report

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A Manual for the Calculation of Ecoprofiles intended for Third Party Certified Environmental Product Performance Declarations

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1. Introduction

The objective of this project is to draft a manual for ecoprofile documentation of the environmental performance of products or services. The ecoprofile may provide the quantitative information given in environmental product declarations. It may also itself serve as an ecolabel (ISO Type-III).

The basis for this work has been a tentative definition of a Type-III ecolabel. The definition stipulates that a Type-III label shall

”provide a quantified declaration of a product´s life-cycle environmental performance under pre-set environmental effect categories, based on Life-Cycle Assessment according to ISO 14040 -14043.”

The work has included:

- identification of a draft set of indicators including how to calculate them
- evaluation of inventory analysis methodology

Ready-made case studies were used for the work. The findings were discussed at several meetings with the project steering committee and in two open workshops.

A number of goals were set in the initial project phase:

- The label consists of a set of indicators which are based on LCA methodology. The indicators, however, shall as far as possible provide quantitative information on actual effects rather than potential impacts by taking spatial, temporal, threshold and linear/non-linear differentiations into account, i.e. account for geographic differentiations. This is referred to as the LCSEA methodology.
- Each indicator shall remain additive within the system that provides the functional unit as well as between different systems. That is, the sum of all relevant site-specific contributions to a defined effect gives the indicator value of the complete system.
- The indicators shall be based on available scientific knowledge and recognized principles.
- The indicators must be robust, i.e. reproducible and transparent.
- The indicators must be reasonably easy to calculate.
- If a method to calculate an indicator according to above conditions cannot be found, other non-effect oriented information (inventory data) may , as a short term solution, be used as a substitute

This manual intends to reflect the short term state-of-the-art. The indicators are to a high extent identical or similar to those discussed in the international “Practitioners manual” (Rhodes et al 1997). Some of the indicators need further development before they may be used on a routine basis. Thus, they are substituted or omitted for the time being according to the goals defined for this project. The LCSEA principles, including ready-to-use indicators are fully discussed in the Practitioners manual.

This draft manual also addresses some relevant inventory issues. However, this manual needs to be practised and further experience of Type-III labelling gathered before an detailed inventory methodology may be defined.

This manual addresses the type of quantitative information that may be included in an ecoprofile at present. It shall be understood as a gross list of indicators. Some of them may and even should be further aggregated before they are communicated to professionals or consumers.

2. How Should This Manual Be Understood?

The manual suggests suitable environmental indicators for ecoprofiles and gives recommendations how to perform an inventory and how to calculate the indicators.

The manual is mainly based on the Nordic Guidelines by Lindfors et al. The authors of this manual presume that the user has experience from LCA work and is familiar with the Nordic Guidelines.

A general conclusion from the case studies is that the methodological choices during the LCA study have a severe impact on the result and can overshadow the improvements made, for example by use of a cleaner technology. It is therefore necessary to provide rules for the inventory methodology to minimise the variations due to methodological choices.

The recommendations are by necessity of a general nature. In the future several more specific recommendations need to be developed for certain product groups or business sectors.

Contrary to most LCA guideline documents Impact Assessment - the Ecoprofile - is addressed in the first sections of this document followed by guidelines for Goal definition and Scoping, and Inventory Analysis.

3. Description of the Ecoprofile

The Type-III ecoprofile consists of several pre-set indicators. Inputs and outputs of the studied system of a product (or a service) are assigned to different indicators and are summarised in the ecoprofile. Ideally this should cover the complete life-cycle of the product or service. However, a distinction is made between cradle-to-gate profiles and gate-to-grave information.

This is due to the greater uncertainties in input data for gate-to-grave information compared to the cradle-to-gate profile. The uncertainties come from difficulties to predict the future fate and treatment of some products. The cradle-to-gate profile shall be based on plant and site specific data whenever relevant. Such profile is possibly able to describe the actual performance of that part of the system. Gate-to-grave information can only be based on generic data, of which some may be extremely uncertain in the sense that they never represent the actual performance of the product. In this document it is suggested that only the cradle-to-gate profiles are calculated as quantitative ecoprofiles. The gate-to-grave information is given in terms of other quantitative or qualitative information. The suggested cradle-to-gate ecoprofile[i] is presented in Figure 1 below. Information related to the gate-to-grave information is discussed in sections below. The latter information is only relevant when the product actually is delivered to the final user, otherwise only cradle-to-gate profiles are requested (producer-to-producer deliveries).

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[i] This is a gross list of information (indicators) given in a **cradle-to-gate profile**. Resource indicators may be aggregated, e.g. to total energy and mass input and output

Ecoprofile valid for year 1997	Cradle-to-gate profile.	
Resources	Input	Output
Fossil fuels (MJ)		
e.g. Oil		
e.g. Natural gas		
e.g. Peat		
e.g. Coal		
Biofuels (MJ)		
e.g. Wood chips		
Other fuels (MJ)		
e.g. Uranium ore		
Biotic raw material (weight units)		
e.g. Water		
e.g. Wood fiber		
Abiotic raw material (weight units)		
Minerals		
e.g. iron ore		
Fossil raw material (MJ)		
e.g. Feedstock oil		
e.g. Feedstock gas		
Emission loading (weight units)		
Greenhouse gas	-	
Strathospheric ozone depl.	-	
Acidification	-	
Ground level ozone	-	
Aquatic oxygen depletion	-	
Toxic emissions (weight units)	-	
Waste (weight units)	-	
Hazardous waste to landfill	-	
Other waste to landfill	-	

Figure 1. The suggested ecoprofile.

Electricity consumption at site (kWh)[ii]	Input
Total use	
Oil power	
Coal power	
Gas power	
Peat power	
Biofueled power	
Nuclear power	
Hydroelectric power	

The cradle-to-gate profile is divided into two horizontal sections:

- Resources
- Emission loadings

The resource part consists of several categories describing the use of resources in the studied system. Since some resources/utilities also are produced by the system, the resource part are divided in 1) inputs and 2) outputs (see also chapter *Inventory analysis*). Subheadings in the resource part are

- Fuels
- Raw material

Under these subheadings only the resources used in a system are declared. In Figure 1 several examples are given under each subheading. Fossil fuel includes oil, natural gas, peat and all different kinds of coal. Biofuels include all renewable biofuels. Other fuels are fuels that do not fit under any of the other headings, e.g. uranium. Biotic raw material are resources of a biological nature and are used in other applications than for energy production. Examples are water for watering of plant cultivations or wood fiber used for production of a wood beam. Abiotic raw material are resources that are not of a biological nature and are used for other applications than as fuels e.g. iron ore for steal production.

The part *Emission loading* consists of several impact categories based on the expected types of impacts on the environment . The impact categories are:

- Greenhouse gas

[ii] Information on electricity consumption may be added if relevant. This means that part of the energy input is doubble-counted, since all energy carriers used to generate electricity are included in the listed resource inputs. Information on electricity consumption shall be given outside the profile to avoid confusion

- Stratospheric ozone depletion
- Acidification
- Ground level ozone
- Aquatic oxygen depletion
- Toxic emissions
- Waste

All of these emission loading categories are output data in the ecoprofile. The recommended units for the impact categories respectively are given in parenthesis after each heading in the ecoprofile in Figure1.

Hazardous waste and other wastes to landfills are quantified for the cradle-to-gate profile under the subheading *Waste*. For the gate-to-grave information the wastes are declared in a different way, which takes risk assessment into account. Read more about this in the chapter *Waste management.*

4. Omitted or substituted Categories

Classification lists of impact categories that should be addressed in some sort of quantitative fashion in LCA are given in Nordic Guidelines and other guideline documents (see Table 1 below). There is a broad consensus on which categories should or could be considered in LCA, though some of them (non-conventional categories) cannot yet be quantified. In this manual almost the same categories are addressed. Inventory data are substituted for some of the categories listed below because of extreme difficulties to define quantitative indicators. The reason for these difficulties are mainly significant data-gaps or lack of robust methods, making it impossible to draw reproducible conclusions concerning the impact category. Others are omitted because they are considered not relevant for this purpose. The substituted or omitted categories are described below.

Table 1A. Input related impact categories in LCA (resource depletion or competition). Conventional = customary impact category in LCA. Non-conventional = less frequently used impact category in LCA.

Impact category	Conventional or non-conventional
Abiotic resources (deposits, funds, flows)	conv
Biotic resources (funds)	conv / non-conv
Land	non-conv

Table 1B. Output related impact categories in LCA. Conventional = customary impact category in LCA. Non-conventional = less frequently used impact category in LCA .

Impact category	Spatial dimension	Position in cause-effect chain of impact category	Conventional or non-conventional	Position in cause-effect chain of corresponding characterisation method(s)
Global warming	glob	begin	conv	begin
Depletion of stratospheric ozone	glob	begin	conv	begin
Human toxicological impacts	glob/cont/reg/loc	end	conv	begin/middle
Ecotoxicological impacts	glob/cont/reg/loc	end	conv	begin/middle
Photo-oxidant formation	cont/reg/loc	middle	conv	middle
Acidification	cont/reg/loc	begin/middle	conv	begin
Eutrophication	cont/reg/loc	begin/middle	conv	begin/middle
Odour	loc	end	non-conv	begin/middle
Noise	loc	end	non-conv	begin
Radiation	reg/loc	begin/middle	non-conv	begin
Casualities	reg/loc	end	non-conv	begin
Occupational health	loc	end	non-conv	middle
Effects on biodiversity	glob/cont/reg/loc	end	non-conv	-

[i] Including if only inventory data may be used

[ii] This is a higher order effect, however, often found in classification lists

A full LCA may in certain applications combine qualitative and quantitative information. Qualitative information is often given using a flagging procedure, e.g. "red-listed compounds" are used or discussed in the text, for example potential effects on biodiversity.

However, since an LCA never can provide full information on all categories, relevant to ecolabelling programmes, it may be argued, that LCA in ecolabelling should be restricted to the types of impacts, on which robust quantitative information may be provided. Value based judgements or other qualitative information might be added to the quantitative ecoprofile.

4.1 Resources - Land

The difficulties to quantify this effect cathegory depends on the lack of available methods. Some efforts have been made to develop such methods (Baumann et al 1992, Heijungs et al 1992, Steen och Ryding 1992, Frischknecht et al 1994) but there is still no consensus in the LCA-field which way to go. However, potential methods are discussed in the Practitioner´s international manual (Rhodes et al 1997).

4.2 Human Health - Toxicological impacts (Excluding Work Environment)

There are no agreed methods for the assessment of human health-toxicological impacts. Several methods have been suggested. However, it was shown that different methods of describing human health-toxicological impacts can give substantially different results (Nordic Guidelines).

Inventory data should be used (need criteria for which to include)

4.3 Human Health - Non-Toxicological Impacts (Excluding Work Environment)

This impact category includes effects like injury and death that are consequences of accidents, noise and vibrations. Also psychological effects like tiredness and stress due to smell and noise can be included in this category. There are no quatitative method available. The category is omitted pending agreed methods

4.4 Human Health Impacts From Work Environment

There are no robust methods for considering work environment in LCA. There is ongoing research in this field, for example by IVL and other Nordic researchers. Work environment in LCA may include accidental, chemical, biological, physical, ergonomic and psychosocial factors. Several methods have been suggested and are presently evaluated. The category is omitted pending agreed methods

4.5 Ecotoxicological Impacts

There are no agreed or robust methods available. Inventory toxic emissions data should substitute for this category and human health in parallell. Criteria need to be developed for which to include.

4.6 Habitat Alterations And Impacts On Biological Diversity

Habitat alteration and impacts on biodiversity is a so called higher order effect category. Therefore, it is no longer included in up-dated LCA classification lists and omitted as an impact category (It is included in the Nordic Guidelines). The issue may be addressed in relation to land use dependent on future development of land use indicators

5. Cradle-to-gate profile

Recommendations

*** The ecoprofile should include the impact categories**
Resources:
- **fossil fuels**
- **biofuels**
- **other fuels**
- **biotic raw material**
- **abiotic raw material**
- **fossil raw material**

Emission loadings:
- **greenhouse effect**
- **stratospheric ozone depletion**
- **acidification**
- **ground level ozone**
- **aquatic oxygen depletion**
- **toxic emissions (inventory data)**
- **waste**

*** Omitted (pending agreed methods) categories are:**
- **resources-land**
- **human health-non-toxicological impacts (excluding work environment)**
- **human health impacts in work environment**
- **habitat alterations and impacts on biological diversity**

*** Land use is excluded until more robust and accepted methods are available. All omitted categories may of course be addressed qualitatively.**

5.1 Calculation Methods - General Principles

If you are not the deliverer to consumer, you calculate the resources, the emission loadings and the waste production that have been accumulated until the product leave the gate of your facility. This means that you add your facility´s environmental impact to the preceeding environmental impacts that have taken place before the raw material for the product-to-be enters your facility. You are also responsible for calculating the environmental impacts from transports of raw material from your sub-suppliers. The deliverer to consumer is also responsible for reporting the environmental indicators concerning the use and disposal of the final product.

The data on the up-stream environmental impact either come from Type-III-labelling of the raw material you buy or from your own inquiries to the suppliers. In the beginning of Type-III labelling the data collection will probably be of the latter type. In the following subchapters the calculation of the different parts of the ecoprofile will be briefly summarised. After that the calculation of each category, especially the emission loadings and the waste category, will be addressed in more detail.

5.1.1 Resources

The resources needed for production of the product/service in question are summarised in the these classes according to the ecoprofile:

- Fossil fuel
- Biofuel
- Other fuel
- Biotic raw material
- Abiotic raw material
- Fossil raw material and as a separate indicator, reported outside the profile
- Electricity consumption

Fuels and fossil raw material should be expressed in MJ, the same is valid for electricity consumption. Other resources should be preferably be expressed in weight units. If actually reused resources beside the chosen functional unit is an output this should be noted in the output column of the cradle-to-gate profile (Open loop recycling allocation is not allowed).

The year for which data is representative should be noted. The resource use should be a representative average for a twelve months period. This is valid except for the final product, for which the resources, emission loadings and waste should be calculated per product unit.

Electricity consumption is included also in the fuel resources. However, the electricity is considered an important information so a separate description is desirable outside of the profile itself. Also the primary resource consumption for each MJ of electricity involves a certain uncertainty as the electricity grids of different countries become more and more integrated.

5.1.2 Emission Loadings

For the emission loadings the calculation is somewhat more complex. The emission of the certain substance in question is first multiplied by the Stressor Equivalency Factor. The Stressor Equivalency Factor is the same as used in common LCA practice and indicates only potential impacts. The result is then multiplied by a so called Receiving Environment Factor, which is a site specific factor, that accounts for the severity of the environmental effects caused by the stressor.

The main principle for calculation can be described as follows:
*Emission loading = A * C * R*
A = Amount of substance emitted (site specific)
*C = Stressor Equivalency Factor (**SEF**)(Weighting factor according to the nomenclature used by ”Nordic Guidelines”, Lindfors et al.) (non-site specific, except for ground level ozone potential where it is regional specific)*
*R = Receiving Environment Equivalency Factor(site specific)(**REEF**)*

The multiplication of A and C is the conventional calculation of <u>maximum</u> potential impact in life-cycle characterisation. It calculates the potential impact associated with the emissions as equivalencies (e.g. NO_x and SO_2 summarized as SO_2-equivalent). That information is non-site-specific and does not account for geographical differetiations etc, i.e. it may be interpreted as the maximum possible contribution. The LCSEA methodology adds a site specific factor that accounts for spatial and temporal differentiations, when relevant. It shall have a numerical value between 0 and 1. It is set equal to 1 if no site specific factor is available. The indicator value for each site is calculated and summarized to the total indicator value. (See example below)However, spatial differentiation cannot be justified for global warming and stratosperic ozone depletion and the Receiving Environment Factor is then set equal to one (1). The emission loading (A * C * R) is the parameter used for final aggregation in the ecoprofile.

In the following paragraphs we will give a short description of the stressor equivalency factors and the receiving environment factors used for the purpose of this project. As stressor equivalency factors we have used the weighting factors recommended by ”Nordic Guidelines” (Lindfors et al.) for the aggregation of impact categories. The receiving environment factors have been developed during the course of this work and are in part reported elsewhere (Pleijel et al.).

Impact category							
Acidification							
Unit operation	**Inventory emiss.**	**kg**	**Stressor equiv. factor**	**Stessor equiv.**	**Reciving environment equivalency factor**	**Loadings**	
SUMMARY OF FUEL EXTRACTION AREA, STENUNGSSUND	NOx	4148,97	0,7	2904,28	0,2	580,86	
	SO2	2209,4	1	2209,40	0,25	552,35	
	SOx	0,766751	1	0,77	0,25	0,19	
Sum							1133,40
SUMMARY OF TRANSPORT, STENUNGSSUND-LUDVIKA	NOx	22,9247	0,7	16,05	0,15	2,41	
	SO2	0,916989	1	0,92	0,225	0,21	
Sum							2,61
SUMMARY OF NURSERY PLANT AND LOGGING AREA, LUDVIKA	NOx	76785,9	0,7	53750,13	0,1	5375,01	
	SO2	1474,71	1	1474,71	0,2	294,94	
	SOx	0,143385	1	0,14	0,2	0,03	
Sum							5669,98
SUMMARY OF TRANSPORT, LUDVIKA-SKUTSKÄR	NOx	12801,4	0,7	8960,98	0,075	672,07	
	SO2	512,054	1	512,05	0,15	76,81	
Sum							748,88
SUMMARY OF SAWMILL AREA, SKUTSKÄR	NOx	50724,4	0,7	35507,08	0,05	1775,35	
	SO2	3180,12	1	3180,12	0,1	318,01	
Sum							2093,37
SUMMARY OF ELECTRICITY	NOx	1,53639	0,7	1,08	0,05	0,05	
	SO2	1,72843	1	1,73	0,1	0,17	
Sum							0,23
Total sum:				**108519,43**			**9648,4688**

Example of a calculation scheme.

5.1.3 Waste

The waste category have been added to cope with the present difficulties considering waste magagement in LCA methodology. According to common LCA practice all waste treatment activities should be included in the studied system boundaries. However difficulties with lack of knowledge of the landfill system and the need of a robust system in the Type-III methodology made it necessary to separate certain parts of the waste issue from the common practice. Depending on which part of the ecoprofile that is calculated the waste category looks different. For the cradle to gate part of the ecoprofile the waste that is landfilled is separated in two classes, one for *hazardous waste* and one for *other waste*. Waste treatment activities other than landfilling is included within the boundaries of the studied system.

It is very difficult to predict what the future waste treatment will look like for a product. Therefore we have chosen not to require an estimation of how the product will be treated. Instead there should be a declaration of the hazardous contents in the product, which can be of help when time for disposing of it comes. Also if possible the final producer may include a recommendation for final disposal of the product.

5.2 Calculation methods

5.2.1 Resources

In the ecoprofile resources are divided into two main categories, namely fuels and non-fuels. Both categories are then further divided into sub-categories. Fuels are divided into fossil fuels, biofuels and other fuels. Explanatory and illustrating examples are given in Table 2.

Table 2. Assignment of primary fuels to fuel categories. The examples given do not necessarily constitute a complete list of existing fuels.

Fossil fuels, including fuels for electricity production
Oil, crude
Natural gas
Coal, hard coal and lignite
Peat
Biofuels, including fuels for electricity production
Wood
Straw
Grain
Other fuels, including fuels for electricity production
Uranium, non-renewable fuel
Hydroelectric power, renewable energy

Primary fuels are energy sources directly extracted from the earth or biosphere. Electricity is not a primary energy source and is therefore not listed in Table 2. Primary energy sources used to produce electricity should, however, be included as fuels among other fuels in the ecoprofile. In addition, the electricity consumption, and the amounts of primary fuels used to produce the electricity, should be listed separately. Table 3 shows the most common primary fuels used to produce electricity.

Table 3. Primary fuels used to produce electricity.

Fuel type	Fuel category
Nuclear power, uranium	Other fuel, non-renewable
Refuse	Other fuel, non-renewable
Hydroelectric power	Other fuel, renewable
Oil	Fossil fuel
Coal	Fossil fuel
Natural gas	Fossil fuel
Peat	Fossil fuel
Biofuels (wood, straw)	Biofuel

The amounts of energy carriers recorded in the ecoprofile should be the crude amounts entering the system as extracted from nature, e.g crude oil before refining or natural uranium. The unit of measurement should be the energy unit MJ, not a mass unit.

Raw material resources are divided into four sub-categories: Biotic raw material, Abiotic raw material, and Fossil raw material. Table 4 gives examples and shows the appropriate units of measurement for each category.

Table 4. Raw material resource categories. The entries are only examples, not a complete list of existing raw material resources.

Resource category	Unit of measurement
Biotic raw material	
Water	tons
Wood	tons
Grain	tons
Abiotic raw material	
Minerals, e.g. iron ore, lime stone, rock salt	tons
Fossil non-fuls	
Feedstock oil	MJ
Feedstock gas	MJ

Fossil raw material, i.e. crude oil and natural gas used as starting materials for the synthesis of other products, are measured in the energy unit MJ, in order to facilitate comparison and possible aggregation with crude oil and natural gas used as energy carriers. All other raw material resources are measured in (metric) tons.

In some cases a manufacturing process may produce some resources as well (usable residues), e.g. excess thermal energy, electricity or an energy carrier like biogas. Such resources may sometimes be used internally within the process, sometimes sold to external customers. Since the practice varies, and since a life-cycle inventory for an ecoprofile is a mono-functional study (section *System Function*), we suggest at this time, that produced resources are treated in the same as consumer waste (section Waste Category), i.e. the produced resources are registered in the profile but not deducted from the gross resource input, nor is any allocation between the product under study and produced resources performed.

When the consumption of resources are recorded as prescribed above, i.e. in absolute amounts pertaining to a selected amount of product, the ecoprofile will *per se* give no indication, whether abundant or scarce resources are being consumed. A more relevant way to describe the impact of resource consumption would be to measure the drain on the existing limited resources on earth by the production and use of the product under consideration. There are several suggestions in the literature how the scarcity of resources should be arithmetically accounted for (Nordic Guidelines and references cited therein). All suggested methods somehow relate consumption to the extractable reserve of the resource under consideration. The most simple way to do this is to divide the consumption in the actual case by the known reserve. This would yield a dimensionless number, which in the actual practice in most cases would be very small. This approach would probably make most ecoprofiles indistinguishable with respect to resource consumption.

A more sophisticated approach is to define a depletion factor by dividing the total annual net consumption worldwide by the known reserve.

$$D_1 = (P-N)/R \quad (1)$$

P = totalconsumption/year
N = total renewal/year
R = known reserve.

The dimension of D_1 is 1/(year). For a non-renewable resource N = 0. As a modification the depletion factor may be weighted by the known reserve.

$$D_2 = (P-N)/R^2 \quad (2)$$

The dimension of the modified depletion factor D_2 is 1/(ton or MJ, year). The impact of each resource consumption in the ecoprofile would be calculated by multiplying the actual consumption by the depletion factor. We have attempted to use the modified depletion factor D_2 during the course of this work, and we have found, that in actual practice the method is difficult or impossible to use. The available deposits of most resources, e.g. of crude oil and of coal, are not known with any certainty, if at all. Arithmetically the multiplication of resource consumptions in ecoprofiles by the modified depletion factor D_2 yields a set of infinitesimally small numbers, making most ecoprofiles indistinguishable with respect to resource consumption and thus meaningless. We have thus resorted to just recording the resource consumptions in absolute numbers.

One way to avoid the problem of indistinguishable, small numbers would be to use the method suggested by F. Kommonen 1997. His approach is to use relative depletion factors. One resource, e.g. crude oil, is selected as a reference resource and assigned the depletion factor 1. The relative depletion factors of all other resources are then calculated by dividing their depletion factors D_1 or D_2 by the D_1 or the D_2 of crude oil.

More recently yet another approach, the Reserve Base Depletion Potential, has beeen introduced by the ISO Subcommittee on Environmental Labelling (Rhodes et al. 1997). The novelty of this approach is to measure resource depletion by the sum of the actual drain on the resource in question and the amount of waste ultimately produced from that resource. This sum is related to the resource amount remaining in the earth plus the resource amount under recycling. Impact categories for natural resources are discussed by Heijungs et al. 1997. Basically they suggest that resources are either aggregated using their energy content as a unit of measurement or else weighted by division by the known reserve or by multiplication by a depletion factor.

Recommendations

- **Consumption of resources are registered as gross resources input and categorised according to tables 2-4.**
- **Produced resources (residues), like excess process energy, is registered but not deducted from the gross input, nor is any allocation performed.**
- **Only specified resources that actually are recovered or reused are notified as output resources. Unspecified outputs with unknown fate are notified as waste to landfill.**

5.2.2. Global Warming Potential (GWP)

The main greenhouse gases are carbon dioxide, methane, dinitrogen oxide and halogenated hydrocarbons. Ozone-forming compounds, like nitrogen oxides and carbon monoxide have an indirect effect, since ozone is also a greenhouse gas. Reliable GWPs for "indirect" greehouse gases are still lacking

When calculating total GWPs carbon dioxide is chosen as a reference, and the emitted amounts of other greenhouse gases are recalculated to CO_2 equivalents. The unit is kg CO_2/kg greenhouse gas. The GWP of a specific greenhouse gas depends on its absorbancy for infrared radiation and on its average lifetime in the atmosphere.

The set of stressor equivalency factors presented in Table 5 has been published by the IPCC (Intergovernmental Panel on Climatic Change) (IPCC), and they have been used by us in this project. Since the different greenhouse gases have different life expectancies the weightings will change with time. The latest set of IPCC data is strongly recommended (currently from 1994). It is customary to calculate the GWPs for three different time-frames, namely 20 years, 100 years and 500 years.

Table 5. Global warming potentials for some greenhouse gases, kg CO_2 equivalents / kg greenhouse gas. Data from IPCC. Freons have been omitted.

Greenhouse gas	GWP, 20 years	GWP, 100 years	GWP, 500 years
CO_2	1	1	1
CH_4	62	24.5	7.5
N_2O	290	320	180
CH_2Cl_2	28	9	3
$CHCl_3$	15	5	1
CCl_4	2000	1400	500
CH_3CCl_3	360	110	35

Since global warming potental, as the designation suggests, is not an impact parameter dependant on the locality, the receiving environment factor is always 1.

Recommendation

*** Global Warming Potentials on a 100-year basis shall be used. The GWP reference year shall be given (e.g. IPCC 1994)**

Exception:

*** If the LCA on which the ecoprofile is based spans a period of time of more than 20 years, the use of radiative forcing according to Pleijel et al. may be considered.**

5.2.3 Stratospheric Ozone Depletion Potential

Many compounds are known to cause ozone depletion. Several of them are listed in the Nordic Guidlines. Ozone depletion potentials (ODPs) calculated by WHO are dependent on the atmospheric lifetime of the compounds, the release of the reactive chlorine or bromine from the compounds and the corresponding ozone destruction within the strathosphere. Typical known compounds are CFCs (“freons”) in different shapes but also others, e.g. listed in the Nordic Guidelines. Chlorinated and brominated compounds that are volatile and stable enough to reach the stratosphere can have an effect on the ozone layer. Not only these but also other types of compounds can effect the layer are for example: methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO), non methane hydrocarbons and carbonyl sulphide (COS). Though, there are no values for ODPs calculated for these compounds. Therefore they are not included for the ODP calculations in this document.

Data of ODPs for the compounds are given as CFC-11-equivalents. In those cases the exact compound are not known but has an suspected ODP worst case weighting factor has been used in the ecoprofile calculations. The receiving environmental factors for ODPs are always 1.

There is an international agreement to phase-out CFCs (the Montreal Protocol). Due to this agreement the use of CFCs has decreased. The actual stratospheric ozone depletion is also expected to peak within a few decades. Therefore it is reasonable to use ODP values for a time-frame of 20 years as the most representative indicator. These are calculated and listed in e.g. the Nordic Guideline

Recommendations

*** Ozone depletion potentials on a 20-year basis shall be used for ecoprofiles.**

5.2.4 Acidification

Nordic Guidelines (Lindfors et al.) recommends, that acidifying emissions be aggregated on the basis of the number of protons per mole, that may be released in a terrestrial system from the emitted pollutant. Sulphur dioxide is chosen as a reference substance, and the amounts of other acidifying pollutants are recalculated to SO_2 equivalents, kg SO_2 / kg acidifying compound. In Northern and Central Europe we may assume, that SO_2 releases two protons per mole and mineral acids, like HCl, their stoichiometric amounts of protons.

Hydrogen sulphide will be oxidised to sulphur dioxide and further to sulphates, when emitted to the atmosphere. One mole of H_2S is thus equivalent to two protons or one mole of SO_2.

For nitrogen compounds, like NOx and ammonia, the situation is somewhat more complex. The theoretical maximum for both compunds is one proton per mole. However, in Northern and Central Europe nitrogen compounds are to a great extent assimilated by the terrestrial system. The assimilated amounts do not contribute to acidification. The theoretical minimum is thus zero protons per mole, corresponding to 100 % assimilation. Ammonia deposited on soil is in this case considered an acidifying compound, since it may be nitrified to nitrate anions. The oxidation of ammonia by oxygen to nitrate ions in aqueous solution will theoretically release one proton per mole of ammonia.

This difference in behaviour of nitrogen compounds is in our calculations accounted for by the receiving environment factors for acidification (section *Calculation Methods*). The stressor equivalency factors for acidification to be used in ecoprofile studies shall consequently be the maximum-case factors.

Table 6 gives examples of stressor equivalency factors for acidification in the maximum scenario. The values are the stoichiometric SO_2 equivalents, for the nitrogen compounds calculated for the 0 %-assimilation (maximum) case.

Table 6. Stressor equivalency factors for acidification, kg SO_2 equivalents/kg substance.

Substance	SO_2 equivalents, maximum
SO_2	1
HCl	0.88
NO_x	0.7
NH_3	1.88
H_2S	1.88

In order to determine the receiving environment factors for acidification the concept of critical load is used. The receiving environment factor is defined as the fraction of the acidifying emission, that is deposited in an area, where the critical load is exceeded. (For a more extensive discussion see Pleijel et al.). Receiving environment factors used by us in this project are given in Table 7. The factors are based on data from 1980 and are intended only for model calculations in this project. Accurate data will be provided.

Table 7. Receiving environment Equivalency factors, Receiving Environmental Equivalency Factors, for acidification. Data from Pleijel et al., based on critical load data from 1980.

Locality	REEF*, SO_2	REEF, NO_x
Northeastern Svealand	0.10	0.05
Northern Lappland	0.05	0.03
Eastern England	0.10	0.10
Central Germany	0.35	0.30
Poland	0.50	0.30

Recommendation

* **For acidifying emissions the stressor equivalency factors shall be kg SO_2 equivalents per kg of substance, calculated from the maximum possible release of protons from the pollutant.**

* **Hydrogen sulphide is regarded as a two-proton acid.**

5.2.5 Ground Level Ozone Potential

Ground level ozone is produced in the atmosphere under the influence of solar radiation in presence of nitrogen oxides. Also the presence of organic species increases the ozone production. For large parts of Europe NO_x is expected to be more important than VOC for ozone prodiction.The ozone formation will vary in different regions and at different times as a result of varying background concentrations and sun-intesities. Both the stressor equivalency factor and the receiving environment equivalency factor are site dependent.

The calculation of this indicator differs from the calculation recommended in Nordic Guidelines, since the stressor equivalency factors are site specific in this case. The site specific stressor equivalency factor heps to calculate the total amount of produced ozone. The Receiving Environmental Equivalency Factor determines how much of the total amount of ozone that is harmful. Receiving environment equivalency factors for the POCPs as amount of harmful ozone created per kg of VOCs may be calculated on a case by case basis (need calculations by experts)

Recommendation

*** Area specific creation of harmful ozone per VOCs is used as indicator value**

5.2.6 Aquatic Oxygen Depletion

An increased input of different nutrients to an aquatic system may lead to an oxygen depletion due to decomposition of the biomass produced due to the nutrients. Decomposition of organic material, measured as COD and BOD, is also oxygen demanding, so emissions of organic material are handled under this heading as well.

Different nutrients limit the production of biomass in different systems. For example, in European aquatic systems, nitrogen and phosphorus are often the limiting nutrients. In Sweden, lakes and the eastern coastal zones are often limited by phosphorus. In contrast, for the western coastal area and the Baltic sea nitrogen is mostely the limiting factor. Weighting factors for oxygen demanding compounds in an aquatic environment are expressed as [g O2 /g emitted compound] and given in the table below.

Table 8. Weighting factors for aquatic oxygen depletion. Data from Lindfors et al.

	Stressor equivalency factor	Receiving environment factor	
Substance		P-limited	N-limited
N to water	20	0	1
NO_3^- to water	4.4	0	1
NH_4^+ to water	15	0	1
P to water	140	1	0
$(PO_4)_3$- P to water	46	1	0
COD	1	1	1

As receiving environmental factors have not been produced yet for specific locations worst scenario conditions have been used. That is, receiving environmental factors have been set to 1, if the corresponding pollutant has an effect, or to 0, if it has not.

Thus, phosphorus-containing compounds, for instance, are asssigned the receiving factor 0 in nitrogen-limited waters and 1 in phosphorus-limited waters.

Recommendation

*** Receiving environment factors for pollutants causing aquatic oxygen depletion are for the time being set on an on-off basis. Either the pollutant has an “effect”, factor 1, or it has not, factor 0. The parameter COD always has the factor 1.**

*** The estimation of the Receiving Environment Equivalency Factor needs expert judgement.**

5.2.7 Waste

According to the LCA methodology all kinds of waste treatment should be included within the boundances of the production system. Therefore the waste treatment system should be considered as any other production process, which means that emissions and resource use for the waste treatment must be calculated. This is however not always the case. Frequently the waste streams are noted as an outflow from the system and the emissions from the waste treatment methods are not calculated. The main reasons for this are:

1. Models for emissions from landfilling and incineration (which includes allocation problems) still need to be developed. At this stage an exclusion of these treatment processes and just a notification of the outflows of waste are considered to give the most robust results.

2. Mobile products and products with a long life time imply difficulties to identify the most representative waste treatment process.

The specific treatment of the production waste is often reasonably well known however seldom the disposal of the product at the end of its life time. Therefore a slightly different description method can be used for waste coming from the cradle to gate part of the product´s life-cycle than from the ”gate to grave” part. A suggestion of how to do this follows.

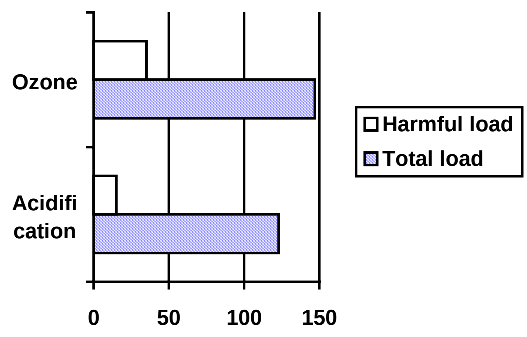
6. Aggregation and communication

The number of resource indicators may be decreased. One option is given in the example below where imputs and outputs of energy carriers and raw materials are summarized into two resource indicators.

Another option that may be valid for consumer oriented information is to identify the for example three most dominant indicators associated with the specific product group and only report those three indicators. Definitions of “dominant” need to be discussed.

Ecoprofile valid for year 1997	Cradle-to-gate profile.	
Resources	Input	Output
Energy carriers (fuels and raw materials) (MJ)		
Raw materials (weight units)		
Emission loading (weight units)	-	
Greenhouse gas	-	
Strathospheric ozone depl.	-	
Acidification	-	
Ground level ozone	-	
Aquatic oxygen depletion	-	
Toxic emissions (weight units)	-	
Waste (weight units)	-	
Hazardous waste to landfill	-	
Other waste to landfill	-	

A lucky location may very well hide a not so good performance, which may be seen as a drawback. For that reason it is suggested that both the stressor equivalencies and the receiving environment equivalencies are reported. This will provide information on both the performance of the technology used (total loadings) as well as the the harmful parts of those loadings



7. Goal Definition and Scoping

In most respects the basic rules and recommendations for LCA as outlined in "Nordic Guidelines" apply. However, in an ecoprofile study there are some special considerations and some divergencies as compared to other types of life-cycle assessments. These divergencies will be pointed out in the following discussion.

7.1 Product Group or Type of Service

An ecoprofile is constructed for a single specific product or service. The assessment will thus never be a comparative study of the advantages and disadvantages of two or more products relative to each other, and there will be no need to consider alternatives to the studied product. The result of the analysis, the ecoprofile, will be a set of absolute numbers, which characterise the product. The task of finding and comparing alternatives is the responsibility of the receiver of the information and thus outside the scope of an ecoprofile study.

A consequence of the discussion above is that allocations need to be performed in multi-output systems. Avoiding allocation by dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes is always preferable, however avoiding allocation by system expansion is not an applicable.

7.2 System Boundaries

An complete ecoprofile should be based on the entire life cycle of the product under study. Basically it shall follow the product from extraction of raw materials from earth and the biosphere to the final consumption of the product. There is one discernable internal boundary, namely the boundary between the production and the final use of the product. Ideally (if not always in practice) it is possible for a producer to describe his production process specifically back to the point where he uses purchased components produced by someone else. In contrast, the final use of a product on a consumer market may be described only by generic data, which assume normal and average use and disposal of the product. The life-cycle inventory for the ecoprofile of a consumer product shall thus be divided into two parts as discussed in previous sections:

- The cradle-to-gate profile
- The gate-to-grave information.

The producer ecoprofile may be combined by several sub-supplier ecoprofiles. The system boundaries of a sub-supplier profile are defined in the same way as those of a cradle-to-gate profile, i.e. from extraction of raw materials to the finished product ready for shipping (cradle to gate). The transport of the sub-supplier´s product from the sub-supplier´s factory to the assembly line of the main product is part of the main cradle-to-gate profile. Figure 2 visualises the definition of system boundaries in an inventory analysis intended for an ecoprofile.

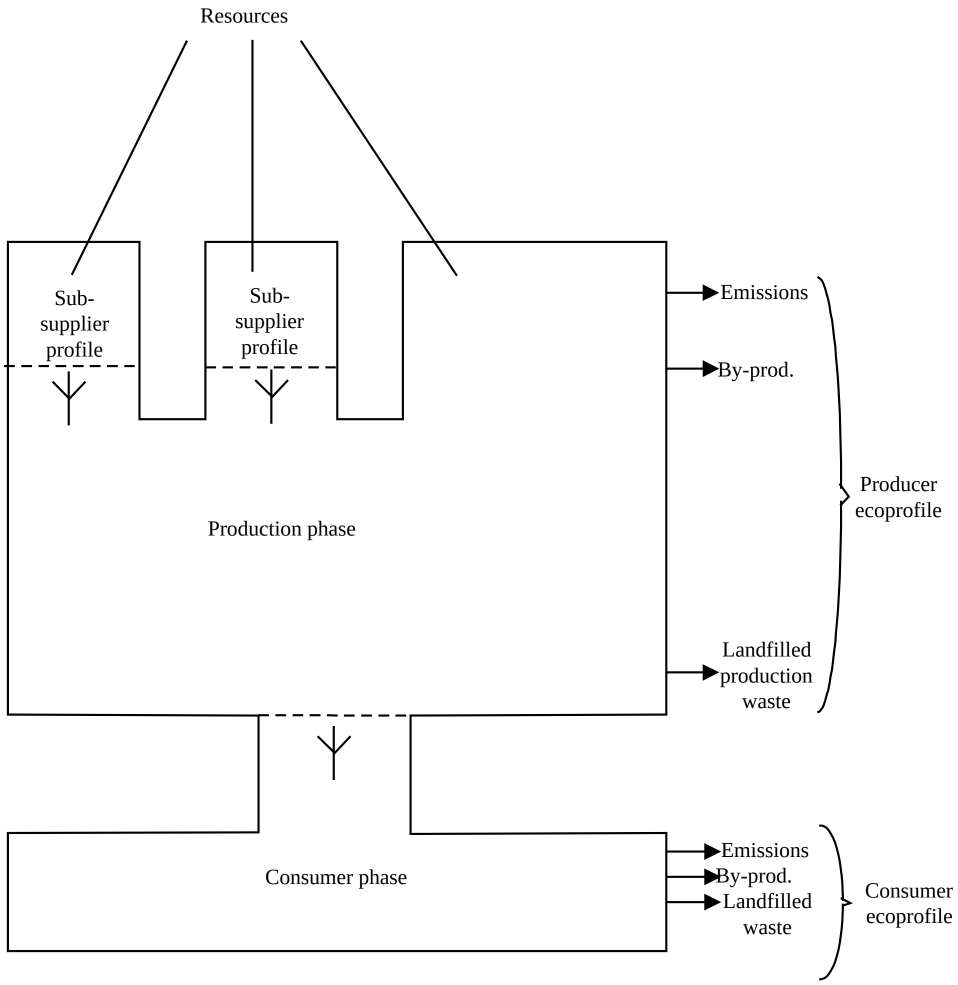


Figure 2. Generalised picture of system boundaries in an ecoprofile analysis. Dashed lines denote boundaries between sub-systems. Arrows symbolise transports of finished goods within the system or, in the case of by-products and waste, away from the system.

A deviation from the common LCA practice described in Nordic Guidelines is that we leave the landfilled waste outside the system boundaries in the producer ecoprofile and that we do not follow the final product through the waste treatment in the gate-to-grave information.

7.3 Temporal Boundaries

The ecoprofile assigned to a product on the market should be based on

- Process data valid at the time of production
- Environmental impact data valid at the time when the emissions from the production and user phase take effect in the environment.

This means that different types of data have different temporal boundaries. As discussed earlier (section Global Warming Potential) a release of greenhouse gases will exercise an effect over hundreds of years, whereas the validity of specific process data expires the instant the process is changed.

Obviously an ecoprofile is a perishable product. Its validity expires as soon as a major technology change is introduced. Its validity will slowly deteriorate as conditions in the receiving environment change. As a practical approach we suggest that data are averaged over one year, and that ecoprofiles are revised once a year. In this way gradual optimisation and up-grading of the production process may be accounted for. In theory gradual changes in the receiving environment could be accounted for in the same way. In the actual practice it will probably be difficult to obtain revised receiving environment factors once a year. However, this is not needed, since the profile is based on <u>indicators</u> intended for comparative assertions <u>not to be confused with the assessment of the actual environmental effects.</u>

7.4 Data Quality Goals

The data quality goal for the cradle-to-gate profile, including sub-supplier profiles, should be to obtain specific process data averaged over one year. The year for which the data is valid should be clearly noted.

Generic data pertaining to normal use of the product under average conditions may be used for the gate-to-grave information. This is valid unless the product is used only in a specific and well-defined process, in which case the specific data for that process should be obtained and used.

Stressor equivalency factors and receiving environment factors should be the most recent ones available for the site of production and the region of use of the product. The data source must be clearly noted.

Recommendations:

- **An ecoprofile shall be based on a complete life-cycle inventory from the extraction of raw materials to the consumption of the product under study.**
- **Landfilling of waste in the cradle-to-gate profile and the disposal process of the spent product in the gate-to-grave information are outside the system boundaries.**
- **The system shall be divided into a cradle-to-gate profile (cradle to gate) and gate to grave information.**
- **Cradle-to-gate profiles shall begin with raw-material extraction and end with one product ready for shipping.**
- **The gate to grave information shall start with the transport of the product from the producer and end when the consumed product is discarded.**
- **Specific process data averaged over a one-year production period shall be used for the cradle-to-gate profile. The year for which the average data is valid should be noted.**

8. Inventory Analysis

Basically the normal rules for inventory analysis, as outlined by the Nordic Guidelines apply. However, as in the case of scoping, there are some special considerations, which are a consequence of the specific purpose of the inventory in an ecoprofile study.

The case studies showed that the choice of inventory methods influenced the results more than plausible technical changes of the processes or plausible changes of the surrounding environment. Since an ecoprofile is intended as a consumer tool to compare different products, it is very important, even more important than in LCA-studies for other purposes, that the inventory methods are standardised.

It is a prerequisite in an ecoprofile study, that all calculated indicators are additive and linearly scalable.

8.1 System Function

The data used for calculating the indicators for an ecoprofile should be based on one year of measurements, e.g. an annual average. This means that to obtain the size of the indicators for the chosen functional unit one has to use the annual average of emissions or resource use and divide it by the annual output. After that it can be transformed to the chosen functional unit. The producer ecoprofile and the gate-to-grave information have different definitions of their functional units.

The functional unit for the **cradle-to-gate profile** does not necessarily have to be related to a certain function. It is often more appropriate to choose a functional unit in terms of ”one product” or ”one kg material”. A producer of raw material in the form of iron does not know in which kind of function the iron will be used for example. Therefore it is in this case better to express the ecoprofile indicators related to weight units of iron. The calculation of the producer ecoprofile can be expressed as

$$I_f = I_y / Py * P_q$$

I_f= size of ecoprofile indicator for one functional unit
I_y= size of ecoprofile indicator for one annual output of products
Py= annual output of products (measured in weight units or quantity of products)
P_q= chosen functional unit expressed in weight units or quantity of products

However, for the gate-to-grave information it is necessary to choose the functional unit according to the common LCA practice, that is in the form of a function. When choosing this functional unit quality aspects such as life-time of the product have to be considered. If we take white roof paint as an example, there might be different qualities of the paint, some paints you have to paint three times to cover one square meter and for some paints it is satisfactory with two layers of paint. Also the service length of the paint can differ. Thus the accurate functional unit for this white roof paint might be ”one square meter of white roof during 10 years”. The calculation of the gate-to-grave information can be expressed as

$$I_f = I_y / Py * P_q * (a * b * ... * n)$$

a*b*...*n = factors that transform the actual product to the chosen function (for example life time, quality e.t.c.)

Recommendation

- **The functional unit for the producer ecoprofile is related to amount in weight units or amount of products, not necessarily a function.**
- **The functional unit for a gate-to-grave information is the function for the final product with considerations made for quality, life time etc.**
- **The indicators in the ecoprofile shall be based on an average yearly production.**

8.1.1 Defining System Boundaries

The question of system boundaries pertaining to the scope of the study have already been discussed in chapter Good Definition and Scoping. In this chapter we will deal with some further aspects of system boundary selection.

8.1.2 Geographical boundaries

In an ecoprofile study the choice of geographical boundaries is usually not left to the judgement of the practitioner. Since the inventory data shall be collected for specific production sites and specific areas of utilisation of the commodity, the geographical location of the processes and of the regions of production of their utility supplies are usually given by the inventory.

8.1.3 Life-Cycle Boundaries

The system boundaries set during the scoping phase define the actual extent of the system under study. When setting the life-cycle boundaries one makes a practical limitation from which up-stream flows energy consumption and emissions may be cut-off (neglected) without loss of significant data, and which unit operations, if any, may or shall be omitted from the inventory.

When making cut-off decisions according to ISO DIS 14041we suggest that the specific principal of “limited loss of information at the final product” is applied.The principal is described in Nordic Guidelines, page 48. Basically it prescribes, that a permissible percentage loss of mass at the final product is stipulated, and that fixed percentage cut-off limits in side-streams are calculated from that figure. In the actual practice, the application of this principal is not always easy or straightforward and it is only applicable for common emission types such as energy related emissions.

The following practical interpretations of the principle have been established during the practical work with the application cases. The calculation procedures are illustrated by Figure 3.

1. If the final product consists of two or more distinctly different and clearly discernible components, each component is studied separately. The starting point for cut-off calculations backwards in the process chain is the marriage point between the components.

   E.g.: Goods and packaging.

2. If the process chain branches out into several flows of comparable magnitude, the largest flow on a mass basis is chosen as the main flow. The other flows are considered to be side or auxiliary flows.

3. If a process changes the magnitude of the main mass flow, the mass change factor is put equal to 1, when calculating the cut-off percentage, i. e. the main inflow is put equal to the main outflow.

   E.g: Chemical synthesís with a yield less than 100 %. The flow of the main starting material is assumed to be equal to the flow of the product.

4. When calculating the maximum permissible cut-off at the individual process stages, the main flow is followed back to the last branching point. The main flow at that point is used as a basis to decide, whether a certain up-stream flow could be discarded or not.
   The same principle and calculating basis is applied to side flows, whether they are branched or not.

The application of the principles above may be illustrated by the case of Tetra Pak milk packaging. Figure 3 illustrates somewhat simplified the production of milk packages. Transports, by-product flows and waste-material flows have been omitted.

The main flow is taken to be the flow from Forest cutting via Kraft pulping without bleaching, Board making, Laminating and Rollpacking. The flows of saw chips, CTMP, bleached kraft, eucalyptus pulp and LD-polyethylene are considered side flows.

If we assume, that a 5 % loss of emission information is acceptable in the final product after Rollpacking, the percentage cut-off after each process step may be calculated as follows:

Cut-off limit = 5 · 26.87/(26.87 + 28.07 + 23.96 + 9.12) = 1.5 %.

Applying a 1.5 % cut-off limit to the outflows from the process stages from Rollpacking backwards to Kraft pulping leads to the conclusion, that the only side flow which may be discarded straight away is the flow of polyethylene film from Film production. Following the side flows from Board making backwards one concludes, that two flows are smaller than 1.5 % · 23.96 kg = 0.36 kg, namely the flow of pulping chemicals to Kraft pulping with Bleaching (0.157 kg) and the flow of pulping chemicals to Eucalyptus pulping (0.31 kg).

All the pulping process stages have mass change factors smaller than 1. When viewing the inflows to these stages from a cut-off point of view, we consider only the ”valuable” part of that flow, i.e. the part of the inflow which remains as pulp. Thus e.g. the assumed inflow of roundwood chips to Kraft pulping is 0.286 · 28.3 kg = 8.09 kg (see Figure 3). The inflow of chemicals, however, is not multiplied by the mass change factor, when it is compared to the cut-off limit.

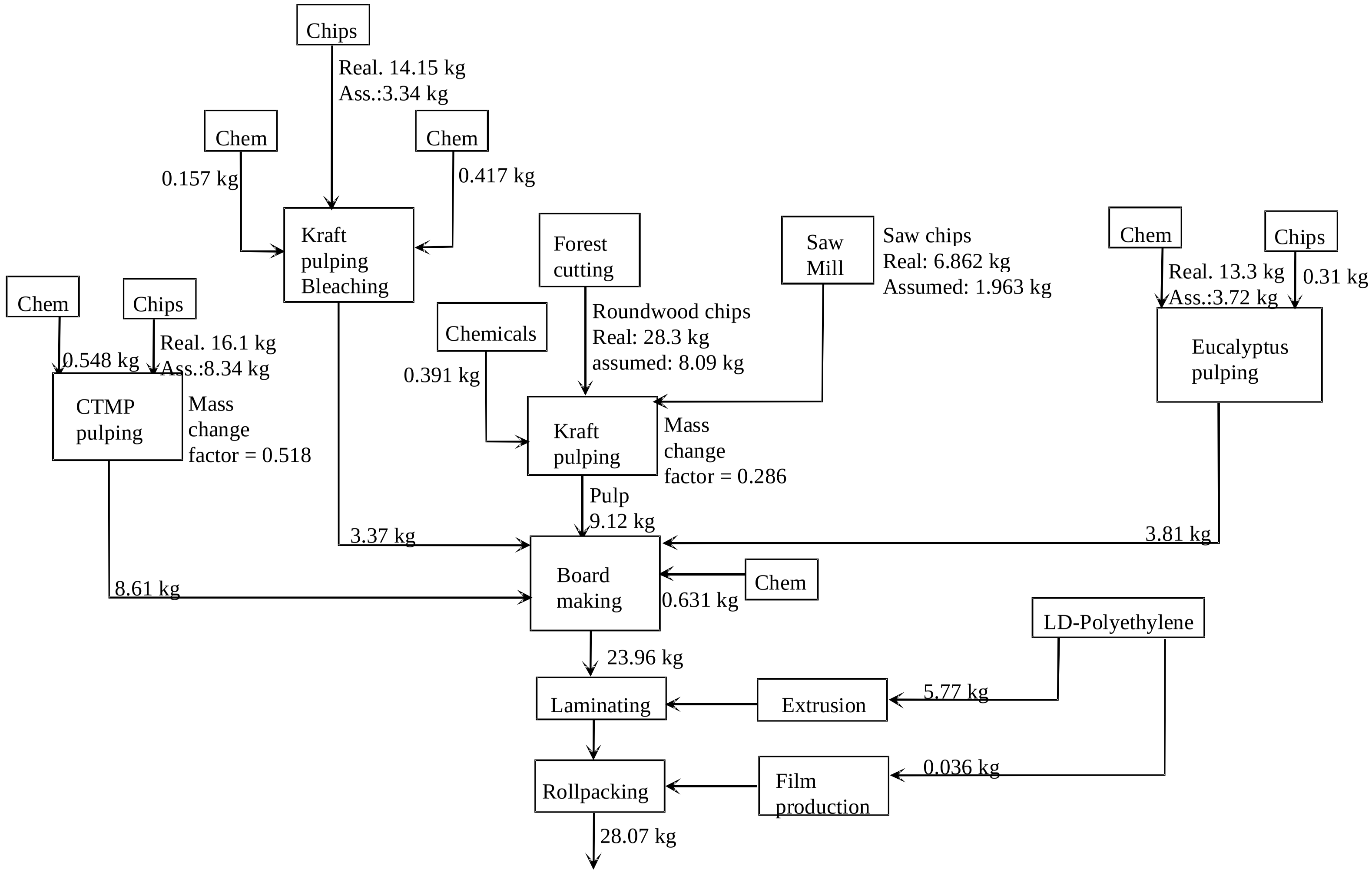


Figure 3. Flow chart for the Tetra Pak milk packaging system, illustrating cut-off calculations.

Normally waste treatment processes, including landfills, should be included in the system. For reasons discussed in section Waste we recommend that landfills are excluded from the system, i.e. they are regarded as part of the biosphere.

A further result of the waste-category discussion is our recommendation that all waste treatment of the spent commodity, i.e. waste-treatment processes in the consumer inventory, are excluded.

These exclusions may lead to significant underestimations of greenhouse gas emissions from the life-cycle of the commodity under study. However, since waste treatment procedures and landfill operation vary from country to country and even from one county to another, it is at this time more accurate just to treat waste as an impact category, rather than to try to calculate emissions from landfilling and/or waste incineration using available generic data. Later on, when recycling processes have been fully established, such processes based on the producer‘s recommendations may be introduced into the ecoprofile inventory as part of the system.

Recommendation:

*** When setting life-cycle boundaries, the cut-off principle of limited loss of information at the final product shall be applied.**

*** A cut-off means that the energy use and the emissions associated with a material flow are neglected (not followed back to its cradle). The material flow itself shall, however, be registered in the inventory as an input**

*** Landfills and waste treatment of the spent product under study are not included in the system.**

*** As a default a 1-% loss of information may be accepted at the final product. When specific inventory recommendations are developed for product groups this may be modified.**

*** A total cut-off means that the entire material flow, including the associated energy use and the emissions, is neglected. As a default a 0,1-% loss of information may be accepted for non-hazardous material flows.**

*** However, business specific cut-off guidelines need to be provided**

8.2 Issues Omitted from Ecoprofile

The rules and recommendations in Nordic Guidelines“ are generally applicable. As in earlier sections there are some specific recommendations, though, due to the intended use of the inventory for an ecoprofile.

8.2.1 Infrastructures

A basic rule is that the ecoprofile shall only reflect environmental impacts caused by the production and use of the specific piece of commodity at hand. The production and use of this specific product are presumed not to change the production system or the transport and handling systems. This means that the manufacture of process equipment and machinery, the construction of buildings and roads and the manufacture of vehicles are not included for up-stream processes, that deliver commodities or services to the primary producer. However, it is sometimes obvious that capital goods or other infrastructures used in primary production should be included, i.e. LCA practise shall be applied

Normal maintenance and the production of wearing parts shall be included in the inventory, in concordance with basic LCA rules. The boundary between permanent and wearing parts is of course gradual. Many machines are gradually renewed during their service lives. As a practical convention we recommend, that pieces of equipment with a life expectancy of three years or less are regarded as wearing parts. This convention is in keeping with financial conventions for depreciation computation. The life-cycles of wearing parts should thus be included in the system. The resource consumptions and emissions caused by the production and use of wearing parts shall be distributed over the amount of products produced during their service lives.

8.2.2 Accidental Spills

Spills, i.e. abnormal emissions, accidental or not, shall not be included, unless they occur with certain regularity. The same applies to other effects, which are not caused by the normal production and handling process. These are fluid definitions.

As a working convention we suggest that one differentiates between accidents and incidents. An accident is an abnormal and unexpected event of such consequences, that the process must be emergency-stopped and shut down permanently, unless measures to reasonably safeguard against a repeat of the event can be taken. This definition excludes accidents from a life-cycle inventory and of course from any ecoprofile.

An incident is an abnormal event causing higher than normal emissions to the surrounding environment without causing an emergency. Incidents which statistically occur with a frequency of at least once every three years are suggested to be included in the system. The effects of the incident are distributed over the amount of products produced during the statistical time interval between two incidents.

8.2.3 Environmental Impacts Caused by Personnel

Personnel-related impacts are usually not considered in life-cycle assessments. In an ecolabel inventory regular transportation of personnel from their normal work station to a work assignment on some other locality, should be included, if such a transport is an integral part of the production process. Travel of personnel between home and work is as usual not included in the system.

Recommendations:

*** Production of plant and machinery shall not be included in the up-streams subsystems.**

*** Maintenance and manufacture of wearing parts shall be included in the system. Equipment with a life expectancy of three years or less is considered a wearing part.**

*** Incidents, i.e. abnormal events of consequences not severe enough to cause an emergency, shall be included in the system, if they occur with a statistical frequency of at least once every three years.**

*** Regular transportation of personnel between different work assignments are included in the system. Other personnel-related impacts are not included.**

8.3 Data Sources and Data Quality

In the future each branch will develop specific inventory recommendation suited for the specific type of operation. Until then we have to settle with more general recommendations.

The main data source should always be the specific production plant or activity. Every exception for this has to be highlighted and justified.

8.4 Data Collection and Calculation

8.4.1 Generic or Specific Data

The question of when to use specific data and when to be allowed to use general data is, as usual, difficult. Data quality can have a severe impact on the results. A general recommendation is therefore to always seek for specific data.

Data should always be specific unless:

1) Generic data are more representative as an annual average

2) Generic data will not affect the result (10 % rule)

Environmental impacts from production of electricity or from production of oil are examples of the first type of situation. In the case of electricity it is practically impossible to estimate the impact that the amount of electrons that is delivered to a specific production plant causes. Oil that is bought on an international market throughout the year is also impossible to trace back to its true origin. Production of these types of products may and in most cases should be described by generic data. In this case the generic data represent the best description of that product or that resource.

The second exception is introduced to make the inventory practically possible. A suggestion is to allow a maximum loss of information corresponding to 10 weight percent of the outcoming product. These 10 % is distributed throughout the production chain according to the same methodology described for cut-off recommendation. Observe:

1) These 10 % include the percentage that is cut-off,
2) Generic data which are more representative as an annual average (exception no. 1) are not included in these 10 weight-%.

Public services might be problem. The aim is to seek for specific data for the treatment plant that receives the waste or sewage in question.

Application of receiving environment equivalency factors (< 1) require that the specific location of each unit operation is known. If not only stressor equivalency factors shall be applied (receiving environment equivalency factor = 1)

8.4.2 Average or Marginal Data

Marginal data should never be used. Annual averages are always recommended.

Data should be expressed on a yearly basis. Data should be measured specifically for each production facility. The data should be normalised to a yearly production of the product in question. The year should be specified for which the average is calculated. The average should be based on either continually collected data over the year or a representative average of frequent measurements. The measurements should also be performed according to possible seasonally variations over the year.

From the measurements it should be possible to calculate a standard deviation for the yearly average. The way the measurements have been performed and the data that is behind the calculated average should transparent easily understood by the reviewer.

8.4.3 Review

A critical third party review according to ISO 14040 is mandatory including validation of numerical data quality.

8.4.4 Advice on the practical performance of data collection

The following is based on experiences from the case studies and the recommendations will, besides facilitating the work for the performed of an inventory, also facilitate the reviewer´s work.

8.4.4.1 Standardised variable names

When complex life-cycle inventories is put together from different sub-inventories, compiled by different practitioners, it more often than not happens that one and same parameter in different studies is given different variable names, e.g. Crude Oil, Fossil Oil (MJ) or Fossil Oil. Since the formation of a total ecoprofile for a product will involve data collection from different sources (for example suppliers) it is necessary with standardised variable names. Often different softwares are used for systemising the data collection. In these programs each variable has to be named. A systematic naming in the inventory phase with respect to the formation of the ecoprofile will help the analyst to avoid miscalculations.

Use the same name throughout the whole inventory and add suffixes which indicates if it is fuel or feedstock, fossil or from a biological origin is strongly recommended. If not exactly the same name has been used by a sub-supplier as a final producer uses the suffixes will help to sort out the types of flow.

Suggested suffixes:

Fossil fuel = (ff)	that is oil, coal, natural gas, peat
Biofuel = (bf)	that is wood, biogas for example

Other fuels = (of)	uranium for example
Fossil raw material = (fnf)	for example oil for production of plastics
Abiotic raw material = (anf)	for example iron ore
Biotic raw material = (bnf)	for example water

Primary resources used for electricity is bookkept both with the rest of the fuels but also separately as electricity resources. These should have an addition of the suffix ”power” after the fuel name.

For example: ”Oil power” for the amount of electricity that is produced from oil.

Waste should be named as specific as possible according to what it is. A suffix (w) or (hw) should be added. hw = hazardous waste and w = other types of waste.
For example: ”grinding sludge (hw)”.

8.4.4.2 Book-keeping rules

Strict book-keeping rules when the basic inventory is performed are an absolute necessity. The ecoprofile in its present form lists oil, natural gas and coal under three different headings, namely Fossil total, Fossil raw material and Electricity consumption. Fossil total incorporates the amounts listed under Electricity consumption but not the amounts listed under Fossil raw material.

Observe that different softwares can have different default names for material and energy flows. These default names can have a structure that is not suited for the ecoprofile. Therefore it is necessary to think twice when building the model.

For example, a practitioner using one of the existing softwares perhaps cannot use the aggregated value ”Fossil fuel” from the inventory matrix in the software as a value for ”Fossil total” in the ecoprofile. The reason is that ”Fossil fuel” as defined in the software does not incorporate fossil fuels used for electricity production. Instead the practitioner has to aggregate all fossil energy carriers as e.g. crude oil, natural gas etc. and then make a separate aggregation of energy carriers for electricity production, e.g. as oil power, gas power etc. Fossil raw material should not be defined as fossil fuels but aggregated separately, e.g. as oil (fnf).

The unit of measurement for fuels and fossil raw material should be MJ, not gramme or kilogramme.

8.4.4.3 Calculations - practical aspects

LCA inventories results in a wast amount of data that has to be further calculated to form an ecoprofile.

If a LCA software is used there might be possibilities to include the calculation of the ecoprofile within the computer model. If calculations has to be perfomed in another program after simluations in the LCA software, the use of a data base software is a well functioning alternative. Calculations in spreadsheet programs such as for example Excel is not that suitable due to the risk of introduction of errors. Using a data base for storing of the data also minimizes the need of storage memory.

In the future, as Type-III labeling develops, existing LCA software will probably be developed for handling Type-III calculations. This would be the best solution, to only have to deal with one software.

Recommendations:

*** Always seek specific data for the specific production plant or activity.**

*** Exceptions from the use of specific data should be highlighted and justified.**
*** Generic data are allowed in two cases:**
- **Specific data are not possible to obtain or that the generic data are more representative than specific data**
- **For practical reasons an allowance of a maximum loss of information corresponding to 10 weight percent of the outcoming product is suggested. The method described for cut-off should be used for choosing the suitable materials flows for which generic data are allowed to be used.**

*** Data should be based on a yearly average and the year for which the data is valid should be noted.**

*** The emissions from the use phase should be based on documented tests, validated consumer surveys or recommendations given on how to use the product.**

*** A strict and transparent book-keeping is strongly recommended. Think twice when using default names in existing LCA softwares, they may not be compatible with the ecoprofile.**

*** The use of suffixes to define types of resources and waste in the inventory are recommended.**

*** When performing calculations of ecoprofiles in a calculation software from data coming from an LCA software, an advice is to use database software instead of spreadsheet software such as Excel.**

8.5 Allocation Procedures

8.5.1 Allocation

Since we in the ecoprofile deal with a single-functional system, a multi-output system must be analysed using allocation methods. Byproducts will be subjected to allocation according to Nordic Guidelines. System boundary expansion is not an applicable method. Multi-input/output allocations shall be performed according to the allocation scheme given in the Nordic Guidelines.

An allocation problem might be approached by:

Avoiding the problem by

- Desegregate "black boxes" into sub-processes, i.e. increase information on quantitative causalities (quantitative models, that link inputs to outputs)

This might however not always be possible in relation to the goal of the study, or it may lead to increased data collection costs which cannot be justified in an initial LCI. A decision on disaggregation should thus be based on the relative importance of the allocation problem. The following procedure should then be followed:

PROCEDURE

A. The relative importance of every single allocation "case" is evaluated by allocating 100 percent (which is the maximum burden) on the product or waste flow under study.

B. If this does not affect the results (qualified judgement, or based on an initial calculation) a conservative approach keeping the 100% should be applied.

C. If the allocation is found likely to affect the results possibilities for disaggregation should be evaluated.

If a further disaggregation is found not to be feasible, and thus allocation is necessary, the following priority list should be used:

1. Allocation based on natural causality or an adequate approximation of that

2. Allocation based on economic/social causality or an adequate approximation of that

3. Allocation based on an arbitrary choice of a physical parameter

With natural causality we mean causal relationships based on natural science such as physics, chemistry or biology. A key question is whether natural causality is involved or not. In the case of multi-output processes, a natural causality implies that it is possible to change the proportion of the products A and B in the figure above. If this is not possible, if the proportions of A and B are fixed, there is no natural causality between the production of product A and the environmental loadings, only between the simultaneous production of A and B and the environmental loadings. In this case an allocation based on natural causality is not possible. An example of this is the simultaneous production of chlorine and sodium hydroxide. The proportions of these two products are fixed by stoicheometric relationships and cannot be changed. An example where there is some natural causality involved is emissions from a landfill. It is, as an example, obvious that metal containing wastes to same extent are linked to metal emissions from landfills. There is however not a clear linkage, other factors may influence the emissions.

An allocation based on natural causality will often result in an allocation based on some physical quantity. In many situations the exact causal relationship will not be known. In this cases, natural causality can be used as a guiding principle, and the allocation can be based on a parameter which is an adequate approximation of the causal relationship. The choice of the approximation must be made on a case-by-case basis, based on the scientific/technical knowledge of the relevant processes.

Economic value can be used as the basis for allocation in most multi-output processes. Different choices of economic parameters can be made, e.g. gross sales value or expected economic.

If exact economic data is not known, economic causation can still be used as a guiding principle. Another parameter can be used as an approximation of the guiding principle. In these cases, the choice must be made on a case-by-case basis, based on knowledge of the relevant processes and products. The approximating allocation parameter may then very well be a physical parameter.

If a physical parameter is used as the allocation parameter, and the choice is not justified as an approximation of a either natural or economic/social causality, the choice is arbitrary. Several alternatives have been suggested and discussed, e.g.:

The mass of the outputs
The energy content of the outputs
The exergy content of the outputs
The area of the outputs
The volume of the outputs
The molar content of the outputs

An arbitrary number, e.g.

a) 100% on one of the products, 0% on the others
b) 50/50 allocation between two products

It should be recognised that the detailed decisions may differ within the same LCA, i.e. depends on the specific conditions for each single allocation decision.

Open-loop recycling is not an issue since ecoprofiles are compiled for single-functional systems. Consequently e.g. residual products not recycled within the system will be noted as outputs in the ecoprofile. Residual products and energy will not be subjected to allocation or expansion of the system boundaries.

8.6 Data Quality Declarations

It is obvious from the preceding rules and recommendations, that an ecoprofile study requires adherence to some specific data-quality requirements. The degree of fulfillment of these requirements should be documented. CPM has recently suggested a systematic declaration procedure for data quality in LCA studies (CPM 1997). This procedure covers most of the data-quality issues, which will arise in an ecoprofile study, and we recommend it for use.

8.7 Uncertainty and Sensitivity Assessment

There are no general methods aggreed upon considering uncertainty and sensitivity aspects in common LCA practice. Some of the problems will probably be solved in the future when more specific data quality recommendations can be formed for specific product categories.

9. Gate-to-grave information

9.1.1 Emissions Associated with the Use Phase

Whether “consumer emissions” should be reported must be determined on a product group specific basis. The rule being that they shall be reported if they do occur. National average REEFs should be applied to calculate harmful loadings.

The emissions calculated from the use phase should be based on documented tests, for example car tests where emissions are measured according to a recognised test plan. They may also be based on recommendations as how to use the product, for example recommendations for dosage of washing powder for 5 kg clothes, if clearly noted, or validated consumer surveys. The basis for the calculation shall be clearly stated.

9.1.2 Transportation from gate to market

Transportation from the gate to the market is not included in the cradle-to-gate profile and need to be reported here as emissions associated with the average transportation distance from the gate to the market. National average REEFs should be used.

9.1.3 List of content

The actual future disposal of the product is seldom known. Any generic approach to model emissions from future waste disposal seems less relevant, since it never will represent the actual fate of the product. Such approaches will never provide objective and consistent data suitable for comparative assertions. Substitute information should include:

1. A declaration of the contents of hazardous substances in the product, exceeding a certain percentage of the product. Declarations of contents must follow consistent criteria. Such critera need to be developed business specific

2. A recommendation as how to dispose of the product. This should preferentially be written on the product itself.

9.1.4 Recyclability

The parts of the product, percentage of the materials that actually are recycled on the relevant market (including energy recovery), may be reported as recyclable fractions. Business specific guidelines should be provided.

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