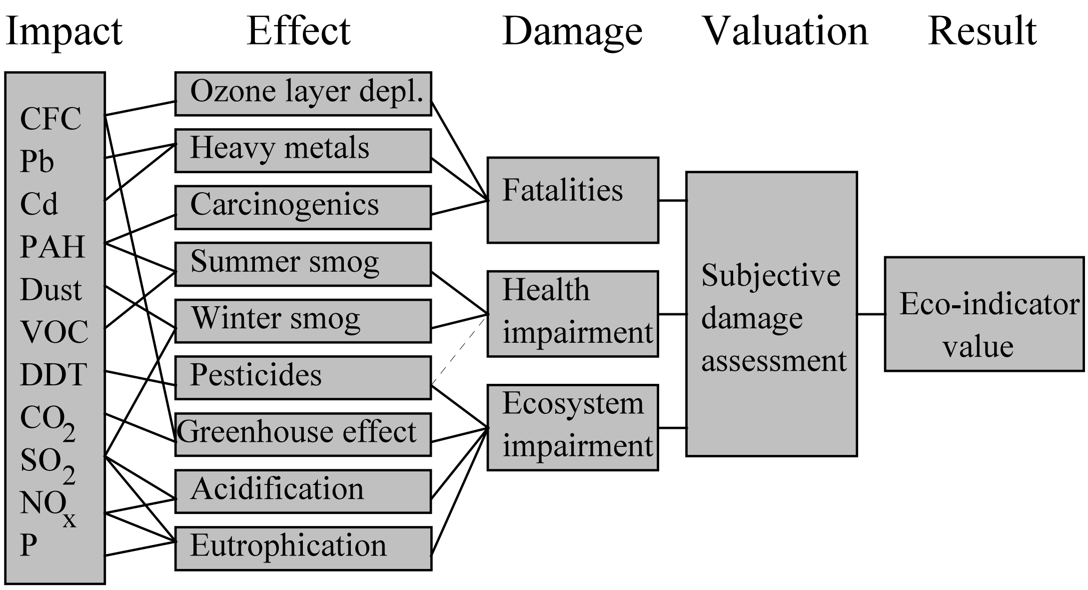
The Eco-indicator 95

Weighting method for environmental effects that damage ecosystems or human health on a European scale.
Contains 100 indicators for important materials and processes.
Updated version, November 1996

Manual for Designers



On the initiative of:

- Nederlandse Philips bedrijven BV
- Océ Nederland BV
- Netherlands Car BV
- Machinefabriek Fred A. Schuurink BV

With the cooperation of:

- University of Leiden (CML)
- University of Amsterdam (IDES, Environmental Research)
- Technical University of Delft (Industrial Design Engineering)
- Centre for Energy Conservation and Environmental Technology Delft
- TNO Product Centre
- Ministry of Housing, Spatial Planning and the Environment (VROM)

Authors:
Mark Goedkoop, Marjolein Demmers and Marcel Collignon of PRé Consultants

Colophon

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The Eco-indicator 95, Manual for Designers, updated version November 1996
This report slightly differs from reports ordered through MHP or PRé Consultants. It contains both new and updated Eco-indicator values. Also some minor adjustments of the text were made.

This project was carried out and financed under the auspices of the National Reuse of Waste Research Programme (NOH). Management and coordination of the NOH programme are the responsibility of:

Novem BV Netherlands agency for energy and the environment
P. O. Box 8242 3503 RE Utrecht the Netherlands
Telephone: +31 (0)30 2393493
Telefax: +31 (0)30 2316491
Project managers: Ms. J. Hoekstra, Mr. J. v.d. Velde

RIVM National Institute of Public Health and Environmental Protection
P. O. Box 1 3720 BA Bilthoven the Netherlands
Telephone: +31 (0)30 2749111
Telefax: +31 (0)30 2744417
Project manager: Mr. G. L. Duvoort

The project was carried out by:

- PRé Consultants
- DUIJF Consultancy BV[1]

In addition to this manual for designers a final report and an appendix are available. The final report describes the Eco-indicator weighting method. The appendix, which is only available in Dutch, describes the full contribution of the cooperating institutes and the full impact tables. Additional copies of this report, the final report and the appendix are available from:

PRé Consultants
Plotterweg 12 3821 BB Amersfoort the Netherlands
Telephone: +31 (0)33 4555022
Telefax: +31 (0)33 4555024
E-mail: info@pre.nl Web site: www.pre.nl

NOH report 9523	The Eco-indicator 95, Final Report	Dfl. 45.00
NOH report 9524	The Eco-indicator 95, Manual for Designers	Dfl. 25.00
NOH report 9514 A	De Eco-indicator 95, bijlagerapport (only in Dutch)	Dfl. 55.00

The reports 9523 and 9524 are also available in Dutch at the same cost. For shipment abroad Dfl 20,- postage and packaging costs will be charged extra. The NOH has made it possible to give a discount off the price of reports used for educational purposes (bulk orders).

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[1] At 25.1.1995 Duijf Consultancy BV went out of business.

Preface

Environmental care behind the drawing board has been a familiar concept for some years in the attempt to achieve more environmentally-sound products. But what is the environment, and how do you bring it behind the drawing board? Until now there is no unambiguous measure for environmental impacts of products, which makes it difficult to develop environmentally sound products. For Philips, NedCar, Océ and Schuurink, this prompted the request to the NOH to start the Eco-indicator project.

Our work within the Eco-indicator project as a multidisciplinary team of representatives from industry, science and government was to give fundamental and in-depth consideration to the question of what the environment actually is and how we should evaluate the consequences of impairment of the environment. Do we evaluate this on the basis of measurable damage to ecosystems or on the basis of impairment of human health? Is raw materials depletion an environmental problem or is it a different problem? And what should be done with local and transient effects?

The outcome of our work is a carefully considered method. It is not a perfect method and it will certainly be possible to improve it. Within the limitations of our knowledge of environmental problems we have attempted to develop the best method feasible at this time. No more, no less.

In addition to the method, which is described in the current report, a list of 100 indicators for commonly used materials and processes has been produced. This list is included it this report and in the Manual for Designers, which is a separate publication from this project. This manual describes the application of the Eco-indicators in the design process, the limitations and the possibilities.

In its “Products and the Environment” paper the Dutch Government announced that it would be developing a method in conjunction with organisations from the community to enable the seriousness of environmental effects to be weighted for the purposes of product policy. In September 1994 *VROM*, the Dutch Ministry of Housing, Spatial Planning and the Environment submitted a proposal for such a weighting method to the *Raad voor het Milieubeheer* [Council for Environmental Management]. In November 1994 the Council responded positively to this proposal. It recommended though that experiments should be carried out initially before definitively specifying the method. Since the Eco-indicator contains all the important features of the *VROM* proposal this means that the Eco-indicator dovetails perfectly with government policy. It will be possible to specify a definitive proposal in 1995 on the basis, among other things, of experiments with the Eco-indicator.

Sincere thanks are extended to the NOH who had the courage and vision to instigate this project at the request of a number of companies. Many thanks are also due to Mr. Sondern (Philips BGTV). Without his enthusiastic chairmanship this project would probably never have got off the ground. The very constructive role of our scientific representatives, Messrs. Sas (CE), Heijungs (CML), Lindeijer (IDES) and Remmerswaal (TUD) also merits special mention.

Mark Goedkoop

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1. Principle of the Eco-indicator

1.1. 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 therefore be possible to include the environmental aspects of a product in the analysis and selection of design options. The Eco-indicator has been developed as an instrument to do just that. It is an easy-to-use instrument that enables the designer to analyse a design solution and to select the most environmentally-friendly of the various options. The Eco-indicator is an instrument 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 Eco-indicator is **not** intended for use in environmental marketing, for environmental labelling or for proving in public that product A is better than product B. In this connection it is as well to point out that many suppliers have already had to retract such claims.
The Eco-indicator is also **not** intended as an instrument for the Government in drawing up standards and 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-friendly. It is, therefore, a tool that can be used within companies or sectors.

1.2. Environmental effects of products

Every product impacts on 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 itself. If we wish to assess a product’s environmental impact, all its 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].

A life cycle assessment can be used in two ways:

1. To determine the total environmental impact of products or design alternatives with the aim of comparing them. For a designer an LCA can provide a solution if he has to choose between design alternatives or between different components or materials.
2. To determine the most important causes of one product’s environmental impact. A designer can then concentrate on these to achieve improvements here first.

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

1. The result of a 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.

[1]. A good introduction to the LCA methodology is: Beginning LCA, A guide into environmental Life Cycle Assessment, NOH report 9453. For more detailed information: Environmental Life Cycle Assessments of Products, Guide and Backgrounds, NOH report 9266 and 9267 or a "Code of Practice", SETAC, Society of Environmental Toxicology and Chemistry, Guidelines for Life-Cycle Assessment, Brussels, Belgium, 1993.

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 such that they fit together like building blocks. Thus there is an indicator for the production of a kilo of polyethylene, one for the extrusion of a kilo of polyethylene and one for the incineration of thermoplastics.

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. The Eco-indicator brings environmental assessments within the designer's reach. Chapter 5 gives a summary of the weighting method. The backgrounds to the weighting method and the calculation of the 100 Eco-indicators are described in a separate Final report (see the Bibliography in this report).

1.3. Definition of the term "Eco"

During the development of the weighting method for the Eco-indicator much attention was given to defining the term "environment", or the actual meaning of "Eco". The following demarcation has been chosen for the Eco-indicator method:

Environmental effects that damage ecosystems or human health on a European scale.

This means that account is taken of the following environmental effects in the Eco-indicator:
- Greenhouse effect. The anticipated temperature rise as a result of the increasing concentration of gases that restrict heat radiation by the Earth.
- Ozone layer depletion. The increase in ultraviolet radiation on Earth caused by high-altitude decomposition of the ozone layer.
- Acidification. Degradation of forests in particular by, for example, acid rain.
- Eutrophication. The disappearance of rare plants that grow precisely in poor soils, as a result of the emission of substances that have the effect of a fertiliser and the changes in aquatic ecosystems.
- Smog. The problems for people with weak airways (asthma patients) caused by the high concentrations of low-level ozone or by dust and sulphur compounds.
- Toxic substances. Substances that are toxic other than as described above, e.g. heavy metals, carcinogenic substances and pesticides.

1.4. Environmental effects that are disregarded

Our definition of the term 'Eco' means that the following environmental problems are not assessed in the Eco-indicator:
- Toxic substances that are only a problem in the workplace but scarcely occur in the outside environment because they decompose rapidly.
- The exhaustion (depletion) of raw materials.
- The quantity of waste; the effects of waste processing *are* included.

These exclusions are discussed in chapter 5.

The Eco-indicator is one of the first weighting systems in the world. This means that it is still of an experimental nature and that there are still fairly major uncertainties in the data and in the methods. For this reason the indicator has no universal and absolute validity. It is the best method that is possible based on our current (limited) expertise, no more, no less. It is anticipated that scientific knowledge will increase in the long term and that the weighting method will be improved. This means that new indicators may perhaps become available to replace the current ones.

2. Eco-indicators

Two means of using the Eco-indicator are presented:
1. An Eco-indicator list with the figures for 100 different processes (including material production processes). These are defined such that they fit together like building blocks.
2. A fill-in form that can be used to calculate the life cycle of a product (component).

2.1. Description of the 100 materials and processes

Eco-indicator values are available for:
- Materials. The total production processes based on 1 kilo material.
- Treatment 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 expressed in the unit tonne-kilometre or per tonne.
- Energy generation processes. Units are given for electricity, heat and mechanical energy.
- Disposal scenarios. These are per kilo of material, subdivided into types of material and waste processing method.

Average European figures are used for the processes that describe material production, treatments, transport and energy generation. The waste processing and recycling processes are based on Dutch figures because of a lack of European data. A particular definition was used for the terms "material" and "process" when determining the indicators. The definitions used are explained briefly below. This report contains an updated version of the Eco-indicator values: some values have changed, some are new. A brief description of the update can be found in the appendix.

2.1.1. 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.

2.1.2. Treatment 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, machines and dies are not included.

2.1.3. 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 1000 kg goods over 1 km (1 tkm). A different unit is used for bulk road transport and air transport.
- Road transport. This is based on the use of a diesel engine. A load level for trucks of 60% (European average) is assumed. Account is also taken of a possible empty return journey. In addition to transport in which the mass is the critical factor (mass per km), an indicator has also been determined for those cases where the volume is the determining factor (m^3 volume per km).
- Rail transport. This is based on the average European ratio of diesel to electric traction and an average load level.

- Air transport. This is based on continental flights. The average distance for such flights is 600 km. Because this distance is relatively short, descent and climbing prove to be determining factors in the environmental impact. The Eco-indicator for air transport is then not based on 1 tonne-kilometre but on 1 kg.

2.1.4. Energy

The energy indicators refer to the extraction and production of fuels and to energy generation. Account is taken of average efficiency. 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.

2.1.5. Waste processing and recycling

Not all products are disposed of in the same manner. When using indicators careful consideration must therefore be given to which waste processing method is the most likely. 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 gives the average contribution by a household based on Dutch figures.
- Municipal waste. In the municipal waste scenario the average processing of waste in the Netherlands 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 a very modern plant with a high-quality scrubbing system. This situation is by no means to be found everywhere but this will change gradually in the coming years. A proportion of the steel (80%) and aluminium (30%) 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 landfill sites with water purification and good seals, as a result of which relatively few harmful substances will reach groundwater sources.
- Recycling. With recycling it is assumed that the materials arrive sorted by type and clean. In the updated version the separated values for recycling and avoided product are also given (see next paragraph).

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

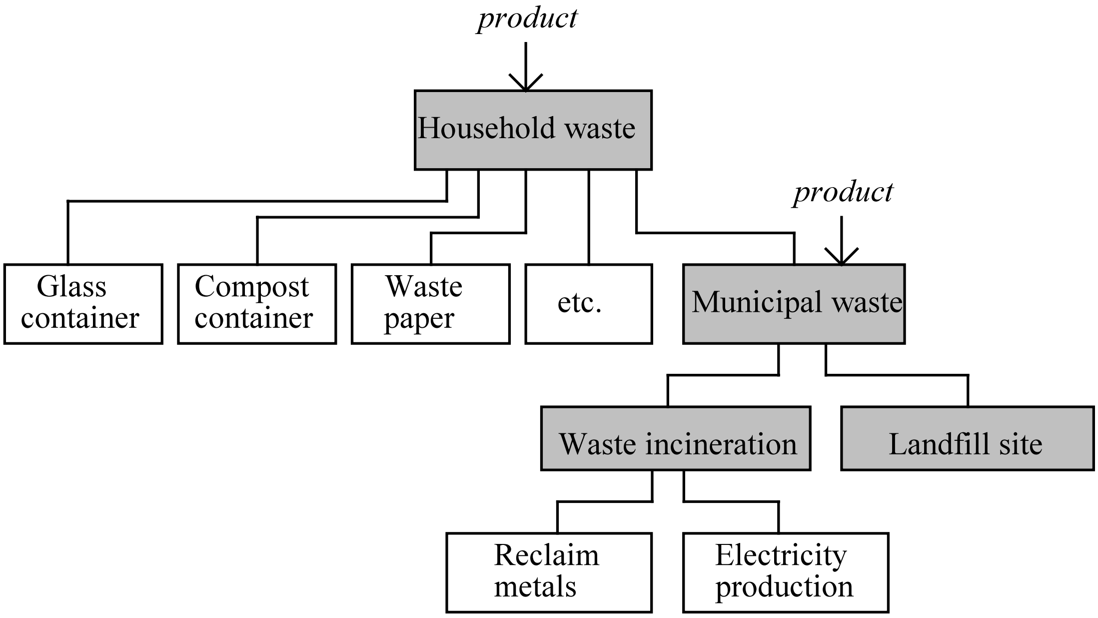

Fig. 1: Schematic representation of the waste scenarios (grey blocks) and mutual interactions. It is up to the user to choose between the different scenarios.

The waste data have been determined for each material fraction rather than for each specific material. A fraction is a group of materials that can be processed in a more or less similar manner. For plastic materials there is a separate PVC fraction because this material has different properties from other thermoplastics particular if incinerated.

2.1.6. Negative figures for waste processing

Some scenarios yield negative figures. The energy and materials 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 pig 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. In the update, the value for recycling is given, as well as the value for the recyling process itself and the substracted value for the avoided emissions.

2.2. List of indicators

The following pages contain the complete (updated) list of indicators. The Eco-indicator value is expressed in Eco-indicator points (Pt). Updated or new values are indicated with an asterix *. In practice the Eco-indicators absolute value is relatively meaningless because the indicator is intended solely for comparative purposes.

In the Eco-indicator list the data are expressed as a milli-indicator to avoid having to work with large numbers of figures after the decimal point (thus 1.8 mPt = 0.0018 Pt). Space has been left to allow new indicators and the results of Eco-indicator calculations for commonly used parts or components to be entered.

Production of metals (in millipoints per kg)

	Indicator	Description
Secondary aluminium	**1.8**	made completely from secondary material (not easy to obtain!)
Aluminium	**18**	containing an average of 20% recycled material
Copper, primary	**85**	primary electrolytic copper from relatively modern American factories
Copper, 60% primary	**60**	normal proportion secondary and primary copper
Secondary copper	**23**	100% sec. copper, (not easy to obtain!)
Other non-ferrous metals	**50-200**	estimate for zinc, brass, chromium, nickel etc.; lack of data
Stainless steel	**17**	sheet material, grade 18-8, 1 mm thickness
Secondary steel	**1.3**	block material made from 100% scrap
Steel	**4.1**	block material with average 20 % scrap
Sheet steel	**4.3**	cold-rolled sheet with average 20% scrap

Processing of steel (in millipoints)

	Indicator	Description
Bending steel	**0.0021**	one sheet of 1 mm over width of 1 metre; straight angle
Bending stainless steel	**0.0029**	one sheet of 1 mm over width of 1 metre; straight angle
Cutting steel	**0.0015**	one sheet of 1 mm over width of 1 metre
Cutting stainless steel	**0.0022**	one sheet of 1 mm over width of 1 metre
Pressing and deep-drawing	**0.58**	per kilo deformed steel, do not include non-deformed parts!
Rolling (cold)	**0.46**	per pass, per m^2
Spot-welding	**0.0074**	per weld of 7 mm diameter, sheet thickness 2 mm
Machining	**0.42**	per kilo machined material ! (turning, milling, boring)
Machining	**0.0033**	per cm^3 machined material ! (turning, milling, boring)
Hot-galvanising	**17**	per m^2, 10 micrometres, double-sided; data fairly unreliable
Electrolytic galvanising	**22**	per m^2, 2.5 micrometres, double-sided; data fairly unreliable
Electroplating (chrome)	**70**	per m^2, 1 micrometre thick; double-sided; data fairly unreliable

Processing of aluminium (in millipoints)

	Indicator	Description
Blanking and cutting	**0.00092**	one sheet of 1 mm over width of 1 metre
Bending	**0.0012**	one sheet of 1 mm over width of 1 metre
Rolling (cold)	**0.28**	per pass, per m^2
Spot-welding	**0.068**	per weld of 7 mm diameter, sheet thickness 2 mm.
Machining	**0.12**	per kilo machined material ! (turning, milling, boring)
Machining	**0.00033**	per cm^3 machined material ! (turning, milling, boring)
Extrusion	**2.0**	per kilogram

Production of plastic granulate (in millipoints per kg)

	Indicator	Description and explanation of score
ABS	**9.3**	high energy input for production, therefore high emission output
HDPE	**2.9**	relatively simple production process
LDPE	**3.8**	score possibly flattered by lack of CFC emission
PA	**13**	high energy input for production, therefore high emission output
PC	**13**	high energy input for production, therefore high emission output
PET amorphous	**7.1**	used for fibres and foil
PET bottle grade*	**7.4**	used for bottles
PP	**3.3**	relatively simple production process
PPE/PS	**5.8**	a commonly used blend, identical to PPO/PS
PS rigid foam	**13**	block of foam with pentane as blowing agent (causes smog)
PS high impact (HIPS)	**8.3**	high-impact polystyrene
PUR flexible block foam*	**5.9**	for furniture, bedding, clothing, leisure goods (water blown)
PUR rigid foam*	**8.4**	in white goods, insulation, construction materials (pentane blown)
PUR semi-rigid foam*	**6.9**	used in dashboards (pentane blown)
PUR energy absorbing*	**8.7**	bumpers (pentane blown)
PVC	**4.2**	calculated as pure PVC, without addition of stabilisers or plasticizers
PVDC*	**9.1**	for thin coatings, calculated without stabilisers and other additives

Processing of plastics (in millipoints)

	Indicator	Description
Injection moulding general	**0.53**	per kilo material, may also be used as estimate for extrusion
Inject. mould. PVC & PC	**1.1**	per kilo material, may also be used as estimate for extrusion
RIM, PUR	**0.30**	per kilo material
Extrusion blowing PE	**0.72**	per kilo, for bottles and such like
Vacuum forming	**0.23**	per kilo
Vacuum pressure forming	**0.16**	per kilo
Calandering of PVC	**0.43**	per kilo
Foil blowing PE	**0.030**	per m^2, thin foil (for bags)
Ultrasonic welding	**0.0025**	per metre weld length
Machining	**0.00016**	per cm^3 machined material

Production of rubbers and elastomers (millipoints per kg)

	Indicator	Description
Raw natural rubber*	**1.5**	dried en baled natural rubber from latex, for vulcanisation
Natural rubber product*	**4.3**	vulcanised with 28% carbon black; used for truck tyres
SBR product*	**5.6**	vulcanised with 26% carbon black; used for car tyres
EPDM product*	**4.1**	vulcanised with 32% carbon black; used for profiles

Production of other materials (in millipoints per kg)

	Indicator	Description
Glass	**2.1**	57% secondary glass
Glass wool and glass fibre	**2.1**	for isolation and reinforcement
Rockwool	**4.3**	score is largely determined by carcinogenic substances
Ceramics	**0.47**	simple applications, e.g. sanitary fittings etc.
Cellulose board	**3.4**	this material is particularly used in dashboards
Paper	**3.3**	chlorine-free bleaching, normal quality
Recycled paper	**1.5**	unbleached, 100% waste paper
Wood	**0.74**	wood from Europe, sawn into planks, without preservatives
Cardboard	**1.4**	corrugated cardboard made from 75% waste paper

Production of energy (in millipoints)

	Indicator	Description
Electricity high voltage	**0.57**	per kWh, for industrial use
Electricity low voltage	**0.67**	per kWh, for consumer use (230V)
Heat from gas (MJ)	**0.063**	per MJ heat
Heat from oil (MJ)	**0.15**	per MJ heat
Mechanical (diesel, MJ)	**0.17**	per MJ mechanical energy from a diesel engine

Transport (in millipoints)

	Indicator	Description
Truck (28 ton)	**0.34**	per ton kilometre, 60% loading, European average
Truck ($75m^3$)	**0.13**	per m^3 km, 60% loading, European average
Train	**0.043**	per ton kilometre, European average for diesel and electric traction
Container ship	**0.056**	per ton kilometre, fast ship, with relatively high fuel consumption
Aircraft (continental)*	**1.7**	*per kg !*, with continental flights the distance is not relevant
Aircraft (intercontinental)*	**0.81**	per ton kilometre

Self-made indicators for components (in millipoints)

	Indicator	Description

Eco-indicator values from: The Eco-indicator 95, Manual for Designers; (NOH report 9523 and 9524)
Updated version November 1996 Changes are marked with *

Waste processing and recycling (in millipoints per kg)

Fraction	Indicator	Notes		
Incineration (in modern waste incinerator with heat recovery and flue-gas treatment)				
Glass	**0.89**	almost inert material on incineration		
Ceramics	**0.020**	almost inert material on incineration		
Plastics and rubber	**1.8**	plastics contain heavy metals, but also have a high energy yield		
PVC	**6.9**	PVC contains heavy metals and has a relatively low energy yield		
Paper and cardboard	**0.56**	heavy metals (ink) are dominant, energy yield is relatively high		
Steel and iron	**1.8**	70% is recovered from slag, particularly larger pieces		
Aluminium*	**-7**	30% recovery from slag, not valid for very thin materials		
Copper*	**-16**	30% recovery from slag, not valid for very thin materials		
Landfill (in modern landfill site with percolation water treatment and dense base)				
Glass	**0**	almost inert material on a landfill		
Ceramics	**0.027**	almost inert material on a landfill		
Plastics and rubber	**0.035**	0.1 % of all heavy metals released		
PVC	**0.077**	0.1 % of all heavy metals released		
Paper and cardboard	**0.16**	10% of all heavy metals (mainly in ink) released		
Steel and iron	**0.80**	small proportion (ca. 1%) of heavy metals released		
Aluminium*	**0.003**	mainly due to contaminants		
Copper*	**4.6**	0.1 % of copper released		
Recycling (note: these values cannot be used for recycling of secondary material)				
	total	process emissions*	avoided emissions*	Total score is split into a score for the recycling process and avoided product
Glass	**-1.5**	*0.5*	*-2*	recycling avoids glass production
Ceramics				no usefull recycling possible
Plastics (PP and PE)	**-0.46**	*2.2*	*-2.66*	if not mixed with other plastics
Engineering plastics*	**-3 - 9.5**	*2.2*	*-5.7- -11.7*	avoided emission is 90% of production
PVC	**-1.6**	*2.2*	*-3.8*	if not mixed with other plastics
Paper and cardboard	**-1.8**	*0.2*	*-2*	recycling avoids pulp production
Steel and iron	**-2.9**	*0.8*	*-3.7*	recycling avoids pig iron production
Aluminium*	**-13**	*2*	*-15*	85% aluminium recovery
Copper*	**-35**	*22*	*-58*	96% copper recovery
Municipal waste (processing of waste by average Dutch municipality)				
Glass	**0.35**	37% incinerated, 63% landfilled		
Ceramics	**0.041**	37% incinerated, 63% landfilled		
Plastics and rubber	**0.69**	37% incinerated, 63% landfilled		
PVC	**2.6**	37% incinerated, 63% landfilled		
Paper and cardboard	**0.33**	37% incinerated, 63% landfilled		
Steel and iron	**1.2**	37% incinerated, from which 70% is recovered, 63% landfilled		
Aluminium*	**-3**	37% incinerated (30% recovery), 63% landfilled		
Copper*	**-2.6**	37% incinerated (30% recovery), 63% landfilled		
Household waste (same, but with average separation by consumer (e.g. glass and paper)				
Glass	**-0.80**	61% separated and recycled, rest is municipal waste (see above)		
Ceramics	**0.041**	almost all processed as municipal waste		
Plastics and rubber	**0.66**	2% separated and recycled, rest is municipal waste (see above)		
PVC	**2.5**	2% separated and recycled, rest is municipal waste (see above)		
Paper and cardboard	**-0.43**	35% separated and recycled, rest is municipal waste (see above)		
Steel and iron	**-0.28**	36% separated and recycled, rest is municipal waste (see above)		
Aluminium*	**-3**	processed as municipal waste		
Copper*	**-2.6**	processed as municipal waste		

Eco-indicator values from: The Eco-indicator 95, Manual for Designers; (NOH report 9523 and 9524)
Updated version November 1996 Changes are marked with *

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)			

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)			

3. 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 the form in.
5. Interpret the results.

In most cases it is recommended that you start simply 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 this product is being carried out or a comparison with another product.
- 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 far from all details 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 not so much a product as a product life cycle. 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.

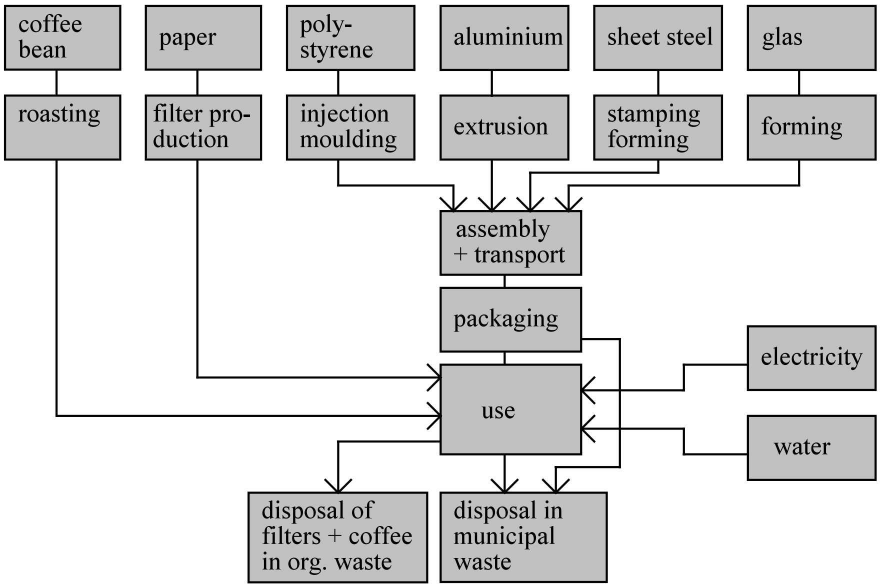

Fig. 2. Example of a simplified process tree for the life cycle of a coffee machine.

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 with the rest.
- The user estimates a quantity himself.

In general it is better to make a number of estimates first and then later to seek more accurate data 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 energy 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 the form in

- 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.

Two forms are available whose main difference is in the length of the tables. Form 1 is particularly suitable for simple products and product comparisons, while form 2 is particularly suitable for detailed analyses of complex products. Like the Eco-indicator lists these are included as loose insert cards at the end of this manual.

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.

It is possible to derive from the size of the scores 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. 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.

4. Examples

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.

4.1.1. 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 profit? 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.

4.1.2. 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. The relative amounts are also indicated by the thickness of the arrows. 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.

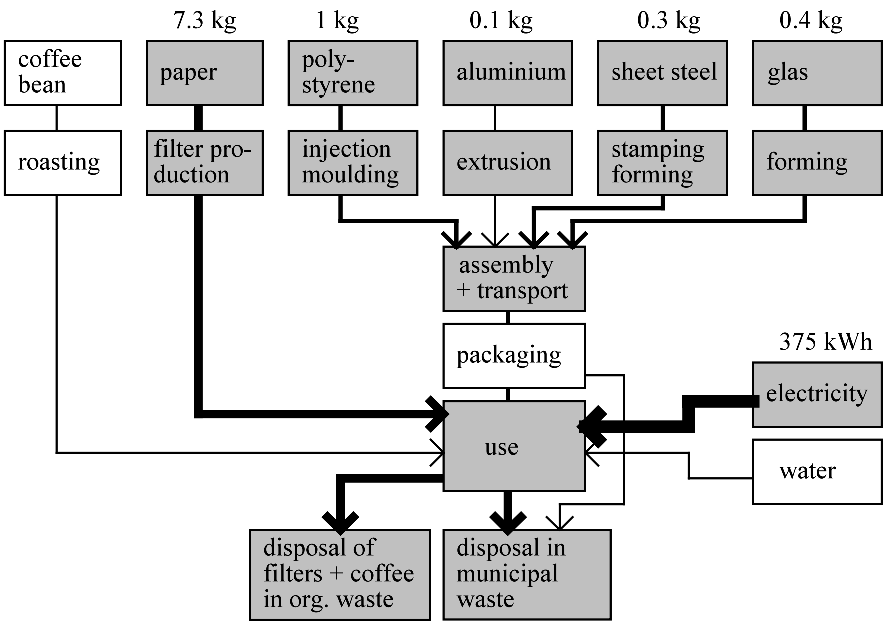

Fig. 3: Process tree of a simplified coffee machine model with amounts and assumptions.

4.1.3. 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 data on separate hot plates. However, inexpensive watt meters are also available for this purpose. The figure of 375 kWh was determined from measured readings.

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.

4.1.4. Step 4: Fill the form in

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. A fully completed form is shown overleaf.

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. Becauseof this, metal processsing 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 aluminium and compostable waste:

- The disposal of aluminium can be substituted provisionally for steel. This is a rough assumption, and it should to be verified later whether this assumption might have a major effect on the conclusions. If so, the assumption will have to be examined more closely.
- No indicator score is given for composting of paper. 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.

Product or component	Project
coffee machine	*example*
Date *17-12-96*	Author *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*	*8.3*	*8.3*
injection moulding PS	*1 kg*	*0.53*	*0.53*
aluminium	*0.1 kg*	*18*	*1.8*
extrusion Al	*0.1 kg*	*2*	*0.2*
sheet steel	*0.3 kg*	*4.3*	*1.29*
glass	*0.4 kg*	*2.1*	*0.84*
gas-fired heat (moulding)	*4 MJ*	*0.063*	*0.252*
Total			*13.2*
Use Transport, energy and possible auxiliary materials			
process	amount	indicator	result
electricity low-voltage	*375kWh*	*0.67*	*251*
paper	*7.3 kg*	*3.3*	*24*
Total			*275*
Disposal Disposal processes for each material type			
material and type of processing	amount	indicator	result
municipal waste, plastic	*1 kg*	*0.69*	*0.69*
municipal waste, steel	*0.1 kg*	*1.2*	*0.12*
municipal waste, Al	*0.3 kg*	*-3*	*-0.9*
household waste, glass	*0.4 kg*	*-0.8*	*-0.32*
municipal waste, paper	*7.3 kg*	*0.33*	*2.4*
Total			*1.99*
Total (all phases)			*290.2*

4.1.5. 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. Replacement by polypropylene (which is, incidentally, much more commonly used for coffee machines) is worth considering.

4.1.6. 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.

4.1.7. Improvements

Based on this Eco-indicator calculation the design team could consider developing a coffee machine with a thermos jug in place 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 process tree form, in which the size of each block is a measure of the relative contribution to the total.

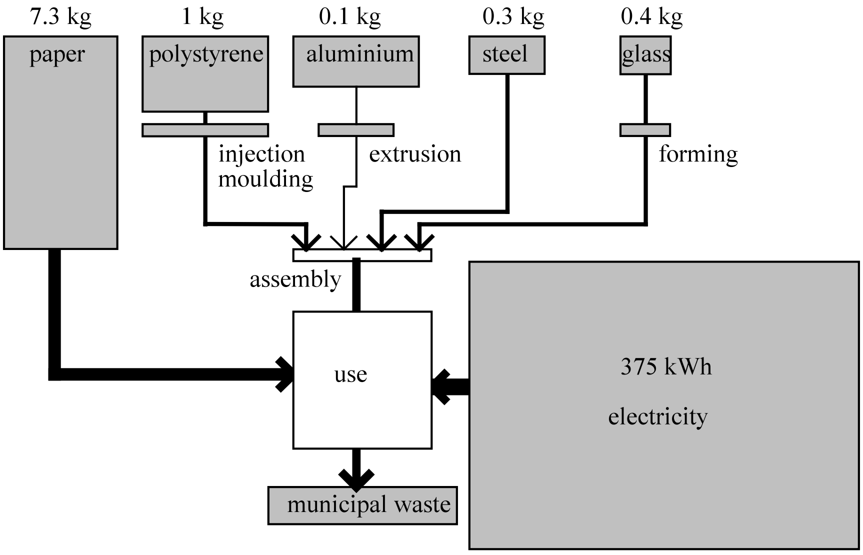

Fig. 4: The coffee machine process tree, where the size of the process blocks is proportional to the relative importance of the process.

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:

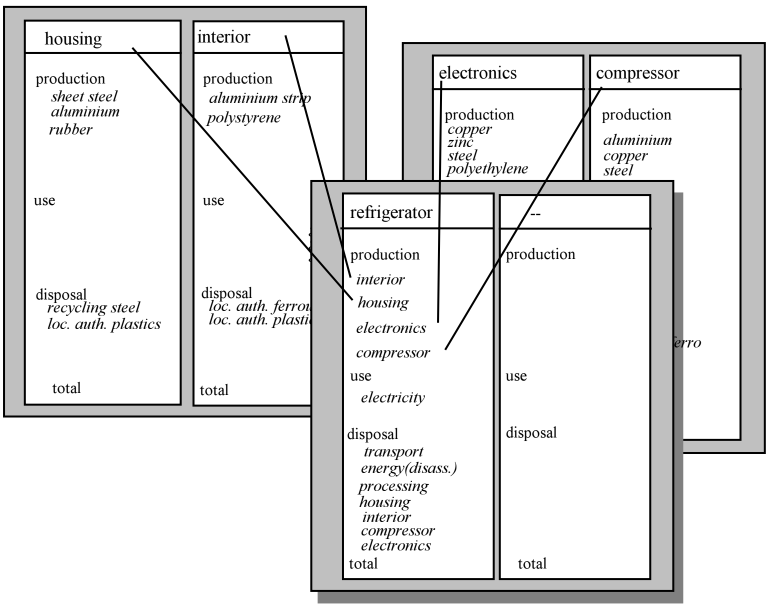

Fig. 5: Example of a completed form (in this case without figures) in which the product is subdivided.

5. Background to calculation of Eco-indicators

5.1. Introduction to life cycle assessment

The Eco-indicator project has kept as close as possible to the methodology of the life cycle assessment (LCA) method. This is an important starting point because an analysis using the Eco-indicator method is intended as far as possible to provide the same result as an LCA. This starting point means that the method's initial phases are the same as the LCA steps:

- Inventory phase. Within the project 100 LCAs have been drawn up (or existing ones have been revised). This means that all the relevant processes have been analysed and all emissions have been collated to form an impact table, a total overview of emissions.
- Classification. A number of environmental effects have been calculated on the basis of the impact table.

Classification enables the environmental effects of two products to be compared. For this the presentation as shown in Fig. 6 is often used. This figure illustrates a comparison between a paper and a plastic bag.

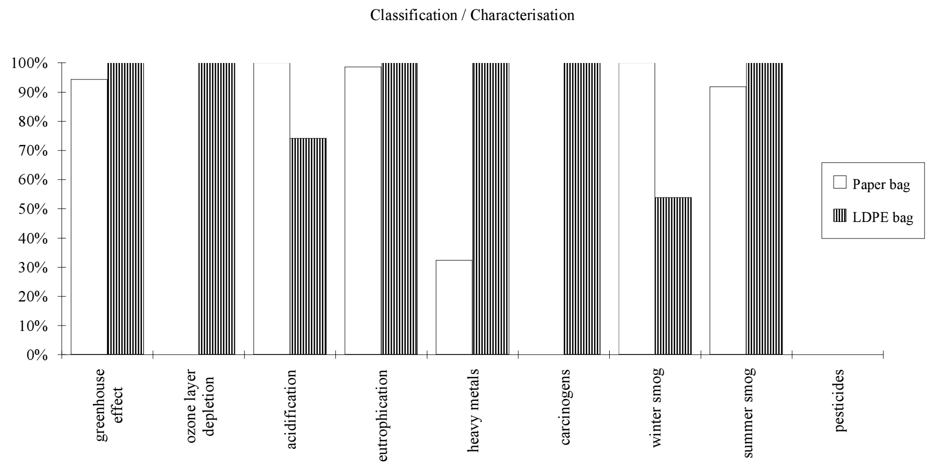

Fig. 6: Example of a comparison between a plastic and a paper bag. The highest score for each effect is set at 100%.

Up to this point the Eco-indicator follows the classic LCA method. In this example the result proves to be difficult to interpret. The paper bag causes more winter smog and acidification, but scores better on the other environmental effects. Thus the LCA does not reveal which is the better bag. What is missing is the mutual weighting of the effects. Although the LCA method describes how this should be, this weighting is almost never carried out because of a lack of data. The Eco-indicator project has plugged this gap.

5.2. Normalisation and evaluation

Based on Fig. 6 it is hardly possible to decide which bag is more environmentally-friendly. In the first place this is because the higher of the two values is scaled to 100%. In reality this is a meaningless scale. A score of 100% can represent a very small or a very large emission. The first step in any further interpretation consists of comparing the scores with another value. In our project we developed an inhabitant equivalent for this, i.e. the environmental effects that an average European causes in a year. In LCA terminology this is called the normalisation step. The values are normalised to the average European, as shown in Fig. 7. The effects are now compared on the scale of inhabitant equivalents. From this it becomes apparent that the scores for ozone layer depletion, eutrophication, pesticides and carcinogens are very low in absolute terms. The two smog scores and the scores for acidification, heavy metals and the greenhouse effect are relatively high.

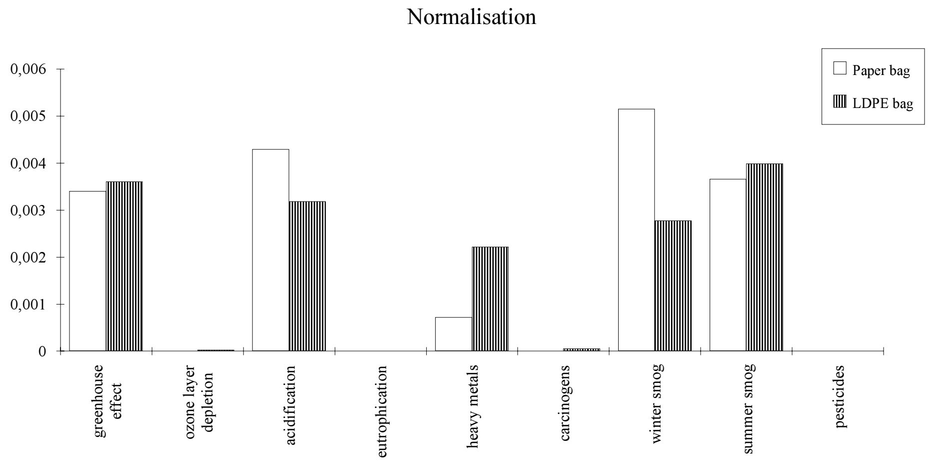

Fig. 7: The effect scores from Fig. 6 are normalised here to the effects that a European causes in one year. 1000 bags thus cause a 0.003rd part of the greenhouse effect that the European causes in one year.

Normalisation reveals which effects are large and which are small in relative terms. However, it does not yet say anything about the relative importance of the effects. A small effect can very well be the most important. A weighting step is therefore necessary to achieve an overall result. This step has been carried out in Fig. 8. The weighting factors used in this last step are discussed in the following paragraph.
All effects are now scaled to a certain measure of seriousness. In this example the seriousness is indicated in Eco-indicator points.

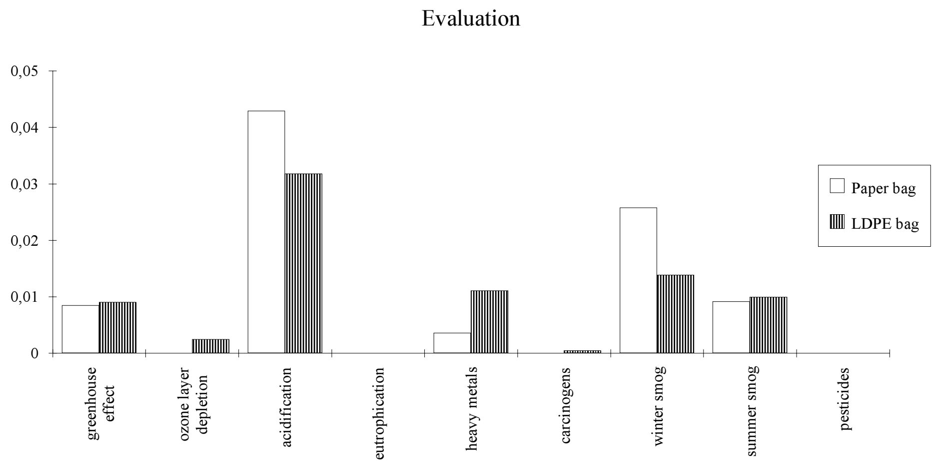

Fig. 8: Weighted and normalised effect scores.

If all the columns are plotted along the same scale the column lengths (Eco-indicator points) can in principle be totalled. This has been done in Fig. 9. It now becomes clear that the paper bag is somewhat less environmentally-friendly, although the difference is minor.

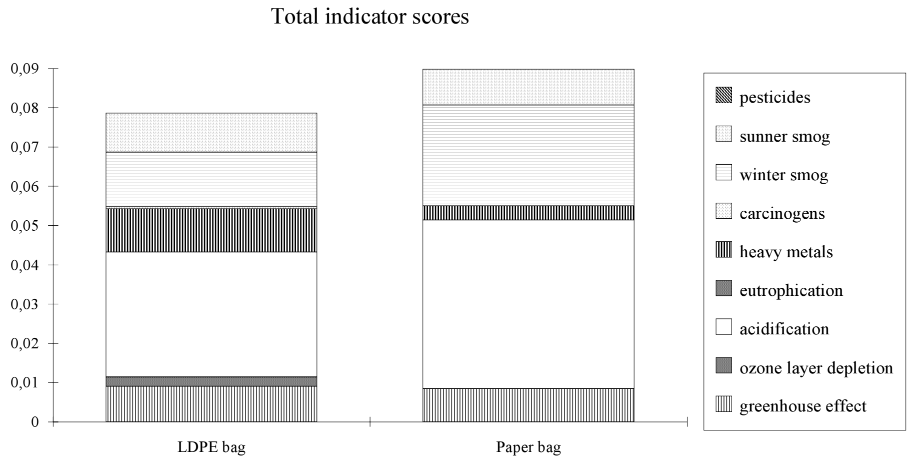

Fig. 9: After weighting the column lengths can be totalled. The paper bag proves to have a slightly greater environmental impact than the plastic bag. However, the difference is so small that, given the uncertainties, no hard-and-fast conclusion is possible in this case.

5.3. Backgrounds to weighting

Based on these graphs the weighting of effects seems to be very straightforward. The problem, of course, lies in determining the weighting factors. Much consideration has been given to this subject in the Eco-indicator project. After detailed analysis of the options the so-called Distance-to-Target principle was chosen for determining the weight factors. This principle has already been in use for some years in the Swiss Ecopoints weighting system. The underlying premise is that there is a correlation between the seriousness of an effect and the distance between the current level and the target level. Thus if acidification has to be reduced by a factor of 10 in order to achieve a sustainable society and smog by a factor of 5, then acidification is regarded as being twice as serious; the reduction factor is the weighting factor. This principle has been refined and improved in the project, but there is insufficient space to detail the improvements here.

The term “target level” still embodies a major problem. What is a good target level, and how can such a level be defined? The above-mentioned Swiss Ecopoints method uses political target levels from government policy papers. These levels are often defined on the basis of a compromise between feasibility (cost) and desirability.
In the Eco-indicator project it was decided to define target levels that are independent of politics and are based on scientific information. The problem then arises again that scientists have different views on what constitutes a good target level. One of the reasons for this is that different environmental problems cause different types of damage. Smog, for example, results in health complaints, while acidification causes major damage to forests. To ensure that the target level for acidification is equivalent to that for smog a correlation must be established with the damage caused by the effect. The premise is that the target level for each effect yields uniformly serious damage. The following damage levels are assumed to be equivalent:

- The number of fatalities as a consequence of environmental effects. The level chosen as acceptable is 1 fatality per million inhabitants per year.
- The number of people who become ill as a consequence of environmental effects. This refers in particular to winter and summer smog. The acceptable level set is that smog periods should hardly ever occur again.
- Ecosystem degradation. A target level has been chosen at which “only” 5% ecosystem degradation will still occur over several decades.

Setting equivalents for these damage levels is a subjective choice that cannot be scientifically based. It is therefore also possible to make different assumptions which could cause the weighting factors to change. The current choice came about after consultation with various experts and a comparison with other systems, including the Swedish EPS system. Fig. 10 is a schematic representation of the principle:

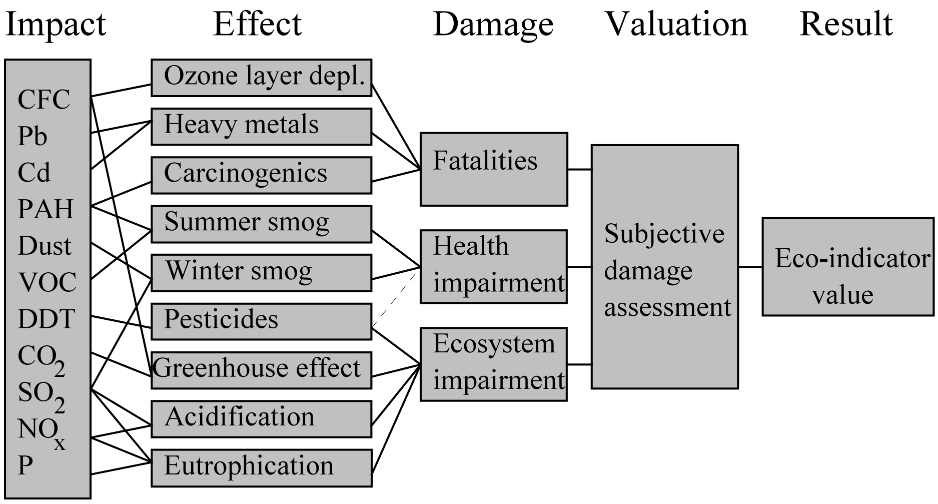

Fig. 10: Eco-indicator weighting principle

To establish a correlation between these damage levels and the effects a detailed study was carried out of the actual state of the environment in Europe. The current status of each effect was determined and by what degree a particular effect has to be reduced to reach the damage level defined for it. Much work has been carried out particularly by the Dutch National Institute for Public Health and Environmental Hygiene (RIVM) in this field. Detailed maps of Europe are now available in which the environmental problems are shown in a high degree of detail. These data were used to determine the current level of an environmental problem and by what factor the problem must be reduced to reach an acceptable level. Table 1 lists the weighting factors and the criteria applied:

Environmental effect	Weighting factor	Criterion
Greenhouse effect	2.5	0.1°C rise every 10 years, 5% ecosystem degradation
Ozone layer depletion	100	Probability of 1 fatality per year per million inhabitants
Acidification	10	5% ecosystem degradation
Eutrophication	5	Rivers and lakes, degradation of an unknown number of aquatic ecosystems (5% degradation)
Summer smog	2.5	Occurrence of smog periods, health complaints, particularly amongst asthma patients and the elderly, prevention of agricultural damage
Winter smog	5	Occurrence of smog periods, health complaints, particularly amongst asthma patients and the elderly
Pesticides	25	5% ecosystem degradation
Airborne heavy metals	5	Lead content in children's blood, reduced life expectancy and learning performance in an unknown number of people
Waterborne heavy metals	5	Cadmium content in rivers, ultimately also impacts on people (see airborne)
Carcinogenic substances	10	Probability of 1 fatality per year per million people

Table 1. Weighting factors for environmental effects

This table reveals that high priority must be given to limiting substances causing ozone layer damage and the use of pesticides. The latter is becoming a very serious problem in the Netherlands in particular. Furthermore, a great deal of consideration must be given to the diffusion of acidifying and carcinogenic substances.

It is apparent from the table that a number of effects that are generally regarded as environmental problems have not been included. The following reasons can be advanced for the omission of a number of effects:

- **Toxic substances that are only a problem in the workplace.** Many substances are only harmful if they occur above a certain concentration. Such harmful concentrations can occur relatively easily in the workplace, while the concentration in the outside atmosphere often remains very low and well below the damage threshold. This happens because the substances are generally greatly diluted and because many substances disappear from the atmosphere because of natural decomposition processes. Only substances that actually occur in harmful concentrations are included in the Eco-indicator, while the rest are disregarded. This means that a product with a low Eco-indicator score can still cause poor working conditions because substances are released that are harmful locally.
- **Exhaustion (depletion) of raw materials.** If a product made of very rare raw materials is used this rarity is not expressed in the indicator; after all, the fact that a substance is rare does not cause any damage to health. The emissions arising from extraction of the raw materials are included and are usually extensive because ever lower-grade ores have to be used. Incidentally, the term "exhaustion" is very difficult to define. Alternatives are available for most raw materials, and recycling could enable raw materials to remain in circulation for much longer. In fact minerals never disappear from the Earth; at worst they are diffused in an unfortunate manner.
- **Waste.** The fact that waste occupies space is not particularly important in environmental terms because the amount of ecosystem lost to the mountains of waste is relatively small compared with the damage to ecosystems caused, for example, by acidification. However, the substances released by waste (heavy metals, or CO_2 on

incineration) are very important. These latter effects are included in the indicator, but the quantity of waste in itself is not part of the assessment process.

As a result of these differences the Eco-indicator can be seen as an indicator of emissions, and raw materials depletion and the use of space by waste must be evaluated separately at present.

5.4. Conclusion

The Eco-indicator is a tool for including environmental aspects in the decision-making process in a practical way. It is not a perfect tool, but it is the best that is currently available.

Bibliography

- Ahbe S. et al. Methodik für Oekobilanzen [Method for environmental Life Cycle Assessments], Buwal, publication 133, October 1990, Bern, Switzerland.
- Goedkoop M.J.; Cnubben P; De Eco-indicator 95, bijlage rapport (annexe report); NOH report 9514 A; PRé consultants; Amersfoort (NL); juli 1995, ISBN 90-72130-76-6 (only available in Dutch).
- Goedkoop M.J.; De Eco-indicator 95, Eindrapportage (Final report in Dutch); NOH report 9514; PRé consultants; Amersfoort (NL); juli 1995; ISBN 90-72130-77-4.
- Goedkoop M.J.; Demmers M.; Collignon M.X.; De Eco-indicator 95, Handleiding voor ontwerpers (Manual for designers in Dutch); NOH report 9510; PRé consultants; Amersfoort (NL); juli 1995; ISBN 90-72130-78-2.
- Goedkoop M.J.; The Eco-indicator 95, Final report (in English); NOH report 9523; PRé consultants; Amersfoort (NL); juli 1995; ISBN 90-72130-80-4
- Goedkoop M.J.; Duijf G.A.P.; Keijser I.V.; Eco-indicator, Development decision support tool for product development, NOH report 9407; PRé consultants; Amersfoort (NL); November 1993.
- Heijungs R. (final editor) et al; Environmental life cycle assessment of products, Guide and Backgrounds, NOH report 9266 and 9267; Leiden; 1992; commissioned by the National Reuse of Waste Research Programme (NOH), in collaboration with CML, TNO and B&G.
- Lindeijer E.W. et al., An environmental indicator for emissions, Centre for Energy Conservation and Environmental Technology (CE) and the Interdisciplinary Department of Environmental Science (IDES) of the University of Amsterdam, 1993.
- RIVM, The environment in Europe: A global perspective, Sept. 1992, ISBN 90-6960-031-5
- SETAC, Society of Environmental Toxicology and Chemistry, Guidelines for Life-Cycle Assessment, a ’Code of Practice’, Brussels, Belgium, 1993.
- SimaPro 3.1, Database software program, with the Eco-indicator methodology included, PRé Consultants, Amersfoort.

Abbreviations

ABS	Acrilonitrile-butadiene-styrene
B&G	Bureau Brand- en Grondstoffen [Office of Fuels and Raw Materials]
Buwal	Bundesamt für Umwelt, Wald und Landschaft [Swiss Federal Ministry for Environment, Forestry and Agriculture]
CE	Centrum voor energiebesparing [Centre for Energy Conservation and Environmental Technology]
CFCs	Chlorofluorocarbons
CML	Centrum voor Milieukunde Leiden [Centre for Environmental Science, Leiden]
CO_2	Carbon dioxide
EPS	Environmental Priority System, developed by the IVL in Sweden and used by Volvo Sweden.
HDPE	High-density polyethylene
HIPS	High-impact polystyrene
IDES	Interdisciplinary Department of Environmental Science (University of Amsterdam)
LCA	Life cycle assessment
LDPE	Low-density polyethylene
mPt	milli Eco-indicator point
NOH	Nationaal Onderzoekprogramma Hergebruik van Afvalstoffen [National Reuse of Waste Research Programme]
Novem	Nederlandse onderneming voor energie en milieu [Netherlands agency for energy and the environment]
PA	Polyamide, nylon
PAHs	Polycyclic Aromatic Hydrocarbons
PC	Polycarbonate
PE	Polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PPE	Polyphenylene ether (or PPO, polyphenylene oxide)
PS	Polystyrene
PUR	Polyurethane
PVC	Polyvinylchloride
RIM	Reaction Injection Moulding
RIVM	Rijksinstituut voor Volksgezondheid en Milieuhygiëne [National Institute for Public Health and Environmental Hygiene]
SETAC	Society of Environmental Toxicology and Chemistry
TNO	Nederlandse Organisatie voor Toegepast Wetenschappelijk Onderzoek [Dutch Organisation for Applied Scientific Research]
VROM	(Ministerie van) Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer [(Ministry of) Housing, Spacial Planning and the Environment]

Eco-indicator update

In the NOH reports 9523 and 9524 we presented a list of 100 Eco-indicators, which had been calculated using the best available LCA data. After publication of the Eco-indicator 95 some organisations commented that the data used had expired, and the given value did not reflect real environmental impacts. This prompted NOVEM/NOH to start an update action. The most important changes will be described below.

We would ask that you no longer use the old work sheets and provide other users, or those who use copies, with the new work sheets. If you use Eco-indicator values in spreadsheets or other software please make the necessary changes.

This update does not mean the Eco-indicator weighting method has been changed. Only the data on emissions from particular processes have been updated. In a few weeks we will start a project aiming at a complete revision of the methodology and the Eco-indicator values. The results of this Eco-indicator 97 project will be made available at the end of 1997.

In order to get some indication of the use of and experience with the Eco-indicator we have added a small survey. After completion, please fax the survey the *new* fax number of PRé consultants: +31 33 4555022.
Your comments will be an important input for the Eco-indicator 97 project.

Below, a brief explanation is given of the updated Eco-indicator values.

Polyurethane foam

ICI pointed out that since long no CFC-22 is used in the production of PUR monomers. The emission came from a report based on old data. Recently a report has been published by ISOPA (European Isocyanate Producers Association), in which ecoprofiles of the PUR precursors MDI and TDI and some production processes of PUR are given. Average compositions of some popular PUR types are also given. Unfortunately, only Eco-indicators for pentane and waterblown foams could be calculated. Some specialty PUR foams are still blown with HCFC and HFCs.
For pentane blown foams part of the blowing agent will remain in the closed cellular structure. How much is released at the treatment stage at the end of the life cycle is yet unknown. No indicator can thus be given for waste treatment of PUR foams.
ISOPA states that any use of PUR foams will need a PUR foam with its own specific composition of ingredients and blowing process. For specific data you are urged to contact your supplier. Please note that for all polymers the Eco-indicator figures are based on the pure polymer, without additions of fillers, pasticizers, colour agents, fire retardants etc. This is also true for PUR.

Rubbers

The Rubber Foundation in Delft stated correctly that natural rubber does not belong to the category of plastics. We were also told that in the Netherlands no emission of ozone depleting chemicals (for rubbers trichloroethylene) no longer occurs.
In cooperation with the Rubber foundation, new indicator values were calculated for natural rubber and elastomers. The new section "production of rubbers and elastomers" gives Eco-indicator values for 1 kg raw rubber as well as natural rubber product and 1 kg elastomer products such as EPDM and SBR.
The final products score respectively 4.3 , 5.6 en 4.1 mPt per kg.
Data are valid for the Netherlands, European data are not yet available. Unfortunately not for all additives data are known. Although the rubber industry is rather conservative in its production methods, it is possible that emission reducing measures have been implemented in North Europe more than in South or East Europe.
In the disposal phase, rubber can be treated as if it was plastic. There are no recycling figures available.

Air traffic

Due to an ambiguity in a report, it was mistakenly understood that aviation fuel containing lead is used by commercial airliners. This is only the case for small propeller driven aircraft. The adjusted value is based on a calculation by Delft University of Technology, using fleet and emission data from Lufthansa.

PVDC and PET

Data has been published by the European plastics industry about PVDC (polyvinylidene chloride, being used as coating) as well as amorphous and bottle grade PET. Bottle grade PET is of course being used to make bottles. Amorphous PET is used for foils and fibres.

Waste and recycling

Eco-indicator values for recycling are calculated using the "avoided emission" method.
The Eco-indicator from the avoided virgin material is subtracted from the Eco-indicator caused by the recycling process. This often leads to negative values. Some users of the Eco-indicator asked to give both values: the Eco-indicator for the avoided emission due to the use of virgin material as well as the Eco-indicator for the recycling process itself. Now two tables are given: an "old" one in which the total score is presented and a new one that gives the indicator for avoided emissions and for the recycling process. It is assumed that 100% avoided emission does not exist, so the value will generally be lower than that of the virgin material.
New indicator values have been calculated for the recycling of aluminium and copper. In the calculation of the avoided emissions we assumed that we avoid average composition of aluminium or recycling, and not only primary aluminium. The other data as such has not been changed.

Survey Eco-indicator 95

After completing this survey please fax it to PRé Consultants' ***new*** fax number +31 33 4555024, or ring +31 33 4555022 if you have any questions.

How often do you use Eco-indicator values?
( ) weekly
( ) monthly
( ) occasionally
( ) never

What do you use Eco-indicator values for?
( ) product development
( ) environmental analysis of products
( ) education
( ) other, namely:

Which other methods do you use to judge the environmental impacts of products?

( ) None	( ) MET matrix
( ) Full LCA	( ) Expert judgement
( ) Embedded energy	( ) Ecopoints (Buwal)
( ) Exergy analysis	( ) Other, namely:

How do you judge the readability of the Eco-indicator reports?

Manual for Designers	Final Report
( ) bad	( ) bad
( ) average	( ) average
( ) good	( ) good
( ) haven't read	( ) haven't read

Do you find that the principles and limitations of the Eco-indicator are clear?
( ) Yes
( ) No
( ) Don't know
( ) I am not interested in the backgrounds

In order to test how clear we have been, please check which environmental impacts have *not* been included in the Eco-indicator 95 methodology according to you understanding?
( ) Waste
( ) Toxic chemicals
( ) Depletion of metal and energy resources
( ) Greenhouse effect
( ) Don't know

In which sectors would you find extra indicators useful?
( ) Energy
( ) Recycling and waste processing
( ) Metals, Plastics and other materials
( ) Material processing
( ) Transport
( ) Standard components

Did the use of Eco-indicators lead to clear improvements of products or other changes?
( ) No
( ) Don't know
( ) Yes, in combination with other methods
( ) Yes, namely:

Did you integrate Eco-indicator values into software to make calculating easier?
( ) Yes
( ) No
If **yes**, what kind of software?:

Please leave your other comments, suggestions and (changes in) your address details below:

Name:

Company: Department

Address:

Town + postal code: Country:

Phone number: Fax number:

Thank you!