REPORT

# Product category rules (PCR) for building products on an international market

## — A PCR based on life cycle assessment (LCA) methodology in compliance with ISO 14025

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**Report Summary**

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Internationally harmonised building product declarations

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**Title and subtitle of the report**
Product category rules (PCR) for building products on an international market

**Summary**

The objective of this *product category rules* (PCR) project is two-fold: to develop an international common operational methodology for building products *environmental declarations* (ED), and to identify aspects that are not yet agreed upon. This PCR cover technical aspects relevant for the declaration of building products based on a life-cycle assessment (LCA) covering the “cradle-to-gate” perspective. The PCR also include specifications to develop a PCR on building products’ applications that account for a full life cycle (cradle-to-grave). Only when the LCA covers a full life cycle is it, in theory, possible to use the result for supporting decision-making in comparative purpose, provided that a common functional unit can be established. The development of EDs also makes the type III declaration a useful tool to aid consumers in decision-making.

To comply with the ISO 14025 standard for EDs, this PCR has to be complemented by administrative rules that are relevant to a program operator and the *environmental declaration type III program* that is specified by this program body. For implementation on the Swedish market, the PCR developed here will be complemented with such administrative issues defined in the type III program “*Requirements for Environmental Product Declarations”*, hosted by the Swedish Environmental Management Council (MSR).

**Keywords**
Building materials, building products, environmental declaration type III, environmental product declaration, life cycle assessment (LCA), product category rules (PCR).

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# PRODUCT-CATEGORY RULES (PCR)

## for preparing an environmental product declarations (EPD)

# Building products

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# Preface

This *product category rules* (PCR) project covers technical aspects for the declaration of building products. To comply with the ISO 14025 standard on *environmental declarations* (ED), this PCR has to be complemented by administrative rules that are relevant to a program operator and the *environmental declaration type III program* specified by this program body. For implementation on the market, the PCR developed here will be complemented by the administrative issues defined in the type III program "*Requirements for Environmental Product Declarations"* (MSR 2000), hosted by the Swedish Environmental Management Council (MSR).

This PCR is the result from a project with the objective to develop an international common operational methodology for building products' ED. This was mainly possible by using experiences from the ongoing work with the framework PCR for building products (TC59/ISO 21930). Special interest was paid to develop general guidelines for a further PCR for building products' applications, and on how an ED covering a full life cycle can be elaborated. Only when the LCA covers a full life cycle it is in theory possible to use the result for comparative purposes, provided that a common functional unit can be established.

The development of general EDs will also make the type III declaration a useful tool to support consumers in their decision-making. Perhaps the most important area of application for a building ED is as a modular information source for an entire building or construction. The modularity in this case means that the entire building or construction work's environmental impact can be calculated by adding up the LCA results from the different building products used in the ED.

This document is the result from the first step of the project named "Internationally harmonised building product declarations".

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**Comment to the revised document**

The original Product category rules (PCR) was launched in March 2005. The document has then been discussed at an international internet discussion forum "Global PCR Forum" in 2005 (http://www.environdec.com/pcrforum/forum.asp) and at a open consultation meeting and thereafter revised.

Stockholm, December 2005

Martin Erlandsson, project leader

# 1 Applied standards

This document covers the relevant common procedures and specifications for calculating, documenting and reporting life cycle assessments (LCA) as part of a practical, international building product declaration. The environmental declaration (ED) in this project includes a qualitative LCA that covers, at a minimum, 'from cradle-to-gate'.

LCA practitioners have to provide life cycle inventory data that fit into the context of different methodologies' settings. It is therefore important to follow already established standards and make methodological specifications to these so as to ensure transparency, modularity and comparability between different EDs.

The following order between standards is valid when a declaration is performed:

1) This document
2) MSR No 1999:2. Requirements for Environmental Product Declarations, Swedish Environmental Management Council 2000-03-27.
3) ISO 14025. Environmental labels and declarations —Type III environmental declarations — Principles and procedures
4) ISO 14040-43[1]. Environmental management – Life cycle assessment –
   - /Principles and framework
   - /Goal, scope definition and inventory analysis
   - /Life cycle impact assessment
   - /Life cycle interpretation

In the future, the list above will have to consider a number of international activities that are underway to harmonise type III ED of building products:

- The forthcoming ISO standard from TC 59 Environmental declarations of building products ISO 21930,
- The forthcoming standards from the European standardisation organisation, CEN BT WG 174, "Integrated environmental performance of buildings", including work on a PCR for building products based on the above ISO standards.

This PCR on building products will be revised and implemented in the Swedish ED scheme, where its revision period will be decided on. The validity of the PCR and its implementation in the Swedish MSR ED scheme is dependent on the timetable of the forthcoming CEN standard that will harmonise building EDs on a European level. In practice, this means that the forthcoming CEN PCR guidance on building products has to be adopted by the various program operators (such as MSR in Sweden) in order to be operational on the market. This PCR should therefore be regarded as a pro-active initiative to support the development and implementation of harmonised standards in the building and real estate sector.

[1] This old family of standards will now result in two forthcoming standards namely ISO 14040 and ISO 14044.

# 2 General information

## 2.1 Introduction

This PCR (product category rules) describes methodology aspects, reporting format and documentation of environmental data, and considerations relevant to building products. These specifications are part of a building product PCR together with supplementary administrative-oriented rules specified by a program operator.

The environmental declarations resulting from this PCR cover building products and their use in different building applications. The life cycle inventory for the reported LCA for the so-called building product ED covers a "cradle-to-gate" perspective, while the building application ED covers a "cradle-to-grave" perspective (see Figure 1).

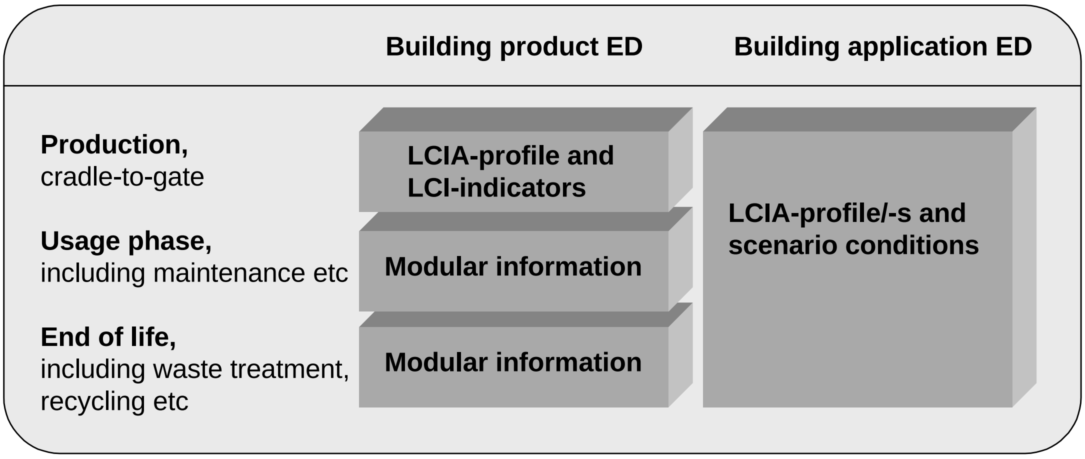


Figure 1 General inclusion and reporting characteristics of environmental information in the two different EDs covered by this PCR.

Perhaps the most import application of a building product ED is as part of a building or other construction. In order to guarantee modularity and comparability between different building products, this PCR comprises general rules which covers all building products. However, based on practical experience, such general PCRs may be insufficient to some product groups. Therefore, a further sub-oriented PCR for these kinds of building product groups can be developed, where general data quality requirements can be revised *as long as the overall modularity and comparability are consistent*. These sub-oriented converging regulations established for selected product groups will be part of an additional PCR work carried out together with other interested parties (see Figure 2).

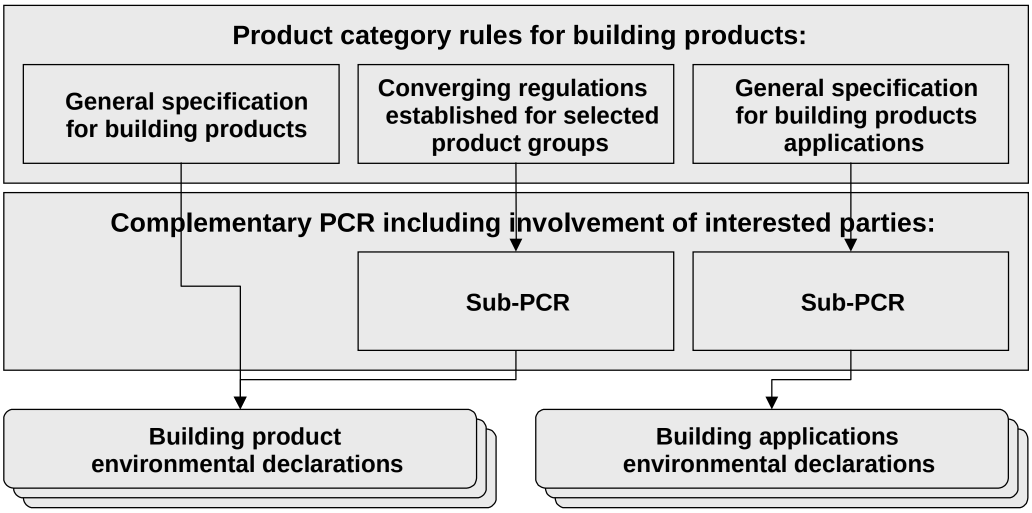


Figure 2 The scope of this PCR and its relation to further sub-oriented PCRs and the final environmental declarations.

From the above, the objectives of this PCR are threefold:

**The *first* objective** of this PCR is to provide reliable life cycle-approached data for building products in the form in which they arrive at a construction site. This ED covers the "cradle-to-gate" perspective and will be referred to as the *building product ED*. This ED can be regarded as an environmental decision-making support tool between business-to-business (B2B). Such an ED can be used:

- as an input source for a more comprehensive LCA for a building or any other construction work, if inventory data are documented and made publicly available.
- to compare different suppliers of the same building material, if the boundary conditions are the same
- to verify that a product continues improving its environmental performance over time, provided that the same system scope is practised

**The *second* objective** of this PCR is to specify the requirements for *converging regulations* for selected product groups to meet the general PCR for building products. The *converging* PCR will mainly cover data quality requirements and calculation rules, but will not necessarily be restricted to these aspects.

**The *third* objective** of this PCR is to specify ED requirements for building products used in different *generic building applications* that accounts for an entire lifecycle. Such an ED can be used to enable informed product comparison, provided that the methodological settings and functional units are the same. This requires the development of a further sub-oriented PCR, hereinafter referred to as the *Building application PCR*, which will be relevant for all products that can be used as part of a defined building function, such as roofing material or façade material. This kind of ED can be a useful tool to support decision-making and consumer communication in the following areas:

- selecting between competing building materials and technical solutions

- information on which environmental aspects are significant from a life cycle perspective for a certain building function (e.g., maintenance) to support improvements.

This kind of ED must be based on generic scenario settings. It is possible that these generic settings are not relevant to a specific building object, which is why the result from a *Building application PCR* **should be regarded as an illustrative example**. The general requirements for developing a *building application PCR* are handled in a separate chapter in this PCR. A Building application PCR is defined for a building function and results in a sub-oriented PCR (see Figure 2). This development includes an open consultation. The program operator is responsible for ensuring that an appropriate consultation has taken place, ensuring credibility and transparency of the PCR.

## 2.2 Applied inventory model nomenclature

The terms presented in Table 1 are used in this PCR for the different flow types relevant for an ED life cycle inventory (LCI). Other terms may be used in other LCA applications. The flow categories are grouped in a number of themes indicating their meaning.

Table 1 Data categories used here for an LCI-profile, developed from Erixon (2000).

| Group theme | Flow type | Possible specifications |
|---|---|---|
| Deliverables | Product | — |
| Resource use | Natural resource | — |
| | Recycled material | Input/output |
| Stressors | Emission | Air, water, soil or intermediate |
| | Resource consumption | — |
| | Explorative impact | — |
| Incomplete inventory | Residue | Input/output |
| | Refined resource | —* |

*Divided in to goods, energy and services to verify data quality requirements and calculation rules.

**Note:** It should be noted that the terminology allows for more specification of the environmental compartments ‘air, water, ground’ than found in Table 1.

**Note:** The structure of Table 1 also constitutes the headings for the *inventory profile* that are the result from the LCI step of an LCA.

**Note:** The terminology will also appear in the optional documentation of the LCI profile in the LCA reporting.

A short description of the different flow types are given below:

**Product** represents the functional output from a process, i.e., any service or goods.

**Natural resources** represent resources extracted from the Earth, including energy carriers.
**Note:** Virgin materials are natural resources.

**Recycled materials** appear in the inventory when a discarded product’s material is recovered and utilised for new products.
**Note:** The allocation phenomenon is also known as part of open loop recycling.

**Emissions** are specified as air, water, soil or intermediate emissions.
**Note:** These recipients could be subdivided further into specified recipients, which is needed if doing a site-specific LCA.

**Resource consumption** refers to the amount of material or energy that is used up and can not be used anymore (i.e., has been transformed into an emission).
**Note:** By accounting for resource consumption, it is possible to calculate (one defined meaning of) **energy use** in an LCA by summing up all consumed resources that contain energy.
**Note:** This inventory category enables "punishment" of products that are responsible for a resource leaving the technosphere.

**Explorative impact** makes it possible to account for and report physical impact on the nature.
**Note:** This inventory category is also known as "land use" and is still in its development. The term 'land use' is not used here as it excludes aquatic activities.
**Residue** represents an unwanted flow (with negative or minor economical value) that will be processed further.
**Note:** Another word for residue is 'waste'. The word 'waste' is not used here as different juridical definitions make it inapplicable to common LCA methodology.
**Note:** Residues belong to the group 'incomplete inventory' and are regulated under cut-off criteria.

**Refined resource** represents a utilised product flow whose upstream environmental burden is not accounted for in the LCI. Flows accounted as refined resources give a numerical specification of data gaps in the inventory profile. The LCA practitioner may connect reported 'refined resources' with delivering processes.
**Note:** Refined resources belong to the group 'incomplete inventory' and are regulated under cut-off criteria.

## 2.3 Application approach for ED and value choices

The scope of an LCA performed for an ED, or based on the result from an ED, should consider aspects that assign environmental impacts to a specific product system. In a decision-making context of a typical ED, it is the goal to reflect those aspects that the producer can assert and has the position to control. This goal is significant in the choice of adequate applied LCA application approach for ED in general.

This goal with an ED implies an attributional application approach, typically answering the question *"What is the environmental impact related to a specific product if a spatially and temporally correct[2] allocation is performed?"*.
This can be compared to a consequential approach LCA that would answer the question *"What is the marginal environmental impact related to a specific product in relation to possible (future) changes between alternative product systems?"*.

As the goal of an ED is that it should be a deliverer's assertion, impact assessment methods that include value choices are not applicable, since the producer cannot objectively guarantee such LCA results (and may result in misleading conclusions). Instead, such value-based impact assessment methods may be applied in the interpretation of the LCA result in other contexts.

Based on the same arguments as above, no additional (historical) environmental burden is allocated to the use of recycled material. Similarly, no environmental burden can be allocated from a specific

[2] This means that the emissions from a production site correspond to what can actually be measured or reported at that specific site (or at that time).

product system to potential future products. This open loop recycling allocation procedure is also justified based on the fact that the goal of the application approach selected model is to detect what can be measured or reported at that specific site.

Based on the same argument, the allocation of the environmental burden from a multi-input/output service, typically exemplified by a waste handling process such as waste incineration with energy recovery, will be allocated to the delivered products. In this case, the environmental burden from the process will be allocated to the delivered energy outputs since it is the energy plant operator who controls the choice of fuel and can take action for cleaner production. In most cases, the original manufacturer can not decide the scrap product's waste-handling alternative. Even though the producers have a responsibility for the recycling and waste management steps, it is the user of the product that has to fulfill these recommendations from the deliverer. This allocation rule consequently stimulates product design and life cycle management to make products that others are willing to use, since the environmental burden of the scrap product will be part of another product's system. This allocation routine therefore supports material recycling and an extended use of resources in general.

# 3 Basic PCR for building products

## 3.1 Methodological requirements

### 3.1.1 Product category description

This PCR is valid for all building products that are manufactured or processed for incorporation in a building or other construction work (i.e., building material, products, components, or building elements). This means that an ED can be specified for a building product or combinations of products:

- in the composition that is derived to the contraction site
- in the final composition it has in the final construction, or
- for the service it provides when it is used in the construction manufacturing.

**Note:** Building services considered being part of the building context such as heating systems are not applicable since the whole building including its operation is required in order to conduct an adequate analysis. Restricted building services that are not dependent on the whole building context are relevant here as part of the 'building application ED' and are handled in chapter 5.

### 3.1.2 Functional or reference unit

A functional unit can only be used as a reference unit in an LCA. The functional unit of a building product is defined on the basis of its performance when integrated into a building, and therefore not applicable for a building product LCI that only covers cradle-to-gate, i.e., a basic building product ED.

The reference unit of a basic building product ED is defined by its performance before it is integrated into a building application. The reference unit together with the reference flow (as described in 14044) provides the reference for adding up material flows within a full life cycle. The declared unit is defined and specified in SI units.

**Example:** The reference unit is typically specified in terms of kg, $m^2$, or $m^3$ of product.

**Note:** When the building product is part of a product mix, the reference unit should make scaling between the different product's underlying articles as simple as possible.

**Example:** For instance, a ventilation pipe should be reported in 'kg' rather than in 'm', since the environmental performance per metre will differ depending on the pipe's diameter. Performance that is reported per kg ventilation pipe is independent of the pipe's diameter.

**Note:** It should be noted that a reference unit per 'piece' is recommended when scaling between different products is not adequate, e.g., per specific refrigerator instead of cooled storage volume.

**Note:** Other words for reference units are inventory unit, declared unit, analysis unit, and unit of product.

### 3.1.3 General product system boundaries

The generic life cycle of a building product includes the parts given in Table 2.

Table 2 The life cycle of a building product divided in three life cycle phases, where the reported LCI/LCA in the ED covers the manufacturing process.

| Generic process steps | Life cycle phase | Covered in the ED as, |
|---|---|---|
| Extraction of resources | Manufacturing phase | Included in the LCA result reported in the ED. |
| Transport of resources | | |
| Raw material production | | |
| Transport of the refined resources | | |
| Manufacturing of the building product | | |
| Transport to customer | Usage phase | Qualitative and quantitative information |
| Construction of a building | | |
| Use of the product in a building | | |
| Dismantling of the building | End of life | Qualitative and quantitative information |
| Transport of scraped building products for waste treatment | | |
| Further processing until the material is recycled, incinerated and transformed into emissions. | | |

### 3.1.4 System boundaries to nature

System boundaries to and from nature are jointly described by so-called elementary flows. The inclusion of resource flows from nature to the technosphere corresponds to resource use and explorative impact, and on the output side emissions and resource consumption. In an ideal LCA, all flows studied shall be traceable to a natural recipient. A flow that cannot be traced back to a natural recipient shall be reported as a flow type within the group theme *Incomplete inventory* where it is regulated by data quality requirements and calculation rules.

Waste to landfills is not traced back to nature in the LCI, since this would involve scenario techniques to model future impacts. To avoid guesses or estimates, a general cut-off is introduced (see section 3.5.6).

### 3.1.5 System boundaries for manufacturing of equipment and for employees

The following system boundaries are applied on manufacturing equipment and employees:

- Environmental impact from infrastructure, construction, production equipment, and tools that are not directly consumed in the production process are not accounted for in the LCI.
- Personnel-related impacts, such as transportation to and from work, are also not accounted for in the LCI.

**Note:** The system boundaries on manufacturing of equipment and for employees are *not* regarded as limiting the scope of the inventory or as an incomplete inventory (i.e., a cut-off).

### 3.1.6 Material recycling and technosphere system boundaries

Allocation of *recycled material*, also known as open loop recycling, is reported in the LCI as an input or output technosphere flow when such materials leave or enter the specific product system. Therefore, a system boundary between the product's systems in a material recycling cascade has to be defined between individual sub-processes.

When a product is discarded and its original function is lost, it can be processed further in a waste management system. Those parts of the initial product system that are utilised in a new product will be accounted for as material recycling in the LCI (as a flow to technosphere). The secondary user of recycled material will account for the use of recycled material (as a flow from technosphere). The exact boundary settings between the first and the next product systems are defined by the *willingness to pay* for the recycled material. This implies that from the moment the user of a secondary material pays for the material, this (secondary) product system will also be responsible for the environmental burden from that point on.

A specification to the general *willingness to pay* rule is needed when a process is paid for both taking care of some of the inputs as well as for the outputs from the very same process. In this case, both product systems share the process and a multi-input output allocation problem must therefore be looked at. This situation is covered in the allocation procedure for combined multi-input and output processes described in the next section 3.1.7 (see Figure 5).

**Example:** In practice, the *willingness to pay* allocation procedure means that if a recycling company pays for discarded aluminium, for example, which also includes dismantling of cars, this company (the secondary user) is also responsible for the incurred environmental impact from that point on. This boundary definition is site-dependent since the market situation can vary in both time and location.

**Note:** A material flow can be accounted for as 'material recycling' even if the specific secondary material user is not known. In practice, this is very often the situation because specific origins and secondary users of waste streams are hard to trace to their source or their specific new application.

### 3.1.7 Multi-input/output process allocation procedures

In a process step where more than one type of product is generated, it is necessary to allocate the environmental stressors (inputs and outputs) from the process to the different products (functional outputs) in order to get product-based inventory data instead of process-based data. An allocation problem also occurs for multi-input processes.

In an allocation procedure, the sum of the allocated inputs and outputs to the products shall be equal to the unallocated inputs and outputs of the unit process.

The following stepwise allocation principles shall be applied for multi-input/output allocations:

— the initial allocation step includes dividing up the system sub-processes and collecting the input and output data related to these sub-processes.

— the first (preferably) allocation procedure step for each sub-process is to partition the inputs and outputs of the system in to their different products in a way that reflects the underlying physical relationships between them.

— the second (worst case) allocation procedure step is needed when physical relationship alone can not be established or used as the basis for allocation. In this case, the remaining environmental inputs and outputs from a sub-process must be allocated between the products in a way that reflects other relationships between them, such as the economic value of the products.

These allocation principles are described below:

***0) INITIAL ALLOCATION STEP***

Before an allocation can be performed, the product system must first be subdivided into sub-processes. To simplify the initial allocation step, we introduce system boundaries indicating where a further allocation is needed. This routine defines the different sub-processes needed in the product-related inventory. A sub-process system's boundary appears

— each time a product is generated and leaves the specific analysed product system,

— each time a waste flow appears and leaves the specific analysed product system,

— when product flows are treated in various ways in a process, or

— when a material recycling loop occurs outside the own process step.

In the last case, when a material recycling loop occurs outside the own sub-process step, such systems can be regarded in a steady state and thereafter allocated[3]. The product system is now subdivided into sub-processes, creating the base for the next allocation step.

**1) FIRST ALLOCATION PROCEDURE**

The first allocation procedure should be performed so that it reflects the way in which the inputs and outputs are changed by quantitative changes in the products (or functions) delivered by the system. This means that the allocation shall be based on the way in which resource consumption and emissions change, following quantitative modifications.

Some common allocation cases and how these should be applied according to the general allocation procedure are described below. The following products or functional inputs/outputs from a sub-process have been identified: services, goods, and energy (subdivided into electricity and heat, where convenient). The following allocation procedures shall be performed for sub-process allocations on goods, energy and services.

***1.1) MULTI-OUTPUT***

**1.1.1) Goods**

A multi-output sub-process delivering goods that are treated equally in the specific sub-process shall be allocated based on the inherent physical property of the different products, such as mass. If these goods are treated differently in the sub-process, the specific sub-process-related physical causality should be taken into account. For example, different products are covered by different amounts of paint, or different raw material fractions are dried differently.

[3] See guidance in Erlandsson (1996).

**1.1.2) Energy, including co-production of heat and electricity**

In a pure energy generation process where either heat or electricity is produced, allocation should be performed on the basis of the inherent energy contents of the produced energy-wares. In the case of combined heat and power production, a distribution based on the best efficiency for the (potential) separate generation of electricity or heat shall be accounted for[4]. For illustrative examples and generic allocation efficiency factors, see Annex D[5].

**1.1.3) Co-produced goods and energy**

In the case of co-production of goods and energy, an allocation can be 'virtually avoided' by performing a limited system expansion around the sub-process. In order to do this, the real sub-process is divided in to two (or more) virtual sub-processes, where the environmental stressors (resource use, resource consumption and emissions) are distributed according to realistic efficiency factors, provided that the energy output was produced alone with the actual process inputs. For illustrative examples see Figure 3, and for generic allocation efficiency factors, see Annex D.

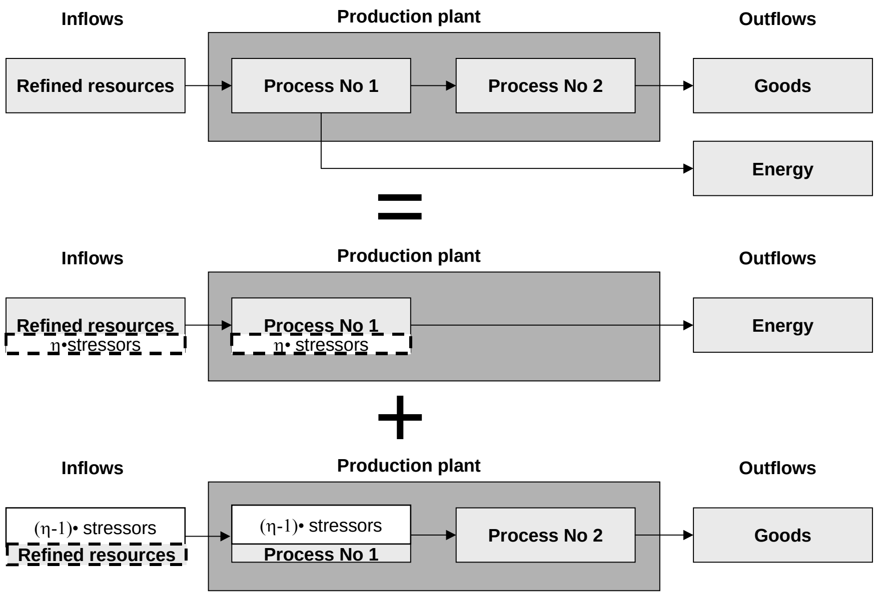


Figure 3 'Virtually avoided' co-production of goods and energy by performing a limited system expansion around the sub-process.

[4] This allocation rule follows the global PCR on "Electricity and District Heat Generation". The Swedish Environmental Management Council, PSR 2004:2, 2004-04-08.

[5] These generic defaults are accepted as specific data. However, actual site-specific data may be used if they can be verified.

**1.1.4) Co-produced goods, heat and electricity**
The multi-output allocation of environmental stressors from a sub-process that delivers heat, electricity and goods at the same time can be handled via a stepwise allocation procedure based on the above-mentioned allocation procedures (see Figure 4).

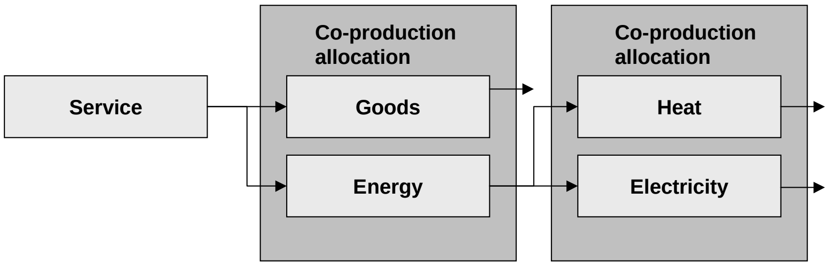


Figure 4 Elements of a stepwise allocation procedure for a service.

This stepwise procedure starts by partitioning the delivered goods and energy and then further partitioning between heat and electricity. It is then possible to allocate the environmental stressors to the individual functional outputs from the sub-process, i.e., goods, heat and electricity respectively.

**1.1.5) Multi-output services**
Services (e.g., transport) can in general be handled as a sub-process that requires both goods and energy resources. This implies that a multi-output service can be handled with the allocation procedures given above, once the physical relationships between the inputs are identified.

***1.2) MULTI-INPUT SERVICES***
A service with a multi-input sub-process generates no physical products. Instead, an allocation must be performed for the upstream product systems that facilitate the service sub-process. For such multi-input services, the allocation shall be based on the physical relationships of the inputs (such as waste incineration or landfill) typically described by the stoichiometry of the reaction. If allocation based on the physical composition and stoichiometry of the inputs is not possible, another allocation principle based on physical and chemical properties should be applied.

***1.3) MULTI-INPUT/OUTPUT SERVICES***
The multi-input/output allocation of a sub-process service constitutes, by definition, a system boundary between two or more product systems, including open loop recycling. To follow the generic allocation rule by partition the inputs and outputs of the system in to their different products in a way that reflects the underlying physical relationships between them, in the case of material recycling, it means that the burden of the resource consumption will always be carried by the outputs. This means that the *resource consumption and emissions from for instance a waste incineration* are allocated to the *downstream* product systems (see figure 5), since these products' characteristics are determined by the waste incineration sub-process step in which the product is generated from. All *other processes* will be allocated to the *upstream* product system (see Figure 5). The allocation specification here is applicable in combination with the multi-input/output allocation rules given above.

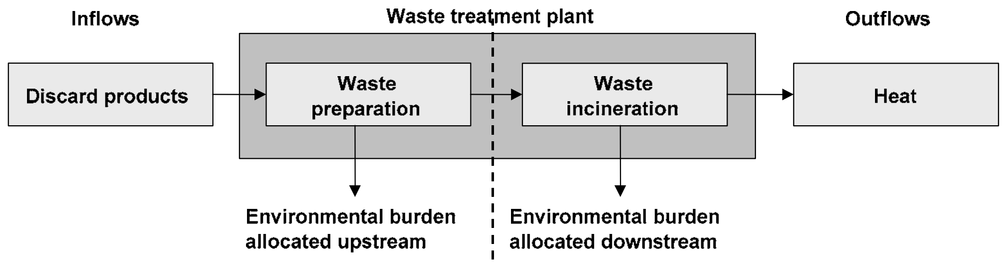


Figure 5 Multi-input/output allocation exemplified by a waste treatment plant with energy recovery, where both the inflows and outflows have positive market values.

**Note:** For these kind of allocation procedure, the recycling company pays for the discarded products that is used in the production of the outflows, which is sold on the market. This allocation procedure, therefore, specifies the *willingness to pay principle*, described in section 3.1.6.

**Note:** The consequence of this allocation rule is that no future scenario has to be defined concerning the secondary user in the recycling cascade, in order to describe the environmental performance of the initial product, i.e. the building product.[6]

**Example:** This allocation rule is relevant for a waste combustion plant, see Figure 5. The distributions of the plant's emissions and resource consumption are allocated to the delivered heat and electricity. Meanwhile, the waste handling before it entered the combustion step will be allocated to the upstream product systems.

**2) SECOND ALLOCATION PROCEDURE (WORST CASE)**

Another situation may occur where no information of the actual sub-process is available, often due to confidentiality issues. In such a case, the entire plant must be regarded as a black box. For this reason, an allocation for the entire product system and the overall representative environmental data shall be made according to the following procedure:

- Perform an allocation based on physical properties or aspects such as product content (for resource use), or specific melting energy by assuming generic energy losses (for energy use).
- For the remaining environmental impacts that cannot be allocated to the products according to the above procedure, economically-based allocation parameters may be used for allocation.

This allocation procedure shall be used with caution and only for the main products from the plant.

[6] This allocation rule does not follow the global PCR on "Electricity and District Heat Generation" (MSR, PSR 2004:2) in respect to the system perspective applied here where, which follows a physical related allocation procedure.

## 3.2 Data quality requirements and calculation rules

In order to be able to compare different EDs, LCA data must have the same quality and utilise homogenous methodology. An environmental product comparison between products from different suppliers requires that the LCA be based on product-specific data. Since this is part of the scope of the use of an ED, site-specific data is essential.

The evaluation of the data quality requirements and calculation rules applied here make use of LCA documentation performed in the life cycle inventory, including different quality classes[7]. Data documentation can be performed at a very detailed level. A level acceptable for the purpose of this PCR is to perform data documentation on the product's different life phases (e.g. manufacturing, assembling, raw material production resource extraction, and transportation).

### 3.2.1 Representativeness

Ideally, the product's life cycle inventory shall reflect the manufacturing and upstream site-specific production conditions. The use of data representative of an average product market should be used for those products in manufacturing that are bought on a spot market or from numerous suppliers. Such environmental product data shall be regarded as 'correct' data set for the site, referred to data quality class 2 (see below).

In the cases where site-specific or current representative data are not found, generic data is acceptable to a certain degree, see examples in Appendix A. These *data substitutions* require a documented motivation that verifies that these data are assumed to be a **conservative** estimate of the real data. These data substitution shall be documented and referred to data quality class 3 (see below). For all cradle-to-gate product data, data substitutions class 3 are accepted up to a maximum of 10% of the total production's environmental impact. 10% is the maximum allowable contribution to any individual mandatory impact category in the resulting cradle-to-gate LCA.

To make this calculation rule verifiable and allow for a data quality evaluation, the life cycle inventory shall be supplemented with the following data quality aspects and reported in an advisable way:

Class 1 — Primarily site-specific data are used
Class 2 — Other data representative for the own process are used
Class 3 — Other data, which are assumed to be a conservative estimate of the actual data, are used
Class 4 — Other data, which are not assumed to be a conservative estimate of the actual data are used, or classification information is lacking.[8]

**Note:** An example of well-documented and verified LCA inventory data that can be used (if relevant to the other data quality requirements) as a conservative generic estimate of the actual data is provided in Annex A.

**Example:** For instance, data on a specific resin used in a building component is lacking and therefore calculated using generic data from another supplier. These kinds of

[7] The data quality classes are based on a streamlined development for aggregated data set performed by Swedish Environmental Research Institute's Initiative (Sirii), found in Erlandsson and Carlsson 2002

[8] Class 4 may be applicable for a converging or an application PCR

approximations shall not account for more than 10% of the total contribution to any included impact category of the building product's cradle-to-gate LCA.

### 3.2.2 Completeness

To verify the completeness of significant emissions contributing to the included environmental impact categories, a data document routine combined with calculation rules is introduced. In order to make a data quality evaluation possible, the following data quality aspects shall be reported in the life cycle inventory in an advisable way:

Class 1 — Data covers all known types of emissions
Class 2 — Data covers all emissions of the most frequent impact categories[9]
Class 3 — Data only covers a few impact categories (i.e. less than the mandatory included in the PCR[7])
Class 4 — Very poor data are used, or classification information is lacking

For all cradle-to-gate product LCA data, quality class 3 (as specified above) is acceptable up to a maximum of 10% of the total environmental impact in the resulting cradle-to-gate LCA. Only 3% is acceptable if the data is of quality class 4. The accepted percentage of data of a given quality class is defined as the maximum contribution to any individual mandatory impact category.

### 3.2.3 Precision

In theory, it is possible to document precision for each individual numerical value of inventory data. However, this degree of detail is far too costly and is usually not applied in generic LCA databases. The evaluation of data precision is performed on the data set as a whole. In order to make data quality evaluation possible for the sake of relevance and comparability the following data quality aspects on data precision shall be reported in the life cycle inventory in an advisable way:

Class 1 — Data based mainly on accurate measurements or calculations
Class 2 — Data based mainly on very few uncertain measurements or calculations
Class 3 — Data based mainly on emission factors, input/output analyses or other rough estimations
Class 4 — Very poor data, or classification information is lacking

For all cradle-to-gate product LCA data, quality class 3 (as specified above) is accepted up to a maximum of 10%, and 3% if the data is of quality class 4. The accepted percentage of data of a given quality class is defined as the maximum contribution to any individual mandatory impact category in the resulting cradle-to-gate LCA.

[9] I.e. impact categories in section 3.7.2.

### 3.2.4 Consistent allocation method

A major methodology aspect that affects the result of an LCA's consistency is the allocation procedure applied. Allocation procedures occur for multi-input/output processes and for material recycling. Ideally, different specifications to a general allocation procedure shall be applied in the LCA in a uniform way.

To make data quality evaluation possible with reference to the allocation procedures defined in section 3.4.7, the following quality aspects shall be reported in the life cycle inventory in an advisable way:

Class 1 — All inventory data are allocated based on uniform allocation procedures based on the first (preferably) allocation procedure.

Class 2 — More than 95% of the inventory data are allocated based on uniform allocation procedures based on the first (preferably) allocation procedure and 5% on the second procedure (worst case).

Class 3 — More than 90% of the inventory data are allocated based on uniform allocation procedures based on the first (preferably) allocation procedure and 10% on the second procedure (worst case).

Class 4 — Less than 80% of the inventory data are allocated based on uniform allocation procedures based on the first (preferably) allocation procedure and 20% on other allocations procedures (e.g., input/output analysis), or classification information is lacking.

For all cradle-to-gate product data, quality class 1 and 2 (as specified above) are accepted. However, for the main manufacturing process data, only quality class 1 is accepted. The accepted percentage on data quality class is defined as the maximum contribution to any individual mandatory impact category in the resulting cradle-to-gate LCA.

### 3.2.5 Cut-off documentation

A cut-off that limits the scope of the inventory of a product system will be reported in the LCI as *residue* and *refined resource*, respectively, according to the nomenclature utilised here. This approach enables a receiver of such an LCI profile to add these missing process steps, if the data is available for this practitioner. Refined resources have to be divided in to goods, energy and services to verify data quality requirements and calculation rules.

Activities or products not included in the inventory are documented in the LCA and reported in the ED.

### 3.2.6 Cut-off decisions on limitations to system boundaries

The downstream processes related to residues going to a landfill treatment shall not be included in the LCI as these include future environmental impacts that have to be treated by scenario technique. Instead, a general cut-off rule is used for residues that end up at a landfill site, i.e., these flows are reported as inventory figures in the ED.

**Note:** This is a general cut-off rule that limits the possibility to compare different EDs, even though they have the same functional unit. A comparison between different EDs with equal functional units is still possible if the environmental impact from the landfill is regarded as the same for the alternatives, or as having no significant impact.

### 3.2.7 Cut-off decisions on data gaps

When gaps in the data are identified, other data should be applied using different calculation or substitution methods. This, however, is limited by the above-mentioned data quality requirements. Therefore, data gaps may appear and are accepted by cut-off rules. These cut-off rules are divided in to *goods* that are lacking or *services* that are omitted in any process.

A cut-off rule that is used for *goods* is that data gap less than 1 weight % of the final product is acceptable.

For *services,* the cut-off rule for omitted life services has to be subjectively estimated. This cut-off rule states that all services or activities that are omitted in the life cycle inventory shall not exceed 1% of the total environmental impact for any individual impact category.

**Example:** An estimate of the significance of an omitted life service or activity can be done by using energy use figures as an indicator of the environmental impact, provided that the energy use figures can be estimated for the omitted services or activities.

**Note:** In the case where these cut-off rules can not be met, it is recommended to follow the stepwise type III ED procedure suggested by the Sirii network (2002) or likewise, where data gaps are accepted (see http://www.environdec.com/stepwise/)

### 3.2.8 Technology and geographical coverage

The technology and geographical representation of the reported product's environmental performance shall be reported in the published ED under 'LCA result'.

A technology coverage description shall be included if a specific technology or technology mix is used that is characteristic for the specific building product.

Geographical coverage shall be included if a specific geographical area is characteristic for the specific building product and has been used to collect LCA data for the main process and the upstream processes.

### 3.2.9 Time-related coverage

LCA data should be collected in such a way that it represents the yearly environmental impact.

Foreground data (i.e., the manufacturing process of the building product's materials and components including assembling) should not be older than two years. Use of background data older than five years should be motivated and documented in the LCA.

An accepted ED is valid for two years[10] and should then be revised. It is recommended that the revised ED be based on the data for a period of the two latest years. The time-related coverage representation of the reported product's environmental performance shall be reported in the published ED under 'LCA result'.

[10] As per the regulation specified by the program operator Swedish Environmental Management Council/Miljöstyrningsrådet (MSR 2000).

## 3.3 Requirements on product content declaration[11]

A detailed list of the product's substances, including CAS[12] number, environmental class and health class, should be included in the product content declaration. It is also recommended to include substances' functions in the product (e.g., pigment, preservative, etc.).

Table 3 Example of a product content declaration, according to the guidelines (example written in italic).

| **All materials/ components, 1)** | **Substances** | **Weight % 2)** | **CAS number** | **Environ-mental class** | **Health class** |
|---|---|---|---|---|---|
| *Pigment* | *Titanium dioxide*<br>*Iron oxides fume* | *6 +/-3*<br>*2* | *13463-67-7*<br>*1309-37-1* | *no*<br>*Data lacking* | *R 37*<br>*Data lacking* |
| *Preservative* | —3) | *3* | — | *no* | *R 46* |
| *etc.* | | | | | |
| … | | | | | |
| *Other, non-allergenic, health-sensitive or environmentally-sensitive substances* | | *<1%* | — | *no* | *No* |
| **Total** | | **100** | | | |

1) Substance(s) do not need to be included if they may affect patent or company secrets.

2) Figures can alternative be given in e.g. g/kg.

3) The substance is confidential that is reported in the product content declaration.

The entire product's contents shall be declared in weight %. In those cases where a complete declaration of contents could affect patent or company secrets, a list of components and their functions is sufficient. However, the weight % of such confidential component shall still be specified in the declaration, including environmental class and health class for each component, in respect to its included substances according to the requirements given below.

[11] The rules on reporting product content declaration follow the national the type II system on building product defined by The Eco Council Society.
[12] The reporting could also be given with use of EINEC number.

**Content declaration guidelines:**
The declaration of contents in the ED shall include all substances in the product that are more than;

- 0,01 weight %, for very persistent and organic very bio accumulative organic compound, see note[13]; or for persistent, bio accumulative and toxic organic substances, see note[14].

- 0,1 weight % for allergenic (R42, R43, R42/43) <u>or lower</u> if this is prescribed by an adequate product related law in respect to the intended market.
- 0,1 weight %, for pure substances or compounds of cadmium (Cd), and
  for each individual substance that fulfil the criteria of the hazard class of toxic to reproduction in category 1 or 2 (R60 and/or R61); or
  for each individual cancerous substances of class 1 or 2 (R45, R49); or
  mutagenic in category 1 and 2 (R46) and ozone-depleting substances[15] (R59); or
  pure compounds of lead (Pb) and mercury (Hg)
- 1 weight %, for each individual substances that fulfil the criteria of the hazard class of carcinogenic in category 3 (R40); or hazard class of mutagenic in category 3 (R68); or toxic to reproduction in category 3 (R62 and/or R63)

  and

- 1 weight %, regardless of their properties not mentioned above.

The general requirement is that the declaration of contents shall also report all substances' inherent properties that are regarded as hazardous, according to the requirements specified in the list above. These hazardous substances shall be reported with the applicable risk classification, as per the regulations for those markets where the product will be used (see Table 3). The following natural substances' inherent properties (i.e. risk classification) do not need to be specified in the content declaration for:

- metals including alloys that are fixed in the building product during its utilisation in the construction, and that the composition (i.e. the entire product) are not classified as dangerous.

- minerals, ores, or other naturally-occurring substances and raw materials, provided that they have not been chemically modified under production, and that they are not classified as dangerous under the EU directive 67/548/EEG.

**Note:** The substance itself do not need to be notified if it may affect patens or company secrets, but it is mandatory to declare its weight-% content and if a risk class is valid according to the requirements specified above.

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[13] Substances that fill (both properties) as per the following:
1) a half-life of > 60 days in seawater or freshwater, or > 180 days in marine and freshwater sediment and
2) Bio Concentration Factor (BCF) > 5000.

[14] Substances with properties as per the following:
1) a half-life of > 60 days in seawater, or >40 days in freshwater, or > 180 days in marine sediment, or > 120 days in freshwater sediment and
2) Bio Concentration Factor (BCF) > 2000 and
3) Chronic NOEC (No Effect Concentration) > 0,01 mg/l.

[15] Substances with an ozone depletion potential, ODP > 0

If there is a difference in the product's contents from when it is delivered to the building site compared to when it is included in the construction, a supplementary product content declaration can be included in the ED.

In those cases where the declaration covers a range of products and the product content varies within the product group, a joint product content declaration can be used provided that it follows the above-mentioned rules conservatively. In other words, the product content declaration should be written up based on the product with the highest concentrations what concerns declaration if inherent properties in respect to health or environmental risk classes. In addition, an average or median value over the entire range of products should be included in the product content declaration (whose sum shall be 100 weight %) supplemented with an interval for those substances varying within the product mix (see Table 3).

## 3.4 Environmental declaration reporting format

### 3.4.1 General structure

The ED includes the compulsory headings and information described below. The recommended length for this kind of ED is between 2 and 6 A4 pages. This template is the basis for all EDs for building products. Text written in *italics* indicate clarifications. Mandatory sub-headings are marked with an asterix (*).

**0) Heading and ED identification**

*A compulsory heading should be developed that includes aspects such as product identification (e.g. model number), name of the company, date of publication and, if relevant, ED registration number, program operator's logo, company's logo, and company's website address.*

**1) Company information**

*Name and contact information of the body responsible for the ED (i.e., supplier, manufacturer or service provider). The description of the company, including administrative information (address, contact person, etc.) and specific information on the company such as the existence of an environmental management system.*

**2) Product information**

**Description of product***, *including aspects like main application of the product and technical properties.*

**Content declaration*** *(materials, substances), as per section 3.3.*

**3) Environmental performance declaration**

**LCA result***, *including results from the LCIA covering the cradle-to-gate perspective and the mandatory impact categories (see section 3.4.2). It is also possible to give complementary LCIA impact categories other than the mandatory ones. These non-mandatory, impact category characterisation factors and method descriptions should be referred to in the ED. The technology and geographical coverage respective the time-related v of the reported LCA result shall be notified in this section of the ED.*

**Other significant environmental aspects*,** *such as environmental impacts that are not covered by the above-reported LCA result should be described in an informed way to give as complete environmental information as possible.*

**Usage phase***, *including qualitative and quantitative environmental information when the product is applied in a building or construction work.*

**Product emissions,** *if relevant, can be reported, including the applied measuring methodology.*[16]

**Recycling and waste management*** *specifies relevant information to support product dismantling and recycling of the product and, if relevant, regulations valid to waste handling of the product or product's parts.*

[16] Typically specified by individual substances and by an emission velocity in μg/m²h.

**5) Other information**

*Supplementary information may be included in order to increase the understanding of the information in the environmental declaration, and ways to get access to it.*

**6) References**

*References referred to in the ED are put together under this heading.*

**7) Information from program operator and certification body**

*Information from the program operator can consist of, but is not limited to, information about the body's name, the program operator's contact information, and the current applied PCR program and version. Information from the certification body can consist of, but is not limited to, information about the accredited certification body, the period of validity for the certification, and the registration number.*

### 3.4.2 Specifications concerning reporting the LCA result

The following information in the building product ED shall be included under the heading "LCA result":

- Functional unit
- Model assumptions; A short description that describes assumptions that are made, including system boundaries should be given in the ED. A figure indicating the process tree covered by the LCI is recommended.
- Technological, geographical and time-related coverage; A short description that is relevant for the declared product shall be specified according to sections 3.2.8 and 3.2.9, respectively.

- The resulting environmental performance of the product per functional unit divided in the categories of LCIA and LCI shall at a minimum include the following information:

**Impact categories to be included in the life cycle impact assessment (LCIA):**

- climate change
- depletion of the ozone layer
- acidification of land and water sources
- eutrophication
- formation of photochemical oxidants

The potential environmental impacts associated with the various types of emissions shall be gathered in the following impact categories:

- Emission of greenhouse gases (expressed as the sum of global warming potential, GWP, 100 years).
- Emission of ozone-depleting gases (expressed as the sum of ozone-depleting potential in CFC 11-equivalents, 20 years).
- Emission of acidifying gases (expressed as the sum of acidifying potential in mol H+/g max).
- Emission of gases that contribute to the creation of ground-level ozone (expressed as the sum of ozone-creating potential, $NO_x$-equivalents and ethene-equivalents).
- Emission of substances to water contributing to oxygen depletion (expressed as the sum of oxygen consumption potential in g $O_2$/g max).

Characterisation factors for the different impact assessment methodologies are found in Appendix C. Resource consumption, human toxicity and ecological toxicity, among others, are not included in the above list of impact categories. If such impact characterisation factors are used in the ED, the characterisation factors and methods shall then be referred to in the ED.

**Categories of life cycle inventory analysis (LCI):**

- use of natural resources
- resource consumption
- use of recycled materials (i.e. inputs)
- materials for recycling (i.e. outputs)[17]
- incomplete inventory, *divided in to*
  - residue, *divided in to*
    - hazardous waste to landfill, *that is accounted for separately according to a cut-off rule*
    - other waste to landfill, *that is accounted for separately according to a cut-off rule*
    - hazardous waste*, that that is handled by any waste treatment (except landfill)*
    - other waste*, that that is handled by any waste treatment (except landfill)*
  - refined resources, *divided into*
    - goods, *inputs from technosphere including intermediary products, raw materials, semi-finished goods, etc.*
    - services and activities, *inputs from technosphere including any service or activity.*

**Note:** Residues are categorised as hazardous waste according to the national regulation where it occurs.

The '**Use of natural resources**' are divided into a number of groups specified below:

- Stock resources, *includes ore, fossil resources, etc.*
- Biotic resources, *includes wood, seed, meat, tar, leather, etc.*
- Flowing sources, *includes wind, solar gain, water*

'**Resource consumption**' is handled by accounting of *primary energy*. Use of primary energy includes accounting of the potential inherent energy of all consumed natural resources and energy from wind, solar and hydropower. Applicable different resource characteristics for *primary energy* are found in Appendix B. 'Resource consumption' is reported in [MJ] as specified below:

- Primary energy, or divided in
  - nuclear thermal primary energy
  - thermodynamic primary energy
  - wind, solar and hydropower

Any other LCI indicators than those listed above may be reported in the ED including reference to the applied calculation method, if relevant.

[17] Note that this heading is only applicable for an application PCR.

Two optional general reporting alternatives are accepted for the resource use and consumption declaration. One alternative is to limit the presentation to the amount of resource (e.g., 800 g stock resources). This alternative requires that the extended inventory list be made publicly available in the complementary ED documentation (see Table 1). The second alternative is to include the complete inventory list in the ED. In this case, a cut-off rule for reporting an individual inventory parameter that is less than 1 weight-% compared to the final product, and less than 1 % of the primary energy resources, is not needed to be reported in the ED. In the latter case, it is optional to use the resource groups specified above.

**Note:** It should be assumed that' renewable' corresponds to 'biotic' and 'flowing' resources, while non-renewable corresponds to stock resources. The term 'renewable, is avoided since it is misleading and can be understood that is also imply to a *sustainable resource management*. In a sustainable management the rate of growth, replenishment or cleansing is taken place at an equal or greater rate than the current depletion. Sustainable resource management aspects are really not verified by the ED by life cycle inventory data in a LCA and should therefore not be used for public communication.

# 4 Guidelines for a converging PCR

A further sub-oriented PCR for a specified building product group may also be developed. This product group will be a specification within the overall building product generic PCR (see section 2.1) and has to be defined. The purpose for developing a converging PCR may be (but is not necessarily limited to) one or more of the following reasons:

- If the generic PCR for building products, including data quality requirements for a specified building product group, is hard to meet.
- If there is a lack of specific data, common generic upstream LCI data applicable for an LCA within a specified building product group has to be established.
- If modular LCI/LCA data for the usage phase and end-of-life should be reported in the ED.
- If a consensus on additional impact categories should be reached, or 'other environmental information' are to be included in the ED, it is recommended that this be based on further PCR work.

The sub-oriented converging regulations established for selected product groups shall be part of an additional PCR work carried out together with other interested parties (see Figure 2). The converging PCR has to be established through open consultation.

The cradle-to-gate LCA resulting in an ED from a converging PCR shall be harmonised with the result from the generic PCR to support modularity at the building level. A converging PCR may define changes to the generic data quality requirements as long as the overall modularity and comparability are consistent. The changed data quality requirements should be conservative for the specific building product group, but not too conservative so that they affect the LCA result when the building product is assessed in a building context. It should be remembered that the building (or other construction) contexts are the most import application of a building product ED, which is why data quality requirements changes are acceptable if well justified.

For some building products, it will be hard to find good quality LCI data for upstream processes. If this is a common problem within any specified building product group, it is possible to develop generic LCI data for the specific product group. The lack of LCI data has to be proven and will not be acceptable if the consequence is that there will not be any environmental difference between the individual specified building products from different suppliers, from a life cycle perspective.

If modular LCI/LCA data for the usage phase and end-of-life shall be reported in the ED, this will require further PCR work to guarantee that the result will be acceptable for public communication. It shall be noted that the LCA methodology specified in the generic PCR only covers the cradle-to-gate perspective, which is why an ED including modular information on the other life cycle phases has to be established in an extensive life cycle approached PCR.

# 5 Guidelines to a building application PCR

It is possible to develop an ED for building products application that accounts for a complete life cycle, making it possible to use the ED for comparative purpose, if an adequate so-called *product category* and functional unit can be defined. In addition to the inventory of the production, this includes the product's usage phase and different end of life alternatives (see Figure 1). Consequently, it is the building application – and not the building materials as such – that will be the basis for the ED LCA and be reported with respect to a functional unit according to the ISO 14040 series.

Such an ED can be used to enable informed product comparison, provided that the methodological settings and functional units are the same. This kind of ED can be a useful tool to support decision-making and consumer communication in the following areas:

- selecting between competing building materials and technical solutions
- information on which environmental aspects are significant from a life cycle perspective for a certain building function (e.g., maintenance) to support improvements.

This kind of ED must be based on generic scenario settings. It is possible that these generic settings are not relevant to a specific building object, which is why the result from a *Building application PCR* **should be regarded as an illustrative example** and its specific relevance must be evaluated by the end user.

A Building application PCR is defined for a specific building application or construction work and requires development of a further sub-oriented PCR (see Figure 2). This development includes an open consultation. The program operator is responsible for ensuring that an appropriate consultation has taken place, ensuring credibility and transparency of the PCR. The general requirements for developing a *building application PCR* are listed below:

- A building product application PCR is relevant for all products that can be used as part of a defined building function/application that can be analysed as a separate part of the building context or any construction work (such as roofing material or façade material, transmission poles).
- The building functional unit has to be defined and forms the basis for comparison within the defined building product application.
- The result from the cradle-to-gate LCA shall include several end-of-life scenarios that may be adequate relevant. Also, prediction of the facilitated building product's service life and varying maintenance may lead to a diverse LCA result for the usage phase. In conclusion, a number of environmental profiles (i.e. the LCIA result) should be reported in the ED to illustrate the range of different scenario alternatives included.
- The scenario development and its inclusion should be specified as far as possible in the PCR work and is one of the most essential parts to be established in the building application PCR. The most significant scenario setting's effect on the reported LCA result shall be stated in the ED.

- The applied LCA methodology and data quality requirements shall follow the generic PCR, when relevant[18].
- The reported ED LCA result shall include an LCIA method, referred to as the environmental profile, applicable for comparative assertion to public communication following requirements specified in ISO 14042.
- The PCR should specify if the ED shall be supplied with a public LCA report. The PCR should then also specify the content of the public LCA report.
- The potential use of comparison between different EDs within the specified building product application shall be stated in the ED.

[18] Note that the general cut-off rule (section 3.5.6) used for the cradle-to-gate LCA is not applicable for an application PCR if it is to be used for comparative purposes.

# 6 Reporting requirements of the ED underlying LCI and LCA result

Data documentation can be performed at a very detailed level. A level acceptable for the purpose of this PCR is to perform data documentation on the product's different life phases (e.g. manufacturing, assembling, raw material production, resource extraction, and transportation). For building elements, for example, a relevant basis for documentation may be the material used for assembly, complemented with the assembly process itself and transportation. Reporting requirements of the ED underlying LCI and LCA results should include data quality classes introduced in section 3.2.

Other data documentation and reporting requirements will be specified by the program operator, such as the specifications in MSR (2000) or similar general program instructions. An essential part of the LCA report is verification, to make sure that the declaration complies with all general program instructions specified by the program operator, in particular the data quality requirements.

If the underlying LCI and LCA results are referred to in the ED, it should be noted if they are 'publicly available', 'available on request' or 'confidential'. If the results are made publicly available, it is recommended that they be published on the web.

# 7 Administrative issues to be handled by the program operator

The program operator is responsible for the administration of the general type III environmental declaration program (e.g. MSR 2000). A number of tasks have to be included in this publicly available *general program instruction*. The following administrative tasks are not included in this PCR, but are examples of aspects that are included in the program operator's general program instructions, the so called MSR 2000:

- procedure for development and maintenance of PCRs
- establishing a transparent procedure for verifying the PCR with reference to other program operators and relevant international standards, including the procedures for an open consultation[19]
- establishing a third part verification procedure ensuring that the declaration PCR requirements are followed by the ED
- maintaining publicly available lists of valid and verified and Eds within the program
- monitoring changes in procedures and documents of related Type III ED programs and revising procedures and documents when necessary
- establishing procedures to avoid misuse of references to relevant international standards, general program instructions, and if relevant, the use of the program operator's logo.
- program operator fees, if relevant.

The program operator's general program instruction is also responsible for the LCA reporting requirements, as mentioned in section 6. The benefit of this is that a number of requirements specified by the ISO 14040 series of standards concerning using LCA results in public comparative purposes can be handled in the program operator's general program instructions. This will actually streamline the LCA work compared to a regular LCA case study aimed for third party, following the ISO 14040 series.

[19] See INTEND (2004).

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# Annex A – Example of generic LCA data sources

Example of generic data sources to be used in a ED if appropriate and with respect to specified data quality requirements and calculation rules.

Table A1 Example of generic data

| ***Material*** | ***Database*** | ***Published*** |
|---|---|---|
| Steel | IISI (International Iron and Steel Institute) http://worldsteel.org | 1998 |
| Copper | ICA (International Copper Association) | 1998 |
| Copper semi products | ICA (International Copper Association) +<br>IME (Institut für Metallhüttenwesen und Elektrometallurgi, Aachen) | 1998<br>1995 |
| Electricity | ETH (Eidgenössische Technische Hochschule).<br>Data is combined with IEA (International Energy Agency) statistics 1998 and found in Buwal 1998. http://www.ethz.ch/ | 1996 |
| Aluminium | EAA (European Aluminum Association)<br>http://www.eaa.net/ | 1996 |
| Plastics | APME (Association of Plastics Manufacturers in Europe)<br>http://www.apme.org/ | 1993-1998 |
| Chemicals | APME (Association of Plastics Manufacturers in Europe) http://www.apme.org/ | 1993-1998 |
| Electronic components | EIME (Environmental Information and Management Explorer) EcoBilan http://www.ecobalance.com/ | 1998-2000 |

## Appendix B – Primary energy calculation rules

- Primary energy use is an indicator to define the extractable inherent energy in the facilitated natural resources.

Since primary energy is an indicator of the utilised energy in relation to the technical theoretical extractable energy in the facilitated natural resource, it represents a system approached energy efficiency. In the theory of combustion, the inherent heat value, defined as gross calorific values for different natural resources, represents the maximum technical theoretical extractable energy in this kind of process. This is why the net calorific (low energy) value is not an appropriate choice for a common calculation rule for primary energy. The use of the net calorific value may result in an energy efficiency figure > 1 in some heat and power flue gas condensation combustion processes.

For natural resources like solar energy, wind energy and hydro electricity, kinetic and potential energy defines the extractable energy sources. Nevertheless, to calculate the primary energy the 'delivered energy' from the plant is used, since this is the common way in international statistics.

With regards to nuclear reactions, the extractable energy is defined by the consumed mass (defined by the extractable energy described by the famous equation $E=mc^2$). Since this approach is not comparable with the classical physical laws it is common to use the **(nuclear) thermal efficiency** instead[20]. Since primary energy is calculated with different physical relations, primary energy may be reported separately in the following groups: '*nuclear thermal primary energy*', '*thermodynamic primary energy*' and '*wind, solar and hydropower*'.

Generic applicable figures to calculate the primary energy from solar energy, wind energy, hydroelectricity and nuclear energy plant are shown in Table B2. In order to calculate the values of primary energy from combustion plants, the Gross Calorific Values (GCV) found in Table B1 can be used as a generic input in calculation. If references other than those reported in Tables B1 and B2 are used, this should be justified in the LCA report.

[20] It should be noted that this is not an ideal indicator, since the same coal-supplied power plant with an identical gas turbine generator will have a higher primary energy use, since the GCV of the coal has to be accounted for when the primary energy is calculated.

Table B1 Gross Calorific Values (GCV) for main resources with energy content.
Ref. Based on Intend 2004, i.e., OECD, IEA, Eurostat "Energy Statistics Manual" 2004. IEA Publications September 2004, and Mörtstedt & Hallsten 1991.

| | |
|---|---|
| **Hard coals GCV (MJ/kg)** | |
| Anthracite | 30,0 |
| Coking coals | 29,3 |
| Other bituminous | 25,3 |
| **Cokes GCV (MJ/kg)** | |
| Metallurgical coke | 27,9 |
| Gas coke | 28,4 |
| Low-temperature coke | 26,3 |
| Petroleum coke (green) | 33,2 |
| **Coal-derived gases GCV (MG/kg)** | |
| Coke oven gas | 19,0 |
| Blast furnace gas | 2,9 |
| **Petroleum products GCV (MJ/kg)** | |
| Ethane | 51,9 |
| Propane | 50,3 |
| Butane | 49,5 |
| LPG[21] | 50,1 |
| Naphtha | 47,7 |
| Aviation gasoline | 47,4 |
| Motor gasoline[22] | 47,1 |
| Aviation turbine fuel | 46,2 |
| Other kerosene | 46,2 |
| Gas/diesel oil | 45,7 |
| Fuel oil, low sulphur | 44,4 |
| Fuel oil, high sulphur | 43,7 |
| **Natural gas GCV (MJ/m$^3$)** | |
| Methane | 55,5 |
| **Wood (MJ/kg dry matter)** | |
| Alder | 18,1 |
| Asp | 19,9 |
| Birch | 20,2 |
| Beech | 19,7 |
| Spruce | 20,7 |
| Pine | 21,2 |

[21] Assumes a mixture of 70% propane and 30% butane by mass
[22] An average for motor gasoline with RON between 91 and 95

Table B2 Calculation procedure and generic efficiency figures for solar, hydro, wind and nuclear power plants.

| | Calculation procedure |
|---|---|
| Hydro power | The delivered energy from the hydro power plant. |
| Nuclear power | For nuclear power plants, the thermal efficiency of the gas turbine generator is used. In the generic case, an efficiency of 33% of the gas turbine generator is accepted for the calculation of primary energy from nuclear power plants. This figure is a common figure and is used, for example, by OECD for statistic matter. |
| Solar energy | The delivered energy from the solar panel or solar cell. |
| Wind energy | The delivered energy from the wind plant. |

# Appendix C – Applied impact characterisation factors[23]

Impact potentials are calculated as the sum of the contributions of the impacts shown in the inventory analysis, each one multiplied by a coefficient called the *"characterisation factor,"* which indicates the scale of the potential contributed by the individual substance to the effect. Operationally speaking, it is thus necessary to use the characterisation factors shown in the tables that follow, indicating the results of the multiplication, substance by substance.

Table C1 Characterisation factors for global warming potentials for the time horizon 100 years, $CO_2$-equivalents.

References: IPCC (Intergovernmental Panel on Climatic Change), 1996. Climate Change 1995. Cambridge University Press, Cambridge.

| Species | Formula | GWP, 100 years |
|---|---|---|
| Carbon dioxide | $CO_2$ | 1 |
| CFC-11 (Trichlorofluoromethane) | $CFCl_3$ | 4000 |
| CFC-113 | $C_2F_3Cl_3$ | 5000 |
| CFC-114 | $C_2F_4Cl_2$ | 9300 |
| CFC-115 | $C_2F_5Cl$ | 9300 |
| CFC-12 (Dichlorodifluoromethane) | $CF_2Cl_2$ | 8500 |
| CFC-13 (Chlorotrifluoromethane) | $CF_3Cl$ | 11700 |
| Dichloromethane | $CH_2Cl_2$ | 9 |
| Sulphur hexafluoride | $SF_6$ | 23900 |
| HALON-1301 | $CF_3Br$ | 5600 |
| HCFC-123 | $CHCl_2CF_3$ | 93 |
| HCFC-124 | $CHFClCF_3$ | 480 |
| HCFC-141b | $CH_3CFCl_2$ | 630 |
| HCFC-142b | $CH_3CF_2Cl$ | 2000 |
| HCFC-22 | $CHF_2Cl$ | 1700 |
| HCFC-225ca | $C_3HCl_2F_5$ | 170 |
| HCFC-225cb | $C_3HCl_2F_5$ | 530 |
| HFC-125 | $CHF_2CF_3$ | 2800 |
| HFC-134 | $CH_2FCF_3$ | 1000 |
| HFC-134a | $CH_2FCF_3$ | 1300 |
| HFC-143 | $CH_3CF_3$ | 300 |
| HFC-143a | $CH_3CF_3$ | 3800 |
| HFC-152a | $CH_3CHF_2$ | 140 |
| HFC-227ea | $C_3HF_7$ | 2900 |
| HFC-23 (Trifluoromethane) | $CHF_3$ | 11700 |
| HFC-236fa | $C_3H_2F_6$ | 6300 |
| HFC-245ca | $C_3H_3F_5$ | 560 |
| HFC-32 (Difluoromethane) | $CH_2F_2$ | 650 |
| HFC-41 (Fluoromethane) | $CH_3F$ | 13000 |
| HFC-43-10-mee | $C_5H_2F_{10}$ | 1300 |
| Methane* | $CH_4$ | 21 |

[23] The selected characterisation factors are found in INTEND (2004) and follows the current MSR. Therefore in future it may require additional reported indicators in the ED if a new MSR will be launched.

Table C1 Continuing

| Species | Formula | GWP, 100 years |
|---|---|---|
| Carbon monoxide | $CO$ | 2 |
| Perfluorobutane | $C_4F_{10}$ | 7000 |
| Perfluorocyclobutane | $C_4F_8$ | 8700 |
| Perfluoroexane | $C_6F_{14}$ | 7400 |
| Perfluoroethane | $C_2F_6$ | 9200 |
| Perfluoropentane | $C_5F_{12}$ | 7500 |
| Perfluoropropane | $C_3F_8$ | 7000 |
| Nitrogen protoxide | $N_2O$ | 310 |
| Tetrachloromethane | $CCl_4$ | 1400 |
| Tetrafluoromethane | $CF_4$ | 6500 |
| Trichloroethane | $CH_3CCl_3$ | 110 |
| Trichloromethane (Chloroform) | $CHCl_3$ | 4 |

* The GWP for methane includes indirect effects of tropospheric ozone production and stratospheric water vapour production, as in IPCC (1994).

Table C2 Characterisation factors for ozone-depleting gases. Semi-empirical polar ozone depletion potentials (ODP) for the time horizon 20 years, CFC-11 equivalents.

References: Solomon & Albritton, 1992, in Nordic Guidelines on Life-Cycle Assessment, Nord 1995:20, Nordic council of Ministers, Copenhagen.

| Species | Formula | ODP [kg CFC-11 eq./kg] |
|---|---|---|
| Bromo-methane | $CH_3Br$ | 0.44 |
| CFC-11 (Trichlorofluoromethane) | $CFCl_3$ | 1 |
| CFC-113 | $C_2F_3Cl_3$ | 0.9 |
| CFC-114 | $C_2F_4Cl_2$ | 0.85 |
| CFC-115 | $C_2F_5Cl$ | 0.4 |
| CFC-12 (Dichlorodifluoromethane) | $CF_2Cl_2$ | 0.82 |
| Chloromethane | $CH_3Cl$ | 0.02 |
| HALON-1202 | $CF_2Br_2$ | 1.25 |
| HALON-1211 | $CClF_2Br$ | 5.11 |
| HALON-1301 | $CF_3Br$ | 12 |
| HALON-2402 | $C_2F_4Br_2$ | 7 |
| HCFC-123 | $CHCl_2CF_3$ | 0.014 |
| HCFC-124 | $CHFClCF_3$ | 0.03 |
| HCFC-141b | $CH_3CFCl_2$ | 0.1 |
| HCFC-142b | $CH_3CF_2Cl$ | 0.05 |
| HCFC-22 | $CHF_2Cl$ | 0.04 |
| HCFC-225ca | $C_3HCl_2F_5$ | 0.02 |
| HCFC-225cb | $C_3HCl_2F_5$ | 0.02 |
| Tetrachloromethane | $CCl_4$ | 1.2 |
| Trichloroethane | $CH_3CCl_3$ | 0.12 |

Table C3 Characterisation factors for acidifying compounds. Characterization factors for acidifying compounds, mol $H^+$/g, maximum. Stoichiometric formation of $H^+$.

| Species | Formula | Mol $H^+$/g max |
|---|---|---|
| Hydrochloric acid | HCl | 0.0274 |
| Hydrofluoric acid | HF | 0.0500 |
| Ammonia | $NH_3$ | 0.0587 |
| Nitrogen dioxide | $NO_2$ | 0.0217 |
| Sulphur dioxide | $SO_2$ | 0.0312 |
| Nitrogen monoxide | NO | 0.0333 |
| Nitrogen dioxide | $NO_2$ | 0.0217 |
| Nitrous oxide | $NO_x$ | 0.0217 |
| | $HNO_3$ | 0.0159 |
| | $H_2SO_4$ | 0.0204 |
| | $H_3PO_4$ | 0.0306 |
| | $H_2S$ | 0.0588 |

Table C4 Characterisation factors for gases creating ground-level ozone. POCP, non-specific hydrocarbons, g ethene-equivalents/g VOC-mix.

| VOC-mix | POCP |
|---|---|
| Hydrocarbons (average) | 0.337* |
| Non-methane hydrocarbons (average) | 0.416* |
| Petrol car, combustion emissions | 0.46** |
| Petrol car, evaporation | 0.42** |
| Diesel car, combustion emission | 0.48** |
| Stationary combustion | 0.44** |
| Use of solvents | 0.29** |
| Industrial processes | 0.27** |
| Oil refinement and distribution | 0.42** |
| Leakage of natural gas | 0.24** |

* Ref: Heijungs et al., 1992, in Nordic Guidelines on Life-Cycle Assessment, Nord 1995:20, Nordic council of Ministers, Copenhagen.
** Ref: Andersson-Sköld et al., 1992, in Environmental Assessment of Products, Institute for Product Development, Copenhagen, Denmark.

Table C5 Photochemical Ozone Creation Potentials (POCP) as ethene-equivalents.
References: Derwent R.G. et al., 1998. Photochemical Ozone Creation Potentials for Organic Compounds in Northwest Europe Calculated with a Master Chemical Mechanism. Atmospheric Environment, Vol. 32, No. 14/15, pp.2429-2441, Elsevier Science Ltd., Great Britain.

| Organic compound | POCP | Organic compound | POCP |
|---|---|---|---|
| *Alkanes* | | *Aromatics* | |
| Methane | 0,006 | Benzene | 0,218 |
| Ethane | 0,123 | Toluene | 0,637 |
| Propane | 0,176 | o-Xylene | 1,053 |
| n-Butane | 0,352 | m-Xylene | 1,108 |
| i-Butane | 0,307 | p-Xylene | 1,01 |
| n-Pentane | 0,395 | Ethylbenzene | 0,73 |
| i-Pentane | 0,405 | Propylbenzene | 0,636 |
| Neopentane | 0,173 | i-Propylbenzene | 0,5 |
| n-Hexane | 0,482 | 1,2,3-Trimethylbenzene | 1,267 |
| 2-Methylpentane | 0,42 | 1,2,4- Trimethylbenzene | 1,278 |
| 3-Methylpentane | 0,479 | 1,3,5- Trimethylbenzene | 1,381 |
| 2,2-Dimethylbutane | 0,241 | o-Ethyltoluene | 0,898 |
| 2,3-Dimethylbutane | 0,541 | m-Ethyltoluene | 1,019 |
| n-Heptane | 0,494 | p-Ethyltoluene | 0,906 |
| 2-Methylhexane | 0,411 | 3,5-Dimethylethylbenzene | 1,32 |
| 3-Methylhexane | 0,364 | 3,5-Diethyltoluene | 1,295 |
| n-Octane | 0,453 | | |
| n-Nonane | 0,414 | *Ketones* | |
| n-Decane | 0,384 | Acetone | 0,094 |
| n-Undecane | 0,384 | Methylethylketone | 0,373 |
| n-Dodecane | 0,357 | Methyl-i-butylketone | 0,49 |
| | | Methylpropylketone | 0,548 |
| *Cycloalkanes* | | Diethylketone | 0,414 |
| Cyclohexane | 0,29 | Methyl-i-propylketone | 0,364 |
| Cyclohexanone | 0,299 | Hexan-2-one | 0,572 |
| Cyclohexanol | 0,446 | Hexay-3-oney | 0,599 |
| | | Methyl-t-butilketone | 0,323 |
| *Alkenes* | | | |
| Ethylene | 1 | *Alcohols* | |
| Propylene | 1,123 | Methanol | 0,131 |
| But-1-ene | 1,079 | Ethanol | 0,386 |
| cis-But-2-ene | 1,146 | n -propanol | 0,543 |
| trans-But-2-ene | 1,132 | n -Butanol | 0,612 |
| Methylpropene | 0,627 | i-propanol | 0,14 |
| cis-Pent-2-ene | 1,121 | i-Butanol | 0,375 |
| trans-Pent-2-ene | 1,117 | s-Butanol | 0,4 |
| Pent-1-ene | 0,977 | t-Butanol | 0,123 |
| 2-Methylbut-1-ene | 0,771 | 3-Pentanol | 0,422 |
| 3-Methylbut-1-ene | 0,671 | 2-Methylbutan-1-ol | 0,407 |
| 2-Methylbut-2-ene | 0,842 | 3-Methylbutan-I-ol | 0,412 |
| Hex-1-ene | 0,874 | 3-Methylbutan-2-ol | 0,366 |
| cis-Hex-2-ene | 1,069 | 2-Methylbutan-2-ol | 0,142 |
| trans-Hex-2-ene | 1,073 | Diacetone alcohol | 0,262 |
| Styrene | 0,142 | | |

Table C5 Continuing

| Organic compound | POCP | Organic compound | POCP |
|---|---|---|---|
| | | *Glycols* | |
| *Dialkenes* | | Ethylene glycol | 0,382 |
| 1,3-Butadiene | 0,851 | Propylene glycol | 0,457 |
| Isoprene | 1,092 | | |
| | | | |
| *Alkynes* | | | |
| Acetylene | 0,085 | | |
| | | | |
| *Ethers* | | *Esters* | |
| Dimethylether | 0,174 | Methyl formate | 0,033 |
| Methyl-t-butylether | 0,152 | Methyl acetate | 0,046 |
| Diethylether | 0,467 | Ethyl acetate | 0,213 |
| Diisopropylether | 0,476 | i-Propyl acetate | 0,213 |
| Ethyl-t-butylether | 0,214 | n-propyl acetate | 0,29 |
| | | n-Butyl acetate | 0,241 |
| *Alcohol and glycol ethers* | | s-Butyl acetate | 0,267 |
| 2-Methoxyethanol | 0,3 | t-Butyl acetate | 0,065 |
| 2-Ethoxyethanol | 0,387 | | |
| 1-Butoxypropanol | 0,436 | *Halocarbons* | |
| 2-Butoxyethanol | 0,438 | Methyl chloride | 0,005 |
| 1-Methoxy-2-propanol | 0,368 | Methylene chloride | 0,068 |
| | | Chloroform | 0,023 |
| *Aldelhydes* | | cis-Dichloroethylene | 0,447 |
| Formaldehyde | 0,519 | trans-Dichloroethylene | 0,392 |
| Acetaldehyde | 0,641 | Tetrachloroethylene | 0,029 |
| Propionaldehyde | 0,798 | Trichloroethylene | 0,325 |
| Butyraldehyde | 0,795 | Methyl chloroform | 0,009 |
| i-Butyraldehyde | 0,514 | | |
| Pentanaldehyde | 0,765 | *Carboxylic acids* | |
| Benzaldehyde | -0,092 | Formic acid | 0,032 |
| | | Acetic acid | 0,097 |
| | | Propanoic acid | 0,15 |
| | | | |
| | | | |

Table C6 Characterisation factors for eutrophicating compoundsg $O_2$/g, maximum.
References: Lindfors, L-G. et al., 1995, Nordic Guidelines on Life-Cycle Assessment, Nord 1995:20, Nordic council of Ministers, Copenhagen.

| Substance | g $O_2$/g, max |
|---|---|
| N to air | 20 |
| $NO_x$ to air | 6 |
| $NH_3$ to air | 16 |
| N to water | 20 |
| $NO_3^-$ to water | 4,40 |
| $NH_4^+$ to water | 15 |
| P to water | 140 |
| $PO_4^{3-}$ | 46 |
| COD | 1 |
| | |

# Appendix D – Generic allocation efficiency factors[24]

This Appendix provides a description of the allocation method for the distribution of the environmental impact associated with the generation of electricity and heat in a combined heat and power plant. The facility parameters to be used for this allocation are also specified.

**Note:** It should be noticed that the allocation specifications in this annex are given in low energy values and not gross calorific value which has to be consider before using figures in Table D1.

## Description of the "Alternative Generation Method"

The Finnish District Heating Association originally developed this allocation method as a proposal for a new and uniform reporting method for European combined heat and power plant generation statistics. The method is still being discussed within Euroheat, Eurostat and Eurelectric. At present there is no uniform standard for the selection of facility parameters. The method is available in different versions, with varying degrees of complexity of the calculation process. The simplest version is used in this application. The allocation method is based on the fact that benefits gained from improved fuel utilisation as well as the environmental impacts connected to combined heat and power generation, are distributed between the two products – electricity and heat – in the same proportion as the fuel needed for separate electricity and heat generation processes. The relationship of distribution is expressed as percentage of the fuel needed for each alternative process with respect to the total quantity needed.

[24] The appendix is cited from MSR (2004) except the clarification note. This means that this PCR follows the only global accepted PCR that handle Electricity an district heat generation. This implies to a basis for modularity on a building level.

The principle behind the allocation method is illustrated below:

Example.
*Existing combined heat and power generation plant for which the allocation is to be made:*
*Electricity generation, net 30 units*
*Heat generation, net 60 units*
*Alternative generation facilities:*
*Heat generation* $\eta_h$
*= 90% (no flue gas condensation)*
*Electricity generation* $\eta_e$
*= 40%*
*Fuel used by alternative electricity generation 30/0.4 = 75*
*Fuel used by alternative heat generation 60/0.9 = 67*
*Total fuel used by alternative generation 142*
*Allocate to electricity: 75/142 => 53%*
*Allocate to heat: 67/142 => 47%*

The choice of parameters for the alternative generation facilities has a direct impact on how the environmental impact is distributed. Various alternative approaches exist for the selection of facility data for alternative generation. The following principle shall apply to allocations upon which Environmental Product Declarations are to be based:
– Facility data for the best possible facility performance
– For the same type of technology and fuel as the facility studied.

In the case of co-combustion of several fuels in a facility, it is up to the author of the Life Cycle Assessment to select facility data and to provide justification for the allocation calculations.

## Basis for Allocation – Facility Parameters for Alternative Facilities

The table below shows the facility parameters to be used in allocation for a number of different combined heat and power generation methods.

Table D1 Facility parameters to be used in allocation for a number of different combined heat and power generation methods

| **Combined heat and power** | | **Alternative heat** | **Alternative electricity** |
|---|---|---|---|
| **Fuel type** | **Technology** | **Efficiency, heat** $\eta_h$ **(%)** | **Efficiency, electricity** $\eta_e$ **(%)** |
| Biofuel | Steam cycle, heat and power | 90 % | 38 % |
| | Steam cycle, heat and power, flue gas condensation | 110 % | 38 % |
| Waste | Steam cycle, heat and power, | 90 % | 35 % |
| | Steam cycle, heat and power, flue gas condensation | 100 % | 35 % |
| Black coal | Steam cycle, heat and power | 90 % | 46 % |
| Natural gas | Steam cycle, heat and power | 90 % | 47 % |
| | Steam cycle, heat and power flue gas condensation | 105 % | 47 % |
| | Combined cycle, heat and power | 90 % | 58 % |
| Oil | Steam cycle, heat and power | 90 % | 46 % |