of materials when designing products, just like the heat capacity, the specific weight, or the electric conductivity of base materials.

This report proposes labels for industrial goods, as well as eco-benchmarkings for company and trader’s activities, goods, and economies as a whole. In this context it should be noted that calculating the material input per unit of GDP is ecologically irrelevant since it does not adequately account for the (miss-) use of natural resources. Relieving the stress that is put upon the planet earth by economic activities requires an absolute decrease in resource flows from the ecosphere to the economy.

How easy it is to be misled can be shown by the following example: In Austria, the total national material input rose by 90 % during the period from 1960 to 1995, while the GNP increased by almost 200 % during the same period of time. The apparent national material intensity decreased by 37 %, while the natural resource flow from the ecosphere almost doubled. This is ecologically an obviously unsustainable situation, even though the numbers indicate otherwise.

MIPS can be lowered - the resource productivity increased - by either using fewer resources, MI per unit service, or by increasing the unit services, S, per constant material input. This means that resource productivity increases are as much reachable by management decisions of consumers as by technical improvements.

While the improvement of eco-efficiency on the product level is imperative for reaching sustainability, this is not a sufficient condition for reaching sustainability on the level of the economy as a whole. Changes in consumer habits in industrialized countries are just as important. They can be induced by education (MIPS for Kids, 1998), consumer information, and by changes in the incentive systems that governments control. Fiscal reforms are unavoidable for this and other economic reasons (Paleocrassas, 1999).

Ultimately, the ecological quality of goods and services could be represented by the sum of three terms that would all have to cover the total life span of products:

MIPS = the Material (incl. energy) Input per unit service
FIPS = the surface (<u>F</u>läche, German word) use per unit service,
and by
TOPS = the eco-toxic exposure equivalent per unit service

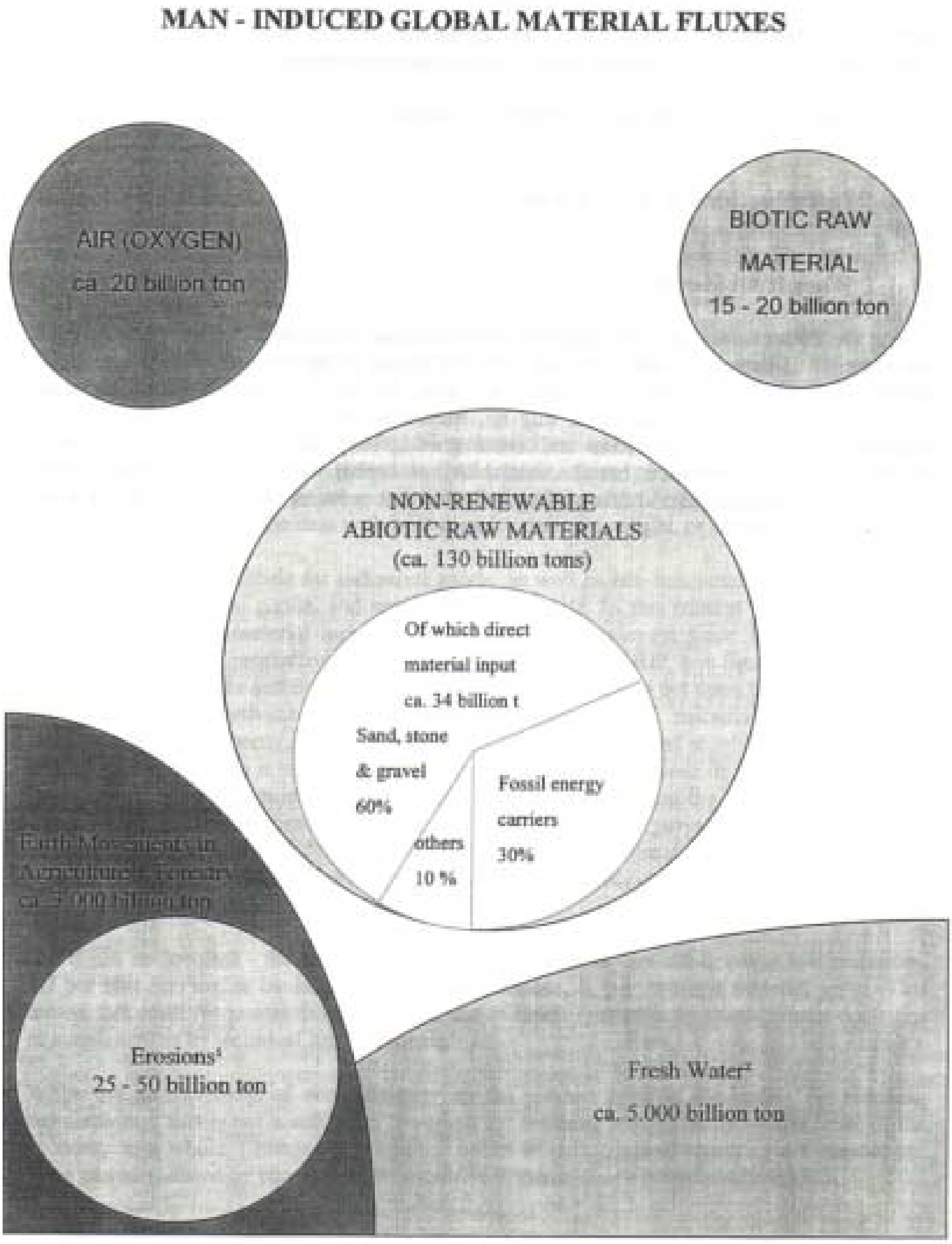
3. Experiences Of The Past

3.1. Things Are No Longer As Stable As They May Appear

During the 20th century, the industrialized countries accelerated their relentless hunt for and consumption of natural resources, which they had begun in earnest after the invention of James Watt's wonderful machine some 100 years earlier. The earth's geological and biological fruits are being dug up, harvested, left behind in the landscape, harnessed, refined, burnt, turned into buildings, infrastructures, vehicles and other goods. They are being "consumed" and discarded with no constraint but the availability of capital, labor, and know-how. These altogether frantic and frequently thoughtless activities continue to be encouraged and favored by subsidies and perverse taxation policies, as well as accounting practices.

On the average, up to 90 % of the biomass harvested as well as more than 90 % of the natural abiotic (non-renewable) materials disturbed by machines in their natural settings are wasted on the way to making products available to the end-user. From this perspective, humankind has hardly any supply problems. Surprisingly, we seem to be serious when calling this dismal situation "high tech", "high hem", and "eco- (something or other"). The products of the future will disturb and consume less natural resources, they will require a higher input of know-how, and will outsell present goods on all markets.

Figure 1



[1] D. Piementel, Sience, Vol 267, 24.02.1995, p.1117.

[2] Postel et al. 1996. (extrapolated).

Text for Figure 1: The dimensions of current human-induced global material streams in billions of annual tons (Air, biotic materials, non-renewable (abiotic) materials, soil, and water).

Source: H. Stiller, Wuppertal Institut

The "throughput economies" of the west have become the world-wide standard of success. Already, man-induced material flows easily rival in quantity those put in motion by geological forces on the continents. The per capita resource consumption has clearly outpaced the population increases and continues to do so. Some 80 tons of non-renewable materials are removed yearly from natural settings to satisfy the present per capita needs of Americans and Europeans. If all people lived like that, a complete layer of 5 mm denatured non-renewable material could be put on the continents, or a continuous layer of half a meter in depth in 100 years. If the car density (cars per person) of the United States were ever to be reached in China, some 20% of her arable land would have to be devoted to roads and parking spaces in order to accommodate the new mobility. If the Chinese ever insisted on a similar *per capita* beer consumption as the Swedes are proud of today, far more than the present world production of barley would disappear in eastern stomachs in liquid form. If six billion people were to copy successfully the life style of the "advanced" industrial nations, three new planets earth would be needed. It seems self-evident, that timely changes in this resource support for life styles are needed, if humankind does not wish to suffer terminal convulsions in the foreseeable future.

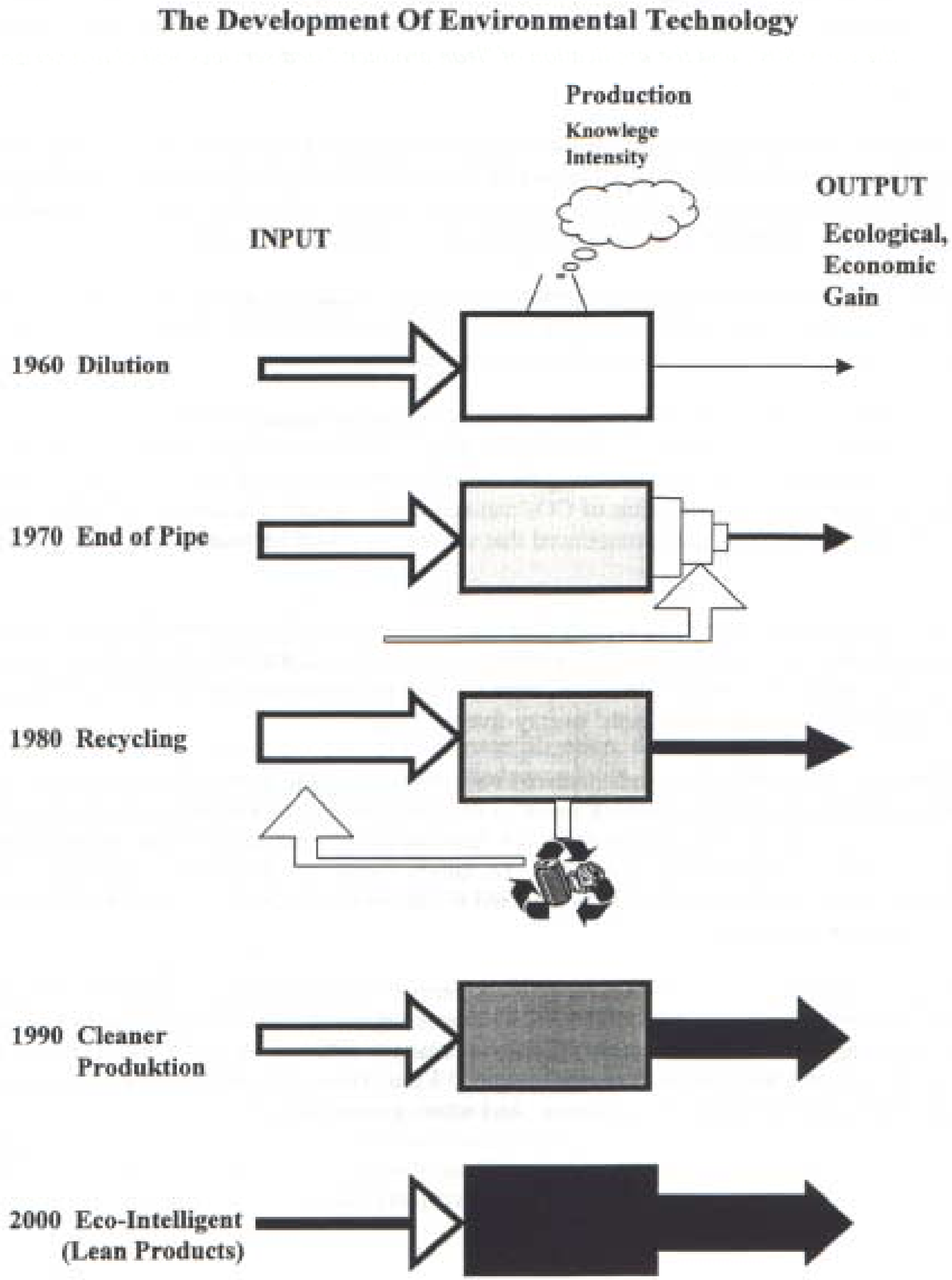
3.2 "Environmental Technologies" Of Yesterday

Under the impression of alarmingly high pollution levels that were reached in the 1960's, and in particular their consequences for public health, the industrialized countries launched a first wave of response to the environmental degradation: Pollution control standards were defined for ambient air and water quality, and later for emissions (Schmidt-Bleek, 1998/2). Technically, diluting the emissions was the least costly way to go. When this approach no longer seemed to suffice, end-of-the-pipe solutions came about in the seventies. Still now, catalytic converters in cars are considered acceptable devices. During the eighties, recycling became the new wave. Not only was the flux of waste to be lowered in this fashion, but the need of natural resources was to be reduced also. Today, slightly more than 1 % of all natural material fluxes are recycled - at staggering costs.

It is not easy to fathom why economics failed to point out right from the beginning that this kind of secondary economy - implanted and entirely depending upon control and command legislation - is largely an artificial economy invented to clean up the basic economy and its technology. Its functioning thus depends to a very large extent upon the richness of nations and can consequently not at all be expected to function in the majority of countries around the world.

"Integrated technologies" and "cleaner production methods" began to appear in the early nineties, avoiding known pollutants through altered processes and consuming less energy. But the basic quality and superiority of existing technologies and products were still not questioned in earnest. Consequently, technological dinosaurs are still being "ecologized" with "cleansing machines" at the tail end of the old ones, driving up the costs as well as the consumption of resources per unit wealth created. The present-day automobile (that in fact is basically an almost 100 year old technology) is a perfect example. Instead of answering the question, how the statistically well known inner-city transportation of people by automobiles could be dematerialized by eco-intelligent solutions, the dinosaurs are still fitted with expensive catalytic converters, whose longtime functioning nobody can guarantee. Three tons of non-renewable materials must be translocated in order to build such a "cleansing" device. Is that "good environmental technology"? Or are devices of this nature rather preventing the development of technical systems with which profits can be made while simultaneously offering precautionary environmental protection?

Figure 2


The Development Of Environmental Technology
Production
Knowlege
Intensity
OUTPUT
INPUT
Ecological,
Economic
Gain
1960 Dilution
1970 End of Pipe
1980 Recycling
1990 Cleaner
Produktion
2000 Eco-Intelligent
(Lean Products)

Text for Figure 2: Starting with increased heights of smoke stacks in the 60s, the development of "environmental technology" proceeded through end-of-the-pipe approaches in the 70s and recycling efforts in the 80s. UNEP-IE started its "cleaner production" scheme in the early 90s, and the application of "lean products" and services will characterize the next few decades.

(This presentation is an adaptation of one that appeared in the 1997 Report of the Czech Cleaner Production Center, Politckych veznik 18, 110 00 Praha 1, Director Vladimir Dobes, Fax: ++ 42 2 260 639. In this report, evidence can be found that investments at the front end of the production are roughly 10 times more effective than at the back-end.)

Classical environmental protection remains a superficial answer to the ecological crisis. It typically works at the end-of-the-pipe and implies additional costs in money and resources. This still allows businesses and politicians to argue conveniently that economies need to prosper in the first place in order to afford environmental protection at all.

As long as "to prosper" means to maintain per capita consumption rates of resources similar to the ones prevailing in highly industrialized countries to date, the pollution control strategy remains profoundly un-ecological as well as uneconomic.

It is not accidental therefore, that classical pollution control measures failed to be internationally harmonized at a meaningful level - as demonstrated recently again by the almost complete lack of success during the United Nations meetings in Kyoto, 1997, and Buenos Aires, 1998 devoted to curbing the emission of CO_2 and some other gases relevant to climatic changes. Even the United States have pronounced that they cannot afford their share to save the earth in this way.

Small wonder, therefore, that twenty five years of costly pollution control efforts have not prevented environmental deterioration from increasing on a global scale. Only that now toxic industrial emissions and effluents are found more in the poorer countries, while they used to be characteristic of the "the North" twenty-five years ago.

Moreover, the wealth of the industrialized countries is based to a considerable degree upon man-induced material flows that occur in the Third World, as for instance natural timber, overburdens from mining mineral resources, and the use of water resources for the production of agricultural products and aluminum. To satisfy Germanys thirst for orange juice, four times as much land would have to be devoted to orange production, as is now being occupied by fruit trees in Germany.

As things stand, the orange trees for stilling Germanys thirst grow mostly in Brazil, some 10000 kilometers away. Ca. 25 % of the people harvesting the oranges is less than 14 years old at an average monthly salary of 70 Euro. 1 kg oranges sell for ca. 0.03 Euro in Brazil, the liter of orange juice in Germany for 0.6 and up to 2 Euro. Thousands of children die each year in Brazil from chemicals poisoning while harvesting agro-products.

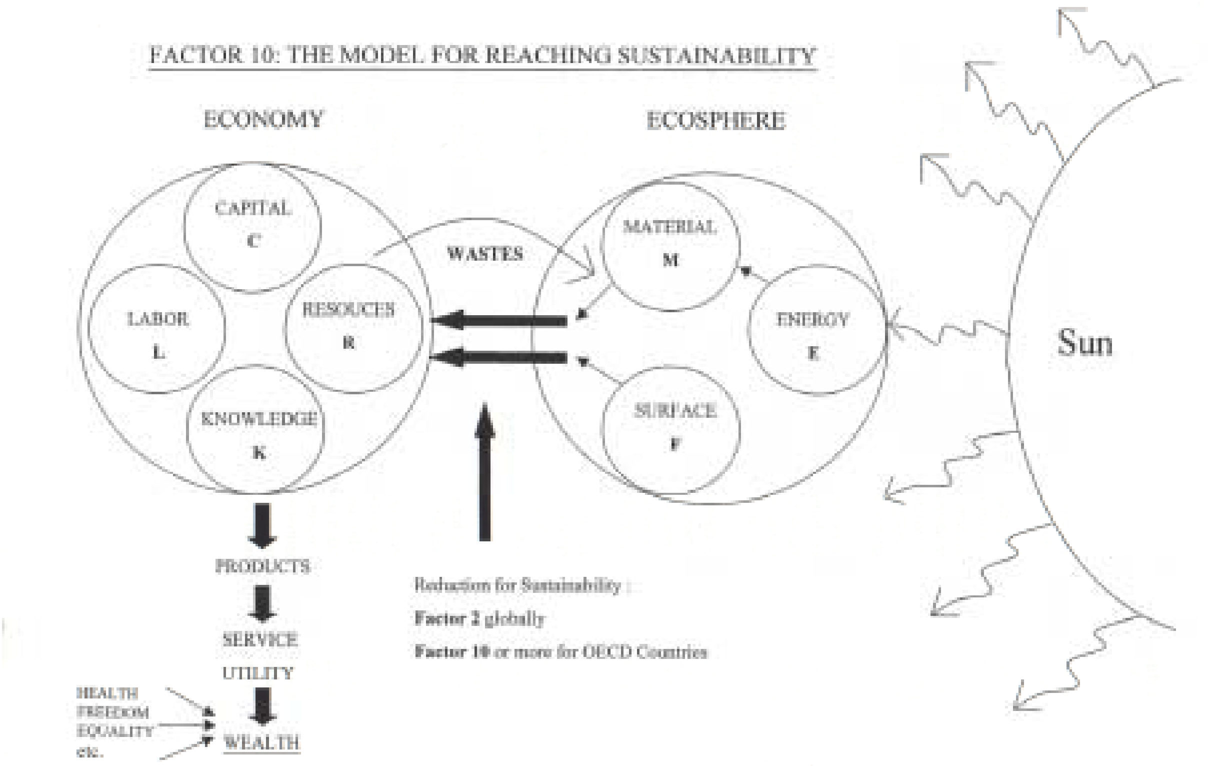
3.3. What We Should Remember

Irreversible disturbances of ecological equilibria are caused directly by technical interference with environmental resources or processes, irrespective of how much material wealth is produced with the masses translocated from their natural settings, and irrespective of how much and what kind of emissions are produced. The impact of all this disruption is increasing, and is beginning to be reflected in economic terms.

For example, there is an increase in the number and severity of natural catastrophes such as storms, floods and droughts, to which the insurance market is responding by sharply raising premiums. Central America will take many years to recover from the devastating hurricane Mitch in early November 1998. The United States has lost some 50 % of its topsoil by erosion, virtually all of it during this century. In the Ruhr valley, some 70 000 hectares of land have subsided due to former deep-mining of coal, with the consequence that waters have to be pumped around the clock forever to keep this area from flooding. Millions of people could otherwise lose their homes.

The massive material translocations - as well as the emissions of toxic materials and greenhouse gases - are exceeding the capacity of the ecosphere to absorb them and shifting ecological balances.

Figure 3



Text for Figure 3: The human economy derives all resources from the ecosphere (the earth). Even solar energy cannot be harvested without technical systems, requiring materials and energy for being built and maintained.

Energy, surface and materials are harvested from the ecosphere as resource inputs for the economy. Here, capital, labor, know-how, and resources are the ingredients for creating wealth, guided by market forces.

4 Goals for Tomorrow

4.1. Curbing Material Flows

A radical reduction of the material throughput in "advanced countries" is imperative during the coming decades, while end use satisfaction as it exists today in industrialized countries must be maintained - or even improved. In this sense, the industrialized nations are the real "development countries".

In order to reliably achieve the necessary dematerialization, decision makers in politics and business, but also the consumers, need valid, understandable, and internationally compatible information about the relative resource intensity of goods on the market, because one can hardly manage that which cannot be measured and compared.

And national accounts must lay open the consumption of natural materials - including their ecological rucksacks - that are invested on a yearly basis in order to create wealth and provide security to people (World Resource Institute, 1997).

But this is not enough. While the improvement of the technical eco-efficiency is imperative for the realization of a sustainable economy, even the most extreme dematerialization of material artifacts alone will not suffice *à la longue*. Rebound (boomerang-) effects must be avoided: As history shows, technical advances in investing fewer resources per unit wealth have traditionally been "eaten up" by increasing consumption. A change in the traditional development of consumption patterns is urgently called for a revision of use - offering new forms of satisfaction, well being, and prosperity.

4.2. All Stakeholders Have Roles To Play

Dematerialization can be looked upon as a strategy in a process of concurrent changes toward sustainability, involving a variety of stake holders: consumers, producers, retailers, scientists, NGO's and government, each with their own concerns and responsibilities, each wish specific roles to play in initiating and managing the process of change (Jansen, 1998; Dutch Program).

The required radical improvement of resource productivity must span the whole spectrum of objects serving peoples needs ("service delivery machines"), starting from simple items all the way to complex technological systems: from the propeller of a ship to propulsion, from the propulsion to the ship as a whole, from a single ship to the complex transportation system. Ultimately, it is the dematerialization of whole economies; measured in terms of the total material flow (TMF), that determines failure or success on the way to sustainability.

The achievement of a target to dematerialize society by a factor 10 or more requires intensive changes in culture, (institutional) structure as well as technology:

- *Culture*, legitimating nature and volume of societal needs to be fulfilled, expressed in consumption patterns dependant on ease and status (*sufficiency*),

- *Structure*, the economic and institutional organization to fulfil legitimated needs *(effectiveness)*,

- *Technology*, providing the technical means by which needs are (to be) fulfilled (*efficiency, productivity)*.

These three elements characterize development of society in a strong mutual interaction and interdependence. The "acceptability" and viability of environmentally efficient technical means is directly connected to the economic and institutional conditions (structure) and to the demands of society (culture). In this context, it should be well understood that these conditions and demands are not static at all: They may change radically as a result of environmental or political shock episodes.

Up to now, three dimensions of change for dematerialization and technology development for sustainability have been discussed (Jansen, 1998):

- The degree of targeted *efficiency* improvement expressed in MIPS factors - up to 10 or more,

- The *complexity* of a product system in the sequence from single product to interlinked technological systems,

- The *interdependencies* of culture, structure and technology in the dematerialization processes.

These dimensions are not mutually independent: the higher the degree of *efficiency* improvement and/or the more *complex* the product system is, the stronger the *interlinkages* will be. Together they determine other dimensions of change, in particular its *intensity* and therewith the *time period* required for change.

Public and private transition strategies should be designed to proceed simultaneously along concurrent tracks with various time horizons.

These tracks can be characterized as follows:

1. **Care** (good housekeeping), corresponding to operational processes like quality management, maintenance, auditing, efficiency drives etc with time scales of up to 5 years. Conventional management is typically associated with this track.

2. **Adaptation and improvement**, leaving fundamental structures and technologies unchanged but implementing incremental changes corresponding to processes like revision, or re-organization with time scales from 5 to 20 years. Factor 4 changes are typical for adaptations. This track requires curious and somewhat daring management.

3. **Renewal**, by fundamental jump-like changes, (resulting often from long term research, but also from chance discoveries), fundamentally affecting structure, culture and technology, with typical time scales of over 20 years for complex systems. Renewal of technology means re-defining actual technology development trajectories and innovating new ones. This track is the *conditio sine qua non* for Factor 10 (and higher) transitions. To be successful, it requires pro-active, far better than average informed and daring management.

Each of the tracks can be coupled with targets on route to a sustainable technology as a function of time. In a continuous attempt to lower the environmental burden, all three tracks are essential: housekeeping and adoption for implementing known techniques and incremental improvements which result in primary efficiency increases and which provide time gains which can and should be exploited to make progress along the third track. Consequently, economically and politically sensible efforts toward sustainability involve all three tracks in a parallel fashion.

The first track of care and good housekeeping may be regarded to be well under way in most industrialized countries. On the second track, a good deal has been achieved but still a lot has and can be done. On the last track, however, only scarce initiatives have been undertaken up to now.

4.3. Factor 10

Factor 10 is not an economic goal,
It constitutes physical guard rails for western economies
To grow within.
It indicates
How many industrialized countries have to increase
Their resource productivity
In order to approach sustainability.

In 1992, Schmidt-Bleek first proposed to halve the global natural material disturbed yearly by technology in order to move decisively toward sustainability (Schmidt-Bleek, 1993). It should be noted once more that this is an absolute (albeit only estimated) target for lowering the yearly totality of natural resources disturbed in their original settings. Therefore, showing the material input per unit of GDP, as a measure for dematerialization can be very misleading.

Since western style wealth, generated at present for less than 20 % people of the world, consumes in excess of 80 % of the natural resources disturbed and harvested globally, the "rich of this world" will have to invent ways to generate their wealth with some 10 % (or a factor of 10 less) of their present consumption in order to let the "poorer" nations claim their fair share of resources - and the worldwide total flow of natural resources could still be halved.

In the future, western style processes, products, buildings, infrastructures, and services would therefore need to be de-materialized by an average factor of 10 (compared to present conditions) in order to move reliably toward sustainability. With increasing world population - or increasing numbers of people living by themselves in any society - the factor 10 would have to grow, too.

Based upon Speth´s work (Speth), Weterings and Opschoor (Weterings, 1992) arrived also in 1992 at the conclusion that "the environment efficiency factor" would need to increase by a factor of 5 to 50, compared to the levels of 1990.

Increasing the resource productivity by a factor of 10 or more is strategically important since it implies that system solutions must be sought, and in many cases entirely new technical approaches be developed in order to provide services with high quality in a more sustainable future. In most instances, neither "good housekeeping" nor mere "ecological adjustment" or "cleaning" of present-day technologies - and most certainly not any end-of-the-pipe solutions - will suffice to reach a tenfold increase in resource productivity.

Increasing the eco-efficiency by a factor of 10 or more in industrialized countries is essential for regaining the ecological stability. Less than a Factor 10 will not suffice to make enough environmental space available for the development of more than 150 countries within the confines of the sustainability goal of halving the yearly global translocation of natural resources.

Factor 10 is strategically important since it implies that system solutions must be sought, and in many cases entirely new technical approaches be developed in order to provide current services with comparable quality to the end-markets. In most instances, neither "good housekeeping" nor mere "ecological adjustment" or "cleaning" of present-day technologies - and most certainly not any end-of-the-pipe solutions - will suffice to reach a tenfold increase in resource productivity

Austria wrote the factor 10 goal into her Environment Plan already in 1995. In 1994, UNEP-IE and the Business Council of Sustainable Development suggested a factor 20 as a goal for sustainability. In 1997, the European environment ministers supported factors 4 to 10 as a strategic goal. Dozens of visits in medium and small sized industries in central Europe have produced convincing evidence that factors of 3 to 8 increase in resource productivity for products can be routinely achieved within a company by making better choices of materials (that is by giving preference to materials with smaller ecological rucksacks than had been previously embodied in their products), and utilizing a wide variety of options for reducing waste, packaging and transportation intensities. To increase the dematerialization further, the utility of the products can be raised in many cases, their longevity improved, as well as cascading uses and recycling options foreseen when designing new products (Schmidt-Bleek, 1998/2).

4.4. Misinterpreting Factor 10

In recent months, some misconceptions surfaced in the international debate about the Factor 10 Concept. It may be worth pointing them out so as to avoid unwanted confusion.

1. Relieving the stress that is put upon the planet earth by economic activities requires an *absolute* decrease in resource flows from the ecosphere to the economy. On the macro-economic level, factor 10 is therefore an *absolute* target for lowering the yearly totality of natural resources disturbed in their original settings by industrialized countries. Therefore, showing the material input per unit of GDP - a practice that enjoys increasing popularity in economics - is irrelevant from an ecological point of view, and can be even misleading since it does not adequately account for the (miss-) use of natural resources.

How easy it is to be misled can be shown by the following example: In Austria, the total national material input rose by 90 % during the period from 1960 to 1995, while the GNP increased by almost 200 % during the same period of time. The apparent national material intensity decreased by 37 %, while the natural resource flow from the ecosphere almost doubled. This is ecologically an obviously unsustainable situation, even though the numbers indicate otherwise.

2. A remarkable statement as regards factor 10 can be found in the OECD document ENV/EPOC/MIN (98) 7/REV1, placed by the Secretariat before the OECD environment ministers on 05-Mar-1998. It states: "Although "Factor 10" may serve as an effective slogan to mobilize political support, it should not be taken literally, as energy and material use are only loosely related to specific environmental problems other than CO2 emissions".

Since its very inception, the MIPS-Concept and Factor 10 were conceived as a systematic and precautionary way out of the present non-sustainable and costly environmental policies. But some experts apparently still subscribe to the belief that sustainability can be approached by policies focusing on the tail-end of the economy, even though these "encourage end-of-pipe solutions and treating or recycling resources, rather than increasing the productivity with which they are used. The result is a steady increase in environmental protection costs" (1997 Carnoules Statement of the Factor 10 Club).

The key measure for reaching sustainability is to drastically enhance the resource productivity, because:

(1) It is scientifically impossible to ever know all important "specific environmental problems" - originating from technology driven emissions, effluents, and wastes. In fact, it is scientifically impossible to ever know all insults to the environment - or "specific" effects - even of a single substance, such as cadmium or CO_2. (Witness the fact that even CO_2 was not a "specific environmental problem" until 1989),

(2) Once "specific environmental problems" were recognized (and politically acknowledged) in the past, it has always been rather difficult and costly to deal *ex post facto* with and correct them on the economic and political levels (witness the reality surrounding

OECD pronouncements on precautionary environmental policies, and the results of Kyoto 1997 as well as Buenos Aires in 1998),

(3) "Environmental damage is caused not only by pollution but also by the processes involved in extracting resources. In fact, resource extraction is the more significant cause, since all materials taken into an economy end up sooner or later as emissions and wastes. Thus, reducing the costs of environmental damage requires both bringing down emissions and reducing the flow of resources drawn from nature in the first place" (1997 Carnoules Statement of the Factor 10 Club).

The environment ministers pronounced in their OECD-News Release of April 3, 1998:

" Ministers agree... to promote an international policy approach that encourages coherence among economic, environmental and societal policies by: ... b) promoting other innovative approaches, such as eco-efficiency, aiming to achieve substantial improvements in resource productivity, for example a factor of 4 and eventually of 10; "

3. In recent months, representatives of car makers are pointing more and more frequently to their successes in dematerializing components, talking proudly about "Factor 4 successes"! This is excellent news. However, such dematerializations rarely add decisively to the overall resource productivity of the "service delivers machine" - the automobile - which is after all their contribution to modern life styles.

Therefore there needs to be a word of strong caution at this point. The resource productivity refers to the amount of natural resources that has to be displaced for generating one unit of service or utility (MIPS) to the end-user. A new bumper - for instance - by itself does not offer the service that a person expects from his vehicle as a transport machine. The bumper is but a (small) part of the overall "service delivery machine" - the car. Consequently, each supplier of "service delivers machines" (mousetraps, cars, or houses) who wishes to demonstrate his contribution to dematerialization has to show that he has found a solution that provides the principal service in question with overall two-. Five-, ten-, or twenty-fold less natural resources - from cradle to grave - than is hitherto the state of the art. As indicated elsewhere, this could involve much more than merely constructing a dematerialized car, mousetrap, or house. For instance, it could include the offer for "care-free" services through leasing contracts, as is practiced today in the transportation industry (Charterway of Mercedes).

4.5. Why Would Entrepreneurs, Politicians, And Consumers Care About Factor 10?

To reach sustainable conditions, the physical dematerialization of the economies is unavoidable. Beyond this general goal on the global scale, could one expect any advantages for individual entrepreneurs, or for politicians in their drive to be re-elected, or for consumers?

A paradigmatic change as foreseen by the Factor 10 Concept will give *entrepreneurs* more flexibility to conduct their business and also freedom from the kind of environmental legislation that is still concentrating on solutions to "specific environmental problems", including the prescription of specific technical approaches (e.g. catalytic converters or electric cars, both of which have enormous ecological rucksacks).

More flexibility would arise with respect to paying taxes. If, say 50 % of the present income related taxes would be shifted to increased resource taxation, companies could counteract resource input taxes by innovation. Since the increase of resource productivity depends both, on lowering MI as well as increasing S, there should be wide margins for taking action. (It is obvious that industries involved in providing raw materials, and firms consuming large quantities of natural resources in order to satisfy customer needs tend to fight such structural changes. Industries threatened by innovations have always behaved this way - often exhibiting a sudden last minute flood of improvements - as for instance the sailing ship industry at a time when steam-shipping had already proven its technical superiority. Unfortunately, the modern political approach is frequently to prevent outmoded industries from dying by direct or indirect subsidies, weakening the market mechanisms in the process).

Returning to the question of increased flexibility: In the transportation sector, choices of appropriate, need-adapted and easy to obtain hauling capacities would increasingly become available, as would be many other tailor-made services.

Many laws and ordinances that presently restrict operations of businesses will be reviewed as firms and individuals began to operate as system players, rather outside their traditional roles. Thus, manufacturers who presently sell their products through traders or sale representatives may begin to lease their products directly to customers, end-users may be getting involved in designing products as "prosumers", and a multitude of individuals may begin to offer services, thus creating jobs. Differences between "new" and remanufactured goods may diminish or vanish, since competition will shift to offering the most cost-effective services.

In Germany today, no one is allowed to imbed old materials in "new" products. And offering lifetime warrantees is illegal as it is considered to be an unfair trade practice!

Legal instruments designed to increase the relative scarcity of resources can obviously not be cast in the traditional form of environmental legislation. They would have to take the form of tradable permits, taxation (e.g. through a natural resource added tax), restricting monopolies, or the shifting/abolishing subsidies. They would be economic instruments. A great number of present standards and norms would have to be reviewed with the goal to deregulate the situation in order to allow dematerialization. (Note: technical safety regulations always cost extra resources!). This applies particularly in the building sector. In Germany, millions of aluminum ladders are still installed on roofs to ascertain safe movement for chimney sweepers who no longer sweep chimneys from the top.

When entrepreneurs achieve decreasing dependence on natural resources through eco-intelligent innovations, they will:

- Interested in replacing present environmental order and demand legislation with economic instruments;

- Give support to and derive income from eco-efficient innovations paving the way to a knowledge driven service economy;
- Motivate their co-workers, improve their momentum, and their fun;
- Improve their innovation and creativity skills;
- Experience new opportunities for "gaining the future"
- Renew the emphasis on local and regional achievements and opportunities, resulting in more independence of "globalization"
- Create job opportunities;
- Create new chances for small and medium sized companies;
- Get the benefit of cost reduction as they save resources;
- Gain sustainable long term competitiveness;
- Shift from capital intensity bred inertia to the agility of service providers with higher return to equity:
- Create long term share holder values;
- Hedge against resource bottlenecks and price instability;
- Create new markets, first-movers making the greatest and most long-lived gains not only in market share but also in respect, standing and influence.

Political leaders, too, will benefit from greater resource productivity, pro-active environmental protection, and from the opportunity to revise public spending programs:

- The goal of reaching "sustainability" would become operational, accountable, and internationally harmonisable;
- The 25 year old goal to institute pro-active (anticipatory/precautionary) environmental protection policies could finally be approached with good chances of success;
- There would be a true chance to reconcile economy, ecology, and consumer quality of life;
- Using markets reduces the need to spend ever greater amounts in command and control bureaucracy;
- National economies will benefit from greater competitiveness;
- Cutting subsidies will reduce government expenditures;
- Shifting the burden of taxation from employment, incomes and profits onto resource use and consumption would reduce distortions that adversely affect competitive advantages, trade, investment, and exchange rates;
- A shift towards service stimulates employment;
- The changes would increase the opportunity for small and medium sized enterprises;
- Current resource intensive technologies and practices lead to enormous loss of natural capital. They put regional economies at risk in the medium term.

Consumers finally would enjoy at least two noticeable advantages if the MIPS-concept were to be systematically applied in practice: MI (Rucksack) or better MIPS- labels would allow fair and easy ecological comparison among products and services on the market. Such labels could be internationally harmonized and supervised by an "international rucksack bourse". And second, a considerable shift from income related taxes to increasing prices of goods and services through resource-input taxation would bestow the individual consumer with a considerable flexibility to determine his tax burden through eco-intelligent consumption decisions.

5. Measuring Environmental Performances

5.1 Complex Realities

When attempting to develop measures for the environmental performance - or ecological stress potential - of economic units such as firms, regions, and households, or of products, infrastructures or services, one important thing to keep in mind is that there are always very large numbers involved. At least 20 million small and medium sized enterprises exist worldwide today, some 5 to 6 million different products are traded internationally (changing in nature and composition at a rapid rate), and there are some 180 countries with differing political and cultural realities - all living within, and depending entirely upon a single system: the planet earth.

When attempting to develop measures for the ecological stress potential of processes, goods or services, one should further keep in mind that most economies function today essentially with one yardstick of success or failure: relative prices of goods and services, expressed in monetary units. And relative prices are not derived from scientific principles. Often they do not even make economic sense. Yet they serve obviously very well on a worldwide basis.

When attempting to render present economies more ecologically sustainable than is the case today, one should therefore attempt to seek first of all to identify the root cause(s) for the unsustainable performance of economies, because:

(1) The fewer indicators one needs to portray the essence of the (un)ecological nature of processes, goods and services, and

(2) The better such indicators can be incorporated into existing economic models that are accepted worldwide,

The better the chances to shift the overall economic performance of individuals, firms, enterprises, regions, countries and the world economy as a whole in the direction of improving ecological sustainability.

In a recent paper, the European Environment Agency has proposed a set of 9 indicators, including MIPS and FIPS (EEA, 1998): Inputs (resource use): raw-material input, gross inland energy consumption, land-use, water consumption; Outputs (impact/pollutants): greenhouse potential, acidification potential, ozone depletion potential, (hazardous) waste, and chemicals. The EEA notes: "There is clearly an element of "double-counting" in accounting for both, input of materials and output of pollutants. However, it is not possible at this stage to focus just on either material inputs or pollutants in order to monitor progress towards sustainability: and "double-counting" is at least erring on the side of caution."

5.2. The Present Situation In Brief

A flood of differing attempts have been undertaken during the past 10 or 15 years in order to describe the "environmental performance" of economic units such as companies, households or regions (Skillius, 1998).

Virtually without exception, these attempts have failed up to now to portray the ecological importance of the disturbance of environmental resources (materials - including water and energy carriers - and surface) in their natural settings as a primary and root cause of technology driven changes of the evolution of the ecosphere. In these attempts, individual environmental stresses resulting from emissions from the technosphere ("climatic changes", "eutrophication of lakes" etc) are selected in various combinations as base lines in order to ascribe the environmental disturbance intensity of economic units, goods or services. In some cases, resource and energy consumption were additionally included, however, ecological rucksacks (see below) were not - or insufficiently - considered.

To illustrate some of the confusion involved, the following points may be helpful: why was CO_2 emission no environmental performance issue 10 years ago? Why are mercury or lead poisonings no longer perceived to be major environmental problems? Are climatic impacts of technology-driven CO_2 emissions the most important possible ecological stress or could other thinkable impacts being similarly important? (They are not!) Suppose that man-made emissions of CO_2 were stopped altogether, would sustainability have been reached? (Compare Figure 1 above!) Is fossil burning the only significant source of man-made CO_2 generation? (It is not!) How long will climatic changes remain on the top of the political list of ecological concerns? Why is soil erosion hardly ever considered when assuming that renewable resources are ecologically desirable materials? Is the consumption of water ok because it is a "renewable resource" (Aral Sea!)? Are buildings, highways, and rail installations ecologically neutral? What are the ecological consequences of underground coal mining? Why is plastic supposedly particularly harmful to the environment? Is cotton an ecologically desirable material when it consumes up to 45 000 kg of irrigation water per kg of cotton?

Not surprisingly, current attempts typically consider great many different parameters for benchmarking operate with "weighing factors", develop various analyses of the same economic entities for "different stakeholders". Results are therefore by and large incompatible, time consuming to obtain cost-intensive, subject to interpretations according to one’s philosophical beliefs, and depending upon political points of view.

It has been shown that energy as a resource consumption factor alone cannot portray the environmental significance of economic activities or outputs even if considered on a life-cycle-wide basis. For instance, the systems-wide resource (material plus energy) productivity of electricity generation by wind and soft coal (lignite) differ by a factor of 50. And the overall environmental performance of a light weight (aluminum) car depends critically upon both, life-cycle-wide material as well as energy consumption (Schmidt-Bleek, 1998).

5.3. Conditions For Ecological Measures

When attempting to develop measures for describing the ecological stress potential of goods and services, of individuals, firms, enterprises, regions, countries and the world economy as a whole, such measures should meet the following conditions:

1. They must be simple, yet reflecting essential environmental stress factors. They must be scientifically defensible, albeit not scientifically complete;
2. They should be based on characteristics that are common to all processes, goods and services;
3. The selected characteristics should be straightforwardly measurable or calculable, irrespective of geographic locations;
4. Obtaining results with these measures should be cost-effective and timely;
5. The measures should permit the transparent and reproducible estimation of environmental stress potentials of all conceivable plans, processes, goods and services from cradle to grave;
6. Their use should always yield directionally safe answers;
7. They should have a bridge to economic models;
8. They should be acceptable and usable on all levels: locally, regionally and globally.

Source: Schmidt-Bleek

System boundaries will have to be carefully selected for all measurement and noted explicitly in all cases so that results can be reproduced and compared.

5.4 Ecological Benchmarking

Benchmarking is a procedure to compare performances, processes, products, and services associated with one economic unit (such as enterprises, regions, countries or households) with the performances, processes, products, and services of other comparable units.

The goal of setting up ecological benchmarks in business is usually to define "best ecological practices", already introduced by a number of proactive companies. Hereby, the best performing companies define the scopes for action. Thus, ecological benchmarks are action-oriented and dynamic, because they are projected on moving targets with respect to: environmental management, eco-innovations of processes, products and services, improved ecological performances, and reduced ecological impacts.

Two different types of ecological benchmarks should be distinguished:

1. Activity-oriented benchmarks, and

2. Result-oriented benchmarks.

Activity-oriented benchmarks refer to the economic unit's environmental visions, goals and programs, its kind of organization and the types of environmental management instruments utilized. These dimensions can ultimately only be described and determined in qualitative terms. Benchmarks of this type refer to internal situations of the economic unit in question: enterprises, regions, countries or households. They indicate the direction in which they wish to move with respect to ecological performance.

The advantage of activity-oriented benchmarks is the ease with which they can be assembled and "measured", in particular when secondary information already exists, as for instance through previous eco-audits. However, hardly any quantitative conclusions can be drawn on their basis.

Result-oriented benchmarks on the other hand are based on real quantities and numerical intensities. For instance, actual quantities of specific emissions, consumption of specific resources, generation of wastes, increases in resource productivity, or number of yearly accidents are considered per unit of output. These quantities can be related to items such as products, services, value added, profits, turn-over, or per capita.

The advantage of result-oriented benchmarks is that they display ecological performances in quantitative terms and changes thereof over time. Unfortunately, the numerical base for such criteria is still deplorably weak and non-harmonized in most instances.

The ultimate proof of a company’s environmental performance is the lowering of the environmental stress potential it is responsible for in terms of (1) its own performance during the manufacturing, storing, transportation, and trading activities, and in particular (2) the nature and performance of the "service-delivery-machines" it places at the disposal of the end-users. In most cases, the ecological nature (e.g. rucksack at point of sale), and the ecological performance (e.g. MIPS) of its products are ecologically far more significant than its activity performance. This implies that the detailed knowledge of the goods offered by a company is clearly more important than its functioning as a manufacturer. Audits rarely reflect this fact.

Another point which is often overlooked is the following: when a car maker lowers the CO_2 emission per passenger-kilometer of his product for instance, only a fraction of the overall resource saving potential in offering automotive transportation is addressed. The question to be answered is always this: what is the life-cycle-wide resource consumption for rendering the principal service of a product, in this case the automobile. A certain car maker continues to proudly declare in public that he has succeeded in dematerializing some parts of his product by a factor of 4. This is fine but hardly any indication for a significant ecological breakthrough.

Capacity utilization is also of key importance. 2 Passengers in a five-seated car does not represent an optimal use of resource investment, both financially and environmentally. And only in this comparative sense can the potential superiority of public transportation systems be understood. Obviously, a bus weighing 10 tons with only three passengers on board is environmentally not as desirable as a Mercedes S class with the same number of passengers.

5.5. Definition of System Boundaries

True wealth is the use of goods,
Not their possession

Aristotle

The answer to the question: "what constitutes an ecologically successful enterprise" depends vitally upon the choice of references. For instance, if products and services are taken as reference items, then the optimization of the ecological quality of these outputs and the way they are produced, packaged, and transported by the enterprise have to be considered, investigated, and projected against the utility (services or bundle of services) the enterprise is capable of offering to customers. As we have seen above, this approach to judging the environmental performance of manufacturing companies makes sense. However, this choice of system boundaries allows only the comparison of the performances of companies producing "like" (functionally equivalent) products or services.

But we can move a decisive step further. For that we have to differentiate between material products on the one hand and the functions or services that these products are able to fulfill on the other hand (Bierter, 1997).

In order to fulfill human needs, products have to function as "utility delivery machines". Human needs are satisfied by functions of products or the services they render, and not by their mere existence.

With this (rather ancient, Aristotelian) conceptual perception of material products and their functions and services, we are able to enlarge the system boundaries and therefore the basis for ecological benchmarking considerably.

The performance of a company - in terms of services delivered to end-users and thereby needs fulfilled - can be judged and "measured" on four different levels:

1. The level of needs:

In the ultimate consequence, entrepreneurial actions always serve to fulfill human needs. Therefore, ecological benchmarking begins with the determination of the principal service(s) that an economic unit is providing with its own or other products. System boundaries for the relevant need areas must then be defined.

2. The level of functions:

Since needs are satisfied by functions or a bouquet of functions - and not by the products themselves - and since the same functions can be fulfilled by quite different products and/or technologies, ecological benchmarking investigates and compares the functional efficiencies, i. e. the resource and energy productivity's, the toxic risk potentials etc., with which defined services are delivered to end-users.

3. The level of products:

Here, ecological benchmarking investigates and compares the product efficiency (resource productivity) over its entire life-cycle per unit service.

4. The level of producing, packaging, transporting and distributing products:

Here, ecological benchmarking investigates and compares different process efficiencies from the economic unit to the consumer.

These four levels are mutually interacting and constitute a hierarchical system. For instance, the satisfaction of specific needs with much less resource and energy inputs, i. e. with much higher functional efficiencies, requires as a rule also new products and new processes of producing, packaging, transporting, delivering, and utilizing products.

Take as an example a car producer. The system boundaries can be defined on four levels:

(1) Individual car components (e. g. carburetor, 3 liter engine);
(2) Car as a whole (e. g. small city cars);
(3) Car-fleet (e. g. average fuel consumption for all types of cars produced/used in one enterprise);
(4) Offering mobility or transport capacity as a business venture.

This example illustrates that the level of needs, on which an economic unit is operating, is the appropriate and at the same time the most comprehensive system boundary for an ecological benchmarking.

6. Activity Oriented Benchmarks

6.1. Eco-Benchmarking Company Activities

Activity-oriented benchmarking displays key elements of good environmental management. Such elements have been assembled - and in part agreed to on the international level - within the EMAS and in the ISO 14 001 standard.

Note that a company or a branch of industry (e.g. forestry or steel making) cannot logically be labeled "sustainable" in and by itself. It can, however, arrange its activities like harvesting, purchasing, manufacturing, packaging, storing, marketing, etc. in the most eco-intelligent way possible. And in particular it can produce eco-efficient products and do everything possible to ascertain that the resources imbedded in its products are not wasted after first use.

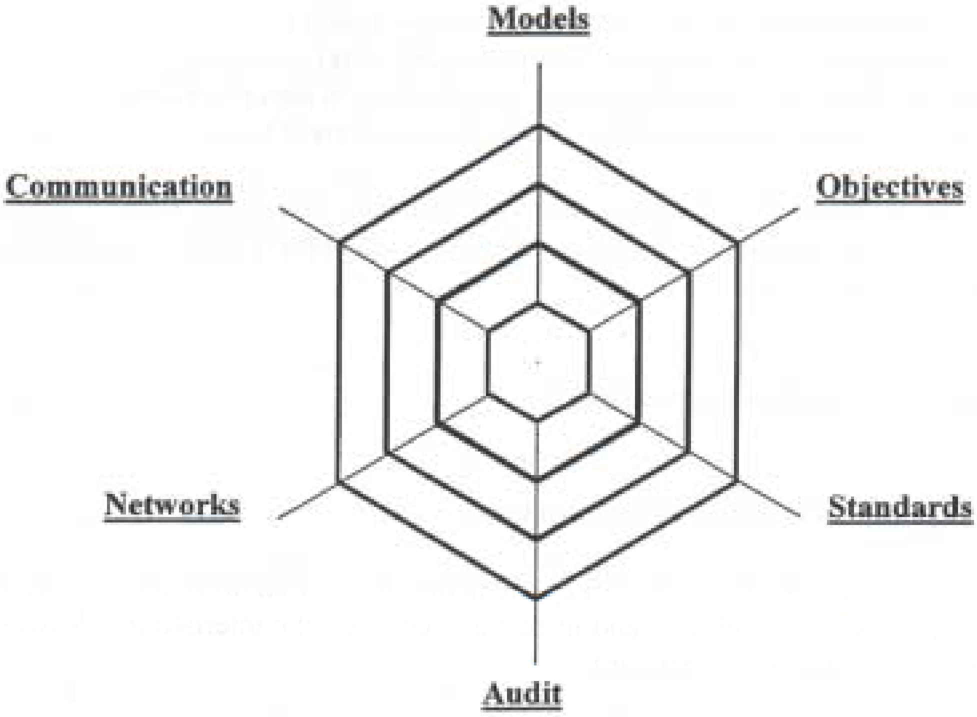
We will now proceed to present a system of activity-oriented benchmarking in the form of an "eco-management compass for producers". In it, 6 separate parameters are being considered. The compass is designed to display strengths of companies in various sectors as well as changes (improvements) over time.

The six Parameters for Activity-Oriented Eco-Benchmarking of Producers Activities are:

(1) Eco-visions/Leitbilder/environmental policies
(2) Environmental objectives/programs
(3) Environmental standards (performance criteria) at home and abroad/conformity with legal provisions
(4) Environmental audits/eco-controlling/eco-balance sheet
(5) Eco-cooperation/clusters/networks
(6) Eco-communication with stakeholders (customers, NGO´s, stock/bond owners, public at large, politicians, administration, mass media).

Source: Willy Bierter

Figure 4



Text for Figure 4: Hexagon ("compass") for displaying and comparing essential components of eco-management. Improving performances are indicated by placing estimated values further away from the center. Values on the 6 axes of the compass can then be connected, thus showing a graphical representation of the overall situation.

6.2. Eco-Benchmarking For Traders and Other Intermediaries

Today, between 50 and 75 % of the market prices of goods are typically vested in their distribution. Traders have sometimes been called the gate keepers on the way toward sustainability.

Practical experience in European countries in attempting to market eco-intelligent products proves this to be true to an astonishing degree. Not only do all SME´s - and many large enterprises, too - virtually depend on the intelligence, knowledge, good will and competence of trading companies, plumbers, builders etc. for placing their products at the disposal of end-users, but it is frequently rather impossible to convince such intermediaries to organize - or be part of - functioning repair services, take-back options, or avenues to eco-efficient re-manufacturing. And only in rare cases do sales person in department stores show interest in selling long-lived products as opposed to products performing "like" services with lesser chances to survive a long period of time.

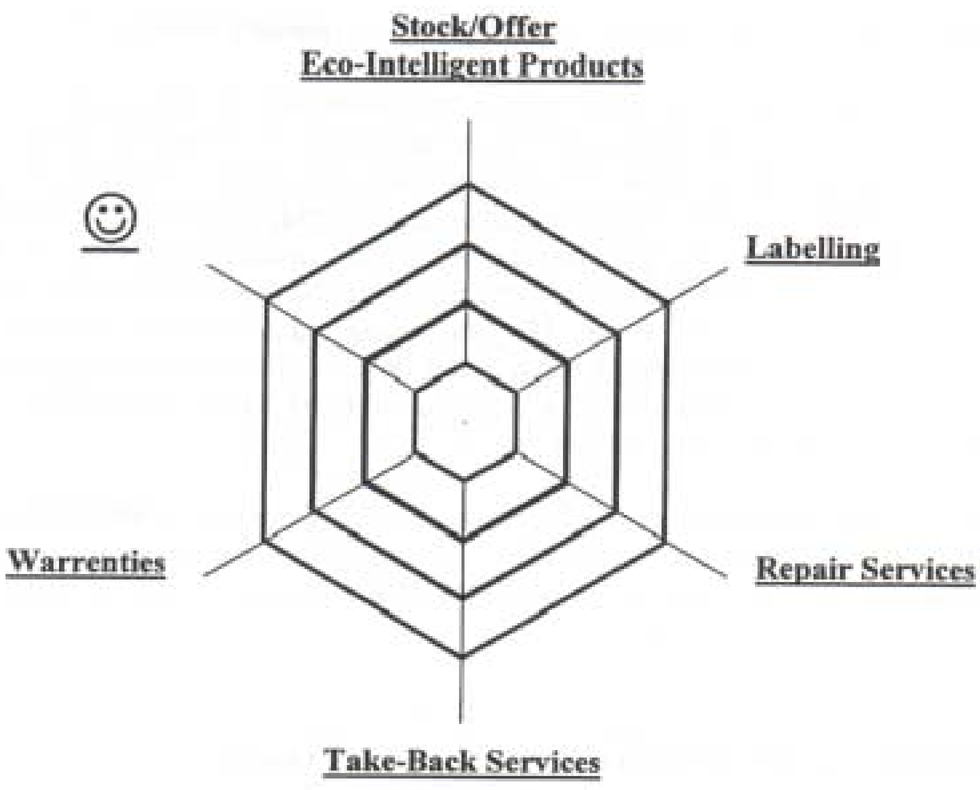
We therefore propose a system of activity-oriented benchmarking in the form of an "eco-management compass for traders". Six separate parameters are being considered. The compass is designed to display strengths of companies in various sectors as well as changes (improvements) over time.

Six Parameters for Eco-Benchmarking Activities of Traders:

- (1) purchasing eco-intelligent products systematically and in transparent ways (see paragraph 7 below);
- (2) displaying openly and in easy-to-understand manners to customers the differences in eco-intelligence of their products, for instance through MIPS-labels (see paragraph 5.3. below);
- (3) Offering realistically priced repair services, where feasible in cooperation with the manufacturer;
- (4) offering take-back options, where feasible in cooperation with the manufacturer;
- (5) offering the longest and best possible warrantee options on all products;
- (6) performing all services with a smile.

Source: Schmidt-Bleek

Figure 5



Text for Figure 5: Hexagon ("compass") for displaying and comparing essential components of eco-management of traders. Improving performances are indicated by placing estimated values further away from the center. Values on the 6 axes of the compass can then be connected, thus showing a graphical representation of the overall situation.

7. Result-Oriented Benchmarks

7.1. Measuring the Resource the Productivity S/MI, MIPS, FIPS, TOPS, and COPS

As outlined in Agenda 21 of the UNCED in Rio de Janeiro in 1992, there is a need for indicators of sustainability. Some national and international bodies as well as scientific institutions have since begun work on this subject (Adriaanse, 1993). The European Environment Agency in Copenhagen has recently moved proactively in this area (EEA, 1998), based, in part, on the work of the Factor 10 Club.

Already in 1992, Schmidt-Bleek had proposed the Material (including energy) Intensity Per unit Service (utility or function) - the MIPS - as a robust initial measure for estimating the (life-cycle-wide) ecological stress potential of goods and services. He argued that the concept of sustainability could be operationalized on the micro-level with respect to resource use when MIPS was used as a measure in conjunction with the goal of dematerializing industrialized countries by a factor of 10 or more (Schmidt-Bleek, 1993/2).

Furthermore, MIPS could also be used as the entry point (or "base set") for a step-system approach in eco-balancing products and services, based on LCA´s (Schmidt-Bleek, 1993).

On the national or regional (macro) level, the Total Material Flow (TMF) approach - derived from the MIPS-Concept - serves a similar purpose (Bringezu, 1993). The Factor 10 goal applies to TMF in particular, as it represents the integral total of all individual material flows on the micro level.

The MIPS - which could be called ***eco-intensity*** **-** is the inverse of S / MI, the measure of ***resource productivity***. Both include the *ecological rucksacks* of all materials - from cradle to grave.

The MIPS includes material along with energy inputs by counting the material fluxes associated with energy inputs. For electricity or solar heat inputs, the system-wide material intensity per unit energy input is taken as MI value. Some 15 systems have been computed and the results published (Schmidt-Bleek, 1998).

As indicated already, computing only the energy use for products or services can lead to serious errors when estimating the environmental impact potential associated with them. For instance, when assessing the MIPS of identical quantities of electricity delivered to the grid on a system-wide basis, German brown coal turns out to be ca. 50 times as material (plus energy) intensive as wind powered or natural gas burning systems, and some 8 times as material (plus energy) intensive as those using hard coal or photo voltaic cells. Another example is the aluminum car of a major European producer. Whereas the energy-only calculation shows that this car becomes more "ecological" than its steel cousin after some 140 000 km, more then 600 000 km must be driven before the lighter car begins to show its better resource productivity on a per kilometer basis (Schmidt-Bleek, 1998).

MIPS is computed in mass per total units of service delivered by the (service delivering) product over its entire useful life span. Resource extraction, manufacturing, transport, packaging, operating, re-use, re-cycling, and re-manufacturing are accounted for, and so is the final waste disposal. As such MIPS is akin - in terms of total material inputs (or "environmental costs" or "natural subsidies") - to the costs per unit service (COPS), the actual price of a haircut for instance or the price for a flight ticket.

This means that for MIPS calculations, the MI values must be the sum total of all natural resource inputs from cradle to grave. These MI values are usually larger than those computed for determining the rucksack of products at the point of sale, because there can be considerable inputs of natural resources for operating, maintaining and disposing the product (e.g.washing machines, motor cars).

Equally, the value for S must be the total number of units of service delivered by the product during its life time, or the expected total number of service units that the product might supply during its life time (in the MIPS-concept, products are "service delivers machines"). This number is usually considerably larger than that that is implied by the warranty on products.

The resource productivity is the inverse of MIPS, or the number of service units one can obtain from a given quantity of material, MI. Conversely, one can define as resource productivity the quantity of resources needed to generate one unit of service or utility. Thus, the resource productivity on the micro-level can be measured by first defining the service or utility, and subsequently aggregating all natural resource (material and energy, including the ecological rucksacks) inputs necessary for rendering that service on a "cradle to grave" basis (EEA, 1998).

When measuring resource productivity by S/MI, "Service" corresponds to "utility" and must first be defined before its specific natural resource consumption can be determined.

Obviously, the resource productivity can be improved by either lowering MI for a given S, or by increasing S with a fixed quantity of resources. Both changes can be achieved through technological as well as managerial changes/innovations. For example, by increasing the longevity of goods, or by leasing rather than selling a product, and by sharing buildings, infrastructures, vehicles or machines can the total number of service units be improved dramatically, without a corresponding increase in the total input of natural raw materials.

Ultimately, the ecological quality of goods and services could probably best be represented by the sum of three terms that would all have to cover the total life span of products:

MIPS = the Material (incl. Energy) Input per unit service
FIPS = the surface (F for "Fläche", a German word for surface area) coverage per unit service,
And by
TOPS = the eco-toxic exposure equivalent per unit service

At the Wuppertal Institute, Christa Liedtke and her coworkers have made considerable progress in developing the details for FIPS and combining it with MIPS. As regards a goal for sustainability, the *rate* of sealing surface areas which are still "natural" (photosynthetically still fully active) should be reduced by at least a factor of 10 within the next decades, whereby densely populated countries should strive for such a reduction perhaps within 10 to 15 years.

It will be interesting to observe whether eco-toxicologists can ever agree on a simple and robust term (or a very few such terms, for instance addressing biotic and abiotic systems separately), that could serve as initial and rough indicator(s) for the eco-toxic intensity (TOPS) of different materials and goods.

7.2. Ecological Rucksaks

There is a new kind of intrinsic material property:
The "ecological rucksack"

When attempting to define the resource productivity for economic outputs, all natural resources that were disturbed or altered in their natural settings must be considered. The three natural resources needed for economic activities are materials, energy, and surface (land-use). As most energy inputs into the economy today are in the form of materials (fossils), and as the conversion or use of energy itself has comparably little impact on the environment, energy inputs into technical processes, products and services are computed in material quantities in the MIPS-concept.

The surface area needs for economic activities are not covered in the present form of the MIPS-concept (Schmidt-Bleek, 1998).

The ecological rucksack is defined as the total quantity (in kg) of natural material (M) that is disturbed in its natural setting and thus considered the total input (I) in order to generate a product - counted from the cradle to the point when the product is ready for use - minus the weight (in kg) of the product itself (Schmidt-Bleek, 1993, 1993/2).

The sum total of natural materials utilized (in kg) to make one kg of technical base (raw or starting) materials available (e.g. wood, iron, aluminum, copper, cement) is expressed as MI, sometimes called the "rucksack factor" of base materials (Schmidt-Bleek, 1998/3).

At the Wuppertal Institute, five different rucksacks were defined to describe the overall natural resource intensity of products. They correspond to the 5 environmental spheres that have been traditionally distinguished in environmental sciences and policies: water, air, soil, renewable biomass, and non-renewable (abiotic) materials. The factor 10 goal for dematerialization is applicable to all.

For industrial products, the rucksack of water typically exceeds that of non-renewable material inputs by a factor of 10 or more. The same ratio applies approximately for the amount of mechanical soil movements (largely by plowing) in the production of food stuff when compared to the biotic (renewable) outputs. In the case of agricultural and forestry products, the erosion in tons associated with the production of 1 ton of product can also be taken as a measure of material (soil) flow intensity. These numbers range from approximately 0.1 to 5 tons erosion per ton of product (Schmidt-Bleek, 1998).

On the average, industrial products carry abiotic rucksacks that are about 30 times their own weight. This means that only about 5 % of the non-renewable natural material disturbed in the ecosphere typically end up in a technically useful form. In the case of a PC, the ecological (abiotic) rucksack weighs at least 200 kg per kg of product. This number calls seriously into question the expectation that modern communication can *eo ipso* contribute to a noticeable dematerialization of life styles.

For base materials (such as iron, plastic or copper), the MI values (rucksack factors) represent a new kind of material property. These factors allow the comparison of technical starting materials as regards their resource intensities and thus allow the computation of the rucksack of products, so long as the material compositions of these products are known (Schmidt-Bleek, 1998/2).

At the Wupperal Institute, MI values (rucksack factors) were assessed for a large variety of materials that make up industrial products. For the time being, they should be considered as preliminary average figures. Within the time and resources available it was not possible to compute specific source and process numbers for all base materials. Nevertheless, they allow the design of dematerialized products in many instances and permit important conclusions to be drawn very fast when comparing the resource intensity of products (Schmidt-Bleek, 1998/2).

Typical approximate MI values (rucksack factors for non-renewable resources) of base materials are as follows:

Round wood = 1.2
Glass = 2
Plastics = 2 -7
Steel = 7
Paper = 15

Aluminum = 85
Copper = 500
Platinum = 500 000

The following examples illustrate how small things can become important when considering opportunities to reach sustainability:

Today, most products carry a small paper sticker, be that for price labeling or carrying line codes for computer identification. If each paper weighed 0.2 grams on an average, and the worldwide consumption were 30 billion (ca.5 per person-day), a total of 1500 tons of paper would be consumed for this purpose per day. As the ecological rucksack of paper is 15, the daily consumption of nature for this purpose would amount to more than 20 000 (twenty thousand) tons of nature which comes to 8 million tons per year. If about half of these stickers are being removed from the products before putting them to use, and two liters of water are consumed in each case for this purpose, a total of 8 million tons (or 8 million cubic meters) of drinking water would have been consumed. That means that a total of 16 million tons of nature has been consumed per year for the purpose of identifying products for the convenience of the vendors. 16 million tons is the weight of 200 000 (two hundred thousand) locomotives (without rucksacks!)! And we have not as yet taken the ink, the glue, the detergent, or an organic solvent for removing the glue into consideration. We have also assumed, that cold water was being used. If it was hot, the total nature consumption could be double as high as shown above.

A similar computation for aluminum covers on plastic beakers for yogurt would show a very similar total consumption of nature per year, if only two yogurts were consumed every three days per person.

Cooling is a very common need for finishing work on steel and other materials. Conventional cooling at roller channels typically requires flows of 1800 to 2400 liters per hour. Equipment designed at SKF-TDC Hetec at Hällafors, Sweden, for minimal lubrication merely requires a flow of 15 milliliters per hour. This amounts to an improvement factor of 120 000 to 160 000.

7.3. Computing MIPS Properly

In order to compute MIPS of products, the ecological rucksacks of goods which can deliver utilities (services) must be known. The rucksacks of such goods in turn are composite values derived from the rucksack factors (MI factors) of base- and building materials, such as copper, cement, plastics, and wood. The conventions for calculating MI factors have been published (Schmidt-Bleek, 1998/3) and must be applied, if authors wish to stay within the confines of the MIPS-concept as it is presently defined (Schmidt-Bleek, 1998).

MI factors not only depend upon certain conventions, they may also change over time as geological concentrations and overburdens at extraction sites, proportions of recycled materials in national stocks, technical processes, and transportation intensities may vary.

The Factor 10 Institute and the Factor 10 Consulting Network are therefore proposing to establish centers for producing and distributing regularly validated MI factors. For the moment, MI factors are available on Internet from the Wuppertal Institute (Dr. Christa Liedtke) **(http://www.wupperinst.org/projekte/mipsonline)** and in several books (Schmidt-Bleek 1998/2/3). These lists also contain the rucksack factors for recycled materials, which normally are considerably smaller (lighter) than those for virgin materials do.

7.4. Toward Eco-intelligent Products and Consumption

7.4.1. Products and Technology-Based Systems

As we have seen, one of the necessary conditions for moving decisively toward sustainability in industrialized countries is the innovation of radically dematerialized products and systems, as well as the change of consumption habits.

In fact, in order to reach a factor 10 or more, technical innovations are frequently not enough. System changes, reaching far beyond the immediate decision sphere of individual manufacturers or end-user are usually called for. System changes may involve whole supply chains, changes in tax and incentive structures, and revisions of use.

As we have seen already: When striving for improvements in resource productivity in terms of MIPS, either lowering MI for a given S, or increasing S with a given quantity of resources can be applied. We have also understood that both changes can be achieved through technological as well as managerial adjustments and innovations.

This means that from a resource conserving point of view, designing eco-intelligent products, services or infrastructures *requires to extract from each investment of natural materials the largest possible number of service units for the longest possible time span.*

It also follows that the capacity/size of "utility delivers machines" should - wherever possible - be adapted to the actual needs, and they should be capable of delivering services for the longest possible time with the least possible resource inputs. Thus, public transportation systems that are oversized or that have a short life time are ecologically counterproductive. Equally, buildings which are constructed with safety margins in static far beyond calculated needs and apartments which cannot easily be adjusted to changing needs, are ecologically (as well as financially) sub-optimal utility-delivery-machines. And certainly computers that are short-lived while offering a glut of functions that hardly anybody uses are not intelligent machines from either an ecological or a financial point of view.

Here follow some definitions that could be helpful for orientation when discussing technical issues in the context of dematerializing the economy.

In recent literature, the term *eco-efficient* appears more and more frequently. Frank Bosshardt, assistant to Stephan Schmidheiny during the preparations of the Business Council, coined this word For Sustainable Development before the 1992 UNCED (United Nations Conference on Environment and Development) meeting in Rio. It is a term referring to both, economy and ecology: *"Eco-efficiency is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity"* (Business Council for Sustainable Development, 1992).

Eco-efficiency is therefore a concept for improving the ecological character of production related activities while maintaining/improving their profitability.

More recently, a plethora of different definitions has been assigned to eco-efficiency, making orientation rather difficult. However, the term has found a wide acceptance, perhaps in part because it allows wide interpretations. *One could say that it is an operational concept that implies the use of less nature for producing more output under profitable conditions and which serves people.* It provides no measure for gaining sustainability. But the MIPS- and the Factor 10 concepts are entirely compatible with it. *The MIPS-concept provides a framework for quantifying essential parts of eco-efficiency, and the Factor 10 provides a goal against which one may determine how much effort is still needed in industrialized societies to approach sustainable conditions.*

As indicated elsewhere in this report, one is not really comparing efficiencies when considering the respective resource productivity or toxicity or ecotoxicity of goods. Efficiency increases normally refer to the output improvement of existing machines and processes at fixed inputs. Such improvements rarely surpass a few percentage points. Historically, less than 1 % per year has been achieved in the average. Improvements in the order of factor 2 would therefore tend to take some 50 years to accomplish.

The resource productivity can follow the path of progress that was achieved by the development of labor productivity: Labor productivity did not rise by any significant increase of labor *efficiency* improvements. The typical traditional shoe-maker or tailor could not possibly increase his or her speed of work more than 10 or 20 % with the old tools. It was the application of more and more intelligent machines replacing hand-craft that allowed "labor productivity" to rise sharply (in reality, of course, human labor was increasingly replaced by machines). In a similar way, energy and material productivity can be increased far beyond the technical potential of efficiency increases of current technological systems. As indicated before, the way toward decisive ecological improvements must start with the question "what is the desired utility? [a] Followed by whatever new and old technical solutions can be employed with an overall minimum of natural resources.

As the originally defined term eco-efficiency also refers exclusively to the production sector of the economy, potentially important adjustments in consumption and society as a whole are not addressed. And thirdly, this term does not consider the importance of minimizing the use of space, the "consumption" of surface area of the earth (the third important natural resource that we need for wealth production in - addition to energy and material).

For these reasons, one might wish to use the term eco-intelligent when referring to systems, goods, services, utilities, consumption, and processes that are more promising than others as regards reaching sustainability.

Eco-intelligent goods are:

Competitively priced services and products (objects, tools, machines, buildings and infrastructures) that yield maximum possible utility - in terms of individual customers preferences - for the longest possible time with a minimum of natural material, energy, surface coverage and dispersion of toxic materials - from cradle to grave.

Five Rules For Eco-intelligent Products

1. The number of service units obtainable from products ("service delivery machines") must be as high as possible during their entire useful life. Built-in obsolescence must stop.
2. The life-long material input into processes, products, and services must be as low as possible.
3. The life-long energy inputs into processes, products, and services must be as low as possible
4. The land use (surface coverage) per unit service must be as low as possible, from cradle to grave.
5. The dispersion of toxics must be minimal.

Source: Schmidt-Bleek

These rules will be reviewed later again when describing the eco-benchmarking of products. They were used in developing systematic approaches for the innovation, production and marketing of dematerialized products (Schmidt-Bleek, 1998/2)

Eco-intelligent production systems are:

Competitively priced technical and organizational procedures, conducted with the help of eco-intelligent goods while minimizing the consumption of natural material, energy, surface coverage, the generation of wastes, and the dispersion of toxic or eco-toxic materials

Eco-intelligent economies are:

Market systems within political boundaries, providing a maximum of wealth to all their people by providing them with eco-intelligent goods that were produced with eco-intelligent production systems.

7.4.2 End-Users and End-Use

When striving for improvements in the specific resource productivity of products or services in terms of MIPS, either lowering MI (material/energy input) for a given S (service or utility), or by increasing S with a fixed quantity of resources can be applied, both changes being accessible through technological as well as managerial innovations.

But while the improvement of the resource productivity on the product level is imperative for approaching sustainability, this is not a sufficient condition in itself on the level of the economy as a whole. Rebound (boomerang-) effects must henceforth be avoided. No longer should technical advances in efficiency or productivity be allowed to be "eaten up" by growing consumption.

As we have seen, the demand for a factor 2 reduction in the global translocation of natural resources is an absolute goal for reaching sustainability.

A basic change in western consumer habits must therefore take place in order to provide the necessary "environmental space" on this planet for all countries. *Advertising conspicuous consumption is incomparably more dangerous for humanity as a whole than advertising the wonders of cigarette smoking since excessive resource consumption threatens the very stability of the system upon which all humans depend for existence.* We need efficient policies for reducing resource consumption, weighing current per capita resource use, respecting cultural preferences, as well as different geographic conditions.

Eco-intelligent consumption is:

The use of eco-intelligent goods within the confines of the overall sustainable availability of natural resources.

Increasing sustainable consumption can be encouraged by a variety of government actions, such as for instance minimum product standards, banning certain dangerous products, enforcing speed limits, extending producer responsibilities, lowering and shifting subsidies, imposing custom duties, and in particular by taxation policies that shift the burden from incomes to the consumption of resources.

Governments can also introduce land-use planning systems; prevent the destruction and regulate the re-use of buildings no longer occupied by the previous owners/renters; provide incentives by changing the cost structure of billings by professionals (for instance invite architects to charge for increasing the resource productivity of renovations rather than on the basis of total costs for construction); promote sustainable actions of commerce and individuals by removing administrative and other obstacles; and entice producers to extend much longer warranties than has been hitherto the case.

In particular, however, governments and private players can give end-users a better chance to better recognize eco-intelligent products by prescribing or introducing proper labeling of products (this would be coherent with Agenda 21, Chapter 4, which reads in part:»encourage expansion of environmental labelling and other environmentally related product information programs designed to assist consumers to make informed choices").

On the other hand, WTO rules under the Technical Barriers to Trade (TBT) Agreement seek to ensure that no technical regulations and standards be adopted in Member states - not even non-governmental labels - as disguised protectionist measures to protect domestic industries from foreign competition. It can be argued that MIPS-labels would not constitute protectionary measures (as long as domestic products carry the same) and furthermore do not fall under the PPM-rules (products and related process and production methods) of the WTO .

Governments can also support information campaigns (for instance financed with funds raised by taxing advertisements), and educational programs (as for instance "MIPS for Kids", a project at the Wuppertal Institute).

And finally, governments should exploit their enormous purchasing power - which in Germany amounts to nearly 20 % of industrial outputs - to apply low-MIPS standards. In order to achieve this effectively, rules governing governmental purchasing with respect to lowest bids and time windows for acquisitions (e.g.Kammeralistik) may have to be overhauled.

7.5. Industrial Products

As was described in paragraph 4.3, items chosen for a system of result-oriented benchmarks should be easily understood, yet reflecting essential environmental stress factors. They must be scientifically defensible, albeit not scientifically complete. They should be based on characteristics that are common to all processes, goods and services. The selected characteristics should be straightforwardly measurable or calculable, irrespective of geographic locations.

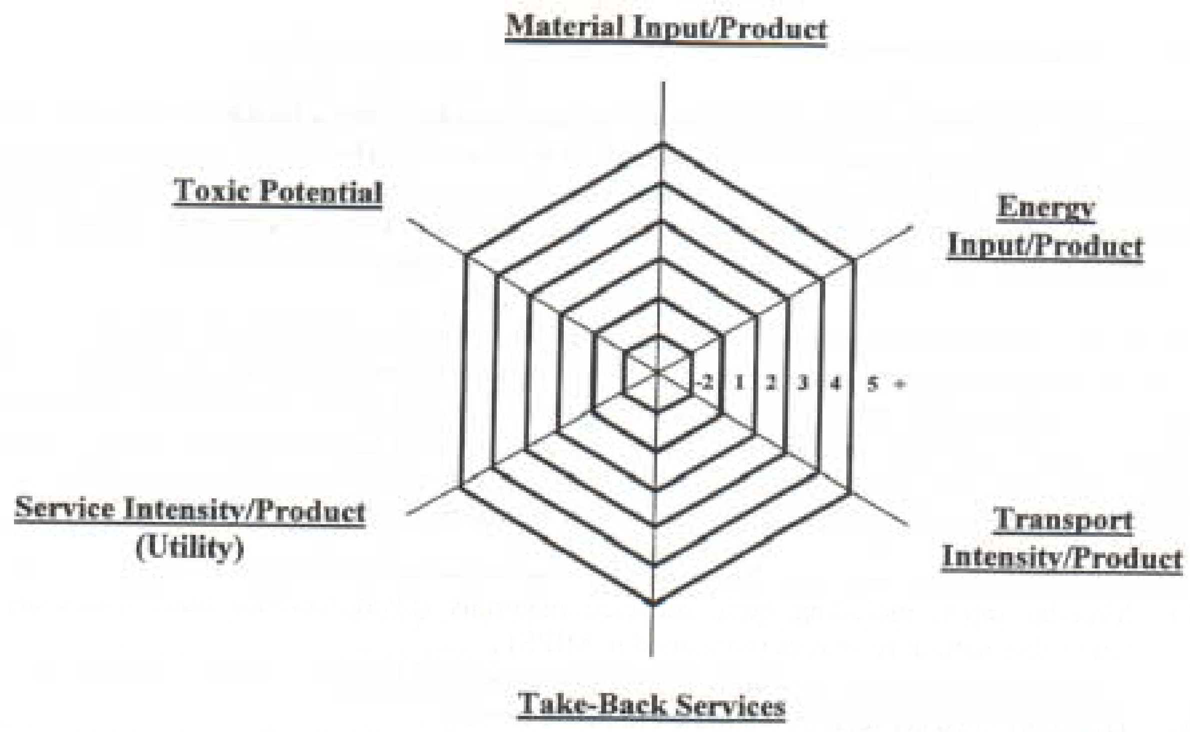
Obtaining results with these measures should be cost-effective and "just in time". The measures should permit the transparent and reproducible estimation of environmental stress potentials of all conceivable plans, processes, goods and services from cradle to grave. Their use should always yield directionally safe answers. They should form a bridge to economic models. And finally, they should be harmonizable on a global level.

The MIPS-concept offers a satisfactory set of such indicators as follows:

(1) Material intensity, including both, recycled materials (revalorization) and sustainably renewable natural resources (contained in MIPS);
(2) Energy intensity (contained in MIPS, available in listings of rucksack factors);
(3) Transport intensity (can be computed in MIPS terms);
(4) Waste intensity during production (can be computed in MIPS terms);
(5) Service extension (S term in MIPS);
And
(6) Health and environmental toxic potential, which is not part of the MIPS-Concept, however, already part of binding regulations in most countries.

Source: Schmidt-Bleek

Figure 6



Text for Figure 6: Hexagon ("compass") for displaying and comparing essential components the eco-efficiency of the eco-performance of a product. The iso-lines with factor 1 represent the reference conditions. Minus 2 would indicate a worsening situation. Factors 2 to 5 + improvements can be displayed on the corresponding axes of the "spider web", away from the center. Values on the 6 axes of the compass can then be connected, thus showing a graphical representation of the overall situation (Wirth, 1997).

Explanations for the dimensions in Figure 6:

- ***Material intensity (MI)*** means the total quantity of natural materials moved in order to make the product available. The rucksack factors for recycled materials are usually considerably less than for virgin materials. This is particularly so for metals. For instance the rucksack factor of copper decreases from 500 to 10. For starting material (e.g. aluminum) the system boundaries are from cradle to finished product. For products capable of delivering services, the system boundary reaches from cradle to grave.

- ***Energy intensity*** is normally contained in MI, however, values are also available separately in tables of rucksack factors. It is of practical significance to consider possible energy savings when analyzing existing or designing new materials or products. However, one should keep in mind that considering energy only could be very misleading when attempting to compute the resource productivity or changes thereof. Energy and material inputs increase the MI term in MIPS, thus lowering the resource productivity.

- ***Transport intensity*.** At the Wuppertal Institute, several typical transportation systems have been computed in terms of MI/ton-kilometer freight. They are available from the Wuppertal Institute and in books published by Schmidt-Bleek . As a rule of thumb, approximately one ton of non-renewable resources consumption must be added every 1000 km to every ton of transported goods when shipping by 40 ton trucks or on rail. Ocean shipping is roughly 10 times less "expensive" in terms of non-renewable natural resources. Transport increases the MI term in MIPS, thus decreasing the resource productivity.

- ***Waste during production*.** As stated already elsewhere in this report, waste on site can contribute considerably to the overall resource intensity of products. Thus, it is not unusual to observe 10 to 20 per cent waste generations during the construction of buildings. All wastes must be multiplied with their rucksack factors in order to compute the resource inputs properly. Waste generation increases the MI term in MIPS, decreasing the resource productivity.

- ***Service extension*.** Here, at least two aspects can be considered from a manufacturer point of view. First, the (maintenance free) useful life time of products should be as long as possible, repairs, and upgrading should be easy, and resource consumption during use as low as possible. Second, a product may be constructed such that it can offer different kinds of services (such as a Swiss army knife). In both cases, the term S in MIPS increases, thus enhancing the resource productivity.

- ***Health and environmental toxic potentials*.** These properties of materials and products cannot be described in terms of resource productivity. In most countries, legal provisions regulate the emission, effluence, handling, sales, consumption etc. of such materials. It is interesting to note that the dematerialization of technologies, and the innovation of new "service delivers machines", offer a significant chance to lower the emission of *known* toxic materials drastically.

7.6. Agricultural, Fishery- and Forestry Products

As is the case with industrial products, here, too, the life-cycle-wide magnitude of energy and natural material consumption per unit output, and the quantity of waste generated from the field/forest/water all the way to the end-user play key roles when eco-benchmarking products from agriculture, fishery- and forestry activities. On the average, some 90 % of the biomass disturbed by technology in their natural setting for harvesting purposes - as well as more than 90 % of the natural abiotic (non-renewable) materials disturbed by machines in their natural settings - are still wasted today on the way to making products available to the end-user.

One could profitably pursue the notion worldwide that the availability of food for people is not primarily a supply problem but largely a question of generating less waste while applying more intelligent conversion, distribution and use techniques to already available bio-masses. This is one of the basic propositions of the *"Zero Emission"* concept (Pauli, 1995).

Given the definition of MIPS, the amount of soil moved by mechanical means for an entire growth cycle must also be considered as part of the material input. It has been proposed to consider the specific erosion per unit output of crops as indicator (Schmidt-Bleek, 1998/3).

Today, food is transported at a furious rate around the globe - including drinking water. To obtain French drinking water in Tokyo, bottled in France, from vending machines are "chique" and an apparently completely normal part of daily life. Growing seasons and limits to local growth have largely become irrelevant in rich countries thanks - among other things - to enormous subsidies of the international transportation systems. Points of origin for vegetable products, meat, sea food, and timber should therefore be indicated to the customer in all cases, so long as the prices of transportation do not "speak the ecological truth" (E.U. von Weizsäcker).

Packaging food products, in particular liquids, is still far from satisfactory from an ecological point of view. For instance, too little incentives are given to the multiple opportunities of using one’s own containers (e.g. for shopping medications, liquids of all kinds, groceries, detergents, paints etc), and supporting cascading uses of containers.

As regards the "extension of services" for Agricultural, Fishery- and Forestry Products, considerably more utility could be gained from the original harvests in many cases than is hitherto the case. For this to come about, the potentials for processing the plants and animals *in toto* would have to be systematically pursued. The technological equivalent is the almost complete use of crude oil (Pauli, 1995).

Health and environmental toxic (hazard) potentials are frequently the subject of labeling requirements, or legal limitations in bringing such products to the market.

7.7. Eco-Benchmarking Countries

On the macro-economic level, resource productivity refers to the aggregate quantity of natural resources consumed to provide housing, rail transport, medical care, higher education, or for generating exports etc. for a given number of people (and/or within certain geographical or political boundaries), for a period of time (normally one year, as this corresponds to the traditional frameworks of national accounts). In short, on a macro-economic level resource productivity refers to the task of providing material welfare to people.

The Total Material Input (TMI), or Total Material Flow (TMF) may be regarded as a highly aggregated indicator that relates to the global environmental pressure associated with the physical basis of an economy (Bringezu, 1993, 1998).

The Factor 10 Concept applies prominently at this level: On the average, industrialized countries are expected to reduce the per capita consumption tenfold within one generation. The average Factor 10 for decreasing the resource consumption in industrialized countries could be differentiated on the basis of national performances, once sufficient information on the TMI of countries was available.

Aggregating all resources that were imported, generated within the borders, minus those exported (including all ecological rucksacks) during the course of one year can assess the sum total resource consumption for a country.

The Wuppertal Institute has developed - in cooperation with the German Federal Statistical Office - an overall material flow account that comprises physical mass balance (FSO 1995). It consists of:

- The domestic extraction from the environment,
- The domestic deposition and release to the environment,
- The imports,
- The exports.

The major points of information for Germany in the year 1991 can be stated as follows:

(1) The throughput of water dominates the account (some 600 tons per capita-year).
(2) The domestic input of abiotic (= non-renewable) raw materials exceeds the input of biotic (= renewable) inputs by a factor of about 50 (based on dry weight of the plant biomass from cultivation) (some 80 tons abiotic material per capita-year).
(3) A tremendous part of the abiotic raw material input remains unused.
(4) The input of biotic raw materials from cultivation is associated with an amount of erosion that exceeds the dry weight of the raw materials. Renewable inputs cannot be regarded as "free" with respect to environmental pressure (impacts).
(5) On the output side the CO_2 emissions into air amounts to about 1 billion tons. This is more than one third of all waste disposals (excluding incineration) and corresponds to about 13 tons per capita in Germany.

Stefan Bringezu and coworkers have also computed the resource intensity of the 58 sectors of the German economy and *inter alias* concluded, that the sector building and dwelling consumes between 25 and 30 % of the total non-renewable material flux. On the basis of such information, focused plans for national dematerialization policies could be developed (Schmidt-Bleek, 1998).

This approach can also be applied to integrate social and economic aspects into the analysis: e.g. one can study the relationship between employment vs. material intensity in regions, or in economic sectors; or one can shed light upon the interrelations between subsidies and economic sectors.

More recently, the World Resources Institute has published a joint study, based on the Wuppertal methodology, in which the national resource performances of Germany, the United States, Japan, and the Netherlands were reported and compared (World Resources Institute, 1987). It is interesting to note that the material welfare of Japanese citizens is being provided with about half the non-renewable resources consumption *per capita* compared to the United States. This, too, is a clear indication that consuming natural resources can be de-coupled from generating welfare.

Once the TMIs of countries are known, one cannot only establish a ranking among them in terms of their *per capita* consumption of natural raw materials, but one can also compute the "true" factor of required dematerialization for each country, as measured against the need for a global reduction of natural raw material fluxes by a factor of 2 and the need for international equity. The Factor 10 that we recommend for industrialized countries as an average yardstick could thus be differentiated and adjusted on a yearly basis.

7.8. Sustainable Human Development Index

TMI- or TMF-ranking allows robust first comparisons among countries as regards their national environmental sustainability performance.

Since reaching sustainability is not only a function of ecological performance, but depends very much also on social conditions, one may wish to search for an integrated index that can allow ranking of countries on a broader - and perhaps more meaningful - basis. Such a ranking would also allow more rational decision making, for instance in areas such as development aid and private financing.

The UNDP has developed a widely accepted ranking, reflecting to some degree the actual situation for human conditions in all countries: the Human Development Index, HDI.

Friedrich Hinterberger, together with other co-workers of the Wuppertal Institute, have recently proposed to add an indicator for environmental sustainability to the HDI and obtain in this fashion a "Sustainable Human Development Index (SHDI)" (Hinterberger, 1998).

For this they make the assumption that the total material inputs into an economy (TMI)(including all rucksacks), can be regarded as a comprehensive measure of its environmental impact potential. This is one outflow of the MIPS-concept.

Traditionally, HDI is computed by adding up three "deprivations" of each country, as described in the "Technical Notes" in the official 1992 HDR publication, on pages 92-96. The three "deprivations" are:

- Life expectancy;
- Educational attainment, and
- GDP.

The "life expectancy deprivation" of a country x, for example, can be computed by subtracting the life expectancy for country x in years from that of the highest expectancy known among all countries, and dividing this number by the difference between the highest and the lowest recorded life expectancy of all countries: (78.6 - life expectancy x / 78.6 - 42.0).

In a like fashion, the "ecological deprivation" TMI - that in reality is a measure for the integrated ecological impact of a country and thus not a deprivation at all -, can be computed. Unfortunately, only a very few TMI´s exist up to now on the level of nations. Very preliminary data for Vietnam indicate that the yearly MI/person for non-renewal natural resources is about 2 tons per capita (Schütz, 1997) (as opposed to 89 for the United States) (World Resources Institute, 1997). For the following, the TMI value of 2 tons/capita-year is therefore taken as the lowest among all countries. Obviously, no great loss in accuracy for the computation of TMI "deprivation" would result, if the real value for Vietnam were either 100 % smaller or larger.

Since a small TMI is more sustainable than a large one, the "TMI Deprivation" of a country x can be computed in the following fashion: **(TMI x - 2 / (89 - 2).** This "deprivation" indicator is then standardized between 0 and 1.

In order to obtain national SHDI values, the three traditional and the TMI deprivations for each country have to be added up, the sum divided by four and the resulting value deducted from 1, according to the procedure established by UNDP in 1992.

Country	HDI Rank	HDI value	TMI per Capita	TMI depriv.	SHDI Value	rank
Japan	1 (2)	. 981	46	. 505	. 864	1
USA	2 (6)	. 976	89	1	. 732	4
NL	3 (9)	. 968	69	. 77	. 784	2
GER	4 (12)	. 955	67	. 747	. 78	3
Vietnam	(102)	. 464	2		. 598	

As a result, the SHDI values of all those industrialized countries for which TMI data are currently available would lead to a lower rank than the present HDI values imply on a world-wide basis. The relatively high ecological impact of the USA, as measured in TMI, is rather evident in its SHDI ranking when compared to other industrialized countries.

Obviously, the opportunities and problems associated with the proposed SHDI must be carefully researched. For this purpose, a number of TMI´s must become available, preferably for countries having a wide spread in terms of HDI.

8. Increasing The Resource Productivity Of Products

The basic rule for dematerializing technical objects is
To build service delivery machines
That allows extracting a maximum number of service units
For as long as possible
From every resource displaced in nature

The following comments are extracts from the recently published guide (which appeared in German) on innovating eco-intelligent products through eco-design (Schmidt-Bleek, 1998/2). This guide is based upon a multitude of practical experiences with small and medium sized companies in Austria and Germany.

8.1. Dialogues For Making Products Better

We all have a common vision

CEO, Midwest Express Airlines
About the attitude of the entire staff

Experience shows that unless the highest level of management makes it its permanent business, a company's effort to improve the resource productivity of its products will very likely fail.

At the same time, the active participation of employees with a wide range of different responsibilities in the company, such as purchasing, marketing, logistics, human resources, and plant maintenance - in addition to the designers and construction engineers - is a crucial factor in obtaining good and lasting results. Some companies even invite end-users (so-called prosumers) to support their efforts.

Well-structured dialogues must be introduced where they are not yet a matter of routine. Frequently, a guiding hand by an external expert can help to overcome the "natural" animosities that can surface when "non-experts" from within the company (or even from without) participate on equal level in discussions that are traditionally conducted among the designers and engineers only. And yet, in many such dialogues it was found that the «non-experts» made valuable and frequently surprising contributions.

This can be a consequence of the fact that part of these discussions center around the question: what does our product really mean to the end-user? What is the primary and what are further needs that could or must be met? Frequently, this question cannot be fully answered by the "professional designers or engineers" alone.

For instance: Not providing the necessary breadth of functions to the end-user is frequently as disadvantageous as overloading a product with functions that are rarely or never required. It is also still surprisingly often the case that products that are highly sophisticated as regards their technical capabilities, do not at all meet simple needs by end-users such as avoiding endless struggles with manuals in order to find switches, fuses, or opening levers inside cars for covers of gasoline tanks.

In this context it is interesting to note that while it is common today to furnish very detailed instructions for technical products, like a toaster for instance, hardly any written instructions for use are furnished for apartments or houses.

The complexity of using computers for the simple exercise of writing texts is mind-boggling, and, of course, different for each system. Why 12 volt DC power supplies are very heavy and have to be carried extra for each lap top remains the secret of the producers. Keeping controls of household equipment out of childrens' reach is also worth some more thought than manufacturers are presently willing to invest.

The readers should also be reminded again, that the basic question here is not to increase the efficiency of an already existing technical process or product, but to find the best, fun to use, and most elegant dematerialized solution for meeting real needs of real people. In this sense, the process of increasing the resource productivity of daily life will never end.

Reaching a factor of 4 or 10 or 20 in dematerialization of utility-delivery-machines is no longer a question of having a heart for the environment, it is more and more becoming a simple old-fashioned question of competition among the best for market shares and niches.

8.2. Knowing the Company

While visiting companies one frequently encounters the fact that not all efforts have as yet been undertaken with a view toward saving energy, avoiding wastes, recycling materials and water, avoiding unnecessary transportation, reducing packaging etc. In short, 25 years of environmental protection efforts and oil shocks have not as yet convinced all entrepreneurs that real savings can be had, in-spite of the facts that unit prices for resources tend to be low and prices of labor for supervising and enforcing rules are high. There are many examples which show that cleaning up pays.

As the Japanese say: waste is Un-Japanese.

8.3. Computing The MI Of An Existing Product

Before systematic dematerialization of rendering a service can proceed, the complete material composition of the existing product need be carefully assessed. This information is usually not on hand when consultations begin. This situation is somewhat akin to the time before chemicals legislation was in place: large chemical firms did not have complete inventories of all products they were ready to offer and had placed on the market during the few years prior to the time when existing chemicals inventories were legally required.

A complete listing for all different material components in the finished product must therefore be established in kg. The wastes for each component generated during manufacturing are added in kg, and the sum for each component multiplied with the corresponding "rucksack factor". Similarly, the packaging for the product, the energy input during manufacturing, and the (average) transportation of materials to the production site, and from there to the customer, need be assessed.

The result is the MI of natural materials disturbed in the environment from cradle to finished product.

Should considerable batches of products never find their way to the end-users - or never be put to use by them -, these quantities must be considered when establishing the real resource productivity for the respective products. Personal computers and textiles belong in this category. In Germany, some 25 % of shoes sold are never worn.

8.4. Comparing MIPS Among Like Products

The MIPS can be computed through dividing the MI by the number of service units that the manufacturer guarantees or otherwise believes that the product can deliver. Service units can for instance be measured in km for land-bound vehicles, in hours for planes, in number of deliverable units of utility during the useful life time, like loads of clean wash or cups of coffee, etc.

A comparable ("like" or functionally equivalent) product of a competitor can be similarly analyzed and the two MIPS-values for the competing products directly compared. Here, again, comparability of utility delivered is a key issue.

The material (including energy) parts for eco-benchmarking products (parts 1 through 5 in the listing of **paragraph 6.5**) have thus been established.

8.6. Dematerializing Products

Next, the listing as described in **paragraph 7.3.** can be analyzed for opportunities to dematerialize the product. Thus, when analyzing the various rucksack components of a house built of wood (not counting the technology inside), it was found that the foundation (cement) and the gold-plated windows made up each ca. 1/3 of the total MI. Changing the foundation design and replacing the gold-plated windows with normal ones, - adding instead venetian blinds to all windows - nearly tripled the resource productivity of the house. Compared to a brick building with "like" service characteristic and life time expectation, the wooden house yielded a more than threefold higher resource productivity.

Another example would be a baby carriage. After establishing the MI for the reference product (a perambulator that had been "ecologized" before in a traditional sense and sold very well), the aluminum parts were replaced with steel, leading to a dematerialization of about a factor 4. The weight increase was less than 5 %.

8.7. The Powers Of S In MIPS

Best results can usually be obtained, when the design of an eco-intelligent product begins with the definition of the service or principal utility that the new "service delivers machine" is to meet. Of course, rare is the case when a product serves only one purpose. Even a mouse trap may have some aesthetic purpose, and a car or a painting by Picasso in private hands is often described as symbols of power or wealth. But each product has only one originally intended *principal utility*, even the Swiss army knife or aspirin. Over time, the relative importance of utilities may change, in which case the product meets a new competition in terms of "lowest possible MIPS" as well as market price.

Defining utilities is nothing new. Economic theories have done so and determined their meaning in a functioning economy since some time.

S cannot be measured. However, it can be defined and then related to measurable quantities like a price or the MI (the rucksack) in order to compare the "price" for getting the desired results from one or the other machine which can deliver the utility.

Note: in order to get satisfaction, one does not necessarily have to own the service delivery machine.

What is new within the MIPS- and Factor 10 Concept is that *utility of a product* replaces the *product* itself in relative importance? Realistically priced access to products and their use as "service delivers machines" moves into center court and goods become mere technical artifacts to make services available. As has been observed many times at the beginning of the industrial revolution: machines have replaced slavery. Since some 20 years now they are primarily replacing human beings in manufacturing as well as service activities!

We have just described the essence in moving from a material throughput (value and job destroying) economy to knowledge based service society in which labor intensive systems maintenance in the end-use sector largely replaces production of new goods.

The individual accessibility to desired services could be described as the basis of the wealth of people. The totality of accessible services within a country is a proxy of the wealth of this nation.

The principal utility expected by end-users is the corner stone and starting point for designing (radically) new and eco-intelligent or "low-MIPS" products.

The foremost task for anyone involved in the design, production, packaging, transporting, marketing, storing, and even in financing future products is to invent a reliable and compatibly priced product which meets the principal utility - and as many additional ones as desired by end-users - with the least quantity of natural material, energy, and space requirement for the complete life span and for the longest possible time.

This, of course, is nothing new to manufacturers in principle. One only has to replace the words *material*, *energy*, and *space* with the single word *money* in the above sentence in order to see the point. The trouble is, that resources are so cheap today that saving them is neither fun nor does it make much difference to the bottom line in many instances. It is still much more efficient to release labor (to the care of society - a modern form of externalization) than saving kilowatt-hours once cost cutting becomes a question of to be or not to be. This unfortunate circumstance is frequently blamed on the so-called globalization. In reality it is primarily the consequence of political signals to the market, which have deliberately undervalued natural resources for many years through taxation, privileges and subsidies.

Let us investigate briefly, by what means the resource intensity S/MI of a product could be moved towards lower values.

Obviously, the technical design of a product can effect both, lowering the rucksack of the product and increase its S, the latter for instance by increasing the longevity, increasing the potential for cascading uses, or increasing the bundle of services offered (e.g. Swiss army knife).

Equally the end-user can increase the resource productivity for a given technical product through management decisions. For instance, one can share a vehicle, use public transportation, use a towel in a hotel or at home more than once, and lease or rent power tools rather than acquiring them.

MIPS is obviously a measure which responds to pressures (innovations) on the supply side as well as on the demand side.

8.8. Designing *New* Eco-Intelligent Things.

Having determined the principal utility expected by the end-user, and the accompanying service bundle desired, the designer (engineer) proceeds to design a "service delivery machine" showing the highest possible resource productivity - from cradle to grave - without at first regarding already existing technical solutions (Schmidt-Bleek, 1995). Only materials with the lowest possible rucksack factors will be considered, longevity will be one of the outstanding features as well as modular design for allowing easy repair and up-grading. The "machine" will have a minimum requirement of materials, energy, and surface area during its entire life time. A considerable number of additional points must be considered, as is customary when new constructions are being considered (Schmidt-Bleek, 1998). And evidently, the result must fulfil customers' expectations satisfactorily.

To illustrate this eco-design approach, here is a practical example. Ursula Tischner has designed a new refrigerator at the Wuppertal Institut. Instead of re-designing the usual stand-alone piece of equipment, she elected to propose a sophisticated insert for a hole in the wall that uses cold air from the outside during winter and provides heat for pre-heating water. The cooling machine is housed separately and can be serviced or replaced by the company that produced it and continues to own it. This refrigerator can also be used, in part or *in toto*, as a normal storage place in the kitchen without cooling. The resulting dematerialization, even without selecting materials with low rucksack factors, amounted to a factor of ca. 8.

And here is a more complex (albeit still theoretical) solution to a large scale problem: city transportation by automobiles:

The present statistical situation for automotive transportation in large cities around the world is well known and quite similar. With an average occupancy of slightly more than one person in 95 + % of all cases, with only ca. 8 % of the total time in motion at an average speed of less than 20 km/hrs, a systematically different approach could look like this: Two-seated cars would be standard at about 1/3 of the present weight and 1/3 of the surface space requirement (resource productivity - MIPS and FIPS - (gain: ca. factor 3), the average rucksack of construction materials would be lowered by a factor of 2.5 (gain in S/MI: ca. factor 3 x 2.5 = 7.5), the life-expectancy could be raised by a factor of 4 (gain in S/MI: ca. 3 x 2.5 x 1.5 = 11). If the capacity utilization could be raised to an average occupancy of 1.8 persons, another factor of about 1.5 could be gained (total gain in S/MI: larger than factor 15). Additional advantages could be netted by a lower fuel consumption, by less cleaning requirements, by using retread tires, and by inertness to weather conditions (no need for garage).

From this rough comparison it becomes obvious that reducing for instance merely the fuel consumption of passenger cars would only take advantage of a (relatively small) part of the overall opportunities to provide more eco-intelligent automotive services in cities.

It is furthermore obvious that regulations, taxes, and special incentives (e.g. free parking and easy access to rentals for special occasions) should be introduced in order to support the move toward a systems change.

The new "Smart" by Mercedes Benz fulfills already some of the conditions outlined above.

A number of publications exist today that contain many practical examples, demonstrating the opportunities of technical dematerializations in all areas of life (Stahel, 1995). Additional publications are in preparation, in particular in the USA and Europe. A recent fair in Klagenfurt, Austria, assembled close to 100 exhibits of producers and institutions under the heading "Factor 4 +". It is to be repeated in October, 1999. MITI of Japan and NIKKEI Tokyo are currently considering to arrange a trade fair for "low-MIPS" products and services in late 1999 in Tokyo.

8.9. Selecting Profitable Design Options

When discussing technical options and management opportunities for dematerializing existing products, or for designing entirely new technical solutions for rendering services in more sustainable fashions, a whole range of possibilities can commonly be identified.

These options are then systematically reviewed and prioritized with respect to their potential of increasing the overall resource productivity, S/MI, of satisfying a specific need or bundle of needs.

As a next step, these options are displayed against the probably least costs - or highest potential for economic gains - if implementation of these options would proceed. In this fashion, the most attractive opportunities appear in the upper right corner when displaying increasingly effective dematerialization actions on the vertical axis, and increasing potentials for financial gains on the horizontal axis.

Different time horizons for various options may also lead to sequencing their implementation.

Three to five realistic and seemingly profitable options usually result during these discussions that can lead to substantial increases in resource productivity while offering the chance of short term pay-backs of investments or even immediate additional profits.

Experience in many SMU´s in recent months suggest, that dematerialization of existing products routinely yield factors of 2.5 and up to a factor of 10 or more in increases of resource productivity (Schmidt-Bleek, 1998/2). These are enormous gains when compared to traditional increases in efficiencies of existing technologies.

9. Purchasing For Sustainability

At this time, many purchasing agents show already a remarkable sensitivity to environmental concerns. The MIPS and Factor 10 Concepts adds an essential new dimension to the parameters which are already considered today.

Obviously, the ecological rucksacks along with the longevity (as maintenance free as possible) of industrial products are key properties when attempting to make the investment of natural materials and energy count most. However, at this time, many industrial goods are far from being optimized for long useful lives. In saturated markets, companies normally believe they could hardly afford otherwise.

As market prices of products are usually stated in costs per unit product at the point of sale, is is frequently quite easy to fool customers into believing that they save money by purchasing less expensive merchandise. In particular, public authorities frequently opt for accepting the lowest bids in terms of cost per unit product, without adequately considering follow-up costs which can easily multiply the real costs per unit service - COPS.

Were all prices for goods be stated in (COPS), competition would center on maximizing utility offered and societies would move more readily in the direction of sustainable knowledge based economies (Lehner, 1999/2).

Nevertheless, there are already important sectors of the economy where long lived products are offered to customers on a routine basis, usually through leasing contracts. The air line industry and the truck-loaning arm "Charterway" of Mercedes Benz are examples.

In the following Table a listing of "dos" and "don’ts" has been assembled that can guide purchasing agents when trying to identify "low-MIPS" goods. At this time, information listed in this table will usually not be easy to obtain. However, over time companies - as well as purchasing agents operating with public funds - may find it possible to include more and more of these information requirements into the conditions of purchase, thus setting an example and helping to move the producing sector in the direction of dematerializing the economy.

10. Marketing Eco-intelligent, "Lean Products"

"It is relationship with our customers
that counts"
CEO, Harley Davidson

Experience shows that environmental labels - even official environmental prices for excellence - do no longer enhance substantially the chances for marketing goods on the market in Europe. In part this is certainly due to the flood of environmental labels presented today - officially sanctioned or not. Customers seem to find it difficult to understand most of these labels, or even mistrust them. For instance, on every packaging for imports to France from China, the "Green Point" appears today on the packaging materials. This practice not only devalues its original meaning, but also is blatantly invalid and fraudulent.

Labels indicating that foodstuff consists of crops raised under "biological conditions" (whether true or not) are still considered seriously by customers, probably because this information relates to health concerns. In this case, customers are apparently willing to pay even considerably higher prices.

MIPS labels for all industrial goods could be assigned internationally and would probably be helpful as a reliable indication for the specific natural resource consumption associated with various products.

When considering marketing strategies for products with high resource productivity’s, there are several additional opportunities that could be exploited.

For instance, manufacturers can point to the longevity of their products and the price advantages associated with gaining better returns (more service for a longer time period) from robust, high quality products. In a sense, they offer "future antiques" for sale. Where feasible, such advantages could even be expressed in COPS - COsts Per unit Service - and compared to like products from competitors.

Long term garnets should underpin claims of longevity. Warranties could be alternatively expressed in "number of units of uses"-warranties, in time periods, or in efficacy. Merck and Co, for instance, offers money-back guarantee on its cholesterol-reducing drug Zocor on the US market. There are several manufacturers on the market today who offer lifetime garnet for their wares (Eddie Bauer, for instance), or open-ended take-back warranties.

Manufacturers can also consider beginning switching from selling products to selling services, e.g. offering their own products for lease or rent on the market. A member of the board of Daimler Benz recently stated that within 20 years his company would no longer sell cars but mobility services instead. Expensive equipment, such as combines, planes, trucks, and yachts have always been available under such conditions. There are signs that many more types of industrial products will be for hire in the future, supported by information systems that make leasing or hiring arrangements much easier than may be the case today.

Manufacturers, in cooperation with department stores or through their own outlets, can also offer combi-packages for leasing, take-back, repair, and maintenance services for high quality products.

Manufacturers serving certain groups of customers, like babies, toddlers, or the elders, can combine their efforts and sell in common outlets. Clothes, baby carriages, furniture, shoes, toys, games and food for instance could be offered for babies in such places, together with leasing, repair and take-back services.

Taxi companies can offer special rates and services, enticing car owners to give up city driving. Hans Loibner in Graz, Austria, not only has reduced considerably the waiting periods for his 300 taxis to arrive, he has reduced empty driving of the fleet by 45 % through the intelligent use of (silent) communication equipment. Additionally, he uses retread tires now, made in Austria instead of Souh Korea, that corresponds to a dematerialization of a factor 2.5.

And finally, manufacturers can influence public officials responsible for the contents of requests for tender to incorporate within the requests proof of high resource productivity.

TABLE: 11 points

Purchasing for Sustainability

Product* Property	Applies to:	Food		Other	
				L**	B***
- aim at maximum possible for -					
longevity				+	+
reparability				+	+
modular design					+
re-manufacturing potential					+
cascading potential					+
simplicity/robustness				+	+
availability of spare parts				+	
labeling of materials	+		+	+	
automatic control for consumption during use				+	+
take-back options					+
recyclability	+			+	
derived from ecological forestry		+			+
derived from low erosion farming		+			+
derived from bio-farming		+			+
- aim at minimum possible for -					
content of eco-toxic materials		+		+	+
content of human-toxic materials		+		+	+
energy input for construction/manufacturing	+			+	
energy input during storage	+			+	
energy input during use		+		+	+
energy input for disposal		+			+
material input for construction/manufacturing		+			+
material input for use		+		+	+
material input for disposal		+			+
MIPS		+		+	+
surface coverage (cradle to cradle)		+		+	+

Product* Property	Relevant for			
	Food		Other	
			L**	B***
weight/volume			+	+
packaging intensity	+		+	+
transport intensity	+		+	+
material diversity				+
number of parts			+	+
number of e-motors		+	+	
unnecessary functions			+	+
maintenance needs			+	+

* includes foods stuff, equipment, tools, vehicles, buildings, infrastructures
** L = Leasing
*** B = Buying

Source: Schmidt-Bleek

Chapter *II* , Fiscal Reform, Resource Productivity and Employment by Yannis Paleocrassiis will be added soon

Chapter *III*, Resource productivity, competitivness and employment in the advanced economies will be added soon

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Table: 12 points

RUCKSACK FACTORS

without transport

	abiot. Mat. t/t	**biot. Mat. t/t**	**Water t/t**	**Air t/t**	**Soil t/t**	**el. E. kWh/t**
Raw Iron	4,66	0	6,6	0,92	0	186
(Electr. incl)	5,55	0	22,13	1,03		0
Steel (Oxy)	4,89	0	7,94	1,03	0	441
(Electr. incl)	6,97	0	44,77	1,30	0	
Steel (Electr)	0,16	0	0,93	0,15	0	681
(Electr. incl)	3,36	0	57,77	0,57	0	
Steel (83:17)	4,08	0	6,75	0,88	0	482
(Electr. incl)	6,35	0	46,97	1,18	0	
Ferronickel (33% Nickel)	46,2	0	62,78	13,5	0	180
(Electr. incl.)	47,1	0	77,85	13,61	0	
Nickel	138,6	0	188,34	40,5	0	542
(Electr. incl.)	141,29	0	233,54	40,83	0	
Aluminium (virgin)	8,45	0	24,57	0	0	16302
(Electr. incl.)	85,38	0	1384,67	9,99	0	
Aluminium (recycled)	0,59	0	10,32	0	0	609
(Electr. incl.)	3,45	0	61,13	0,37	0	
Copper (estimated) (virgin)						3000
(Electr. incl.)	500	0	260	2	0	
Copper (recycled)	4,04	0	6,31	0	0	1196
(Electr. incl.)	9,66	0	106,7	0,73	0	
Lead**	15,6	0	0	0	0	no info
Zink**	23,1	0	0	0	0	no info
Silber**	7505	0	0	0	0	no info
Gold**	539254	0	0	0	0	no info
Calcium Carbonate (CaCO3)	1,19	0	1,11	0	0	53
(Electr. incl.)	1,44	0	5,56	0,03	0	
Calc.Carbon. ground up (CaCO3)	1,19	0	1,11	0	0	103
(Electr. incl.)	1,66	0	9,71	0,06	0	
CaO	2,55	0	2,65	0,03	0	144
(Electr. incl.)	3,23	0	14,68	0,12	0	

	abiot. Mat. t/t	biot. Mat. t/t	Water t/t	Air t/t	Soil t/t	el. E. kWh/t
Beton B25	1,22	0	1,44	0,03	0,02	24
(Electr. incl.)	1,33	0	3,43	0,045	0,02	
Cement Portland	2,42	0	2,76	0,23	0	171
(Electr. incl.)	3,22	0	17	0,34	0	
Dolomit	1,19	0	1,11	0	0	53
(Electr. incl.)	1,44	0	5,56	0,03	0	
Dolomit ground up	1,19	0	1,11	0	0	103
(Electr. incl.)	1,66	0	9,71	0,06	0	
Diabas broken	1,15	0	1,32	0,01	0	58
(Electr. incl.)	1,42	0	6,13	0,05	0	
Feldspat ground up	1,15	0	1,32	0,01	0	107
(Electr. incl.)	1,65	0	10,28	0,08	0	
Quarzsand	1,34	0	0,12	0,02	0	15,6
(Electr. incl.)	1,42	0	1,43	0,03	0	
Mixture** Sand and Gravel	1,18	0	0	0	0	no info
Aluminium Oxide	4,64	0	9,08	0,08	0	540
(Electr. incl.)	7,43	0	58,62	0,45	0	
Salt (NaCl)	1,24	0	2,29	0,02	0	0
Kalisalts**	5,69	0	0	0	0	no info
Flußspat**	2,75	0	0	0	0	no info
Diamonds ** South Africa	5260000	0	0	0	0	no info
Colemanit	6	0	1,18	0	0	53
(Electr. incl.)	8,39	0	5,63	0,04	0	
Borax (synthetic)	5,4	0	6,62	0,39	0	76,7
Borax (electr. incl)	5,75	0	13,02	0,43	0	
Soda	3,72	0	15,5	0,91	0	172
(Electr.incl.)	4,46	0	27,7	1,02	0	
Lignite	9,5	0	6	0	0	39
(Electr.incl.)	9,68	0	9,3	0,024	0	
Anthrazite	1,96	0	2,5	0	0	80
(Electr.incl.)	2,36	0	9,15	0,050	0	
Anthrazite import to Germany. from deep mines	1,7	0	1,73	0,35	0	86
(Electr.incl.)	2,11	0	9,15	0,049	0	
Coke	3,17	0	3,22	2,97	0	225
(Electr.incl.)	4,22	0	22	3,1	0	

	abiot. Mat. t/t	biot. Mat. t/t	Water t/t	Air t/t	Soil t/t	el. E. kWh/t
Light Oil heating	1,21	0	6,8	0	0	32
(Electr.incl.)	1,36	0	9,45	0,02	0	
Havy Oil heating	1,24	0	6,87	0	0	55
(Electr.incl.)	1,5	0	11,47	0,034	0	
Raw Oil	1,17	0	3,54	0,003	0	9
(Electr.incl.)	1,22	0	4,28	0,008	0	
Diesel	1,21	0	7,03	0	0	32
(Electr.incl.)	1,36	0	9,71	0,02	0	
Naphtha	1,32	0	7,35	0	0	79
(Electr.incl.)	1,69	0	13,91	0,048	0	
Natural Gas	1,2	0	0,23	0	0	3,3
(Electr.incl.)	1,22	0	0,50	0,002	0	
PVC-Pulver	2,6	0	21,9	0	0	1153
(Electr.incl.)	8,02	0	118	0,71	0	
NaOH (50%)	0,61	0	1,15	0	0	1156
(Electr.incl.)	6,05	0	97,6	0,71	0	
Cl2	0,61	0	0,65	0	0	1156
(Electr.incl.)	6,05	0	97,1	0,71	0	
Cumol*	4,04	0	23,7	2,13	0	130
(Electr.incl.)	4,65	0	34,5	2,21	0	
Phenol*						
(Electr.incl.)	3,19	0	18,72	1,89	0	102
Aceton*						
(Electr.incl.)	3,19	0	18,7	1,89	0	102
NH3	1,16	0	1,14	2,06	0	582
(Electr.incl.)	3,6	0	39,96	2,43	0	
Methanol	0,71	0	1,31	0,34	0	35
(Electr.incl.)	0,88	0	4,25	0,36	0	
Formal-dehyde soln (37%ig)	0,319	0	2,44	0,94	0	57
(Electr.incl.)	0,64	0	7,2	0,98	0	
Ethylene	3,17	0	13,03	1,87	0	153
(Electr.incl.)	3,89	0	25,76	1,96	0	
Benzol	3,52	0	13,97	2,08	0	171
(Electr.incl.)	4,32	0	28,23	2,19	0	
Propylene	3,17	0	13,03	1,87	0	153
(Electr.incl.)	3,89	0	25,76	1,96	0	
AlCl3*	2,98	0	10,39	0,414	0	1201
(Electr.incl.)	8,61	0	110,6	1,15	0	
O2 (liquid)	0	0	1002	0	0	994
(Electr.incl.)	4,66	0	1085	0,61	0	
N2 (liquid)						

	abiot. Mat. t/t	**biot. Mat. t/t**	**Water t/t**	**Air t/t**	**Soil t/t**	**el. E. kWh/t**
(Electr.incl.)	0,5	0	8	1,14	0	
Pine (cut and dried.)	0,33	5,51	0,52	0,06	0	113
(Electr.incl.)	0,86	5,51	9,97	0,13	0	
Douglas wood (cut and dried)	0,13	4,37	0,27	0,1	0	108
(Electr.incl.)	0,63	4,37	9,24	0,17	0	
Starch						
(Electr.incl.)	1,07	0	22,1	1,56	0	577 MJ
Gypsum	1,33	0	1,5	0	0	106
(Electr.incl.)	1,83	0	10,34	0,065	0	
Flat Glass	2,33	0	4,52	0,69	0,13	86
(Electr.incl.)	2,96	0	11,73	0,74	0,13	
Glas container (53% recycled)	1,02	0	1,83	0,49	0,06	140
(Electr.incl.)	1,73	0	13,49	0,58	0,06	
Glas container. non-recycled	2,19	0	4,14	0,62	0,14	157
(Electr.incl.)	3,04	0	17,21	0,72	0,14	
Electricity. public grid, Germany	4,69	0	83,431	0,613	0	0

*Minimal estimate

**Raw material extraction and overburden only