The MIPS Concept (Material Input Per Unit of Service): A Measure for an Ecological Economy

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Abstract – Sustainable development which is based on the economic, environmental and social dimension has been a never-ending theme since the issue of the Brundtland Commission Report in 1987 and then followed by the publication of the Rio Declaration in 1992. One requirement to reach a sustainable development in a company is first by establishing a sound environmental management. The MIPS Concept that was developed by Prof. "Bio" Schmidt-Bleek and the Wuppertal Institute Germany in 1993 is very useful to measure the environmental performance from a business activity. Using this concept, one may analyse the entire working process including all inserted natural resources (material and energy) in the process to produce a desired product or service, which then can be used as the basis to set up the Life Cycle Analysis. This concept invites engineers in a company to plan and design an environmental friendly process and also motivates them to make use of natural resources as wisely as possible. With this paper, the author will try to introduce the MIPS Concept and describe how the MIPS Concept can be applied to measure the environmental stress in a cradle-to-grave process.

Keywords – MIPS, ecological rucksack, dematerialization, Factor 10, resource productivity, Eco-efficiency.

INTRODUCTION

According to DUNPHY *et al.* [1], sustainability is defined as *"living and working in ways that meet and balance existing economic, environmental and social needs without compromising the well-being of future generations"*. Based on the orientation to achieve sustainability, companies are required to make decisions and carry out programs and projects in a manner that maintains or enhances financial viability while maximising benefits to the natural environment and humans and their cultures and communities [2].

In reference to balancing economy and environment, handling environmental problems in a company is a priority. Businesses around the world are coming under increasing pressure to reduce or eliminate the environmental impacts of their operations. In order to accomplish these goals, they need to implement effective Environmental Management Systems (EMS) to measure, monitor and report the environmental aspects relating to their activities, products and services [3]. Such environmental management approaches, actually, can have both environmental and economic benefits. "Cleaner Production Assessments", for example, highlight opportunities for efficient use of raw materials and pollution prevention, leading to cost savings. More broadly, better environmental management is being seen as a key source of competitive advantage for industrial companies. A whole range of benefits can accrue from improved environmental performance, ranging from reduced effluent charges to better community relation [4].

In the fall of 1996, the International Organisation for Standardisation published the ISO 14001 Standard setting out the requirements for an EMS. This voluntary standard provides businesses with an internationally recognised and accepted framework for implementing and maintaining a "cradle-to-grave" system for environmental management. However, the standard contains no environmental performance requirements. Besides, implementing and maintaining such an EMS is not sufficient in and of itself. According to the tried and true adage:

"You can not manage what you can not measure".

Therefore, to improve their environmental performance, businesses need to measure and monitor their product life cycle [3].

A global framework for such environmental performance measurement, monitoring and reporting system is already emerging. One of them is the MIPS Concept (Material Input Per Unit of Service).

THE MIPS SUPPORTING CONCEPT

Material Flow

In running their economic activities, humans remove materials and process them until the expected utilisation of the goods is achieved. These material flows, which are directly associated with energy transformation, includes ploughed soil, building materials, excavation materials, sand, minerals, water (used for hydroelectric power, irrigation, industry and drinking water), as well as industrial, agricultural and forest products and all emissions, effluents and solid waste [5].

Humans move material from the natural resources more than the environment can do by wind and water, by volcano eruptions or by erosions. Humans control the face of earth and the ecological framework, not the environment. For our own survival interest and for the interest of the ecological proportion stability, in which and from which we live, we should give a chance to the environment to regulate its ecological framework on this planet. This condition demands us to run our economy gently [6].

Each movement of material, each dislocation of matter from one place to another is a material flow, with concomitant effects on ecological coherence. These can be positive, but bring mostly negative effects. Prof. Schmidt-Bleek [5] stated:

"The more 'environment' required for the product, the worse it appears from an ecological perspective".

Ecological Rucksack

Because of ecological reasons, it is very necessary to reduce the huge material flows from the environment into the economic life cycle that we set in the industry.

Each finished goods and services carry an ecological rucksack. This rucksack is filled with all the material resources that we moved and put in the process of production. The ecological rucksack is often much more heavier than the finished product itself [6]. For example, to get 1 ton of copper, 500 tons of non-renewable natural resources have to be moved from its natural place (environment) before 1 ton copper can be taken from the economic life cycle process. So, this ratio of 500 ton/ton copper is called the ecological rucksack of copper [7]. In one part of the world, the production of 1 kg wool needs more than 40,000 litre water [6]. Figure 1 gives an impression, how strong the ecological rucksacks stress the mass of the material [7].

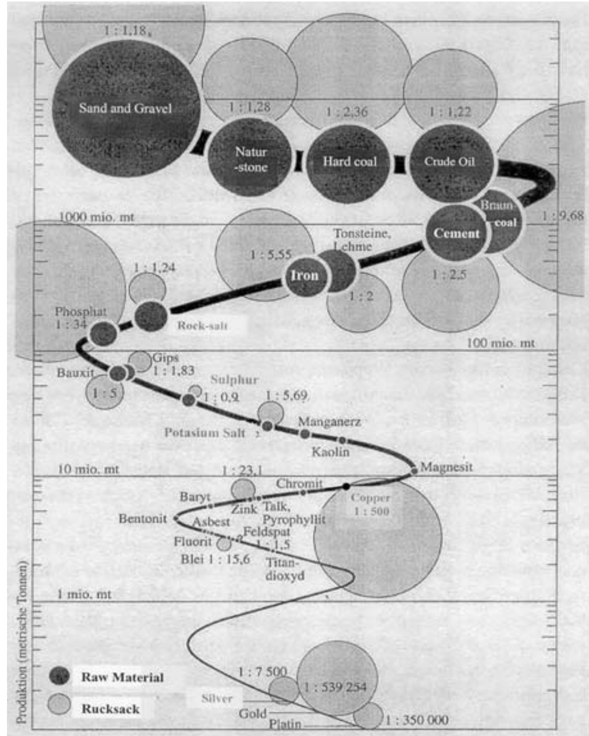

Fig. 1: The Ecological Rucksack of Some Materials (Based on the world production of different economical goods in 1983) [7].

Dematerialization

In principle, the environmental burden could be lowered while maintaining the living standard by introducing functionally equivalent goods that have reduced material intensities (dematerialised goods) into the market [8].

Dematerialization is a matter of slowing down and reducing this grossly wasteful movement and misuse – or rather, abuse – of materials and use of energy. The objective is to stop the waste and reduce the burdens we now impose on the environment. For example, to produce a computer weighting about 20 kg, the movement of 14 tons of solid materials (not yet including the use of water) from nature into the technosphere is required. That is, as mentioned above, the ecological rucksack of a computer, a rucksack that increases the environmental "cost" of the computer with a Factor 700 [9].

M. J. Welfens from the Wuppertal Institute for Climate, Environment and Energy in Germany has developed strategies to practice dematerialization. Strategies for dematerialization mean that resources are used in a more efficient way [10]. Different strategies should focus on each stage of the product life cycle: from raw material extraction to waste treatment (Fig. 2).

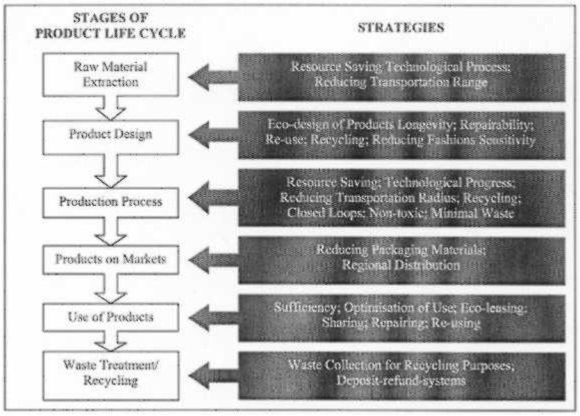

Fig. 2: Strategies for Dematerialization [10].

Dematerialization is simply the key to modernisation of the industry, says Prof. Dr. Franz Lehner, President of the Institute of Work and Technique, Nordrhein-Westfalen Germany. He predicts:

”They who have mastered this field, will also have the power over the world in his hands. Countries that pay little notice to this trend, will become or stay as the Third World countries”.

Dematerialising in economy does not mean going back; it means progress, as such a development would not be possible without concomitant technical improvements [8].

But then some questions arise. How much natural resources should we save? Or how much resource consumption is too much? Or why shouldn't we just save as much as we can? The answer to that is that we would most possibly drastically miss our target, and aim at any other different target. “Too much” saving would do the environment no harm, but maybe then we will have to restrict ourselves so much that we will never come to our target [8].

It is worth to remember that:

“Only when we are aware that for each gram of copper, 500 gram natural resources must be transported, would we think about saving the use of copper gently”.

Factor 10

Once again we have to keep in mind, although we reduce the natural resources consumption in producing products, the service or quality that we can get from the use of a product must be kept. An example, if we produce a chair with 12 kg of weight, at least it carries 12 kg of natural resources (often more). If we then produce the same type of chair with only the half of the weight than before (6 kg), it is said that we have already dematerialised the chair with a Factor 2 (with the same quality and comfort). If we make a 1.2 kg chair that has the same quality, it means that we have fulfilled the demand for dematerialization by the Factor 10 [6]. Factor 10 in this context means production of goods or services with only one tenth of the present amount of resources (materials and energy) [9].

According to the Factor 10 Club[1], the appropriate dematerialization in industrialised countries should amount to an average Factor of 10 or more to make sufficient room for an adequate technical development of the rest of the world. Anything less than a Factor 10 cannot be considered sufficient from an ecological point of view [9].

But why does it have to be a Factor 10? Factor 10 is a result of a simple calculation which is illustrated in Figure 3, as the present consumption of natural resources by the whole community may not be fulfilled in the future. Figure 3 shows, how mankind in the next decades can slowly develop into a phase where the natural resources still have a future: Industrialised countries reduce their consumption immediately and drastically in the next decades, while the Third World countries temporarily still increase their consumption. Slowly they all move to the same level of consumption – which is a tenth of what the industrialised countries are now consuming. A tenth must satisfy the rich. That is the demand of the Factor 10 [6].

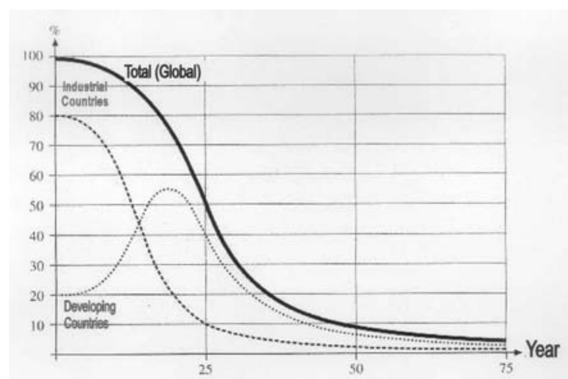

Fig. 3: Consumption of Industrialised and Developing Countries [8].

But in the economy, Factor 10 is not only a demand, but also an innovation- and development motor. It drives the creation and the utilisation of knowledge and also creates new development and job market [6].

[1] Factor 10 Club was developed by Prof. Schmidt-Bleek, and founded in October 1994 in Carnoules, France. The members hail from 12 countries, including India, Canada, Japan, USA, as well as from most western European countries. The Factor 10 Club was called into being because of mounting concerns over the unacknowledged role of human-induced global material flows, and the ecological ramifications of their unchecked growth [11].

Resource Productivity

If large material flows must be moved to produce a product, or to offer a service, then this product or service has a high "material intensity". In an analogous way, if it takes a relatively large quantity of resources to produce very little, the "resource productivity" is low. The Environmental Citizen Organisation (ECO) in 1998 defines resource productivity as "*a measurement of how many service units one can get from a given amount of material*". Therefore, the utilisation of a product must be maximised (without reducing the comfort). For example, a 3-passenger car has a higher resource productivity than a 1 passenger car [8]. If a product that is usually used to serve a person or to satisfy the need of one person, but is then used to serve 10 persons (without minimising the quality of its service), then we could also say that the resource productivity has been achieved by a Factor 10.

Instead of resource productivity, we could also speak of Eco-efficiency. If the resource productivity rises while the material consumption remains the same, material wealth increases. Put differently, dematerialised technologies can yield more service units with constant or falling material effort. Were one to increase the global resource productivity 4 fold, it would be possible – under this definition – to double the number of service units and have the material inputs cut in half [8].

When we don't start to think about all these, then it would not make any difference whether just one passenger or 300 passengers are sitting in a subway. Because the same miles are travelled for both cases. The MIPS is up till now the only tool to measure how much utilisation from a certain amount of resources is to be expected (resource productivity) [8].

With increased resource productivity, one increases the benefit per given unit of resource use, and the increase of resource productivity is an important goal in a dematerialised society. Dematerialization or resource productivity by a Factor 10 is hard to achieve. But it is achievable.

THE MIPS CONCEPT

The MIPS Concept is the measurement for material and energy intensity from processes, products, infrastructure and services in our economical system [7]. This concept uses a resource indicator to measure the environmental performance of a cradle-to-grave business activity. Calculations are made per unit of delivered "service" or function in the product during its entire life cycle (manufacturing, transport, package, use, reuse, recycling, new manufacturing from recycled material, and final disposal as waste). The MIPS is thereby defined for service-yielding final goods, and not for raw or auxiliary materials which enter the manufacturing process of the final good [8].

The whole material and energy input are indicated in kilogram or ton, measured from the beginning (raw material extraction process from the environment) until the end process (disposal of waste material to the environment).

The MIPS is the inverse of resource productivity. It also includes the materials and energy used up during the use and discarding phases of the product. Productivity of material can be measured from the model below (Fig. 4) as the ratio of the quantities C to A, while the MIPS would be equal to (A + B) / D [12].

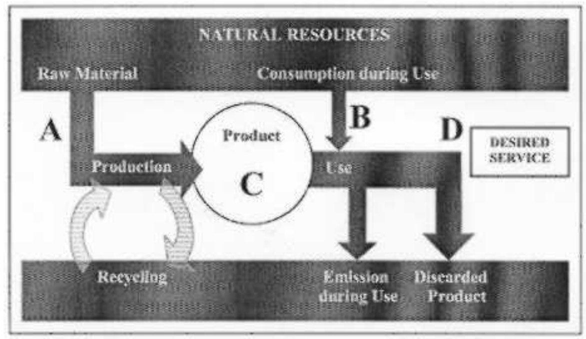

Fig. 4: Product Life Cycle according to the MIPS Concept [12].

With the help of MIPS, we can calculate, how productive we set ecological resources in, in order to utilise them. And also with the help of this method, we may able to optimise this resources insertion. Thus, MIPS is a benchmark in the best tradition of economical principles [8]:

- to achieve a certain result with a minimum input (dematerialization) and/or
- to reach a maximum result with a certain input (resource productivity).

THE DEVELOPMENT OF MIPS CONCEPT

Table I: The Development of MIPS Concept [13]

Year	Progress
1989	The first illuminating thought came from Prof. Dr. Friedrich "Bio" Schmidt-Bleek to develop a concept for dematerialization and resource productivity towards sustainable development.
1992	The beginning of the development of the MIPS Concept in the division of the Material Flow and Structural Change in the Wuppertal Institute Germany under the guidance of its Vice President, Prof. Schmidt-Bleek.
1993	Refinement of the MIPS theory and the basis of the MIPS calculation. The beginning of the material intensity analysis for certain raw material.
1994	The publishing of the book *"Wieviel Umwelt braucht der Mensch"* from Prof. Schmidt-Bleek. The establishment of Factor 10 Club by Prof. Schmidt-Bleek in Carnoules, France.
1995	Preparation of the foundation of environmental management system based on the MIPS method. Comparison of the material intensity of different processes in the utilisation of synthetic material.
1996	The publication of the book *"Ökologische Wirtschaftspolitik"* by Friedrich Hinterberger, Fredluks and Markus Stewen that deals with economic-politically conversion of the Factor 10.

The introduction and application of the MIPS concept in Europe by the European Research Network "CompETE" (Competitiveness, Employment, Technology, Environment).

CALCULATING THE MIPS VALUE

To obtain the MIPS value, we can refer to the following steps [14]:

Step 1: Characterising the Product Life Cycle scheme, into: Input, Process and Output.

- Under the column "Input" and "Process" will be listed all materials that are set to production process (from the top to down).
- Under the column "Output" are all core and by-product produced, including waste materials and emissions.

Step 2: Specifying all material inputs (MI: material and energy) from each process. The material input comprises all the materials primarily taken from nature that are needed in production. The measuring unit is the mass given in kg or ton. The energy used will be presented in kWh or MWh for electricity or MJ for fossil fuel.

Step 3: Characterising the materials into [15]:

a. *inorganic (non-renewable) material*, including:
  - mineral raw material (saleable extraction, e.g. sand and gravel, ores, etc.)
  - fossil energy carriers (e.g. coal, oil, gas)
  - non-saleable extraction (e.g. overburden, gangue, etc.)
  - excavation (e.g. for construction)

b. *organic (renewable) material*, including:
  - plant bio-mass from cultivation (agriculture and forestry)
  - bio-mass from wild harvest (e.g. fishing, hunting, harvesting)

c. *moved soil (agriculture and forestry)*, including: all soil moved at the earth's surface (i.e. all bio-geologically formed soils containing at least 2% humus, e.g. cropland, pastures, forest soils).

d. *water*, including:
  - surface water
  - ground water
  - deep ground water

e. *air*, including:
  - air for combustion
  - air as raw material for chemical/physical trans-formations

Step 4: Retrieving the value of the material intensity (MI-Value) for each material. There are 3 sources to obtain the Material Intensity Value of raw materials, which are from:

- *the "Module of Material Intensity Value"* prepared by the Material Flow and Structural Change team from the Wuppertal Institute Germany, the team that participated in the development of the MIPS Concept.
- the Table *"Material Input for Specific Raw Materials and Products"* in the book "Das MIPS-Konzept - Weniger Naturverbrauch - mehr Lebensqualität durch Faktor 10" from Prof. Schmidt-Bleek, the inventor of the MIPS Concept [8].
- the *"MIPS Measuring Tool"* in the homepage http://www.energiepark.at/mips that has been designed by PROFACTOR Produktionsforschungs GmbH and WIFI Österreich Wirtschaftskammer [16].

Step 5: Multiplying the MI-Value (obtained in step 4) with the weight of the material and energy (for each of them).

Step 6: Summing up the result of the multiplication of MI-Value and the weight of material and energy.

Step 7: Dividing the total sum (∑ MI) with the output unit or service unit (S).

$$\text{MIPS} = \frac{\text{MI}}{\text{S}}$$

Prof. Dr. Friedrich Schmidt-Bleek and Prof. Dr. Franz Lehner [6] stated:

"The higher the value of MIPS, the worse the ecological quality"

Basically, the MIPS value can be reduced in two ways. *Firstly*, the necessary material expenses to fulfil certain services may be reduced. For this, it is necessary to generally have a new technology concept. *Secondly*, the need for material prosperity may also be reduced, which then in turn sinks the supply of service goods in the community through a change a consume behaviour and new design service products. A sustainable economy is only possible -according to the present knowledge-when these two ways are followed [17].

THE ADVANTAGES AND DISADVANTAGES OF MIPS

From a technical perspective, the use of the MIPS concept has the following advantages and disadvantages.

Some advantages are mentioned below [5]:

\+ Material and energy expenditures are measured in the same units. In doing so, contradictions in the ecological evaluations are avoided, and the evaluation becomes directionally stable.

\+ The MIPS Concept helps in the design of industrial products, in the planning of environment-friendly processes, facilities and infrastructures, as well as in the ecological assessment of services.

\+ The MIPS Concept can serve as the basis for a comprehensive ecological labelling strategy, and can be an aid in purchasing decisions and customer counselling.

Some of the disadvantages of the MIPS Concept are [5]:

- The MIPS Concept does not take into account the specific "surface-use" for industrial as well as for agricultural and forestry activities. This is of considerable importance as the amount of the earth's surface available for our purposes is limited.
- The MIPS Concept does not take into account the specific environmental toxicity of material flows. The approach is not intended to supplant the quantification of Eco-toxicological dangers of materials in environmental policy, but rather to supplement it by stressing the material and energy intensity of economic services.
- The MIPS Concept makes no direct reference to questions of biodiversity. It seems fair to speculate that the chances for species survival is related to the intensity of soil and resource use. Therefore we can not exclude the notion that the material intensity of a society's economy has something to do with its contribution to species extinction.

CONCLUSION

Fundamental ecological information is ultimately important to the whole management system of the company and for the innovation management. The decision-makers of a company must have total knowledge about:

- the ecological rucksack of relevant materials,
- the company's material and energy flow of a product life cycle,
- ecological-economical trade possibilities.

By conducting the material intensity analysis with the MIPS Concept, the company can explicitly have a better understanding of those items above. The MIPS Concept enables us to compare which product or production process is more ecological than the other. We should remember that the more material we use in a production process, the more likely it has to have a bigger environmental impact.

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