Ministry of Housing, Spatial Planning and the Environment

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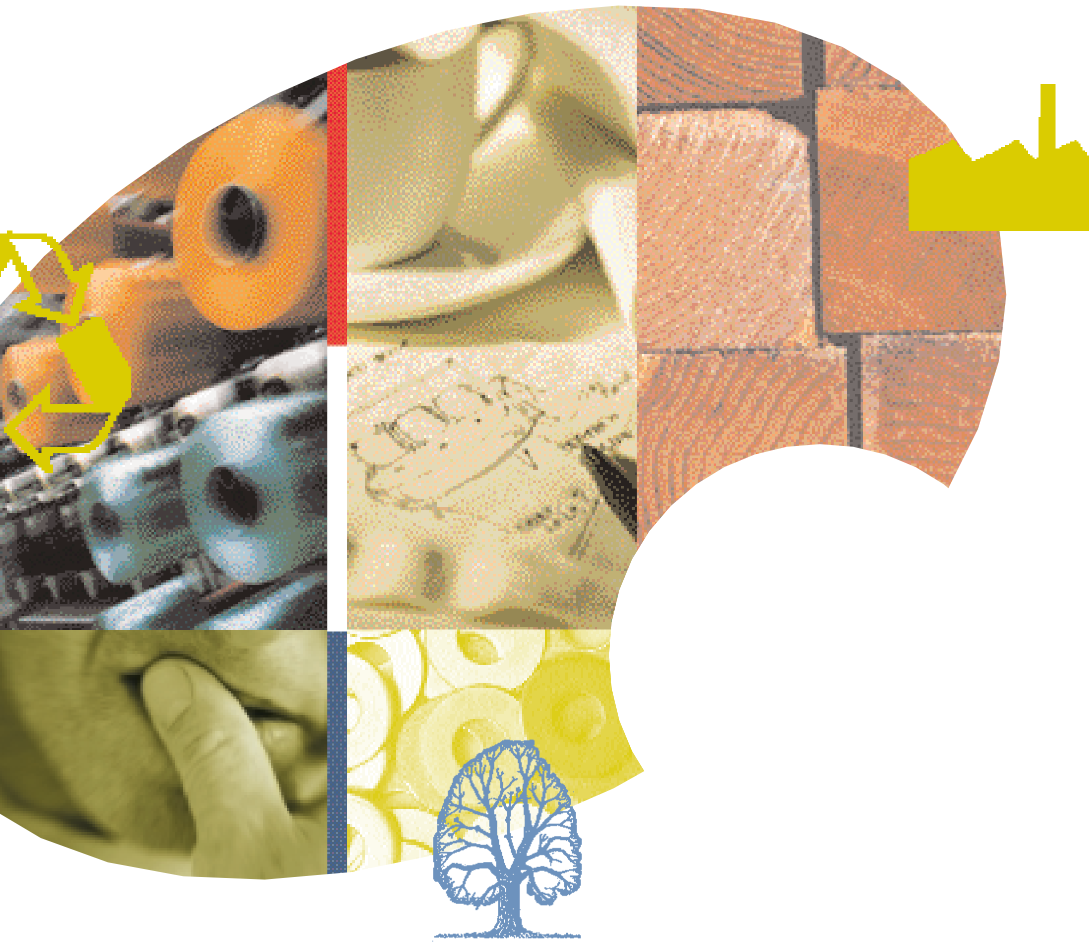
Eco-indicator 99 Manual for Designers

A damage oriented method for Life Cycle Impact Assessment



The Eco-indicator 99

A damage oriented method for Life Cycle Impact Assessment

Manual for Designers

Stay updated via the Eco-indicator 99 e-mail user group

In order to receive feedback from you and to be able to send updates we have established a free e-mail user group. The discussion will be monitored and controlled by the development team. This team will encourage factual and concise discussions focussed especially on the Eco-indicator 99 applications and the methodology.

To join the Eco-indicator Internet User Group simply send an empty e-mail to: join-eco-indicator@lists.lyris.net

After confirmation you receive a welcome message with simple instructions and some “house” rules. From that moment, until you unsubscribe you will receive all e-mail send to the user group and of course, you can send e-mail yourself.

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Preface

Sustainable production and consumption can only be achieved if all market actors take their own responsibility. The ultimate goal is therefore taking into account environment in every decision making process by industry, retailers and consumers. This is a steadily growing process that needs to be fostered by sufficient incentives both from the demand as the supply side. To this end a comprehensive set of policy instruments has been developed in the Netherlands under the label of Integrated Product Policy (IPP).

At the centre of IPP is the introduction of Product Oriented Environmental Management System [POEM] which is being developed in a concerted action both by industry and by government in recent years. The objective of POEM is to establish a systematic drive for continuous improvement of the life cycle environmental performance of products within all sorts of enterprises by integrating environmental aspects in strategic management decisions.

POEM has to be seen as an elaboration of Environmental Management System that focuses particularly on product development and product (re)design. The complexity of the decision process involving all environmental aspects means very often an unbridgeable gap for designers. Although life cycle assessment [LCA] is a good tool to assess the environmental performance of a product, and although it is widely used by designers, LCA is time consuming and costly. Designers have to make many decisions especially when designing complex products. Moreover the results of LCA are mostly not straightforward in favour of one product or material design over the alternative one. Results of LCA have to be interpreted or weighed. The Eco-indicator 95 methodology is an LCA weighing method specially developed for product design. This method has proved to be a powerful tool for designers to aggregate LCA results into easily understandable and user-friendly numbers or units, the so-called Eco-indicators.

The Eco-indicator '95 methodology is being used very often by designers but is criticised by environmental experts at the same time because some environmental aspects were not accounted for in the method. The new Eco-indicator 99 method includes many more aspects and is therefore more complex than the 95 version but the resulting Eco-indicators are still the same user-friendly units.

The weighing system between the different environmental aspects - the core of the Eco-indicator method - has also been changed. The 1995 Eco-indicator used the so-called Distance-to-Target approach. This method was criticised because there was no clear-cut objective way to define sustainable target levels. This problem is in the present Eco-indicator method avoided by introducing a damage function approach. The damage function presents the relation between the impact and the damage to human health or to the ecosystem.

Contributions of many LCA experts have been merged in this 99 method. I would particularly acknowledge the contributions from several Swiss Experts and of the National Institute of Public Health and the Environment [RIVM].

The Eco-indicator 99 does reflect the present state of the art in LCA methodology and application. This of course does not mean that all problems are solved. Further developments in environmental science, material technology and LCA methodology will take place and should result in future improvements of the Eco-indicator. But we are convinced that the revised Eco-indicator methodology is sufficiently robust to play an important role in eco-design for the next years.
I hope the Eco-indicator 99 method and the resulting Eco-indicators shall contribute to the incorporation of environment in product development decisions.

Director Industry- and Consumer Policy

Harry Baayen

The application of standard Eco-indicators

This manual is intended to be used by for designers and product managers that want to apply the standard Eco-indicator values for the assessment of environmental aspects of product systems. Although the application of these standard values is basically very simple it is very important to understand some of the backgrounds, the features and the limitations. This manual aims to give this information.

1.1 Standard Eco-indicators

Standard Eco-indicators are numbers that express the total environmental load of a product or process. These indicators can be found on separate pages in the back cover of this report. With appropriate LCA software it is possible to calculate additional indicators. News about updates and additional indicators can be obtained by registering in the internet Eco-indicator usergroup (see text box on the contents page).

With the standard eco-indicators any designer or product manager can analyse the environmental loads of products over the life cycle. Next to this different design alternatives can be compared. This report describes the application of the standard indicators as well as the inherent limitations.
The standard Eco-indicators are calculated with a rather complex methodology. This methodology is summarised in a popular way in chapter 5. For an in depth description we refer to the Methodology report “The Eco-indicator 99 Methodology report” and the annexe report. These can also be found on the internet (www.pre.nl).

1.2 Environmental effects of products

Every product damages the environment to some extent. Raw materials have to be extracted, the product has to be manufactured, distributed and packaged. Ultimately it must be disposed of. Furthermore, environmental impacts often occur during the use of products because the product consumes energy or material. If we wish to assess a product’s environmental damage, all it’s life cycle phases must therefore be studied. An environmental analysis of all the life cycle phases is termed a Life Cycle Assessment, or LCA for short[1].

[1] Frequently a distinction is made between full and screening LCAs. Screenings are often based onstandard databases. An Eco-indicator analysis can be regarded as a screening LCA. A good introduction in the LCA methodology is "Beginning LCA, a guide into environmental Life Cycle Assessment, NOH report 9453", issued by Novem in Utrecht (the Netherlands). Also LCA software demos can be a good introduction into the subject.

To date, a designer, wishing to use life cycle assessments in the design process, has been faced by two major problems :

1 The result of a full life cycle assessment is difficult to interpret. Within a life cycle assessment it is possible to determine the contribution of a product life cycle to the greenhouse effect, acidification and other environmental problems while the total environmental impact remains unknown. The reason is the lack of mutual weighting of the environmental effects.
2 In general the careful collection of all the environmental data in a product’s life cycle is complex and time-consuming. As a result extensive LCAs cannot usually be carried out during a design process.

The Eco-indicator project has resolved these problems as follows:

1 The LCA method has been expanded to include a weighting method. This has enabled one single score to be calculated for the total environmental impact based on the calculated effects. We call this figure the Eco-indicator.
2 Data have been collected in advance for the most common materials and processes. The Eco-indicator has been calculated from this. The materials and processes have been defined in such a way that they fit together like building blocks. Thus there is an indicator for the production of a kilo of polyethylene, one for the injection moulding of a kilo of polyethylene and one for the incineration of polyethylene.

The Eco-indicator of a material or process is thus a number that indicates the environmental impact of a material or process, based on data from a life cycle assessment. The higher the indicator, the greater the environmental impact.

1.3 The "Eco" we indicate

Discussions on the environment are frequently confused. An important reason for this is the usually unclear definition of the term environment. In the Eco-indicator 99 we have defined the term "environment" with three types of damage:

1 Human Health; Under this category we include the number and duration of diseases, and life years lost due to premature death from environmental causes. The effects we include are: climate change, ozone layer depletion, carcinogenic effects, respiratory effects and ionising (nuclear) radiation.
2 Ecosystem Quality; Under this category we include the effect on species diversity, especially for vascular plants and lower organisms. The effects we include are: ecotoxicity, acidification, eutrophication and land-use.
3 Resources; Under this category we include the surplus energy needed in future to extract lower quality mineral and fossil resources. The depletion of agricultural and bulk resources as sand and gravel is considered under land use.

Next to the effects mentioned here there are some additional effects that could contribute to these three damage categories. We believe we have captured the most relevant effects, but unfortunately a method as this can never be absolutely complete[2].

Another limitation is in the selection of the damage categories themselves. For instance we could have included damage categories like the damage to material welfare or the damage to cultural heritage, but we did not choose to do so.

1.4 Differences with the Eco-indicator 95

The concept of working with standard Eco-indicators is not new. In the Eco-indicator 95 project this principle was introduced[3]. The most important difference with the 95 version of the method is the much improved methodolo-

2 The following effects that may be relevant are not included:

- *Human Health: Noise, endocrine disrupters and non carcinogenic or non respiratory effects of some substances like heavy metals.*
- *Ecosystem Quality: Greenhouse effect and ozone layer depletion (both are included in Human Health) and the effect of phosphates.*

In general these shortcomings will not have a very big effect, but in specific cases, for instance when systems that produce high noise levels, or emit large amounts of heavy metals or phosphates, the Eco-indicator value may misrepresent the environmental load.

3 The Eco-indicator 95 final report, NOH report 9514, July 1995; ISBN 90-72130-77-4

gy for calculating the indicators and the expansion of the indicator lists.
The most important difference in the methodology is the much better scientific basis for the damage model and with that the much greater reliability. Next to this also the concept of the methodology has changed. In the Eco-indicator 95 we used a mixture of damage modelling and the Distance to Target approach. In the Eco-indicator 99 we no longer include the Distance to Target principle in our reasoning. In stead we have fully developed the damage approach (see also preface and chapter 5). Next to a better scientific basis, we made a number of other important improvements:

- much better and more explicit procedure for the weighting between the damage categories
- much better description and definition of the damage models
- thorough description and specification of the uncertainties and assumptions
- Inclusion of the fate (dispersion and degradation) of emissions in the environmental compartments[4]
- much wider range of emissions and effects, like resource depletion, land-use and ionising radiation.

As a result of these changes the results of Eco-indicator assessments may change when the 99 method is applied in stead of the Eco-indicator 95 method. The most important expected effects are:

- Because resource depletion is included, processes that require oil or gas or certain minerals will get a higher value.
- Because land-use is included, agricultural production processes will have a higher indicator. Also in the landfill of products with a large volume this is noticeable.
- Because the dispersion and degradation of substances is included, substances with a short lifetime will contribute much less to the Eco-indicator scores.
- Although with the inclusion of ionising radiation nuclear energy should get a higher value, in practice this effect is not noticeable.

Apart from these extensions of the methodology, we can also notice a shift of focus.

The Eco-indicator 95 and 99 values are not compatible! This means it is not possible to mix old and new indicators in an analysis. It is also not possible to give a conversion factor.

1.5 Uses and limitations

During the design process a large number of options are usually generated. These solutions are analysed by the designer after which the best design options are chosen. To enable environmentally-aware designs to be produced it must be possible to include the environmental aspects of a product in the analysis and selection of design options. The standard Eco-indicator values have been developed as an instrument to do just that; they are meant to be a

4 *In the Eco-indicator 95 this was done in an extremely crude way. Substances with a short lifetime were simply disregarded.*

tool for designers. It is a tool to be used in the search for more environmentally-friendly design alternatives and is intended for internal use.

- The standard Eco-indicator values are not intended for use in environmental marketing, for environmental labelling or for proving in public that product A is better than product B.
- The standard Eco-indicator values are also not intended as an instrument for the Government to be used for setting standards and drawing up guidelines.

This is made clear in the "Products and the Environment" policy paper in which the Dutch Government announces the development of indicators. The use of Eco-indicators has just one purpose, namely making products more environmentally-sound. It is, therefore, a tool that can be used within companies or sectors.

1.6 ISO and the Eco-indicators

Approximately at the same time this report is published the first ISO 14042 standard on life cycle impact assessment is published. The Eco-indicator methodology that is used to calculate the standard values conforms well to this standard, although some details will perhaps deviate. An important provision in the ISO 14042 is that single scores like Eco-indicators may never be used in comparative assertions disclosed to the public.

1.7 The unit of Eco-indicators

The standard Eco-indicator values can be regarded as dimensionless figures. As a name we use the Eco-indicator point (Pt). In the Eco-indicator lists usually the unit milli-point (mPt) is used, so 700 mPt= 0.7 Pt).

The absolute value of the points is not very relevant as the main purpose is to compare relative differences between products or components. The scale is chosen in such a way that the value of 1 Pt is representative for one thousandth of the yearly environmental load of one average European inhabitant[5].

5 This value is calculated by dividing the total environmental load in Europe by the number of inhabitants and multiplying it with 1000 (scale factor).

Description of the standard Eco-indicators

Standard Eco-indicator 99 values are available for:

- **Materials.** The indicators for production processes are based on 1 kilo material.
- **Production processes.** Treatment and processing of various materials. Expressed for each treatment in the unit appropriate to the particular process (square metres of rolled sheet or kilo of extruded plastic).
- **Transport processes.** These are mostly expressed in the unit tonne-kilometre.
- **Energy generation processes.** Units are given for electricity and heat.
- **Disposal scenarios.** These are per kilo of material, subdivided into types of material and waste processing methods.

Average European figures are used for this calculation. A particular definition was used for the terms "material" and "process" when determining the indicators. The definitions used are explained briefly below.

Production of materials

In determining the indicator for the production of materials all the processes are included from the extraction of the raw materials up to and including the last production stage, resulting in bulk material. Transport processes along this route are also included up to the final process in the production chain. Which process that is, can be derived from the explanation in the Eco-indicator list. For plastic, for example, all the processes are included from extraction of the oil up to and including the production of the granules; for sheet steel all the processes are included from extraction of the ore and coke up to and including the rolling process. The production of capital goods (machines, buildings and such like) is not included.

Production processes

The Eco-indicators for treatment processes relate to the emissions from the process itself and emissions from the energy generation processes that are necessary. Here too, capital goods, like machines and dies, are not included.

Transport

Transport processes include the impact of emissions caused by the extraction and production of fuel and the generation of energy from fuel during transport. The unit is the transport of one tonne (1000 kg) goods over 1 km (1 tkm). A different unit is used for bulk road transport .

- Road transport. In addition to transport for which the mass is the critical factor (ton*km), an indicator has also been determined for those cases where the volume is the determining factor (m3 volume * km).
- Rail transport. This is based on the average European ratio of diesel to electric traction and an average load level.
- Air transport for different types of cargo plane.

A loading efficiency for European average conditions is assumed. Account is also taken of a possible empty return journey. Capital goods, like the production of trucks and road or rail infrastructure, and the handling of cargo planes on airports, are included as they are not negligible.

Energy

The energy indicators refer to the extraction and production of fuels and to energy conversion and electricity generation. The average efficiency is used. For the electricity score account is taken of the various fuels used in Europe to generate electricity. An Eco-indicator has been determined for high-voltage electricity, intended for industrial processes, and also for low-voltage electricity, particularly for household and small-scale industrial power consumption. The difference is in mains losses, and the required infrastructure such as cables. Next to European averages specific indicators are given for a number of countries. The large differences between countries can be explained from the different technologies used to produce electric power.
For solar energy we used photo-voltaic cells that are to be used on houses. The environmental load is mainly from production and disposal of the cells and other equipment.

Waste processing and recycling

Not all products are disposed of in the same manner. Therefore, when using indicators careful consideration must be given to which waste processing method is the most appropriate.
Where a product consists mainly of paper or glass and the design is such that the materials can be disposed of in recycling containers for glass or paper, it is reasonable to assume that a proportion of households will remove these materials from the waste stream and dispose of them separately. If, however, a product has only a small paper or glass component it is not so realistic to assume that these materials will be collected separately. In such cases it is likely that the product will end up in the municipal waste processing system. Scenarios have been calculated for both of these cases. In addition, scenarios have been provided for the incineration, landfill disposal and recycling of products. The latter scenarios are not widespread in practice.

- **Household waste.** In an average household a number of materials such as glass, paper and compostable waste are collected and recycled separately once the decision has been taken to dispose of a product. The rest is put in the dustbin and is thus routed to the municipal waste collection system. The household waste scenario is based on the waste handling in an average household in Europe.
- **Municipal waste.** In the municipal waste scenario the average processing of waste in Europe is modelled. It is assumed in this that a certain proportion is landfilled and the rest is incinerated. The environmental impact of transport in the dustcart is also included.
- **Incineration.** It is assumed that incineration is carried out in an average Swiss plant with an average (year 2000) scrubbing system. This situation does not represent the average for Europe but this will change gradually

in the coming years. A proportion of the steel and aluminium is also reclaimed and recycled from the incinerator slag. In addition, energy is generated and supplied to the grid as electricity.

- **Landfill disposal.** Landfill disposal is based on modern Swiss landfill sites (year 2000) with water purification and good seals, as a result of which relatively few harmful substances will reach groundwater sources.
- **Recycling.** Recycling processes cause an environmental load as all other processes do; however recycling processes also result in useful products. These products can be interpreted as an environmental gain, as they avoid production of materials elsewhere. In the table we present both the environmental load as the environmental gain. The problem is however that both the gain and the load can differ considerably from case to case. This depends among others on the purity of the input materials and the quality of the output materials. As a result the figures must be interpreted as an example for a rather ideal and thus optimistic situation. Because of this the date is rather uncertain and should be interpreted with care.

The interactions between the household waste, municipal waste, incineration and landfill disposal scenarios are shown graphically in Fig. 1.

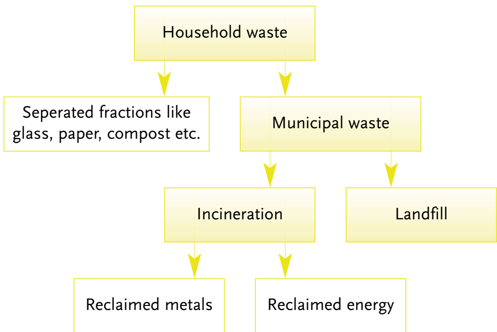

Figure. 1: Schematic representation of the waste scenarios (grey blocks) and mutual interactions. It is up to the user to choose between the different scenarios.

The waste data have been determined for most important plastics, metals and packaging materials. No waste treatment processes have been given for building materials and chemicals. Building materials that do not burn are usually land-filled or reused as road construction material or as coarse fraction in concrete. Building materials that are to be regarded as chemically inert have no other environmental impact than that they occupy an area in a landfill. A general figure for land-filling a certain volume has been given. This value is valid under the assumption that the waste has a height of 10 meters. If the height is only 5 meters, the indicator value should be doubled.
For the disposal of chemicals the situation is more complex; no general value could be given, except for the refrigerants.

Negative figures for waste processing

Some disposal scenarios yield negative figures. This occurs when the waste processing results in a useful by-product that can be recycled or reused. The energy and materials flows that are reclaimed are regarded as an environmental profit. If 1 kg scrap is reclaimed less iron has to be produced elsewhere. The environmental effects for the production of 1 kg crude iron are therefore deducted. This is referred to as a substitution rule. In a number of cases, particularly with recycling, the deduction is greater than the environmental impact of a process, which gives rise to the negative figures.

Operating instructions

The following steps must always be followed to ensure correct application of the Eco-indicator:

1 Establish the purpose of the Eco-indicator calculation.
2 Define the life cycle.
3 Quantify materials and processes.
4 Fill in the form.
5 Interpret the results.

In most cases it is recommended that you start simple and carry out a “rough” calculation in the first instance. Details can then be added and data can be revised or supplemented at a later stage. This ensures that you do not waste too much time with details.

step 1

Establish the purpose of the Eco-indicator calculation

- Describe the product or product component that is being analysed.
- Define whether an analysis of one specific product is being carried out or a comparison between several products.
- Define the level of accuracy required.

If the purpose of the calculation is to obtain a rapid overall impression of a product’s major environmentally-damaging processes, it is sufficient to include a number of core items. This will result in approximate assumptions being made and only main processes being included. At a later stage, however, you may well wish to look specifically and in detail for alternatives to aspects of the problem or, for example, to compare a new design with an existing one. In that case a more meticulous approach is necessary and a solid, fair basis for comparison. It is also possible with comparisons to disregard components or processes that are common to both product life cycles.

step 2

Define the life cycle

- Draw up a schematic overview of the product’s life cycle, paying equal attention to production, use and waste processing.

With a life cycle assessment the essential feature is to analyse a product life cycle and not so much only a product. It is therefore necessary to have not only an (outline) description of a product but also an outline of the life cycle. The performance provided by the product and the waste scenario are important elements of the description. A simplified life cycle of a coffee machine for domestic use is given below. Such a process tree provides a useful insight for further analysis.

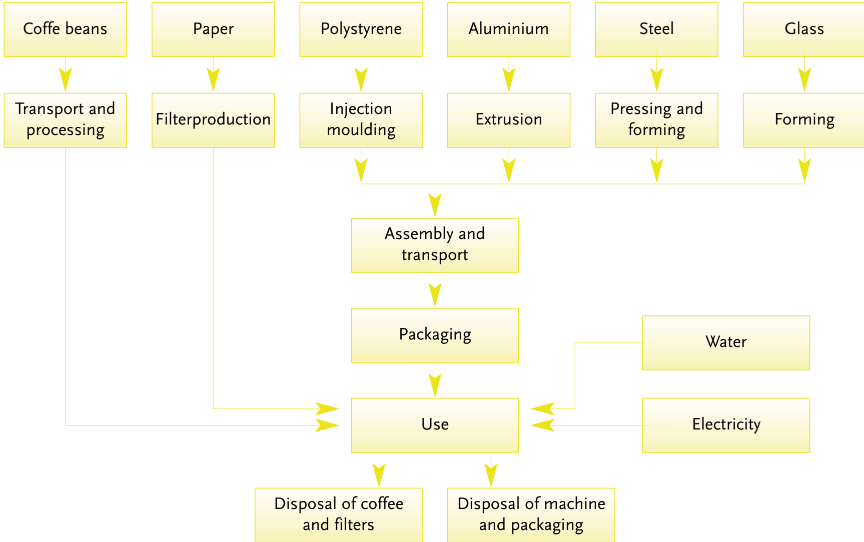

Figure 2: Example of a simplified process tree for the life cycle of a coffee machine.

step 3

Quantify materials and processes

- Determine a functional unit.
- Quantify all relevant processes from the process tree.
- Make assumptions for any missing data.

In the LCA method the description of product, life cycle and performance is termed the functional unit. A quantity can now be determined for each process in the process tree on the basis of this functional unit and the product data. Particularly when making comparisons it is important that the performance delivered by both products is the same.

Not all details of a product life cycle are generally known; a number of estimates are therefore also needed. These estimates can have two results:

- The omission of a component or process. This is only acceptable if its contribution is minor compared to the rest.
- The user estimates a quantity himself.

In general it is better to make a number of estimates first and to seek more accurate data later on if this turns out to be necessary.

Examples of functional unit

1 A functional unit for a domestic coffee machine is determined as follows. The purpose of the coffee machine is to make coffee and keep it hot. The following are therefore chosen for the functional unit: all the products and processes needed for the provision of coffee for a household for a certain period. A certain period then has to be specified (say, five years) and the average coffee consumption per household has to be estimated. This can be, for example: making 5 cups of coffee twice a day and keeping it hot for half an hour after brewing. The number of filters (3650) and the ener-

gy consumption can then be included based on this assumption. A possible difference also surfaces between the use of a thermos jug and a hot plate.

2 A disposable napkin is compared with a washable one. The purpose of nappies is to absorb faeces and urine before an infant is potty-trained. One assumption for a fair basis for comparison can then be: the number of nappies and processes required for a period of 30 months before the infant is potty-trained. Washing and drying of the washable nappy are then also included.

step 4

Fill in the form

- Note the materials and processes on the form and enter the amounts.
- Find the relevant Eco-indicator values and enter these.
- Calculate the scores by multiplying the amounts by the indicator values.
- Add the subsidiary results together.

A simple form has been developed to make the Eco-indicator calculations. Like the Eco-indicator lists this form is included as separate insert in the back cover of this manual. This sheet can be copied for personal use. Next to this sheet specialised Eco-indicator software is available.

If an indicator value for a material or process is missing this causes a problem that can be resolved as follows:

- Check whether the missing indicator could make a significant contribution to the total environmental impact.
- Substitute a known indicator for the unknown one. If you study the list you will see that the indicator values for plastics are always in the same range. Based on this it is possible to estimate a value for a missing plastic that is within this range.
- Request an environmental expert to calculate a new indicator value. Software packages are available for this purpose.

The omission of a material or process because no indicator value is available is only admissible if it is clear that the anticipated contribution of this part is very small. It is generally better to estimate than to omit.

step 5

Interpret the results

- Combine (provisional) conclusions with the results.
- Check the effect of assumptions and uncertainties.
- Amend conclusions (if appropriate).
- Check whether the purpose of the calculation has been met.

Analyse which processes and phases in the life cycle are the most important or which alternative has the lowest score. Always verify the effect of assumptions and uncertainties for these dominant processes. What happens to the result if an assumption changes slightly? Does the main conclusion stand or do the priorities or the preference for a product change? If so, the assumption will have to be reassessed, and supplementary information will have to be sought.

Please be aware of the fact that the standard Eco-indicator values from the list are not exact. At the end of chapter 5 we discuss some of the reasons for this uncertainty and we suggest a procedure to deal with it.

Example

A number of examples have been described to illustrate the use of the Eco-indicator. The first is the example of a simple analysis of a coffee machine during which the steps defined in the previous chapter are followed again.

4.1 Simple analysis of a coffee machine

A design team is designing a new coffee machine model for domestic use and wishes to take environmental aspects into account. To enable priorities to be established at the outset of development work an analysis of the current model is carried out.

Step 1: Establish the purpose of the Eco-indicator calculation

The purpose of the calculation is to establish priorities, in other words: Where can the designer best start to achieve the greatest possible environmental improvement? The purpose is therefore not to compare two coffee machines. In the first instance it is possible to make fairly "rough" calculations, and simplifications are permissible.

Step 2: Define the life cycle

The process tree is illustrated in Fig. 3. The amounts listed in step 3 are also included in the process tree. A simplified model of a coffee machine is used in which only the polystyrene housing, the glass jug, the steel hot plate and an aluminium riser pipe are included (the mains cable and the switch have been omitted from this example).

The white blocks in the figure below have been disregarded in the Eco-indicator calculation. The consumption of coffee and water has been omitted because it is difficult for the designer to influence this. The packaging has been omitted because this is not under study at this stage.

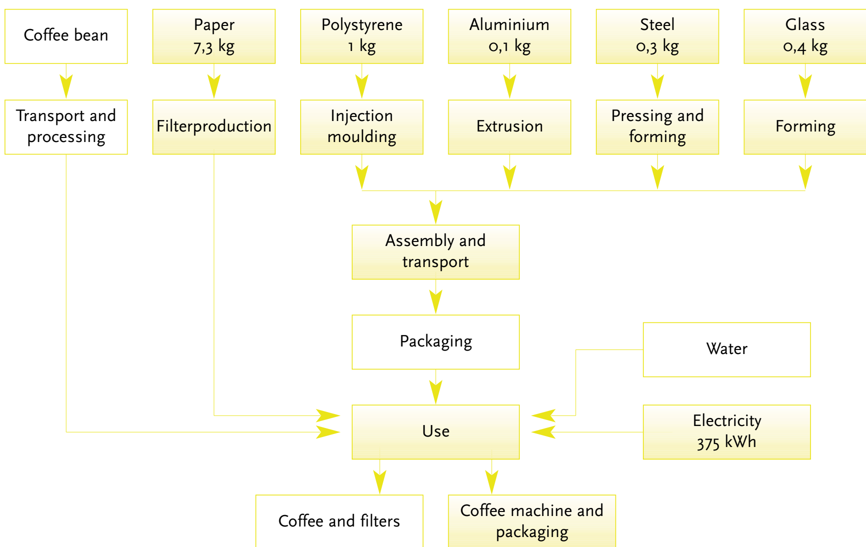

Figure 3: Process tree of a simplified coffee machine model with amounts and assumptions. White boxes are not included in the analysis.

Step 3: Quantify materials and processes
The amounts of materials and the processing processes can now be looked up or measured. The amounts of materials used can be derived from the design specifications or, if it is an existing machine, by weighing the components. An assumption of the frequency of use is needed for the required amount of electricity and the number of filters. In this example it is assumed that the machine is used twice a day for five years at half capacity (5 cups). It is further assumed that the coffee is kept hot for half an hour after it is ready. This is the same functional unit described under step 3 in the last chapter.

It can easily be calculated that in this case 3650 filters are needed with a total weight of 7.3 kg. The electricity consumption is rather less easy to determine, but an initial approximation is possible by multiplying the time taken to brew the coffee by the rated power. The energy consumption for keeping the coffee hot is even more difficult to measure but can be derived from simple measurements.

Assumptions must also be made about consumer behaviour for the disposal stage. It is not reasonable in this case to assume that the machine will be dismantled and disposed of separately in different collection systems by the consumer. We therefore assume that the machine will be put in the dustbin and thus processed as municipal waste. Only the glass jug, provided it is designed such that it will fit through the opening of the glass container, can be regarded as household waste. In this scenario account is taken of the fact that a certain proportion of households dispose of glass in the glass recycling container and that this glass will therefore be recycled. For this reason it is unnecessary to include a separate glass recycling stage in the calculation (see the sample form).
Some of the filters end up in the dustbin and some with organic waste.

Step 4: Fill in the form
The form can now be filled in for each phase in the life cycle and the relevant Eco-indicator values can be recorded. Take care with the units! The score is then calculated for each process and recorded in the "result" column.

When the Eco-indicator list is consulted it sometimes turns out that not all the required processes are included. Assumptions will have to be made for the missing data. In this example this involves a number of treatment processes and waste processes. The following assumptions are necessary:

- The indicators are very low for the stamping and forming of steel. Because of this, metal processing can be disregarded.
- No data are known for the glass forming. However, an estimate of the amount of energy can be made (in this case 4 MJ) based on the melting point, the specific heat and the assumed furnace efficiency.

The disposal phase contains no indicator value for compostable waste. Two approximations are possible:

- Ignore the possibility of composting and assume that all the paper ends up in the municipal waste processing system.

- Assume that composting has a negligible impact and can thus be omitted. In this example it has been decided to choose the approximation that all the paper ends up in the municipal waste processing system.

A fully completed form is shown below:

Product or component	*Project*
coffee machine	**example**
Date	*Author*
14-4-2000	**PRé**
Notes and conclusions	
Analysis of a coffee machine, assumption: 5 years' use, 2 x per day, half capacity, keep hot for 30 minutes	

Production (Materials, treatments, transport and extra energy)

material or process	amount	indicator	result
polystyrene	1 kg	360	360
injection moulding PS	1 kg	21	21
aluminium	0,1 kg	780	78
extrusion Al	0,1 kg	72	7
steel	0,3 kg	86	26
glass	0,4 kg	58	23
gas-fired heat (forming)	4 MJ	5,3	21
Total [mPt]			536

Use (Transport, energy and possible auxiliary materials)

process	amount	indicator	result
electricity low-voltage	375 kWh	37	13.875
paper	7,3 kg	96	701
Total [mPt]			14.576

Disposal (Disposal processes for each material type)

material and type of processing	amount	indicator	result
municipal waste, PS	1 kg	2	2
municipal waste, ferrous	0,4 kg	-5,9	-2,4
household waste, glass	0,4 kg	-6,9	-2,8
municipal waste, paper	7,3 kg	0,71	5,2
Total [mPt]			2
Total [mPt] (all phases)			15.114

Step 5: Interpret the results

The results on the form reveal that the use phase has the greatest impact. The number of points is many times higher than the totals for the production and waste phases. The design team will therefore have to assign greatest priority to lower energy consumption when developing the new coffee machine model. Reducing paper consumption with the one-off filters is a clear second.

Amongst the materials the impact of the polystyrene housing is predominant.

Verification

The effect of assumptions is negligible in this case, apart from the assumption regarding use (and the service life). The measured electricity consumption is reasonably reliable, but the assumption that coffee will be made twice a day for five years and kept hot for half an hour is not based on any concrete data. If, however, it is assumed that the machine is only used once a week the conclusion that energy consumption is predominant remains unchanged.
The indicator values relating to the assumption for the disposal of aluminium and paper do not give rise to any other conclusions. Even with accurate waste figures, the contribution of the waste phase will remain only a fraction of the indicator for the use phase.

Improvements

Based on this Eco-indicator calculation the design team could consider developing a coffee machine with a thermos jug instead of a hot plate. In addition, the coffee machine could be fitted with a permanent filter in place of one-off paper filters. These design alternatives can, of course, be calculated in the same way with the Eco-indicator.
This result will permit the user to see how much environmental impact these design alternatives will have with reference to the coffee machine as described above. The result of this analysis is shown again below in Fig. 4 in the form of a process tree, in which the size of each block is a measure of the relative contribution to the total.

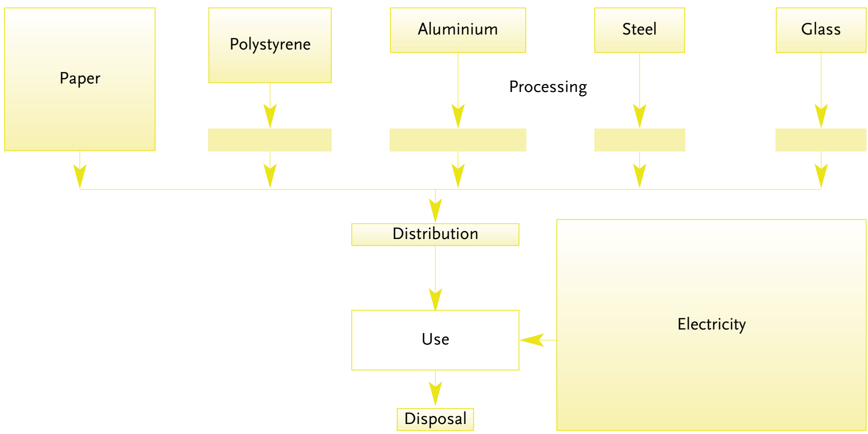

Figure 4: The coffee machine process tree, where the size of the process blocks is proportional to the relative importance of the process.

4.2 Example of a complex product

If products contain many components the form quickly becomes too small. In such cases a product can be defined by subdividing it into "subassemblies", in just the same way as in technical drawings. One column in the form can then be used for each assembly. The total scores of these forms are carried over to the main form. The use phase can also be included in this form. Fig. 5 illustrates this method of completing the form for a refrigerator:

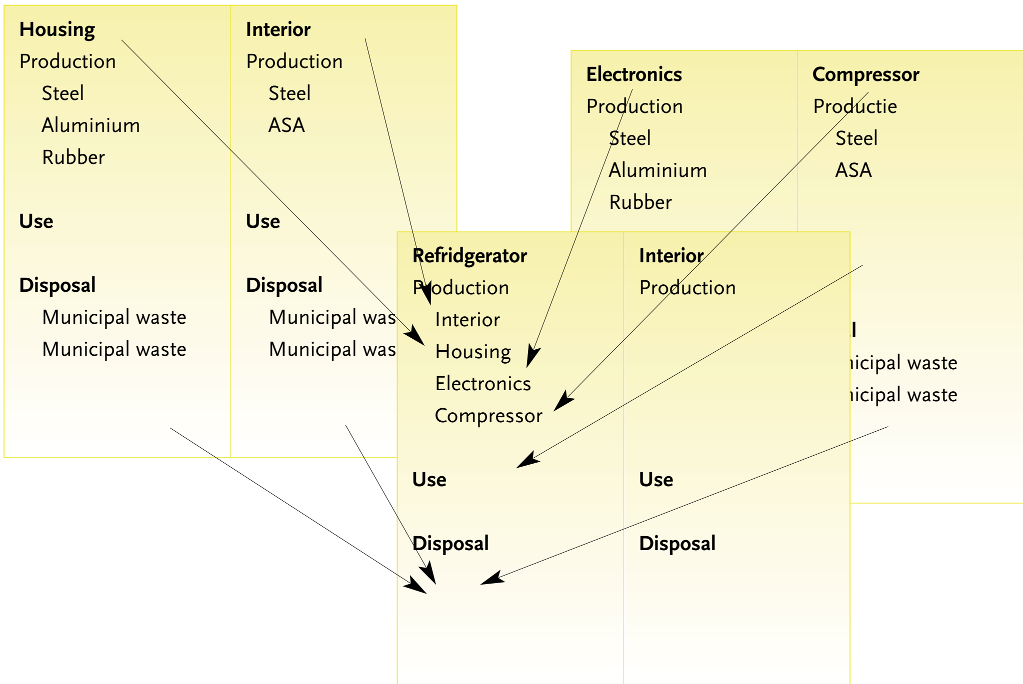

Figure 5: Example of a completed form (in this case without figures) in which the product is subdivided.

The Eco-indicator 99 methodology

The Eco-indicators calculated here have been calculated with a specially developed methodology. The details of this methodology can be found in the Eco-indicator 99 methodology report that is available from www.pre.nl.

5.1 Three steps

In order to calculate the Eco-indicator score, three steps are needed:

1. Inventory of all relevant emissions, resource extractions and land-use in all processes that form the life cycle of a product. This is a standard procedure in Life Cycle Assessment (LCA)
2. Calculation of the damages these flows cause to Human Health, Ecosystem Quality and Resources
3. Weighting of these three damage categories.

In the figure 6 these steps are illustrated. Below we discuss these steps in inverse order, thus starting with step 3. This inverse order was also our line of thinking during the development.

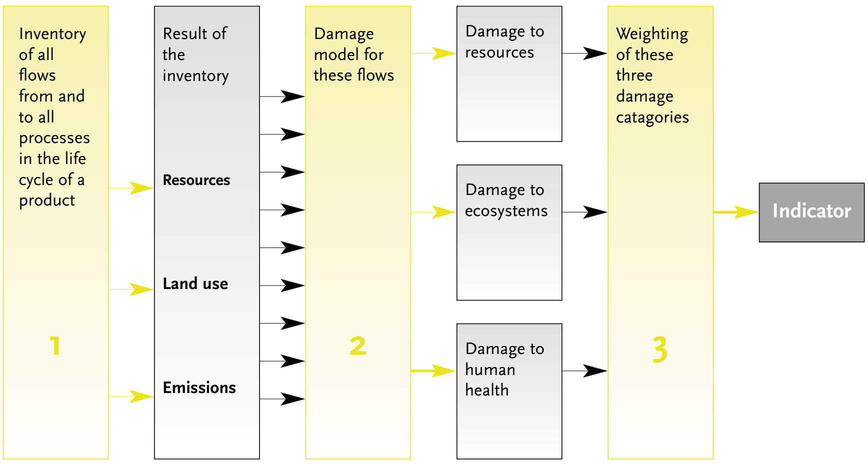

Figure 6: General procedure for the calculation of Eco-indicators. The light coloured boxes refer to procedures, the dark coloured boxes refer to intermediate results.

5.2 Weighting (step 3)

The most critical and controversial step in a methodology as this is the weighting step.

Traditionally in LCA the emissions and resource extractions are expressed as 10 or more different impact categories, like acidification, ozone layer depletion, ecotoxicity and resource extraction. For a panel of experts or non-experts it is very difficult to give meaningful weighting factors for such a large number and rather abstract impact categories. The problem is that panel members cannot really grasp the seriousness of these impact categories, without knowing what effects are associated with them. An additional problem is that 10 is a relative high number of items to be weighted.

In the Eco-indicator 99 methodology development we started with the design of the weighting procedure and asked ourselves what type of information a panel can handle in a weighting procedure. Our conclusion was that we should not ask the panel to weight the impact categories but the different types of damage that are caused by these impact categories. The other improvement is to limit the number of items that are to be assessed to three. As a result, the panel is asked to assess the seriousness of just three damage categories:

1 Damage to Human Health, expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs), an index that is also used by the World bank and the WHO.
2 amage to Ecosystem Quality, express as the loss of species over a certain area, during a certain time
3 Damage to Resources, expressed as the surplus energy needed for future extractions of minerals and fossil fuels.

The panel used in this project consisted of 365 persons from a Swiss LCA interest group [Mettier 1999]. This group can unfortunately not be regarded as representative for the European population. The reason for choosing this group was the assumption that such a group would better understand the questions posed to them. In spite of this limitation, we still use the results.

The results from this group indicate that the panellist find damage to Human Health and damage to Ecosystem Quality about equally important while damage to Resources is considered to be about half as important.

5.3 The damage model (Step 2)

In order to be able to use the weights for the three damage categories a series of complex damage models had to be developed. In figure 7 these models are represented in a schematic way.

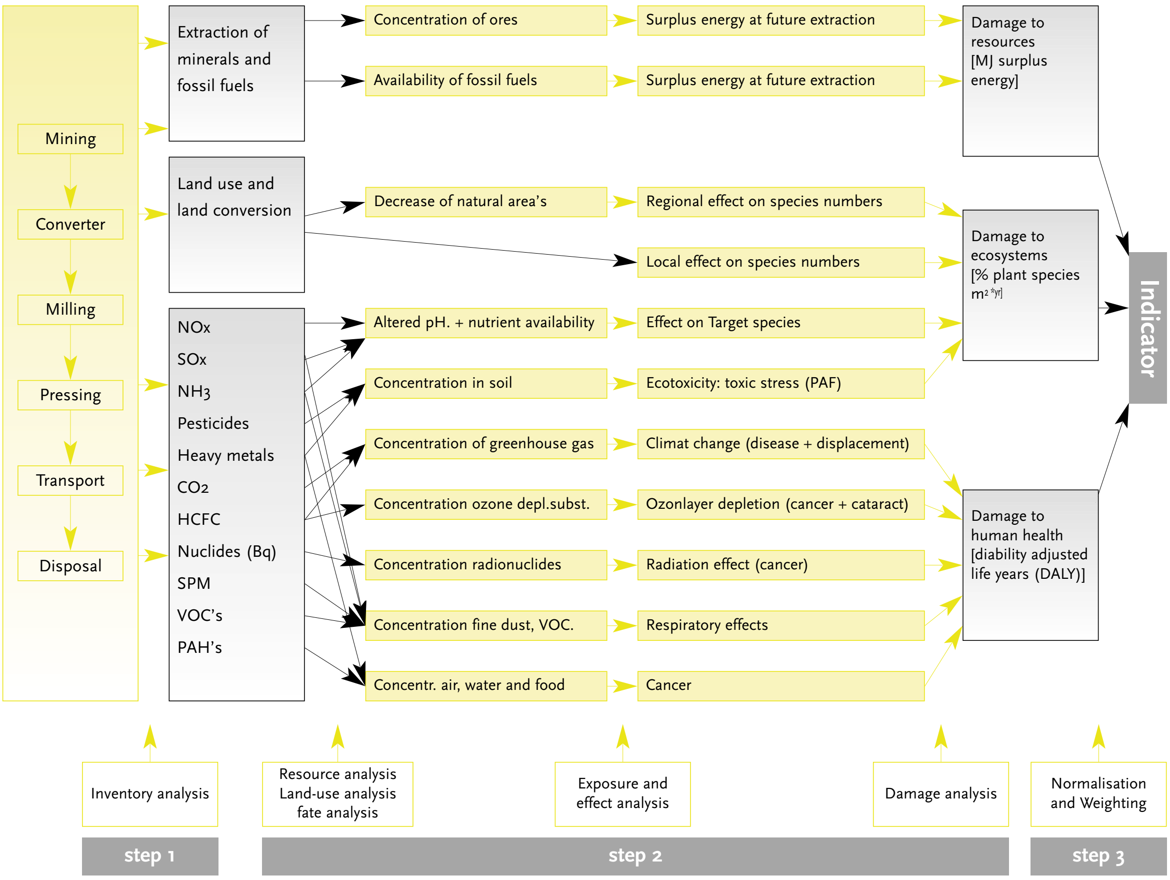

Figure 7: Detailed representation of the damage model (step 2)

The damage model for emissions

For the calculation of the damages caused by emissions four steps are needed [Hofstetter 1998].

Fate analysis

When a chemical substance is released it finds its way through the environmental compartments air, water and soil. Where the substance will go, and how long it will stay depends on the properties of the substance and the compartments. A well soluble substance will be collected in the water compartment, while a substance that easily binds to organic particles may end op in specific types of soil. Another aspect is the degradability, as most organic substances have a limited lifetime. In so called "fate analysis" models the transfer between compartments and the degradation of substances is modelled. As a result the concentrations in air, water, soil and food can be calculated.

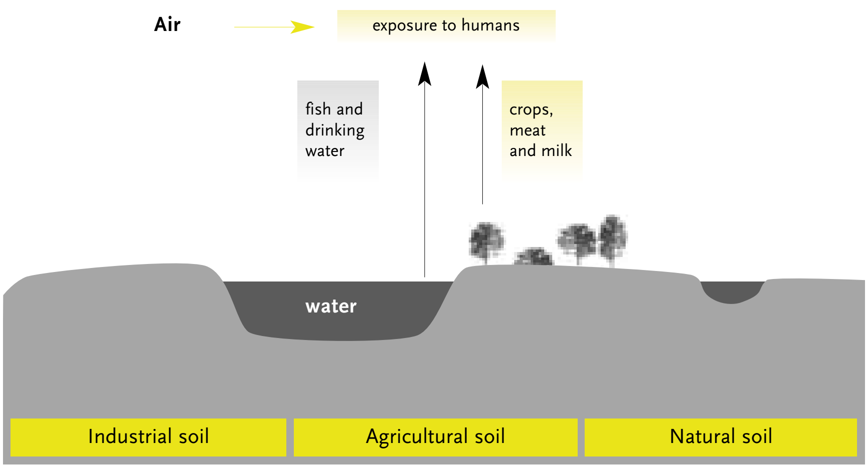

Figure 8: Schematic representation of a fate model used for toxicity. For other substance types other fate models are used.

Exposure
Based on the calculated concentrations we can determine how much of a substance is really taken in by people and by plants or other life forms.

Effect analysis
Once the exposure of a substance is known it is possible to predict the types and frequencies of diseases and other effects.

Damage analysis
The predicted diseases can now be expressed into our damage unit. For instance if we know that a certain level of exposure causes ten extra cases of a certain type of cancer, we can find data on the average age people get this type of cancer and the average chance that people will die. Based on this data, we can calculate how many years of life are lost, and how many years are lived disabled, as people are ill and have to be treated in hospital. For the toxic effects on ecosystems we calculate what percentage of plants and lower species are exposed to toxic stress, while for acidification and eutrophication we model what percentage of plants are likely to disappear (Potentially Disappeared Fraction). Damages to higher species like birds and mammals could not be calculated, but there are good reasons to assume that the damage to plants and lower organisms is also representative for the damage to populations of higher animals.
For most substances the damages are calculated on a European scale. For some substances, like greenhouse gasses, ozone-depleting gasses, radioactive substances with a long lifetime, the damage is calculated on a world-wide level, as these substances are dispersed world-wide.

Damage model for land-use
Mankind is occupying large areas for urban and agricultural purposes. This

is an important reason why many species are threatened with extinction, and therefore it is important to include the effects of land-use by man-made systems into the Eco-indicator. Also here the disappearance of species is taken as the damage unit.

Different types of land-use will have different effects. For instance a paved parking lot will have less plant species than an organic meadow. On the basis of field observation studies [Köllner 1999] we have developed a scale expressing the species diversity per type of land use. A complication is the fact that the species diversity depends on the size of an area. This means that the construction and use of a parking lot does not only have an effect on the actual area of the lot, but also on the surrounding region, as due to the parking lot the natural areas will become slightly smaller. We call this the regional effect. In the Eco-indicator 99 both the regional and the local effect are taken into account.

Damage model for resources

By extracting minerals we reduce the quality of the remaining resources. This is because mankind always extracts the best resources first, leaving the lower quality resource to future generations. For instance in the Bronze Age, our ancestors found ores with a few percent of copper, while nowadays the average grade is around 0.7%.

The damage to resources will be experienced by future generations as they will have to use more effort to extract the remaining resources. We express this extra effort as "surplus energy" [Müller-Wenk 1998]

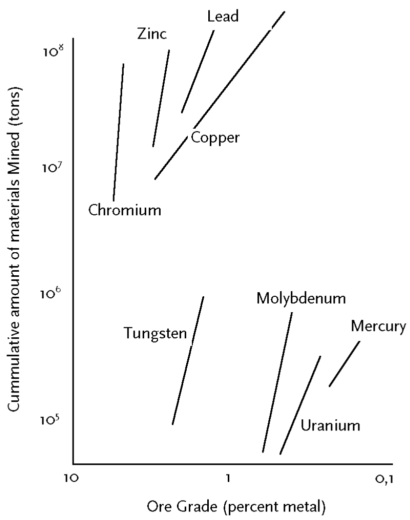

Figure 9: The relation between the availability of resources and the ore grade on a logarithmic scale for a number of minerals. A steep line indicates that the availability increases sharply if mankind is able and willing to accept a slightly lower ore concentration. A flat line means that even at lower concentrations, the availability will not increase very much. The latter case is more problematic than the first. [Taken from Chapman 83]

For fossil fuels a similar reasoning applies, although we cannot use the term concentration here. However, a wealth of statistical data indicates that gradually the supply of easily extractable fossil fuels, like liquid oil will decline. This does not mean we are faced with the end of fossil resource, but that other lower quality resources like oil shale will have to be used. Also here lower quality can be translated into surplus energy, as the exploration of for instance shale will require significant more energy than the extraction of liquid oil.

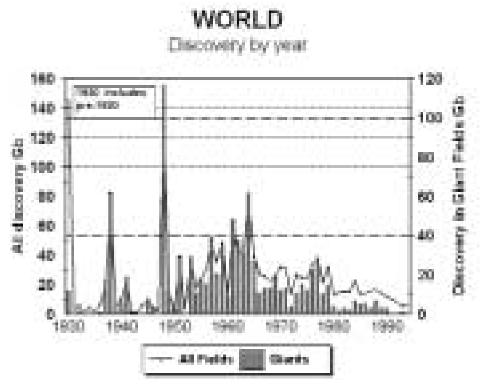

Figure 10: The discovery rate of liquid oil has dropped ton average of about 6 Gigabarrel per year, while the extraction is almost tenfold. The so-called giant fields have all been discovered during the fifties, sixties and seventies. The present knowledge of geology is so well developed that it is unlikely that many new giant fields can be found.

5.4 Inventory of the processes (Step 1)

For the standard Eco-indicators we have mainly used the energy database developed by ESU-ETH in Zürich [ESU 1996]. This data is well known and well documented. Next to this some data from the SimaPro LCA software tool has been used.

In the inventory of such data it is very important to use a consistent methodology concerning items like:

- System boundaries (what is included and what not).
- Allocation (how do we deal with industrial processes that produce more than one output).
- Regional aspects (do we use Dutch, Swiss or average European data).
- General data quality issues (age, representativeness, average or modern technology etc.).

In annexe 1 a brief description of these issues is given.

We would like to warn users of this methodology not to mix databases with indicators that have been developed with different methodologies, as has been done by some software developers with the Eco-indicator 95 methodology.

5.5 Uncertainties

Of course it is very important to pay attention to the uncertainties in the methodology that is used to calculate the indicators. We distinguish two types:

1 Uncertainties about the correctness of the models used.
2 Data uncertainties.

The first type of uncertainties include value choices like the choice of the time horizon in the damage model, or the question whether we should include an effect even if the scientific proof that the effect exists is incomplete.

The data uncertainties refer to difficulties in measuring or predicting effects. This type of uncertainties is relatively easy to handle and can be expressed as a range or a standard deviation. Uncertainties about the correctness of the model are very difficult to express as a range.

Uncertainties about the correctness of the model

In debates about the seriousness of environmental effects opinions are usually very diverse. This may have to do with differences in knowledge levels, but also fundamental differences in attitude and perspective play an important role. Some people would argue long time effects are more important than short term, while others could argue that on the long term environmental problems can be solved by technological developments and if the appropriate measures are taken. An other difference would be that some people would only be concerned about an issue if sufficient scientific proof is available, while others would argue that every possible effect should be taken seriously.

Such fundamentally different perspectives cannot be reconciled, and there is no way to determine if a perspective is right or wrong. This is a problem because as developers of the Eco-indicator 99 methodology we are frequently confronted with model choices that are dependent on such different perspectives. As we cannot develop a different version for every individual perspective we have used three “Archetypes” of perspectives.

A very simplified characterisation, using just three criteria of these versions is:

Perspectief of basishouding	Time perspective	Manageability	Required level of evidence
H (Hierarchist)	Balance between short and long term	Proper policy can avoid many problems	Inclusion based on consensus
I (Individualist)	Short time	Technology can avoid many problems	Only proven effects
E (Egalitarain)	Very long term	Problems can lead to catastrophy	All possible effects

These “Archetypes” are taken form the Cultural Theory framework [Thompson 1990 and Hofstetter 1998], and is frequently used in social science. Of course the theory does not want to imply there are just three types of people. The archetypes are conceptual models; most people use all three perspectives in their daily life.

As a consequence there are three different versions of the Eco-indicator 99 methodology. The figures published in this report are based on the H (Hierarchist) version, which is chosen as default. The other versions are available in LCA software, and can be used to investigate the influence of the different modelling choices on the result.

Also in the panel procedure (step 3) it was possible to distinguish the archetypes. For the inventory (step 1) this has not been tried as we used standard available data.

Data uncertainties

Data uncertainties deal with completely different issues. For instance we are confronted with the uncertainty in the expected number of cancer cases when a group of people are exposed to a certain substance, or the uncertainty in the concentration of a certain mineral. In the methodology report the data uncertainties for almost all human health effects and for most ecosystem effects, as well as for the panel procedure are determined and described. Unfortunately uncertainties in the acidification, eutrophication and resources, as well as the uncertainties in the normalisation values are not available.

In considering uncertainties it is important to distinguish between the absolute and relative uncertainties. With the latter we mean the uncertainties in the differences BETWEEN the indicators. This relative uncertainty is the most important for the practical application of the user who wants to compare materials or design options.

The relative uncertainty can be much smaller than the absolute uncertainty. This is because these uncertainties are correlated and have the tendency to compensate each other.

Examples:

1 Suppose product A is made of 5 kg polyethylene and product B is made of 6 kg of the identical polyethylene. In this case it is safe to assume that product B will always have a higher environmental load no matter how big the uncertainties in the indicators are, because any flaw in the methodology would be completely compensated.

2 Suppose now that product B is made out of polypropylene. In this case the uncertainties play a limited role, as the production processes and the most important emissions and raw materials will not be very different. For instance if there is a large flaw in the data for extraction of oil in the dam-

age model for resources, this flaw would have the same effect in both cases. Similarly a flaw in the CO_2 damage model would also work almost exactly the same. As a result we can conclude that the uncertainties in the Eco-indicators when more or less similar processes are compared will be small.

3 Suppose now that product B is made out of wood. Now the uncertainties can be very significant, as the processes and the most important emissions and resources are almost completely different. A flaw in the damage model for extraction of oils is not compensated by a similar flaw in the production process of wood, as relatively little oil is used in the harvesting and transport of wood. Similarly, a flaw in the model for land-use (production forest) is not compensated by the flaw in the model for a refinery, as the amount of land used per kg of oil is low. This means that when the Eco-indicator values are used to compare two completely different materials or processes one must allow for a large error margin before a conclusion can be drawn.

From this we can conclude that it is very difficult to generalise the uncertainties in the indicator, as much depends on the way model flaws compensate each other. As a very provisional and general guideline we recommend the following guidelines when different life cycles are compared:

1 Determine the most important processes (the processes with the highest contributions)
2 Determine if these processes are expected to have similar or dissimilar raw materials, operating principles and emissions.
3 If these dominant processes are considered to be quite similar, the difference between the Eco-indicator scores should be 10 to 50% if a conclusion is to be drawn on which one is the best option
4 If these dominant processes are considered to be dissimilar or completely different the Eco-indicator scores should at least differ more than 100% before a reliable conclusion can be drawn.

When important strategic decisions are to be based on the analysis, we recommend using the Eco-indicator methodology in fully transparent LCA software, as this will allow for a much better understanding of the uncertainties.

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Notes on the process data

The last column of the indicator list contains a code, referring to the origin of the process data, like the emissions, extracted resources and land-uses. In Chapter 5 of the Manual for Designers we refer to this as the data collected under "Step 1".

Below the data sources are briefly described. In all cases the data has been entered into LCA software (SimaPro) and then evaluated with the Eco-indicator 99 methodology.

1 By far most data have been taken directly from the ESU-ETH database Ökoinventare für Energiesystemen (Environmental data on energy systems), the third edition, produced by ETH in Zurich. This very comprehensive database includes capital goods (i.e. concrete for hydroelectric dams and copper for the distribution of electricity) and items like exploration drilling (exploration drilling) for energy systems. Also for transport, capital goods and infrastructure (maintenance and construction of roads, railways and harbours) are included. For material production capital goods are not included. Finally it is important to note that land-use is taken into account in all processes.

2 The Swiss ministry of Environment (BUWAL) has developed a database on packaging materials with the above-mentioned ESU-ETH database as the starting point. However, in this database all capital goods are left out. For the Eco-indicator 99 project we used the data on waste disposal and a few specific packaging materials. For disposal data we made a number of recalculations to include the "positive" effects form reusing material (recycling) or energy (waste incineration). Next to this we used the [OECD 1997] compendium to generate waste scenarios for municipal and household waste for Europe. An important difference with the Eco-indicator 95 is that now we use European in stead of Dutch scenario data. [BUWAL 250-1998]

3 The European Plastics industry (APME) has collected state of the art data for average environmental load for many plastics. As far as possible we used the ESU-ETH version (see 1), as this combines the APME data with much better detailed energy and transport data. The data marked with a 3 are thus the original data, but as they use rather simplified energy and transport data, they can deviate approximately 10 % from the other indicators [APME/PWMI]

4 Processing data has mostly been taken form the Eco-indicator 95 project. In virtually all cases only the primary energy consumption has been taken into account. Material loss and additional materials as lubricants are not included. It should be noted that the energy consumption of a process is very much determined by the type of equipment, the geometry of a product and the scale of operation. Therefore we suggest to take these indicators only as a rough estimate and to calculate more specific data by determining the exact energy consumption in a particular case and to use the indicator for electricity consumption to find a better value. Experience shows that mechanical processing contributes relatively little to the environmental load over the lifecycle. This means the crude nature of the data does not really have to be a big problem. [Kemna 1982]

5 Data on alkyd paint production have been added on the basis of a somewhat older study of AKZO.

6 The KLM environmental annual report was the basis for the data on air transport. This data includes the handling of planes on the ground. [KLM 1999]

7 Data for recycling of plastics are taken from an extensive study of the Centre of Energy Conservation and Clean Technology [CE 1994]

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ADDENDUM

Methodology update and standard indicators

The annexe of this report gives the standard Eco-indicator scores for materials and processes as calculated in April 2000. Since then, some errors have been found in the Eco-indicator calculations, most significantly in land-use, radiation and depletion of minerals.
The Eco-indicator 99 methodology provided with the SimaPro LCA software, used to make the calculations, has been updated. The changes however cause deviations in the Eco-indicator scores as reported in this manual and the results calculated with the updated method in the software.

If the updated Eco-indicator 99 (H)/(A) method from April 2003 is used to calculate new indicator scores, most indicators become slightly higher (varying between 0-5%). The ranking between the materials and processes is comparable. Electricity in France and Switzerland show the biggest changes, as these have relatively high contributions from land-use and radiation. The table below shows the recalculated Eco-indicator scores for electricity.

Electricity (in millipoints per kWh)

	Indicator	Description	
		Including fuel production	
Electr. HV Europe (UCPTE)	23	High voltage (> 24 kVolt)	1
Electr. MV Europe (UCPTE)	23	Medium voltage (1 kV – 24 kVolt)	1
Electr. LV Europe (UCPTE)	27	Low voltage (< 1000Volt)	1
Electricity LV Austria	18	Low voltage (< 1000Volt)	1
Electricity LV Belgium	24	Low voltage (< 1000Volt)	1
Electricity LV Switzerland	10	Low voltage (< 1000Volt)	1
Electricity LV France	12	Low voltage (< 1000Volt)	1
Electricity LV Greece	62	Low voltage (< 1000Volt)	1
Electricity LV Italy	48	Low voltage (< 1000Volt)	1
Electricity LV the Netherlands	37	Low voltage (< 1000Volt)	1
Electricity LV Portugal	47	Low voltage (< 1000Volt)	1

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Production of ferro metals (in millipoints per kg)

	Indicator	Description	
Cast iron	240	Casting iron with > 2% carbon compound	1
Converter steel	94	Block material containing only primary steel	1
Electro steel	24	Block material containing only secondary scrap	1
Steel	86	Block material containing 80% primary iron, 20% scrap	1
Steel high alloy	910	Block material containing 71% primary iron, 16% Cr, 13% Ni	1
Steel low alloy	110	Block material containing 93% primary iron, 5% scrap, 1% alloy metals	1

Production of non ferro metals (in millipoints per kg)

	Indicator	Description	
Aluminium 100% Rec.	60	Block containing only secondary material	1
Aluminium 0% Rec.	780	Block containing only primary material	1
Chromium	970	Block, containing only primary material	1
Copper	1400	Block, containing only primary material	1
Lead	640	Block, containing 50% secondary lead	1
Nickel enriched	5200	Block, containing only primary material	1
Palladium enriched	4600000	Block, containing only primary material	1
Platinum	7000000	Block, containing only primary material	1
Rhodium enriched	12000000	Block, containing only primary material	1
Zinc	3200	Block, containing only primary material (plating quality)	1

Processing of metals (in millipoints)

	Indicator	Description	
Bending–aluminium	0.000047	one sheet of 1mm over width of 1 metre; bending 900	4
Bending–steel	0.00008	one sheet of 1mm over width of 1 metre; bending 900	4
Bending–RVS	0.00011	one sheet of 1mm over width of 1 metre; bending 900	4
Brazing	4000	per kg brazing, including brazing material (45% silver, 27% copper, 25% tin)	1
Cold roll into sheet	18	per thickness reduction of 1 mm of 1 m2 plate	4
Electrolytic Chromium plating	1100	per m2, 1 _m thick, double sided; data fairly unreliable	4
Electrolytic galvanising	130	per m2, 2.5 _m thick, double sided; data fairly unreliable	4
Extrusion – aluminium	72	per kg	4
Milling, turning, drilling	800	per dm3 removed material, without production of lost material	4
Pressing	23	per kg deformed metal. Do not include non-deformed parts!	4
Spot welding–aluminium	2.7	per weld of 7 mm diameter, sheet thickness 2 mm	4
Shearing/stamping–aluminium	0.000036	per mm2 cutting surface	4
Shearing/stampin–steel	0.00006	per mm2 cutting surface	4
Shearing/stamping–RVS	0.000086	per mm2 cutting surface	4
Sheet production	30	per kg production of sheet out of block material	4
Band zinc coating	4300	(Sendzimir zink coating) per m2, 20-45 _m thick, including zinc	1
Hot galvanising	3300	per m2, 100 _m thick, including zinc	1
Zinc coating (conversion um)	49	per m2, 1 extra _m thickness, including zinc	1

Production of plastic granulate (in millipoints per kg)

	Indicator	Description	
ABS	400		3
HDPE	330		1
LDPE	360		1
PA 6.6	630		3
PC	510		1
PET	380		3
PET bottle grade	390	used for bottles	3
PP	330		3
PS (GPPS)	370	general purposes	3
PS (HIPS)	360	high impact	1
PS (EPS)	360	expandable	3
PUR energy absorbing	490		3
PUR flexible block foam	480	for furniture, bedding, clothing	3
PUR hardfoam	420	used in white goods, insulation, construction material	1
PUR semi rigid foam	480		3
PVC high impact	280	Without metal stabilizer (Pb or Ba) and without plasticizer (see under Chemicals)	1
PVC (rigid)	270	rigid PVC with 10% plasticizers (crude estimate)	1*
PVC (flexible)	240	Flexible PVC with 50% plasticizers (crude estimate)	1*
PVDC	440	for thin coatings	3

Processing of plastics (in millipoints)

	Indicator	Description	
Blow foil extrusion PE	2.1	per kg PE granulate, but without production of PE. Foil to be used for bags	2
Calandering PVC foil	3.7	per kg PVC granulate, but without production of PVC	2
Injection moulding – 1	21	per kg PE, PP, PS, ABS, without production of material	4
Injection moulding – 2	44	per kg PVC, PC, without production of material	4
Milling,turning,drilling	6.4	per dm3 machined material, without production of lost material	4
Pressure forming	6.4	per kg	4
React.Inj.Moulding-PUR	12	per kg, without production of PUR and possible other components	4
Ultrasonic welding	0.098	per m welded length	4
Vacuum-forming	9.1	per kg material, but without production of material	4

Production of rubbers (in millipoints per kg)

	Indicator	Description	
EPDM rubber	360	Vulcanised with 44% carbon, including moulding	1

Production of packaging materials (in millipoints per kg)

	Indicator	Description	
Packaging carton	69	CO_2 absorption in growth stage disregarded	1
Paper	96	Containing 65% waste paper, CO_2 absorption in growth stage disregarded	1
Glass (brown)	50	Packaging glass containing 61% recycled glass	2
Glass (green)	51	Packaging glass containing 99% recycled glass	2
Glass (white)	58	Packaging glass containing 55% recycled glass	2

Production of chemicals and others (in millipoints per kg)

	Indicator	Description	
Ammonia	160	NH_3	1
Argon	7.8	Inert gas, used in light bulbs, welding of reactive metals like aluminium	1
Bentonite	13	Used in cat litter, porcelain etc.	1
Carbon black	180	Used for colouring and as filler	1
Chemicals inorganic	53	Average value for production of inorganic chemicals	1
Chemicals organic	99	Average value for production of organic chemicals	1
Chlorine	38	Cl_2. Produced with diaphragm production process (modern technology)	1
Dimethyl p-phthalate	190	Used as plasticizer for softening PVC	1
Ethylene oxide/glycol	330	Used as industrial solvent and cleaning agent	1
Fuel oil	180	Production of fuel only. Combustion excluded!	1
Fuel petrol unleaded	210	Production of fuel only. Combustion excluded!	1
Fuel diesel	180	Production of fuel only. Combustion excluded!	1
H_2	830	Hydrogen gas. Used for reduction processes	1
H_2SO_4	22	Sulphuric acid. Used for cleaning and staining	1
HCl	39	Hydrochloric acid, used for processing of metals and cleaning	1
HF	140	Fluoric acid	1
N_2	12	Nitrogen gas. Used as an inert atmosphere	1
NaCl	6.6	Sodium chloride	1
NaOH	38	Caustic soda	1
Nitric acid	55	HNO_3. Used for staining metals	1
O_2	12	Oxygen gas.	1
Phosphoric acid	99	H_3PO_4. Used in preparation of fertiliser	1
Propylene glycol	200	Used as an anti-freeze, and as solvent	1
R134a (coolant)	150	Production of R134a only! Emission of 1 kg R134a to air gives 7300 mPt	1
R22 (coolant)	240	Production of R22 only! Emission of 1 kg R22 to air gives 8400 mPt	1
Silicate (waterglass)	60	Used in the manufacture of silica gel, detergent manufacture and metal cleaning	1
Soda	45	Na_2CO_3. Used in detergents	1
Ureum	130	Used in fertilisers	1
Water decarbonized	0.0026	Processing only; effects on groundwater table (if any) disregarded	1
Water demineralized	0.026	Processing only; effects on groundwater table (if any) disregarded	1
Zeolite	160	Used for absorption processes and in detergents	1

Production of building material (in millipoints per kg)

	Indicator	Description	
Alkyd varnish	520	Production + emissions during use of varnish, containing 55% solvents	5
Cement	20	Portland cement	1
Ceramics	28	Bricks etc.	1
Concrete not reinforced	3.8	Concrete with a density of 2200 kg/m3	1
Float glass coated	51	Used for windows, Tin, Silver and Nickel coating (77 g/m2)	1
Float glass uncoated	49	Used for windows	1
Gypsum	9.9	Selenite. Used as filler.	1
Gravel	0.84	Extraction and transport	1
Lime (burnt)	28	CaO. Used for production of cement and concrete. Can also be used as strong base	1
Lime (hydrated)	21	Ca(OH)2. Used for production of mortar	1
Mineral wool	61	Used for insulation	1
Massive building	1500	Rough estimate of a (concrete) building per m3 volume (capital goods)	1
Metal construction building	4300	Rough estimate of a building per m3 volume (capital goods)	1
Sand	0.82	Extraction and transport	1
Wood board	39	European wood (FSC criteria); CO2 absorption in growth stage disregarded	1*
Wood massive	6.6	European wood (FSC criteria); CO2 absorption in growth stage disregarded	1*
Land-use	45	Occupation as urban land per m2 yr	*

Heat (in millipoints per MJ)

	Indicator	Description	
		Including fuel production	
Heat coal briquette (stove)	4.6	Combustion of coal in a 5-15 kW furnace	1
Heat coal (industrial furnace)	4.2	Combustion of coal in a industrial furnace (1-10MW)	1
Heat lignite briquet	3.2	Combustion of lignite in a 5-15kW furnace	1
Heat gas (boiler)	5.4	Combustion of gas in an atmospheric boiler (<100kW) with low NOx	1
Heat gas (industrial furnace)	5.3	Combustion of gas in an industrial furnace (>100kW) with low NOx	1
Heat oil (boiler)	5.6	Combustion of oil in a 10kW furnace	1
Heat oil (industrial furnace)	11	Combustion of oil in an industrial furnace	1
Heat wood	1.6	Combustion of wood; CO2 absorption and emission disregarded	1*

Solar energy (in millipoints per kWh)

	Indicator	Description	
Electricity facade m-Si	9.7	Small installation (3kWp) with monocrystaline cells, used on building facade	1
Electricity facade p-Si	14	Small installation (3kWp) with polycrystaline cells, used on building facade	1
Electricity roof m-Si	7.2	Small installation (3kWp) with monocrystaline cells, used on building roof	1
Electricity roof p-Si	10	Small installation (3kWp) with polycrystaline cells, used on building roof	1

Electricity (in millipoints per kWh)

	Indicator	Description	
		Including fuel production	
Electr. HV Europe (UCPTE)	22	High voltage (> 24 kVolt)	1
Electr. MV Europe (UCPTE)	22	Medium voltage (1 kV – 24 kVolt)	1
Electr. LV Europe (UCPTE)	26	Low voltage (< 1000Volt)	1
Electricity LV Austria	18	Low voltage (< 1000Volt)	1
Electricity LV Belgium	22	Low voltage (< 1000Volt)	1
Electricity LV Switzerland	8.4	Low voltage (< 1000Volt)	1
Electricity LV Great Britain	33	Low voltage (< 1000Volt)	1
Electricity LV France	8.9	Low voltage (< 1000Volt)	1
Electricity LV Greece	61	Low voltage (< 1000Volt)	1
Electricity LV Italy	47	Low voltage (< 1000Volt)	1
Electricity LV the Netherlands	37	Low voltage (< 1000Volt)	1
Electricity LV Portugal	46	Low voltage (< 1000Volt)	1

Transport (in millipoints per tkm)

	Indicator	Description	
		Including fuel production	
Delivery van <3.5t	140	Road transport with 30% load, 33% petrol unleaded, 38% petrol leaded, 29% diesel (38% without catalyst) (European average including return)	1
Truck 16t	34	Road transport with 40% load (European average including return)	1
Truck 28t	22	Road transport with 40% load (European average including return)	1
Truck 28t (volume)	8	Road transport per m3km. Use when volume in stead of load is limiting factor	1*
Truck 40t	15	Road transport with 50% load (European average including return)	1
Passenger car W-Europe	29	Road transport per km	1
Rail transport	3.9	Rail transport, 20% diesel and 80% electric trains	1
Tanker inland	5	Water transport with 65% load (European average including return)	1
Tanker oceanic	0.8	Water transport with 54% load (European average including return)	1
Freighter inland	5.1	Water transport with 70% load (European average including return)	1
Freighter oceanic	1.1	Water transport with 70% load (European average including return)	1
Average air transport	78	Air transport with 78% load (Average of all flights)	6
Continental air transport	120	Air transport in a Boeing 737 with 62% load (Average of all flights)	6
Intercontinental air transport	80	Air transport in a Boeing 747 with 78% load (Average of all flights)	6
Intercontinental air transport	72	Air transport in a Boeing 767 or MD 11 with 71% load (Average of all flights)	6

Recycling of waste (in millipoints per kg)

	Indicator			Description	
	Total	**Process**	**Avoided product**	Environmental load of the recycling process and the avoided product differs from case to case. The values are an example for recycling of primary material.	
Recycling PE	-240	86	-330	if not mixed with other plastics	7*
Recycling PP	-210	86	-300	if not mixed with other plastics	7*
Recycling PS	-240	86	-330	if not mixed with other plastics	7*
Recycling PVC	-170	86	-250	if not mixed with other plastics	7*
Recycling Paper	-1,2	32	-33	Recycling avoids virgin paper production	2*
Recycling Cardboard	-8,3	41	-50	Recycling avoids virgin cardboard production	2*
Recycling Glass	-15	51	-66	Recycling avoids virgin glass production	2*
Recycling Aluminium	-720	60	-780	Recycling avoids primary aluminium.	1*
Recycling Ferro metals	-70	24	-94	Recycling avoids primary steel production	1*

Waste treatment (in millipoints per kg)

	Indicator	Description	
Incineration		Incineration in a waste incineration plant in Europe. Average scenario for energy recovery. 22% of municipal waste in Europe is incinerated	
Incineration PE	-19	Indicator can be used for both HDPE and LDPE	2*
Incineration PP	-13		2*
Incineration PUR	2,8	Indicator can be used for all types of PUR	2*
Incineration PET	-6,3		2*
Incineration PS	-5,3	Relatively low energy yield, can also be used for ABS, HIPS, GPPS, EPS	2*
Incineration Nylon	1,1	Relatively low energy yield	2*
Incineration PVC	37	Relatively low energy yield	2*
Incineration PVDC	66	Relatively low energy yield	2*
Incineration Paper	-12	High energy yield CO_2 emission disregarded	2*
Incineration Cardboard	-12	High energy yield CO_2 emission disregarded	2*
Incineration Steel	-32	40% magnetic separation for recycling, avoiding crude iron (European average)	2*
Incineration Aluminium	-110	15% magnetic separation for recycling, avoiding primary aluminium	2*
Incineration Glass	5,1	Almost inert material, indicator can be used for other inert materials	2
Landfill		Controlled landfill site. 78% of municipal waste in Europe is landfilled	
Landfill PE	3,9		2
Landfill PP	3,5		2
Landfill PET	3,1		2
Landfill PS	4,1	Indicator can also be used for landfill of ABS	2
Landfill EPS foam	7,4	PS foam, 40 kg/m3, large volume	2*
Landfill foam 20kg/m3	9,7	Landfill of foam like PUR with 20kg/m3	2*
Landfill foam 100kg/m3	4,3	Landfill of foam like PUR with 100kg/m3	2*
Landfill Nylon	3,6		2*
Landfill PVC	2,8	Excluding leaching of metal stabilizer	2

Landfill PVDC	2,2		2
Landfill Paper	4,3	CO_2 and methane emission disregarded	2
Landfill Cardboard	4,2	CO_2 and methane emission disregarded	2
Landfill Glass	1,4	Almost inert material, indicator can also be used for other inert materials	2
Landfill Steel	1,4	Almost inert material on landfill, indicator can be used for ferro metals	2
Landfill Aluminium	1,4	Almost inert material on landfill, indicator is valid for primary and recycled alu.	2
Landfill of 1 m3 volume	140	Landfill of volume per m3, use for voluminous waste, like foam and products	*
Municipal waste		In Europe, 22% of municipal waste is incinerated, 78% is landfilled. Indicator is not valid for voluminous waste and secondary materials	
Municipal waste PE	-1,1		2*
Municipal waste PP	-0,13		2*
Municipal waste PET	1		2*
Municipal waste PS	2	Not valid for foam products	2*
Municipal waste Nylon	3,1		2*
Municipal waste PVC	10		2*
Municipal waste PVDC	16		2*
Municipal waste Paper	0,71		2*
Municipal waste Cardboard	0,64		2*
Municipal waste ECCS steel	-5,9	Valid for primary steel only!	2*
Municipal waste Aluminium	-23	Valid for primary aluminium only!	2*
Municipal waste Glass	2,2		2*
Household waste		Separation by consumers of waste for recycling (average European scenario)	
Paper	-0,13	44% separation by consumers	2*
Cardboard	-3,3	44% separation by consumers	2*
Glass	-6,9	52% separation by consumers	2*

Product or component	Project
Date	**Author**

Notes and conclusions

Production

Materials, processing, transport and extra energy

material or process	amount	indicator	result
Total			

Use

Transport, energy and any auxiliary materials

process	amount	indicator	result
Total			

Disposal

Disposal processes per type of material

material and type of processing	amount	indicator	result
Total			
Total (all phases)			
Product or component	Project		
Date	Author		
Notes and conclusions			

Production

Materials, processing, transport and extra energy

material or process	amount	indicator	result
Total			

Use

Transport, energy and any auxiliary materials

process	amount	indicator	result
Total			

Disposal

Disposal processes per type of material

material and type of processing	amount	indicator	result
Total			
Total(all phases)			

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