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"MIPS and Ecological Rucksacks in Designing the Future"

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How the Quest for a New Economy Began

The story of MIPS, the ecological rucksacks and Factor 10 started 12 years ago during Sylvester eve in a little village in Austria. At that time I was responsible for the work on the economic reform for the COMECON countries at the International Institute for Applied Systems Analysis – IIASA. We had a number of Russian friends with us that night, among them "Stash" Shatalin, the chief economic advisor to President Gorbachev. When I proposed to him that we should tackle introducing the western environmental policies in Russia – additional to the economic reforms - Stash said: "Njet. Lets first make the market economy work Then we get rich in Russia. And after that we may afford your kind of environmental protection" [1].

From then on I was possessed with the question how sustainability - just introduced into the political debate - could possibly be approached worldwide if apparently the poor countries could not afford to apply our well conceived and functioning environmental protection measures ? Had more than 150 countries had to become rich first – and consume untold quantities of natural resources in the process - before they were rich enough to begin protecting the environment properly and we could jointly begin the process toward ecological sustainability ? Would that not be far too late, considering for instance the already threatening climatic changes ?

After that brief exchange with Shatalin it began to dawn on me that we had managed to establish a multi-billion-dollar *secondary* economy – a kind of *planned* economy if you wish - by governmental edict. The principal purpose of it was at that time to stave off dangers to human health arising from deleterious emissions and wastes emanating from the *real* economy, namely the one that was (and is) responsible for creating growth and wealth for people.

Even today many people continue to believe that a healthy economy is one that consumes increasing quantities of energy and natural resources in order to generate increasing prosperity. Even today the principal yardstick for monitoring the vigor of economies is

[1] P. O. Aven, S. S. Shatalin and F. Schmidt-Bleek, "Economic Reform and Integration", Proceedings of 1-3 March 1990 Meeting, IIASA, CP-90-4, 1990

GDP. Even today environmental protection efforts consume additional energy and natural resources, over and above the “real” economy [2].

So what is the way to avoid ever-increasing costs for protecting the environment? Or is there perhaps even a way to reward increasing protection efforts within the “real” economy through market forces while simultaneously decreasing the resource use ?

The “Gedankenblitz” occurred to me at a silent location: If too much environmentally dangerous material escapes at the back-end of an economy, one should curb the input streams of natural resources at the front end of the wealth machine [3].

Of course some questions had had to be answered before this rather simplistic idea could be taken seriously.

The first one is: Could technology provide goods and services that offer undiminished end-use satisfaction with substantially less natural resources than is the case today?

The answer is yes. It can !

It is a question of engineering intelligence how much and what kind of energy and mass one invests for generating a certain quantity of value or utility. A service oriented knowledge society, supported by (dematerialized) information technology, can go a long way to replace mass and energy by brain-power. In fact, how else can growth be had on a planet with limited resources in the face of a growing population with increasing demands?

I will deal with design and other technical aspects in the second part of this paper.

In my train of thoughts about the future the question arose, what could be the *required* reduction in using nature as input into the *worldwide* economy in order to approach sustainability? I did a very simple computation based on available evidence and arrived at about a *Factor 2* as the best possible estimate. Nobody has as yet contested this rough number to my knowledge.

But surely the poor of this world, some 80% of its population, were not ready to reduce the little they had access to. They dream of proper health care, shelter, washing machines and cars – not the least because we beam these dreams into their huts incessantly by satellite. We call this stimulating consumption in order to keep the throughput economy running (see above). So if the worldwide take of nature must be reduced by a *Factor 2* and equity demands that 5 or 8 billion people must have a better life than now, the rich must reduce their current take *at least* by a *Factor 10*. In my opinion, anybody suggesting less than *10* should clarify the underlying assumptions.

When designing products for improved resource productivity, the resource intensity of raw material plays an important role. For instance, we figured out that 1 kg of copper requires 500 kg of non-renewable nature before it is available in pure and useful form. The *“rucksack factor”* of virgin copper is therefor said to be 500. The *“rucksack factor”* for aluminum is 85, for paper 15, for steel around 10 and for most plastics considerably less than 10. The *“ecological rucksack”* of any product can thus

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2 “1997 Carnoules Statement to Government and Business Leaders”, International Factor 10 Club, see www.factor10-institute.org

3 F. Schmidt-Bleek, - „Wieviel Umwelt braucht der Mensch – mips, das ökologische Mass zum Wirtschqften“, Birkhäuser, Basel, Boston, Berlin, 1993; appeared in Japanese (4th edition, Springer Tokyo), Chinese and Finnish. English version in www.factor10-institute.org under the title “The Fossil Makers”.

be computed, provided its material composition and its weight are known. The *"ecological rucksack*" of a product is defined as the total natural material used for this product minus its own weight. A product may obviously have a much larger - or smaller - *"ecological rucksack"* than its competitor and still weigh the same [4].

I will come back to the practical application of the rucksack concept in the second part of this paper.

While painstakingly working through dozens and dozens of supply chains in order to evaluate the *"rucksack factors"* for raw materials we discovered that it is the rucksack of finished products rather than the process of manufacturing that determines the overall resource intensity of the economy:

Sustainability is won on the market or not at all.

Since nothing can be managed without a measure I began early to search for practical and robust indicators that could safely guide the design of *all* goods and infrastructures on the micro level, and *all* policies on the macro level in the direction of higher resource efficiency. Such measures had to be easy to understand and apply in a world market where perhaps 50 million different products and services are traded every day. The indicators had to be cost-effective in their application, directionally true, and cover the whole life span of products.

In view of the discourse above it should not come as a surprise that I proposed to use the "input of natural materials (including their rucksacks) per unit service or utility" – MIPS- as an indicator to be used on the micro level and "the total yearly material flow (including their rucksacks)" –TMF- as an indicator on the policy level. I have also suggested that COPS, the "costs per unit service or utility" would be a suitable kind of price for *all* goods and services in a service oriented society [5].

I will come back to the practical use of MIPS for technical developments in the second part of this paper.

As we all know, trends based on indicators are what the mass media transport best when it comes to complex issues. Public attention needs to be drawn to the fact that everyone of us is needlessly wasting natural resources every day. Without this there will simply not be a meaningful public debate on sustainability and no agreement on the *"landing place"* we wish to approach for a more sustainable future.

The national German statistics office is now collecting TMF information on a routine basis. And the German federal ministry responsible for research has expressed interest in establishing a national center for information on material flows and resource productivity, including MI and MIPS data. I was recently informed that the Japanese Academy of Science has developed similar plans.

Perhaps the most puzzling question that must be answered before policies can be designed for approaching sustainability through increased resource productivity is this: Why are natural resources wasted today? Why is it that resources play hardly any role as a production factor in "modern" economic theory?

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[4] F. Schmidt-Bleek and Co-workers: "MAIA, Einfürung In Die Material-Intensitätsanalyse Nach Dem MIPS-Konzept", Birkhäuser, Basel, Boston, Berlin, 1999

[5] F. Schmidt-Bleek, „Das MIPS-Konzept – Faktor 10", Droemer, München, 1998

The simple answer is: Because the price of many natural resources is so low that it does not pay to optimize their use or increase their productivity. At the same time, great efforts are made by manufacturers to increase the labor productivity in order to survive in a competitive market since human labor is expensive. To the extent that machines are replacing humans in the production and service sector, this development puts even an additional strain on the natural resource base [6].

This situation is *not* the fault of the market. This situation is a perfectly logical consequence of the old paradigm where increasing flows of resources through the economy were spawning increased wealth. Accordingly, fiscal policies, subsidies, R&D priorities, standards, norms, requirements for securing venture capital, property rights and many other factors are shaped to support the "throughput economy". In short, the economic boundary conditions are squarely in the way of sustainability. Or, to put it the other way around: If politicians are really interested in approaching sustainability (and substantially lowering unemployment in the process) they need to start a systematic analysis of the economic boundary conditions soon and get prepared to adjust them step by step. In doing so, they can use the *Factor 10/MIPS* Concept as a guide.

I will go one step further and say this: If national governments are interested in reasonably sustainable economic and social conditions in the long run, and in particular if they care for a strong export showing of their country in the future, they would be well advised to begin the process of increasing the resource productivity at once. There are simply not enough resources on this planet to globalize the western life-style. And worse, long before we run into physical resource scarcities, the environmental services will be largely in shambles if we continue operating our "throughput economies". And the life-sustaining services of the environment cannot be generated by technology – at any costs.

Pro-active business leaders are aware of this situation. And they are pretty upset because the present price situation allows only rather limited dematerialization moves under profitable conditions. For instance, business and opinion leaders at the B 21 meeting in May 2000 at Tokyo agreed that the present resource depletion is undermining our economy and our future. They called for fundamental changes in our present economic systems, corporate activities, and lifestyles. They agreed that corporations should take the leading role in encouraging governments to change the economic framework and incentive structures. In their view, *restructuring the global economy to make it environmentally sustainable represents the greatest investment opportunity in human history* [7].

In June 2000 the *"Alliance for Global Eco-Structuring"* was founded at my institute in Carnoules with the aim to draw industry's attention to the fact that it would be in their own best interest to support governments pro-actively in undertaking appropriate changes of the current economic boundary conditions. Representatives from Japan, Germany, Thailand, France, the Netherlands and Sweden issued the "Carnoules Appeal" [8] to that effect which enjoys increasing attention and support, particularly in Germany.

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6 Franz Lehner and F. Schmidt-Bleek, "Die Wachstumsmaschine – der ökonomische Charm der ökologie", Droemer, München, 1999

7 GREB 21 Meeting, Tokyo, 22. May, 2000; Organizer B-LIFE 21-Business Leaders' Inter-Forum for Environment 21; Secretary General and Founder of B-LIFE 21: Tadahiro Mitsuhashi, Senior Editorial Writer, NIKKEI-Nihon Keizai Shimbun, Inc. For the text of the B21 Tokyo Statement see: www.factor10-institute.org and Annex

8 See www.factor10-institute.org

However, prior to changing economic boundary conditions the consequences of such changes must be analyzed. This has not happened yet. Therefore I have recently suggested that a systemic and well-focused major new research effort be launched in order to develop realistic options for change. Encouraging first discussions have taken place.

And now I will turn to some practical applications of MIPS and *"ecoligical rucksacks".*

Designing Products and Services for the Future

From an engineering point of view, perhaps the most important message that emanates from the discussion above is the fact that there will be no sustainability without intensive technical innovation.

The principal task for engineers, designers, architects and natural scientists is to create products and systems that allow to extract a maximum amount of utility from the least possible use of nature for the longest possible time with the least possible use of space.

In short: In products for sustainability, mass, space need and energy have to be replaced by brain power.

When I first published the *Factor 10*, engineers thought such acrobatics in numbers were far away from real life - until they discovered that I was *not* talking about 1000 % improvements in efficiency of existing technology, but rather meant the sharp reduction in use of nature for satisfying defined human needs. The focus of the MIPS/Factor 10 Concept is on *service*, *utility* and *values*, not goods. As Aristotle remarked already more than two thousand years ago*: "True wealth is the use of things, not their possession*".

Today, industrial products carry an average *rucksack* of some 35 kg of non-renewable natural resources pro kg of product. Their *"water rucksack"* is typically some 8 to 10 times bigger. That means that considerably more than 90 % of the originally disturbed non-renewable natural resources are wasted on the average before a product is ready for the market. The rucksack of "high tech" products such as computers or catalytic converters for automobiles are much larger. They weigh several hundred kg pro kg.

Agriculture fares no better. Considerably less than 10 % of the bio-mass produced is actually consumed or used to satisfy needs of end-users. And on the average, several tons of erosions are generated for every ton of crop in most countries, largely due to "modern" mechanical preparations of soil.

Let us briefly return to MIPS and the *"ecological rucksacks"* at this point in order to understand better how they can be used to design new dematerialized products and to compare their ecological quality with that of others.

In order to facilitate the rapid computation of the *rucksacks* of technical products at the point of sale, the *rucksack factors* for a large number of *base materials* have been compiled, based upon average geological concentrations and the most commonly used processes involved in making them available for further use. Many such *"rucksack factors"* are available from the Wuppertal Institute via internet (http://www.wupperinst.org). As I have indicated before, it seems now very likely that there will be a center for resource productivity data in Germany where reliable data can be obtained in the future.

Rucksack data by themselves give no information on the resource needs pro unit of service (or per unit utility or extracted value). This is why MIPS was invented, the environmental impact potential of the useful output from a product, stated in terms of its specific material plus energy input, or the *Material Input Pro unit of Service (or utility or extracted value)*, - the ***MI / S**, or **MIPS**.* The material and energy input MI can obviously be measured and is (up to the point of sale) identical in concept to the *final gross sale value* of products.

I will insert here a word about the importance of **energy** with respect to environmental protection.

Many expert seem to believe that the consumption of energy is by itself a good indicator for the environmental quality of products like washing machines or cars. *This is not the case*. What needs to be considered foremost is the material intensity of every unit of energy at the point of its application. The *"ecological rucksacks"* of energy carriers like brown coal, gas or oil vary greatly, as do their transportation intensity and the energy extractable per unit weight. The MI per unit electricity delivered to the grid varies by a factor of 50, depending how the electricity was generated. While brown coal is the worst heat source for electricity generation, electricity generated by wind is among the best. Photovoltaic is no better as a source of electricity than hard coal.

One can go as far as saying: To the first approximation, the quantity of energy use is ecologically not important. The problem of energy use today is primarily its material intensity. One of the outstanding engineering tasks is therefor the generation of useful energy with the smallest material (including transportation) intensity possible [9].

Dematerializing the economy by a Factor 10 on the average lowers the overall energy demand by roughly a Factor of 5.

For these reasons, the MIPS Concept includes the energy intensity of "ecological rucksacks" in material equivalents.

For products that can deliver services, or are utile, the MI term in MI/S is the total MI of the product (the "service delivery machine") plus the material and energy needed (e.g. water and electricity in a washing machine) during its entire useful life time: MI is the total natural material input from resource extraction, production, use, maintenance, repairs, disposal etc.

S can<u>not</u> be measured. It is a matter of social choice. And social choice depends to a significant extent upon the efficiency of the market. Once the economic boundary conditions have been adjusted, as indicated in the first part of this paper, social choices are likely to become more environmentally benign since prices should more closely reflect the "ecological truth".

The capacity utilization of a product needs also be considered when designing products for the future. For instance, the MIPS of a bus or a car depends critically upon how many people are being transported simultaneously (on the average). The MIPS of a passenger car can obviously be better (lower) than that of a bus which transports only a few passengers most of the time (as is not entirely uncommon with certain public transport systems).

The MIPS can be improved (can be lowered) by either lowering MI for a given S, or by increasing S with a fixed quantity of resources (improving the capacity utilization). Both changes can be achieved through technological as well as social innovations. For example, by increasing the longevity of goods, 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

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9 F. Schmidt-Bleek, "Das MIPS Konzept – Faktor 10", Droemer, München, 1999

absolute input of natural raw materials. Using a towel in a hotel 2 or three days instead of one day only increases the resource productivity by a factor of 2 to 3.

This is in fact the approach to a knowledge based dematerialized economy.

The inverse of MI / S, namely S/MI, is the measure for *resource productivity*. Resource economists should note that the resource quantities employed here contain the ecological rucksacks of all inputs.

As is the case with rucksack data, MIPS, too, is important for driving innovation, design, manufacture, use, and the marketing of products in the direction of dematerialization because MIPS permits the step by step accounting of added resource productivity. It can equally play an important role in the development of research, innovation, trade, and taxation policies. MIPS also allows to assess the “ecological price” for all possible goods and services.

The hallmarks for products of the future can be summarized as follows:

- The number of service units obtainable from a product (the "service delivery machine") must be as high as possible.
- The life-long material input into processes, products, and services must be as low as possible.
- The life-long energy inputs into processes, products, and services must be as low as possible
- The land use (surface coverage) per unit service must be as low as possible, from cradle to grave.
- The dispersion of toxins must be minimal

Increasing the resource productivity of goods can be achieved in different ways:

- they can be made to last longer, require less maintenance and repair and consume less input of natural resources while performing their assigned tasks;
- they may be constructed in a modular way so as to allow easy up-dating, re-manufacturing, and re-cycling;
- they can be designed to yield different types of utility with only slightly increased rucksacks, such as the famous Swiss army knife; and
- they can be dematerialized by replacing materials with high rucksack factors by those materials with smaller rucksack factors. In fact, this is usually the fastest and most cost-efficient way to obtain good results.
- However, from the point of view of approaching sustainability, a more challenging and far-reaching approach is this: Define first the utility demanded by society - or a bundle of related utilities - and then create a new type of service delivery machine – or a systems solution - that can reliably deliver this utility with the highest possible resource productivity – or with the smallest possible MIPS.

In other words: There is *no technology fix* involved when generating dematerialized services. This implies that any technical route toward delivering utility with less resource inputs than previously necessary is to be favored. This is an open invitation for pro-active inventors to continuously look for new and better ways to serve human needs. In fact, it is to be expected that equivalent services will be made available over time for which the material needs are replaced by knowledge and know-how by factors far beyond 10.

In 1993 we started at the Wuppertal Institute in Germany to get involved in practical approaches of dematerialization. Starting in 1997 my newly created *Factor 10* Institute in the Provence continued practical work in Europe and Japan, and since

1998 the *International Factor 10 Innovation Network* has shown in more than 150 enterprises how systematic new design and sensible management approaches can profitably increase the resource productivity of goods and services [10] [11] [12] [13].

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10 F. Schmidt-Bleek, Ursula. Tischner, " Produktentwicklung – Nutzen gestalten – Natur schonen", Austrian Chamber of Commerce, Wien, 1995

11 Walter Stahel, Willy Bierter, F. Schmidt-Bleek, "Ökointelligente Produkte, Dienstleistungen und Arbeit", ", Birkhäuser, Basel, Boston, Berlin, 1997

12 F. Schmidt-Bleek, "Ökodesign – Vom Produkt zur Dienstleistungserfüllungsmaschine", Austrian Chamber of Commerce, Wien, 1999

13 F. Schmidt-Bleek, Ch. Manstein and G. Weihs, "Klagenfurt Innovation", Klagenfurt,, ISBN 3 900743 74 6, 1999. Report on a training program for 50 SMEs for the Design of sustainable products, services, and management (also available in Japanese).