7 Ready-made Methods for Life Cycle Impact Assessment

7.1 Semi-quantitative LCIA Methods

There are several different qualitative methods for conducting an LCA. When working with a *ready-made method* one needs to do the review of the life cycle of the product or service just as in a proper full scale LCA – agree of systems boundaries, allocations etc. The difference lies in the way in which the impact assessment is performed: different impact categories are taken into account, different environmental models and equivalence factors are used for the characterisation, different reference points are used during normalisation and different ways are used when conducting the weighting phase.

The ready-made methods, among others, include:

- EPS system (Environmental Priority Strategies in product design).
- EDIP/UMIP (Environmental Development of Industrial Products, in Danish UMIP).
- Eco-points.
- Eco-indicator.
- MIPS (Material Input per Service Unit).
- Ecological footprints.

There are several more than those listed. The Eco-indicator concept seems to be the most successful one in practical LCIA applications.

In the ready-made methods there is a straightforward way to aggregate the environmental impacts into a single index or a simple set of characterisation indicators, as in the Eco-indicator. This means that the environmental impacts are measured along the same scale, and they can simply be summed up. This scale is different for the different methods. It may for example be physical-chemical properties, surface area, or weight.

When the environmental impacts, emissions etc, has been listed one goes back to a table where all the different impacts are translated into the particular scale used to make a final impact assessment.

7.2 The Eco-indicator and Eco-points

7.2.1 The Eco-indicator Methodology

The eco-indicator was first introduced in 1995 as Eco-indicator 95 by Goedkoop and co-workers [Goedkoop, 1995] to provide engineers and designers with a simple method to estimate the environmental impact of proposed design solutions. It was thus in the first place intended for internal use in com-

In this Chapter

panies when working with product development. In 1999 a more complete version was published, Eco-indicator 99. This version was adapted to European conditions. Thus the geographical dimension of the LCA was taken care of already in the database, and no special study of the local conditions for each pollutant was needed.

The Eco-indicator method is a multi-step process (Figure 7.1). It starts with the calculation of the environmental loads from the product life cycle. In the following two steps the exposure and effect of the exposure, using average European data, are calculated. Then follows the critical issue: what should be considered an environmental problem. In the Eco-indicator approach three damage categories, so-called *endpoints*, are distinguished: Human Health, Ecosystem Quality and Resources.

The three categories are not sufficiently self-explanatory, and a description of what is included in each of the three terms is necessary for building up the methodology.

The *Human Health* category contains the idea that all human beings, present and future, should be free from environmentally transmitted illnesses, disabilities or premature deaths.

The *Ecosystem Quality* category contains the idea that non-human species should not suffer from disruptive changes in their populations and geographical distribution.

The *Resources* category contains the idea that nature's supply of non-living goods, which are essential to human society, should be available also for future generations.

It would also be possible to select other damage categories, such as material welfare, happiness, equality, safety, etc., but in the Eco-indicator methodology they are not included. This is partially because it is too complex to define or model such damage categories, and partially because in general products can have both an intended positive effect as well as a negative (environmental) effect. This may for instance lead to the strange conclusion that pesticides have a strong positive effect on human welfare (e.g. because of increased food production), while at the same time Human Health (because of their toxicity) could be threatened.

Figure 7.2 shows in general the Eco-indicator methodology. The white boxes refer to the procedures; the other boxes refer to the (intermediate) results.

7.2.2 Eco-indicator for Human Health

The health of any human individual, being a member of the present or a future generation, may be damaged either by reducing the duration of his or her life by premature death, or by causing a temporary or permanent reduction of body functions (disabilities). The environmental sources for such damages include e.g.:

- Infectious diseases, cardiovascular and respiratory diseases, as well as forced displacement due to the climate change.
- Cancer as a result of ionizing radiation.
- Cancer and eye damages due to ozone layer depletion.
- Respiratory diseases and cancer due to toxic chemicals in air, drinking water and food.

These types of damages represent important threats to Human Health caused by emissions from product systems. The

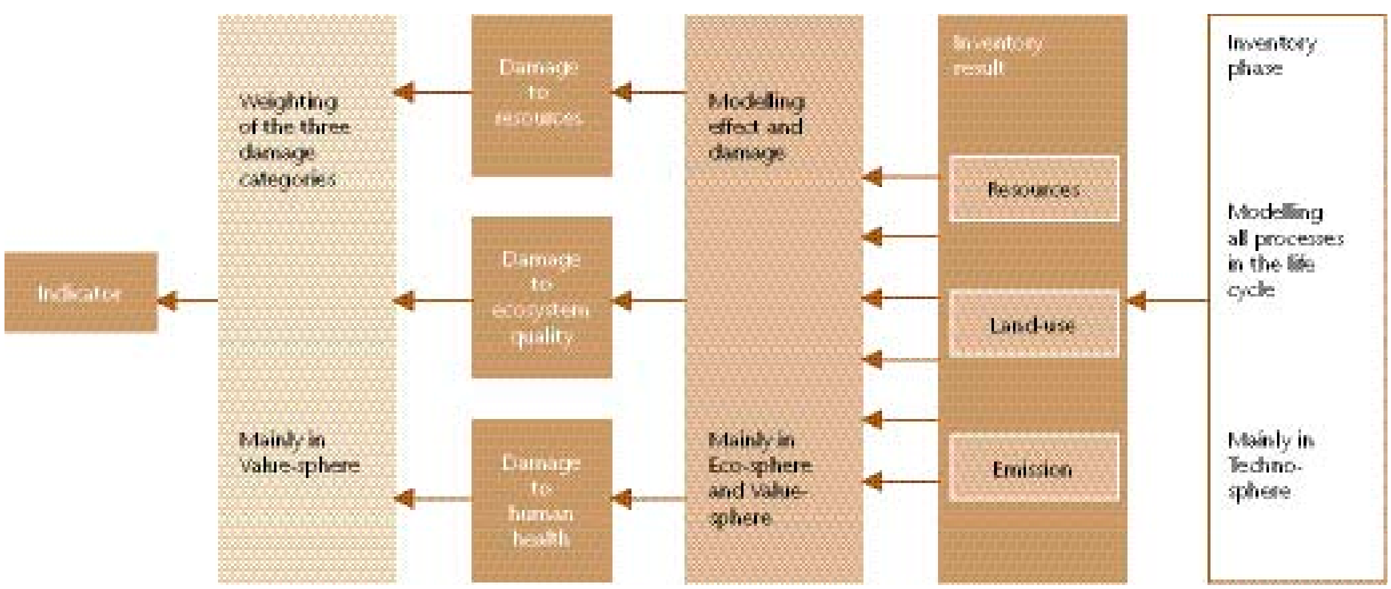

Figure 7.1 *The eco-indicator concept [Goedkoop, 1995].*

damage category is, however, far from complete. For instance, health damage from emissions of heavy metals such as Cd and Pb, of endocrine disrupters etc. as well as health damages from allergenic substances, noise and odour are not yet modelled in Eco-indicator 99.

7.2.3 Eco-indicator for Ecosystem Quality

Ecosystems are very complex, and it is very difficult to determine all damage inflicted upon them. An important difference compared with Human Health is that even if you could, you are not really concerned with the individual organism, plant or animal. The species diversity is used as an indicator for Ecosystem Quality. You can express the ecosystem damage as a percentage of species that are threatened or that disappear from a given area during a certain time.

For *ecotoxicity*, Eco-indicator 99 uses a method recently developed in the Netherlands for the Dutch Environmental Outlook [Van de Meent et al., 1997]. This method determines the Potentially Affected Fraction (PAF) of species in relation to the concentration of toxic substances. The PAFs are determined on the basis of toxicity data for terrestrial and aquatic organisms like microorganisms, plants, worms, algae, amphibians, mollusks, crustaceans and fish.

The PAF expresses the percentage of species that is exposed to a concentration above the No Observed Effect Concentration (NOEC). A higher concentration caused a larger number of species that are affected. The PAF damage function has a typical shape as shown in Figure 7.3. A Logistic PAF-curve expresses the potential affected fraction of species at different concentrations of a substance.

When a chemical is emitted in an area, its concentration in the area will increase temporarily. This change in concentration will cause a change in the PAF value. The damage caused by the emission of this substance depends on the slope of the curve in a suitably chosen working point.

Being based on NOEC, a PAF does not necessarily correspond to an observable damage. Even a high PAF value of 50% or even 90% does not have to result in a really observable effect. PAF should be interpreted as toxic stress and not as a measure to model disappearance or extinction of species.

For *land use*, Eco-indicator 99 also uses the Potentially Disappeared Fraction (PDF) as an indicator. In this case however, you do not consider target species but all species. The damage model is rather complex, and include four different models:

- The local effect of land occupation.
- The local effect of land conversion.
- The regional effect of land occupation.
- The regional effect of land conversion.

The local effect refers to the change in species numbers occurring on the occupied or converted land itself, while the regional effect refers to the changes on the natural areas outside the occupied or converted area. The regional effect was first de-

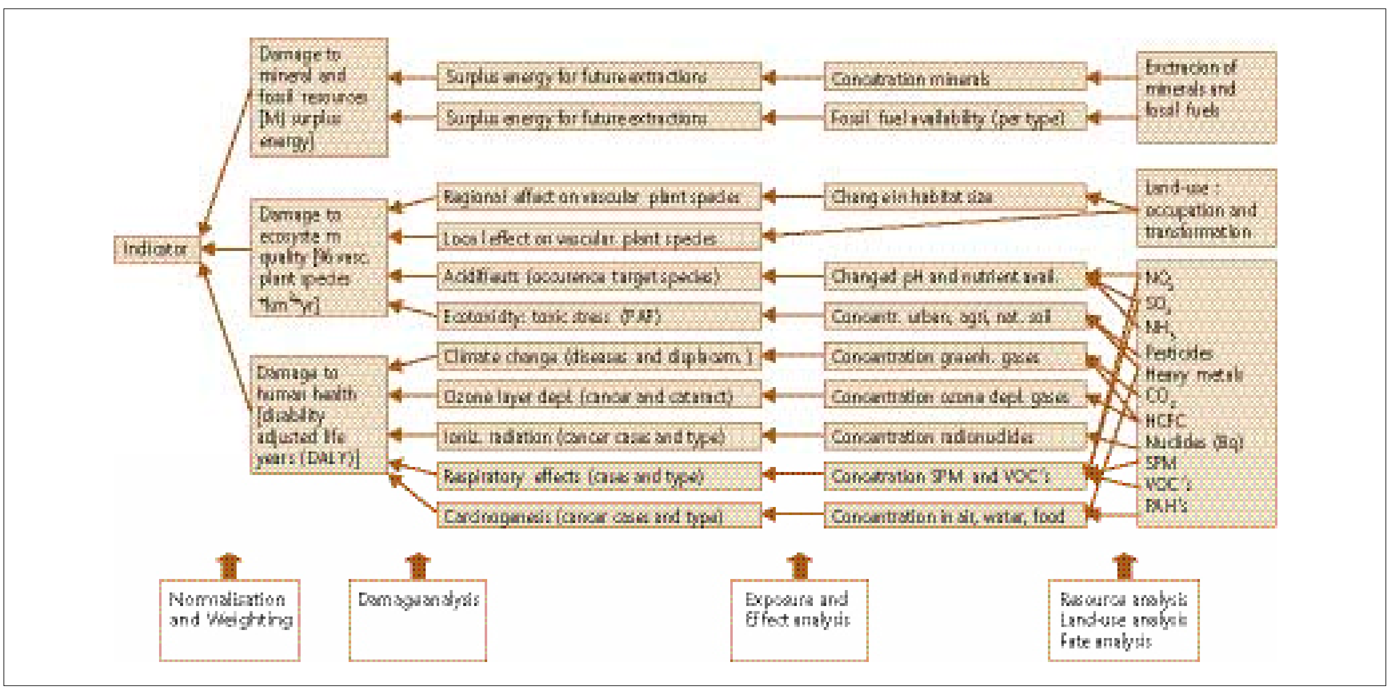

Figure 7.2 *Eco-indicator methodology [Goedkoop, 1995].*

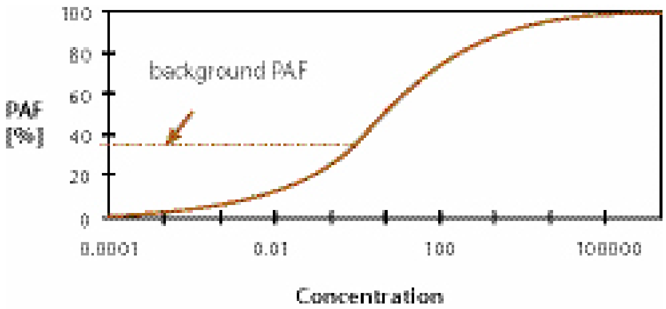

Figure 7.3 *The PAF-curve, Potentially Affected Fraction of species as a function of the concentration of a single substance (%) [Goedkoop, 1995].*

scribed by [Muller-Wenk, 1998]. The data for the species numbers per type of land-use and some of the concepts used for the local effect are based on [Köllner and Jungbluth, 1999].

The data on the species numbers are based on observations, and not on models. The problem with this type of data is that it is not possible to separate the influence of the type of land use from the influence of emissions. For this reason special care must be taken to avoid double counting of effects which are included in land-use and which could be included also in other damage models.

The Ecosystem Quality damage category is the most problematic of the three categories, as it is not completely homogeneous. As a temporary solution one may combine PAF and PDF.

7.2.4 Eco-indicator for Resources

In the case of non-renewable resources (minerals and fossil fuels), it is obvious that there is a limit on the human use of these resources, but it is rather arbitrary to give data on the total quantity per resource existing in the accessible part of the earth crust. The sum of the known and easily exploitable deposits is quite small in comparison with current yearly extractions. If one includes occurrences of very low concentrations or with very difficult access, the resource figures become huge. It is difficult to fix convincing boundaries for including or not-including occurrences between the two extremes, as quantity and quality are directly linked.

To tackle this problem, the Eco-indicator methodology does not consider the quantity of resources as such, but rather the qualitative structure of resources.

Market forces assure that the deposits with the highest concentrations of a given resource are depleted first, leaving future generations to deal with lower concentrations. Thus in theory, the average ore grade available for future generations will be reduced with the extraction of every kilo. This decreasing concentration is the basis for the resource analysis.

The resource analysis is quite comparable to the fate analysis; instead of modelling the increase of the concentration of pollutants, we model the decrease of the concentration of mineral resources.

Chapman and Roberts [1983] developed an assessment procedure for the seriousness of resource depletion, based on the energy needed to extract a mineral in relation to the concentration. As more minerals are extracted, the energy requirements for future mining will increase. The measure of damage used in the Eco-indicator for resource extraction is based on this work. It is the energy needed to extract a kg of a mineral in the future. Much of the data is supplied by [Muller-Wenk, 1998].

7.2.5 Calculating the Eco-indicator Value

The Eco-indicator values for a certain impact are expressed as a sum of impacts for each of the three categories. Each of the impact categories are expressed in one unit. Impact on human health is expressed as DALY, Disability Adjusted Life Years, that is the number of years of life lost and the number of years lived disabled. Impact on ecosystem quality is expressed as the loss of species over a certain area during a certain time PDF *x* m^2 *x* year (PDF=Potentially Disappeared Fraction). Depletion of resources is expressed as surplus energy needed for future extractions of minerals and fossil fuels. The principle of damage assessment is shown in Figure 7.4, [Goedkoop and Oele, 2001].

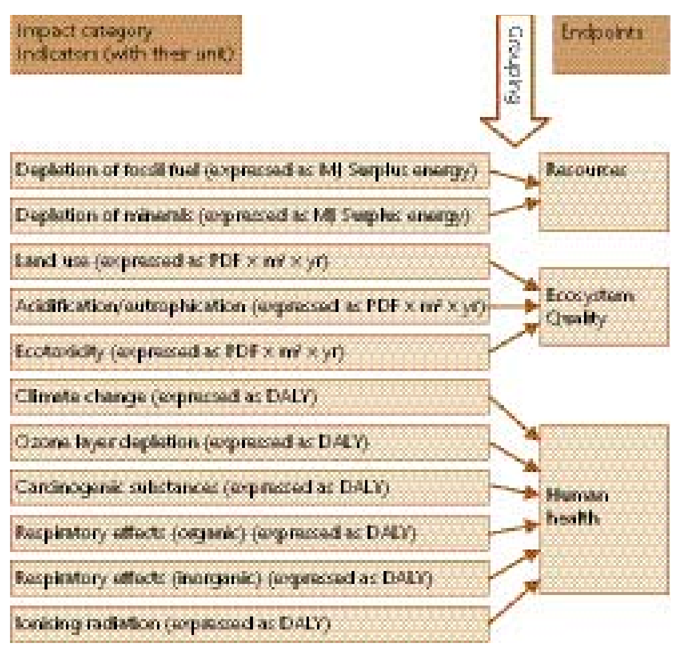

Figure 7.4 *Principle of damage assessment in Eco-indicator 99.*

In the Eco-indicator tables published by Goedkoop and Spriensma [1999] the seriousness of the impact is judged from three perspectives, the hierarchist, the egalitarian and the individualist perspectives. The egalitarian uses the precautionary principle systematically and a long-term view is applied. This means that nothing is taken for granted and a maximum possible impact is used for the indicator. The individualist uses only proven effects of a certain impact when calculating the Eco-indicator value. Finally the hierarchist uses impacts, which are substantiated by scientific facts, but not necessarily demonstrated in actual cases. The hierarchist values normally end up between the other two (Table 7.1; See also Box 2.5 for further explanations of the three concepts).

When including all three in a report on the life cycle impact assessment of a future product, it will give an idea of the range of possible future impacts as judged by the Eco-indicator 99 method. In this way a final report will contain nine values, three perspectives for each of three damage categories. In addition one needs to be aware that a number of possible environmental effects are not treated in the Eco-indicator 99 method.

7.3 Proxy Methods

7.3.1 Using Single Dimensions to Asses Environmental Impact

Proxy methods are those where a single dimension is used to reflect the total environmental impact of a product or service.

Very early on, *energy consumption* was used to estimate the total impact of a product. Cramer et al. [1993] used the reduction of energy consumption to assess the improvement of a product over its predecessors. In a life cycle perspective it is important to include energy use in all stages of a product or service, extraction of resources, large e.g. for aluminium, production stage, use phase and waste phase. All other kinds of impact are then assumed to be roughly proportional to energy use.

Money can also be used as a proxy parameter for environmental impact. The costs of controlling and reducing impacts are added up using the target values in permits according to environmental authorities. Money is also used as a parameter in the EPS method (see below) then using the willingness-to-pay for avoiding the impacts to estimate the costs.

Table 7.1 Weighting indices according to Eco-indicator 99. *Selected illustrative data from Goedkoop and Spriensma [1999], based on distance-to-target principle, and as seen from three different cultural perspectives; hierarchist, egalitarian and individualist. (See also Box 2.5).*

Substance	Damage category	Hierarchist weights	Egalitarian weights	Individualist weights
Resource use (/kg)				
Coal (29.3 MJ/kg)	Resources	0.00599	0.0687	0
Crude oil (41 MJ/kg)	Resources	0.140	0.114	0
Natural gas (30.3 MJ/kg)	Resources	0.108	0.0909	0
Aluminium ore (Bauxite)	Resources	0.0119	0.0168	0.667
Copper ore	Resources	0.00987	0.0140	0.553
Iron ore	Resources	0.000690	0.000976	0.0387
Zinc ore	Resources	0.00178	0.00253	0.10
Ecosystem quality land use (/m² year or /m²)				
Industrial area	Occupation (/m² year)	0.0655	0.0819	0.0466
Industrial area	Conversion (/m²)	1.96	2.45	1.39
Forest land	Occupation (/m² year)	0.00858	0.0107	0.00610
Farm land	Occupation (/m2 year)	0.0897	0.112	0.0637
Farm land	Conversion (/m²)	2.68	3.35	1.91
Emission to air (/kg)				
CO	Human health, respiratory	0	0.00579	0
CO_2	Human health, climate	0.0297	0.0222	0.0497
NH_3	Human health, respiratory	0.0902	0.673	0.938
NH_3	Ecosystem quality	1.21	1.52	0.863
NH_3	Sum, NH_3 to air	2.112	2.193	1.801

In the MIPS method *material flows* caused by the production, use and wasting of a product or service are used as a proxy parameter. The MIPS method has been carefully evaluated and it is argued that the material flows are roughly proportional to toxic flows and other impacts, which should make MIPS a valid proxy method.

Surface area use is a proxy method in the ecological footprint method. In this method a calculation is made of the area in nature used for the services a product needs. This method is today the most widely used proxy method for estimating the total impact of a person, household, a city or a country.

7.3.2 The MIPS Methodology

Material Input Per Service unit, MIPS, is a concept developed by the Wuppertal Institute for Climate, Environment and Energy, Germany. It was developed to answer the question of how flows of materials (abiotic materials, water and air) in nature are mobilized to provide a certain product or service in society. From a practitioner's point of view the algorithm used in a MIPS analysis is entirely different from the methodologies presented so far. In practice the analysis is performed in the following stages:

1. Firstly, the life cycle of the product to be investigated is defined, and the relevant data describing of material and energy consumption during successive life stages is gathered.
2. The data for material and energy consumption expressed in appropriate units are multiplied by corresponding coefficients derived from a MI, *material intensity*, database in three categories: water, air and abiotic resources.
3. The results are summed up to obtain overall environmental loads for each life stage or the whole life cycle. The life stages which cause the highest environmental burden can be identified with the most exploited part of the environment (water, air or abiotic resources) indicated. For a comparative LCA analysis, the most preferable option can be chosen.

Table 7.2 *Examples of MIPS indices, or material itensities, MI (http://www.wupperinst.org/Projekte/mipsonline).*

Materials/products/modules	Abiotic materials (t/t)	Water (t/t)	Air (t/t)
Primary steel	7.0	44.6	1.3
Secondary steel	3.5	57.5	0.6
Copper	500	1378.6	2.0
Aluminium	85.0	1379.0	10.0
Plastics	8.0	117.7	0.7
Glass	3.0	11.7	0.7
Fuel	2.5	11.7	3.3
Operating liquids	1.2	4.3	3.1
Non-electric energy	1.4	9.5	3.1
Oil	1.2	4.3	3.1
Tyres	2.9	19.4	0.7
Road infrastructure maintenance	150	211.7	5.1
Peripheral infrastructure	21.2	319.6	2.4
Car maintenance	12.52	92.5	1.6
	kg/unit	**kg/unit**	**kg/unit**
Autocatalysts	2000.0		
Car washing	27.5	583.7	3.5
	kg/kWh	**kg/kWh**	**kg/kWh**
Process (electric) energy	4.7	93.1	0.6
	kg/tkm	**kg/tkm**	**kg/tkm**
Transport	0.25	1.8	0.1

7.3.3 Calculation of MIPS

The MIPS is a material intensity concept, a measure of the quantity of materials consumed to provide a certain service. MI indices show how much water, air and abiotic resources are needed on average to produce a unit amount of a certain material. For example to obtain 1t of primary steel 7t of abiotic resources, 44.6t of water and 1.3t of air are used. Thus much more resources – a total of 53 tonnes – are used to produce a smaller amount of useful product – 1 tonne of steel. As a consequence, these material flows result in various kinds of emissions, exhaustion of resources etc, which can lead to different environmental damage and effects on health. The material that is moved or extracted but not included in the final product is called "the ecological rucksack".

The MIPS database, which can be found on the Internet, consists of calculated indices for basic chemicals, building materials, etc, which usually are inputs in industrial systems. Unfortunately, the data do not cover all of possible inputs but just the most common of them, which is the major weakness of the method. Still several hundreds MI indices are available. (see Internet Resources). Examples of MI indices are given in Table 7.2.

7.3.4 Strength and Weaknesses of MIPS

The MIPS method is useful to estimate the material flows and ecological rucksacks associated with many services. The MIPS method is clear and easy to implement, allows quick assessment and gives the result as a single value, a kind of environmental index. A MIPS analysis is possible to carry out with a simple calculator, which is also an advantage. This feature makes MIPS analysis suitable for screening.

There are also several drawbacks, not surprising considering that it is a simple method. First it does not cover all important impact categories. Even if it shares this weakness with practically every LCIA method, it is more evident here. Most often mentioned is that some ecological rucksacks are trivial and does not represent serious environmental impacts. Thus moving gravel, sand and stone, often for building purposes, are not necessarily environmentally serious, but may result in a large MIPS value. A second criticism is that toxic effects or materials are not evaluated separately, that is, MIPS is only a quantitative, not qualitative, method. One may however do this and derive what is called TIPS (Toxicity Input Per Service unit) or refer to the observation that as an average the material flows in practice is proportional to toxic material flows. Still, if toxicity should be considered properly for a specific product or service, a more advanced LCIA is required, either an eco-indicator analysis or a full LCA.

The results obtained with the aid of MI indices are not good enough to be used externally as marketing claims. However the MIPS analysis shares this limitation with most present LCIA methods.

7.3.5 The Ecological Footprint Method

The concept of the *ecological footprint* was introduced by Wackernagel and Rees [Wackernagel and Rees, 1996] in the late 1980s and early 1990s. The idea was to reduce all ecological impacts of a product or service to the surface area in nature that was necessary to support its use /production. They argued that any production or other service in society is dependent on one or several *ecological services*, and that each of these required a small area in nature. The sum of these areas constituted the footprint of that production or service. Five main categories of ecological services were considered:

Box 7.1
How to Calculate the Ecological Footprint

It is easiest is to calculate a footprint for a country since the statistics needed are usually available on a national basis. The energy used, food products, built areas, paper consumed etc., all in the national statistics, may be converted to per capita by dividing by the number of inhabitants.

Detailed statistics are used for the calculations. For example what is the footprint of a daily newspaper? One tonne of paper requires 1.8 m^3 of wood. This is compared to the productivity of 2.3 m^3/ha/yr (an approximate value for Baltic region forests), yielding 0.78 ha. Since a common daily paper itself weighs some 100 kg a year, it has a footprint of 0.078 ha. This is an underestimation since many components, for example energy and transport, were not included. On the other hand the use of recycled paper decreases the figure, up to three times (up to 2/3 of the fibres may come from recycling).

For energy calculations three methods have been used. For 100 Gigajoules biomass, some 1.25 ha land will be needed. If wood is converted into ethanol we get the same figure, 1.25 ha. If we estimate the area needed for CO_2 absorption corresponding to the same amount, it is 1.0 ha. The area for producing 100 Gigajoules is much smaller for windmills and hydropower stations.

Source: M. Wackernagel and W. Rees (1996), Our Ecolgical Footprint. Reducing human impact on the Earth.

1. *Agricultural land*, needed for food production, grain or meat.
2. *Forest land*, needed for production of fibres, timber, paper etc.
3. *Energy land*, needed for production of energy, calculated as biomass or other forms of energy, such as ethanol from grain or methanol from wood
4. *Waste sinks*, land to absorb waste, such as carbon dioxide or nutrients.
5. *Built land*, used for infrastructure, buildings, roads, etc.

The calculation of a footprint is possible by quite simple methods (http;//www.footprintnetwork.org). The results and methods are very useful for pedagogical purposes. It is easy to understand, even for small children, and it demonstrates clearly that no service or products can appear unless some ecological services are used. As an exercise it is possible to calculate the ecological footprint of your daily newspaper (Box 7.1). When a more sophisticated LCA analysis of the newspaper is not possible, the calculation of a footprint may suffice for the purpose at hand, and of course it is much quicker.

The method has several weaknesses. The footprints do not include impact on humans; the capacity of nature to absorb many of the emissions of a modern production are not reflected; the damages to ecosystems is not properly included.

Nor is the exact value of the footprint without weak points. The importance of marine areas for ecological services is not normally taken into account, nor are different types of natural areas, even though these have different capacities to provide the services in question. Thus the absolute values of footprints may be questioned. Still if the same factors are used in the calculations, comparisons of products or services should be valid.

7.4 Ready-made Methods for Design of Industrial Products

7.4.1 EPS, Environmental Priority Strategies

EPS was created to provide designers with a simple means to compare products or product designs using a single score. EPS stands for Environmental Priority Strategies in Product Design. It was originally devised by Ryding and Steen [1991] for the Volvo Car Company in Sweden. It has later been further developed [Steen and Ryding, 1992 and Steen, 1999].

EPS addresses five categories of impact:

1. Human health,
2. Biological diversity,
3. Ecosystem production capacity
4. Abiotic resources and
5. Cultural and recreational values

Each of these has several sub-categories, called *unit effects*. An example of a unit effect is the decreased production of 1 kg of crop seed or wood or fish caused by an emission (a unit effect of category 3 Ecosystem production capacity). The effects are expressed in the unit of economic value as measured by the willingness-to-pay to avoid the effect. The price of avoiding the unit effect thus serves the purpose of being a weighting factor in the EPS method. The method lists known impacts and for each of them an uncertainty factor. (This uncertainty factor addresses the same problem that the Eco-indicator method handles by giving three values.)

The EPS method starts as always by assessing the impact or emissions from each life stage of a product. One then translates each emission into a price based on its effect on each unit effect. The sizes of the impacts are then multiplied by the respective index (price) and summed up.

7.4.2 Calculating the EPS Index for Emission of one kg of Mercury

By way of illustration we will calculate the EPS index for the emission of 1 kg of mercury [data from Steen, 1999a and 1999b]. Emission of mercury is common e.g. in combustion of coal in a coal-fired power plant, or in incineration of household solid waste. Reduction of mercury emissions is possible with proper flue gas cleaning. The EPS index can be used in product development but in this case also for a cost-benefit analysis regarding the installation of flue gas cleaning equipment.

For the Human Health category it is assumed that 400,000 persons are affected per year. 1 kg of Hg is 1.2×10^{-8} of the global annual emissions. The value of the unit effect is set to 10,000 Euro/person/year. The indicator value is thus the product of these three or 48.08 Euro.

For the Ecosystem Production category only effects on fish are considered. It is assumed that 18,500,000 kg of fish is affected. As before, the contribution to global annual emissions is 1.2×10^{-8}. The value for avoiding the effect is for one kg of fish set at 1 Euro per kg. The product 0.22 Euro is the indicator value for the category Ecosystem Production.

For the Biodiversity category the EPS method uses the NEX index, the Normalised Extinction of Species reported for the 1990s. It is 0.01 for mercury. As before, the contribution to global annual emissions is 1.2×10^{-8}. The value of avoidance is 110×10^{9} per NEX. The product for this category is 13.2 Euro.

For the Cultural Values category there is no defined impact, and the Abiotic Resources category is not used for emissions. The sum of the index for the impact of one kg of emitted mercury is thus 61.5 Euro.

7.4.3 EDIP Environmental Development of Industrial Products

EDIP was created in Denmark with the purpose of making possible the comparison of products or product designs in Danish industry using a single score [Wenzel et al., 1997]. The impact categories used in EDIP include global warming, ozone depletion, acidification, eutrophication, waste, persistent toxicity, ecotoxicity, human toxicity, and work environment. The toxicity values are based on physicochemical data such as bioaccumulation potential (expressed as water-octanol distribution, k_{ow} coefficient), and concentration in air inhaled.

Each impact is then divided by the total impact in the relevant geographical area, such as a country. In this way an estimate of the relative contribution to the total impact is received. The fraction of each category is then multiplied with a weighting factor to reflect its severity. The products are then added up to a total index. Weighting is done using Danish statistics.

The result is thus an index, which is a dimensionless number.

Study Questions

1. Describe how you work with the Eco-indicator method.
2. Describe the MIPS methodology, and its strengths and weaknesses.
3. Describe the ecological footprint methods, and its strengths and weaknesses.
4. Describe the EPS method.
5. Discuss differences between Eco-indicator, MIPS and ecological footprint.
6. How do you understand impact categories and damage categories?
7. What is an ecological service?
8. Clarify the notion of Hierarchist, Egalitarian and Individualist understanding of seriousness of impact.

Abbreviations

EDIP Environmental Development of Industrial Products.
EPS Environmental Priority Strategies in product design.
DALY Disability Adjusted Life Years.
LCA Life Cycle Assessment.
LCIA Life Cycle Impact Assessment.
MIPS Material Input per Service Unit.
NEX Normalised Extinction of Species.
NOEC No Observed Effect Concentration.
PAF Potentially Affected Fraction.
PDF Potentially Disappeared Fraction.

Internet Resources

PRé Consultants: Eco-indicator 95
impact assessment & ecodesign method
http://www.pre.nl/eco-indicator95/

PRé Consultants: Eco-indicator 99
impact assessment & ecodesign method
http://www.pre.nl/eco-indicator99/

The Wuppertal Institute
http://www.wuppertalinst.org

The Wuppertal Institute – The MIPS database (MI indices)
http://www.wupperinst.org/Projekte/mipsonline/

The Global Footprint Network
http://www.footprintnetwork.org/

A simple way to calculate your own footprint
http://www.bestfootforward.com/footprintlife.htm

Centre for Environmental Assessment
of Product and Material Systems, CPM,
Chalmers University of Technology – tools for LCIA
http://www.cpm.chalmers.se/freetools.htm

Software Tools Collection at Tufts University,
MA, USA (Gloria, 2005).
http://www.life-cycle.org/

Information at ESU-services
(energy-materials-environment) of Rolf Frischknecht.
http://www.esu-services.ch