Takeda Award 2001 Achievement Fact

Techno-Entrepreneurial Achievements for World Environmental Well-Being

Technical Achievement:

The development and promotion of the Ecological Rucksacks and Material Input per Unit Service (MIPS) concepts, as measures of the ecological stress of products and services

The prize is awarded jointly to Friedrich Schmidt-Bleek (Factor 10 Institute) and Ernst Ulrich von Weizsaecker (Founding President of Wuppertal Institute.)

Friedrich Schmidt-Bleek is honored for developing and promoting the Ecological Rucksacks and Material Input per Unit Service (MIPS) concepts.

Ernst Ulrich von Weizsaecker is honored for his contribution in refining and promoting the Ecological Rucksacks and Material Input per Unit Service (MIPS) concepts.

(Awardees are listed in alphabetical order.)

〈Executive Summary〉

Friedrich Schmidt-Bleek presented the Ecological Rucksacks and MIPS concepts in 1993 as broad measures of environmental stress. Mankind has benefited enormously from nature as mankind has progressed to become a rich society characterized by material wealth. At the same time, the pursuit of this type of prosperity has caused great destruction in the process of obtaining and using natural resources - excavating, extracting natural resources, and channeling water from rivers and lakes for irrigation, among other activities. Schmidt-Bleek has proposed that such dislocation of natural materials is the fundamental cause of environmental damage. Therefore, all products and services used by people carry a“ rucksack ”of all the materials displaced or processed during the life-cycle of that product or service.

This creative concept was invented by Schmidt-Bleek and termed the "Ecological Rucksack." There is an Ecological Rucksack associated with each product. It is calculated to indicate the weight of all the materials displaced in the production of the good or service. Schmidt-Bleek developed a second indicator known as Material Input per Unit Service, or MIPS, which is the ratio of the Ecological Rucksack value per unit of service provided. MIPS reflects the "real" value of the goods and services and attempts to place these in the economic product function. By associating a MIPS value with each product, companies, governments, and individuals can take into account the environmental stress created by the production of these products.

Ernst ulrich von Weizsaecker, who was president (1991-2000) of the Wuppertal Institute for Climate, Environment and Energy, invited Schmidt-Bleek to the Institute to further develop these concepts. Following collaboration between Weizsaecker and Schmidt-Bleek, the Ecological Rucksacks and MIPS concepts were extended to more refined one connecting resource productivity with energy efficiency (mainly limited to the production process of raw materials), and making clear the relationship between those concepts and toxicity or hazards.

Von Weizsaecker wrote the book, Factor 4, which introduced these important concepts globally. The Wuppertal Institute continues to undertake great efforts to disseminate these concepts and promote the collection of basic data for the calculation of MIPS in collaboration with Schmidt-Bleek.

As a result of this line of investigation, we can reduce adverse environmental stresses by designing MIPS to lower values, i.e. taking smaller Eco-Rucksack values or larger service values for each product. The values of Ecological Rucksack and MIPS are simple measures indicated by weight, and therefore they have practical use in industrial fields.

Though MIPS is an approximate value, it makes it possible to understand complex environmental stresses comprehensively. It is hoped that the use of MIPS will increase awareness of the environmental stress of different products and services and eventually intertwine the marketability of a product with its environmental stress. That is, the use of MIPS will influence economic activities by reflecting the true cost of goods and services, including environmental stress costs.

For these reasons, the development of the Ecological Rucksacks and MIPS measures is an important milestone towards creating a sustainable society. The Takeda Foundation honors this achievement for its technological creativity and bestows the Takeda Award on this achievement.

Achievement and Creativity

1. Introduction

Recent discourse on environmental problems started from discussions regarding“ end of the pipe ”technologies. Considerable research studies and substantial dialogue have been conducted on this topic. It has been suggested that if mankind continues to add environmental stress to the earth, our society will face the very dangerous prospect in the future.

In 1972, Meadows, et al., argued in *The Limits to Growth*[1] that human society would be disrupted if economic growth proceeds at its current pace.

In 1987, the World Commission on Environment and Development focused on“ Sustainable Development.[2] ”

In 1992, the first international Earth Summit convened in Rio de Janeiro, and the United Nations General Assembly passed a resolution to establish a UN Commission on Sustainable Development.

In 1992, Meadows, et al., explained in *Beyond the Limits* [3] that the rate of exhaustion of natural resources and the production of wastes by mankind was exceeding the sustainable limit, and if the use of materials and energy continues unabated, the global economy would be disrupted in several decades. They urged steps to achieve a rapid increase in material and energy efficiency.

As illustrated above, it is increasingly recognized throughout the world that humankind must reduce the rate of resource exhaustion in order to establish the sustainable economy.

2. The technological measures for environmental stresses

In 1993, Friedrich Schmidt-Bleek proposed the Ecological Rucksacks and MIPS (Material Input Per unit Service) concepts as effective technological measures for ecological management.[4] He posited that enormous amounts of ores, gravels, water and various materials that were moved by mankind add strong stress to the environment. He also created the

Ecological Rucksacks and MIPS concepts as measures that indicate the environmental stresses caused by the processing and use of goods. These environmental stresses are expressed by the weight of materials that are moved in nature in order to produce material goods. These measures describe the complicated environmental stress factors in an aggregated form. The Ecological Rucksacks and MIPS give reproducible results and effective technological measures, and thus are technologically creative.

Ernst ulrich von Weizsaecker invited Schmidt-Bleek., the inventor of the Ecological Rucksacks and MIPS concepts, to the Wuppertal Institute. Initially, the Ecological Rucksacks and MIPS concepts were mainly concerned with materials, but after the discussions with von Weizsaecker, the concepts were extended to include relationships with energy efficiency and resource productivity. In addition, relationships with toxic materials became clear. Furthermore, von Weizsaecker presented in his book [5] that the concepts were very important to our society in the 21st century. This presentation by von Weizsaecker made the Ecological Rucksacks and MIPS concepts famous worldwide.

Schmidt-Bleek and the Wuppertal Institute have been collecting basic data that are necessary to calculate MIPS and popularize the concepts under associated activities. As an example, the“ Klagenfult Innovation ”was reported [6].

3. Ecological Rucksacks and MIPS

3.1. Ecological Rucksacks

Schmidt-Bleek thought that in each product or service that we use, we are carrying “ in a rucksack ”the materials that were moved from their locations in nature to make the goods or services. These are called ecological rucksacks (Figure 1). The ecological rucksacks indicate the amounts of materials that were moved in nature to make the goods, and so the ecological rucksacks represent the degree of stress exerted by the goods on the environment.

The ecological rucksacks of goods are easily calculated. All materials used in the production of goods are listed by weight and multiplied by rucksack factors, and then summed to include all materials.

$$MI = \Sigma (Mi \cdot Ri)$$

Here, MI is the ecological rucksack or material intensity, and Mi is the weight of the material in terms of kilograms, and Ri is the rucksack factor. Figure 2 shows the process for calculating ecological rucksack of an automobile.

The rucksack factor (or MI factor) is the amount (in kilograms) of materials moved to obtain 1 kilogram of the resource. For example, Steel: 21 (One kilogram of steel carries an ecological rucksack of 21 kilograms.), Aluminum: 85, Recycled Aluminum: 3.5, Gold: 540,000, Diamond: 53,000,000, Rubber: 5.

The rucksack factors of the main essential materials necessary for economic activities have been studied at the Wuppertal Institute.

3.2. MIPS

MIPS is the material intensity per unit service or per unit function.

The measure for the environmental stress intensity is the Material Intensity Per unit Service with respect to the entire product life - MIPS. Energy consumed during the entire product life is also taken into account. MIPS are thereby defined for service-yielding, final goods. The material transportation and energy requirements for the entire product life are also taken into account.

It is now possible to show how material requirements are divided over the various process steps of the life of a service-yielding final good, including the process of manufacturing, using (operating, maintaining, cleaning), repairing, re-using (perhaps using only component parts), collecting, sorting and disposing the good. Additionally, transportation enters the calculation as an almost ubiquitous link between various steps. This is then related to the total number of deliverable (or, in hindsight, delivered) use, function or service units.

In the case of non-reusable packaging material and throwaway products (which actually vanish in landfills and are not used for other purposes), the“ S ”(Service) of MIPS is equal to one. The MIPS value in this case is equal to the aggregate amount of material for all process increments.

The MIPS value decreases as the number of service units delivered by the product rises. Each successive service unit cuts in half the value of MIPS achieved with the previous use. The MIPS value thus shrinks with each successive use, and the environmental compatibility of the product improves in step.

A sundial is the simplest example. Here, neither material nor energy is required at any time during the use of the device, and it is never cleaned. The device never needs any extra material during its service life, and so its MIPS decreases continuously.

In the case of a washing machine, the MIPS curve falls more slowly because water, energy and detergent are used in each wash cycle. If the use of water and energy rises with the age of the machine, the curve might even reach a minimum, after which it would start to rise again. If a repair becomes necessary (figure 3, point X), we have a“ MIPS stimulus, ”after which the curve begins to fall again. A repair that is very“ expensive ”in terms of material, energy or transportation (point Y) can lead to a situation in which the machine is operating at a higher MIPS value than when it was new. This would be an example of an ecologically absurd repair-if MI (the material intensity) for the distance Y-B were greater than for O-A. (In other words, if the MI value of the repaired machine is higher than the original MI value of the new machine.)

The MIPS value is calculated as follows:

$$MIPS=MI/S$$

MI is the ecological rucksack.
“ S ”is the service number, and represented as S=n･p.
“ p ”is the number of people who use the good simultaneously.
“ n ”is 1 for consuming products, and n is the number of times of usage or the amount of usage , for examples hours or surface area for durable consumer goods.
In the case of a cup of orange juice, S=1. If a person uses a bicycle for n kilometers, S equals n. If p persons use a train for n kilometers, then S equals n･p.

3.3. The relationship between MIPS and resource productivity

We are now concerned with the question of defining resource productivity as carefully as possible, so that it can increase its status as a criterion for economic and technical decision-making.

The resource productivity of a good is the total sum of available service units, divided by the total consumption of material for the service-yielding good, as calculated from cradle to grave, including the material flows needed for the purpose of providing the requisite energy. In other words, the resource productivity of a good is the inverse of its MIPS, and is measured in“ per kilogram ”terms.

Resource productivity is also called eco-efficiency. The material wealth of a region could then be expressed in terms of service units available in the region. If resource productivity rises while material consumption remains the same, material wealth increases. Put differently,“ dematerialized ”technologies can yield more service units with constant of falling material effort. Were one to increase the global resource productivity fourfold, it would be possible, under this definition, to double the number of service units and have the material inputs cut in half. Dematerializing in economic terms does not mean moving back to lower consumption; it means progress, as such a development would not be possible without concomitant technical improvements. We can refer to this as a technical approach to a sustainable economy.

3.4 What MIPS can-and cannot-do

From a technical perspective, the use of the MIPS has the following advantages:

1) Material and energy expenditures are measured in the same units. In so doing, contradictions in ecological evaluation are avoided, and the evaluation becomes directionally stable.
2) The concept can be used to set up Life Cycle Analysis at the level of screening procedures. The effort involved in the analysis is hereby dramatically reduced, and the results become directionally stable. Decisions about successive analyses can follow in the form of a phased plan.
3) The concept can serve as an instrument with which to test the ecological significance of technical procedures in light of their contribution toward a sustainable economy, as well as for measuring attendant successes.
4) The MIPS approach helps in the design of industrial products, in the planning of environmentally friendly processes, facilities and infrastructures, as well as in the ecological assessment of service.
5) The concept can serve as the basis for a comprehensive ecological labeling strategy, and can be an aid in purchasing decisions and consumer counseling.
6) The MIPS approach is suitable as a tool for distinguishing ecologically sensible recycling loops and circulation systems from those that are ecologically absurd.
7) The approach can be used to establish ecological tariffs, issue licenses, set insurance premiums, assess taxes, and to make decisions about subsidies.
8) The concept is suitable for examining various codes and standards for their ecological coherence.
9) The MIPS concept can help make decisions about what kinds of research and development projects deserve financial support.
10) The MIPS approach should be well suited to assessing technical projects which are part of development aid to the Third World, and for the former socialist countries, with respect to their environmental characteristics.
11) The concept shows promise in the context of future international harmonization because of its simplicity. This would be important for the possibility of making progress toward ecological structural change on the level of major regions such as the European Union, or worldwide.

The concept cannot cover the following problems.

1) The 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.
2) As already indicated, the MIPS approach 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.
3) The MIPS concept makes no direct reference to questions of biodiversity. It seems to speculate that the chances for species survival are related to the intensity of soil and resource use. Therefore, one cannot exclude the notion that the material intensity of a society's economy has something to do with its contribution to species extinction. The inference that some countries are not very densely populated is not helpful in this context, as the population density has no direct bearing on the material intensity of the prevailing lifestyle.

It should be noted again that the measures proposed by Dr. Schmidt-Bleek are intended as a first approximation of an indicator that can technically describe the environmental stress intensity of a highly diverse set of goods and services.

For example, in 1996, Theo Colborn [7] warned that some synthetic materials destroy the hormone system of livings. Problems such as this cannot be addressed by MIPS. It is necessary to combat such problems with materials that are nontoxic for human health.

4. Toward building a new economical model for ecological management

Human activity is mostly driven by economic market principles. Ecological management is not an exception, and is also driven by economical market principles. Many environmental experts argue that effective ecological management must also be driven by economic market principles. For example, the following description is in "Factor 10":

"Because the only arguments accepted today are economic ones. I must come up with an economic reason why nature should not be destroyed,"

(Professor Manfred Max-Neef, Universidad Bolivariana)

Economic activity by human beings has reached a level that cannot ignore limited resources, and that causes serious ecological problems. It is difficult for today's economic activity itself to solve this ecological problem. In order to solve the problem, a new economical model including ecological management, one which can be supported by people, must be created.

Ecological Rucksacks and MIPS, as technological measures, are expected to provide an actual starting point in the endeavor to build a new economic model. The service concept in MIPS is also an important concept for changing people's sense of values from owning goods to enjoying service. An interdisciplinary effort involving economists, environmentalists, and other scientists and engineers is needed to develop this model. The resulting economic model may be different from that in use today, but the new model should be promoted and anticipated.

5. CURRICULUM VITAE

Schmidt-Bleek, Friedrich

1958 Diploma, Chemistry, University of Bonn
1960 Ph.D., Nuclear and Radiation Chemistry, University of Mainz
1993-1997 Director, Dep. Of Material Flows and Eco-restructuring and Vice President of Wuppertal Institute (1994-1997)
since 1997 Founding President Factor 10-Institute

Weizsaecker, Ernst U. von

1965 Diploma, Chemistry and Physics, University of Hamburg
1969 Ph.D., Biology, University of Freiburg
1991-2000 President of Wuppertal Institute for Climate, Environment and Energy
since 1998 Member of the German Parliament
since 2000 Founding President of Wuppertal Institute for Climate, Environment and Energy

REFERENCES

1) Donnella H. Meadows et al, The Limits to Growth, New York 1972.
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5) Ernst Ulrich von Weizs ae_ker et.al., Factor 4, Droemer, Muenchen,1995.
6) F. Shmidt-Bleek, et.al., *Klagenfurt Innovation*, *Klagenfult*, 1999, ISBN390074307406, Report On An Eco-Design Training Pro gram For 50 Small And Medium Sized Enterprises.
7) Theo Colborn, et.al., *Our Stolen Future*, 1996.

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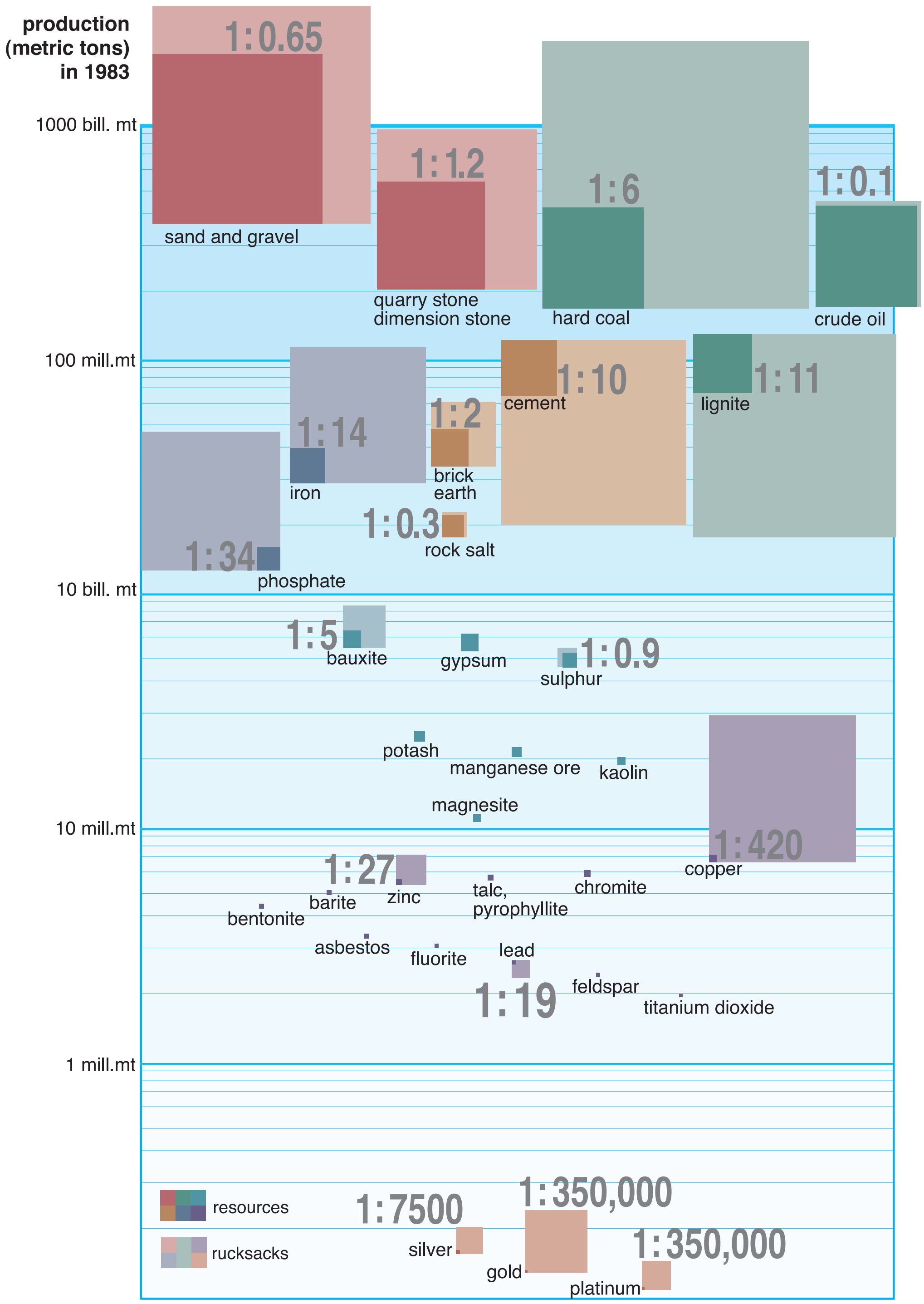
Figure 1. Ecological rucksacks (light color squares) of various base materials for world wide usage in 1983 (deep color squares)



Source: :Lütting/Walter/Merian/IEA Coal Research/US-DOG;Rucksacks:Schüty,Liedtke

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Figure 2. Example of ecological rucksack of automobile.

$$\sum (M_i \cdot R_i) = MI$$

- M_i: material (e.g. Steel, glass)
- R_i: material intensity of base material (rucksack)
- MI: total material input

$(M_1 \cdot R_1)$ e.g. steel plus rucksack

$+ (M_2 \cdot R_2)$ e.g. glass plus rucksack

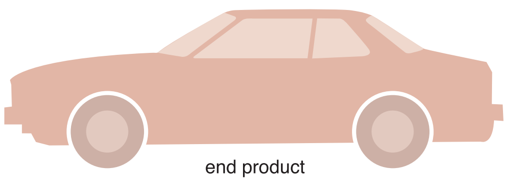
$+ (M_3 \cdot R_3)$ e.g. plastics plus rucksack

⋮

$+ (M_z \cdot R_z)$

an example of determining of ecological rucksack

e.g. an automobile



Ecological rucksack of an automobile is the sum of all ecological rucksacks of materials used.

$$MI = M1*R1 + M2*R2 + M3*R3 + M4*R4 = M5*R5 + \cdots\cdots Mi*Ri$$

used materials:steel(M1),glass(M2),plastics(M3),ceramics(M4),platinum(M5)...

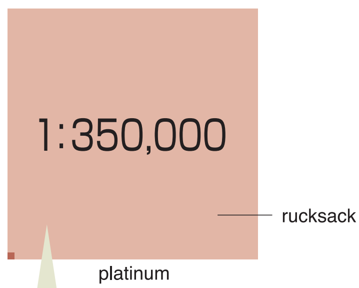
When about 3g of platinum are used in the catalytic converter in an automobile in addition high-quality steels, ceramics and other materials

Ri of platinum(rucksack factor) = about 350,000

Ecological rucksack of 1g platinum is 350kg.

ecological rucksack of 3g platinum (in kg)

$$MI = 0.003 \times 350{,}000 = 1050$$



Ecological rucksack of the catalytic converter almost equals the weight of an automobile itself

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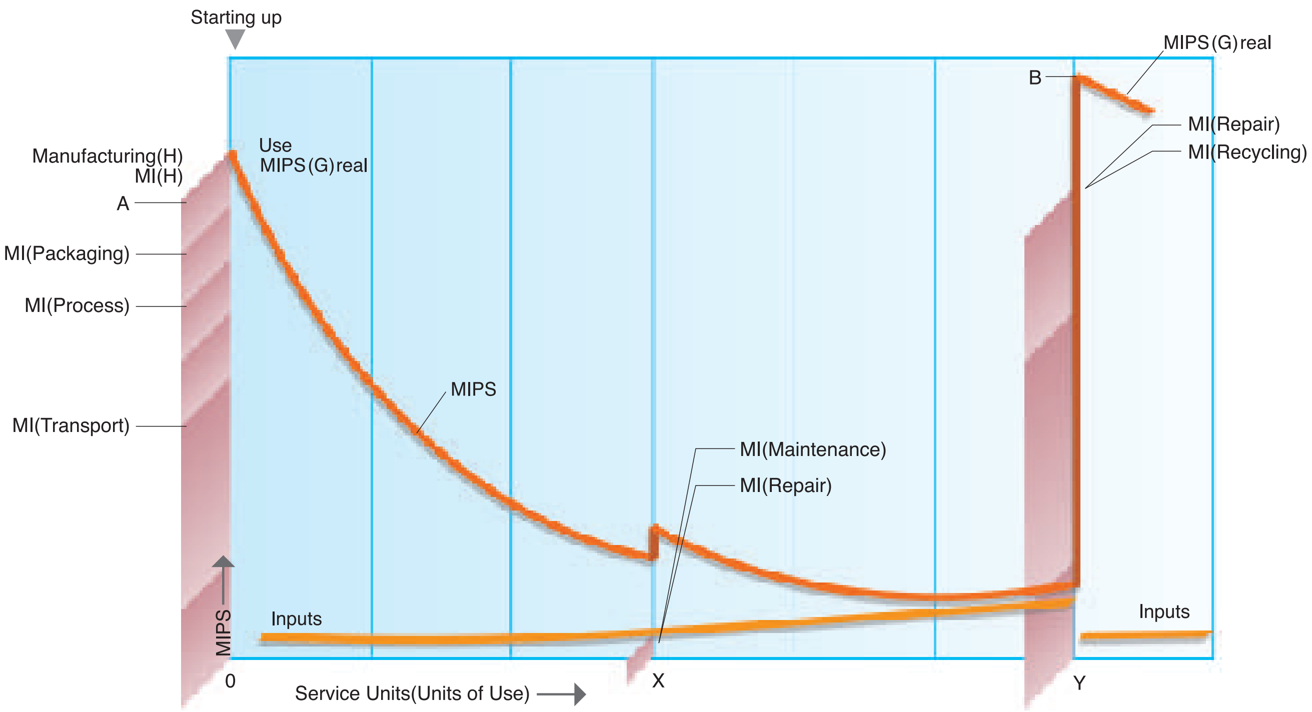
Figure 3. The MIPS trajectory with increasing numbers of extracted utility units (service units), in the case of a washing machine



The MIPS trajectory with increasing numbers of extracted service units, such as with a washing machine. In this case, though, a small repair requiring resource inputs (energy, materials, transportation etc.) was performed at point X, increasing the relative ecological rucksack of the project. At point Y, a much more substantial repair became necessary. This repair leads to an ecologically absurd result and also would most likely be a bad investment of money.