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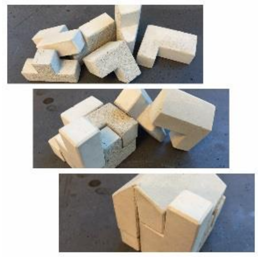

Harmonising the documentation of scenarios beyond cradle to gate, EN 15804[1]

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1. Abstracts

This document shall provide scenario inputs for those preparing complementary product category rules (c-PCR[6]) to NS-EN 15804 for construction products and works on how to include scenarios for life cycle modules A4 to D. The purpose is to provide guidance for developing environmental product declarations (EPDs) with better and more complete scenarios appropriate for the Norwegian market.

2. Introduction

This document provides guidance to those preparing complementary product category rules (c-PCR) to NS-EN 15804 for construction products and works on how to include scenarios for life cycle modules A4 to D.
For many years there have been an 'additional Norwegian requirement' that requires the transport (A4) distance from the production site to the central warehouse to be declared. New tools for calculating the environmental impact of transportation (A4) to the construction site, improves the accuracy of calculations and enhances the documentation[7].

Better dialogue between LCA developers and manufacturers of building materials, better use of installation instructions, use of SINTEF Technical Approval (SINTEF TA), have provided opportunities for improved environmental impact for the information modules A5 to D.

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1 This document forms part of the project report submitted to Husbanken 'Bedre grunnlag for valg av miljøvennlige byggevarer III' Husbanken 14/6084-4.

2 Norwegian Institute of Wood Technology

3 SINTEF Building and Infrastructure

4 Østfoldforskning AS

5 Responsible editor: The Norwegian EPD Foundation

6 ISO/DIS 21930:2016 use the term 'sub-category PCR'

7 Østfoldforskning AS

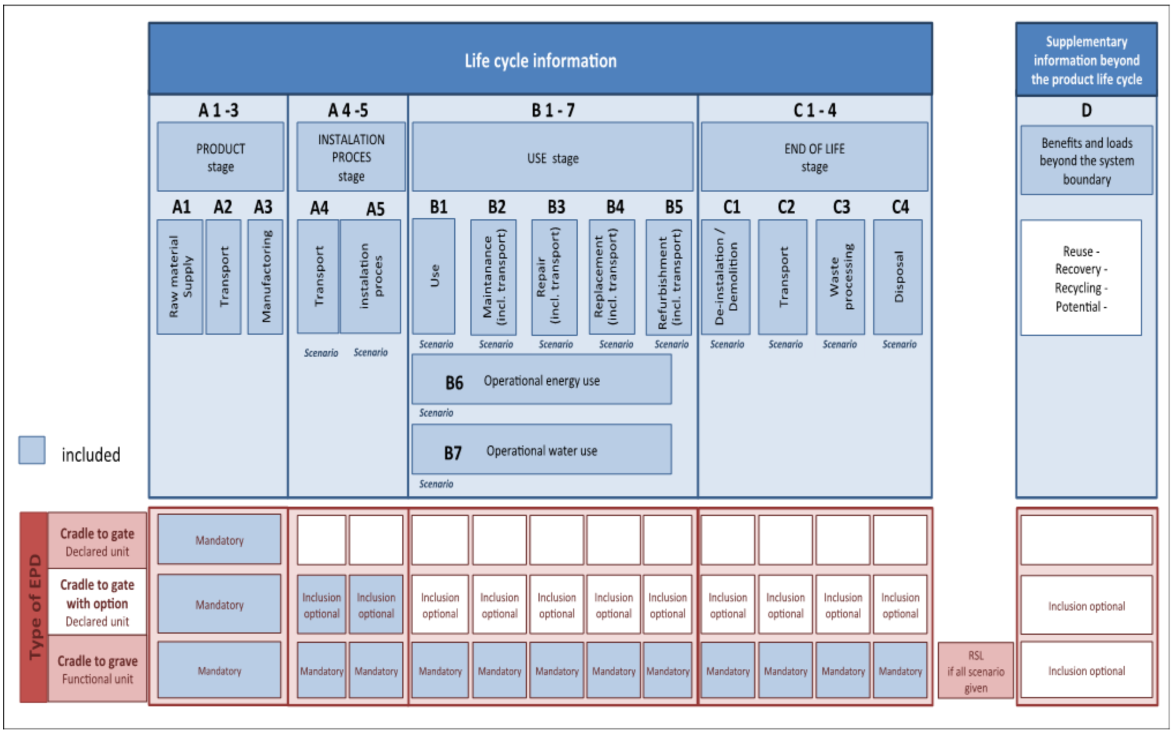

Figure 1: Life Cycle Modules according to NS-EN 15804: 2012 + A1: 2013

3. Terms and Definitions

3.1 Lifetime-Based Terms for Construction Products

Reference Service Life (RSL)
The reference service life is the service life of a construction product that is expected under a reference set of in-use conditions, and which can form the basis for estimating the service life under other in-use conditions.

The RSL is applied to the functional unit, for the calculation of replacement (B4) and refurbishment (B5) of construction products (see Sections 6.4 and 6.5).
[SOURCE: ISO 6707-1:2014 & ISO 15686-1: 2011]

Expected Service Life
The expected service life is the maximum period of useful life as defined by the manufacturer, and is not to be confused with product warranties or guarantees.
[SOURCE: ISO 26782: 2009]

3.2 Lifetime-Based Terms for Construction Works

Design Life
The design life is the intended service life (deprecated), expected service life (deprecated) or service life of construction works intended by the designer.
[SOURCE: ISO 15686-1: 2011]

Estimated Service Life (ESL)
The estimated service life is the service life of a building, or parts of a building, expected in a set of specific in-use conditions, determined from reference service life data, after taking into account any differences from the in-use reference conditions.
[SOURCE: ISO 15686-1: 2011]

Reference Study Period
The reference study period is the period of time in which time dependent characteristics of the construction works are analysed. In some cases, the reference study period may significantly differ from the design life of the building
[SOURCE: 15978: 2011]

Required Service Life (ReqSL)
The required service life is the service life of construction works required by the client or through regulations.
[SOURCE: 15643-1: 2010]

4 Methodological Aspects

4.1 Product Description and Intended Use

A c-PCR always states which construction products it is valid for. A c-PCR is also required to give a description of the intended application and use of the construction product. If a c-PCR covers a product group that is applicable to several application areas, then those applications should be specified.

The reference service life is dependent on these aspects, namely; intended application and specific in-use conditions. If the product has a SINTEF Technical Approval (SINTEF TA), then the area of application is described in the SINTEF TA.

When defining these aspects in the c-PCR, it may be helpful to view the intended application within a construction works context. ISO 21931-1: 2010 introduces a functional equivalent that represents the required technical characteristics and functionality of a building. Similarly, EN 15978: 2011 states that the functional equivalent of a building or an assembled system shall include the following aspects:

- building type (e.g. office, factory, dwelling)
- required service life
- relevant technical and functional requirements (e.g. the specific requirements from the client or from regulations)
- pattern of use

It is strongly recommended to develop c-PCRs, which emphasise a product's functionality and specific intended use.

4.2 Functional Unit

The functional unit (FU) is a quantified description of the performance of a product system, and is used as a reference unit. It is therefore important to define both quantitative and qualitative aspects, such as; the intended area of application, specific in-use conditions and the product's RSL.

To follow are two examples of how a FU are described in PCRs:

<u>EXAMPLE: Concrete element</u>

a) 1 m² of an exterior load bearing wall
b) 1 linear meter of a beam with a defined load bearing capacity, which fulfils the performance requirements concerning construction, for example thermal insulation, sound insulation and fire resistance for a defined reference service life.

When the intended use of in-situ concrete or a concrete element in the building or civil engineering works is known, the RSL of the product shall be consistent with its estimated service life (at least equal to).

4.3 RSL Requirements

The RSL can only be determined for a cradle to grave EPD, or a cradle to gate EPD with options whereby life cycle modules A1 to A5 and B1 to B5 have been provided.

The RSL declared should relate to the declared functional technical performance, and to any maintenance or repair required in order to fulfil the declared functional technical performance during the estimated service life (ESL) for the construction work. The declared technical performance may be based on specifications given in relevant standards.

NS-EN 15804 requires that the RSL information is declared in an EPD that assesses the use stage. Although, a c-PCR may provide default RSL for a given product group, you should always check the RSL of a product with the manufacturer.

4.4 Reference Study Period versus Estimated Service Life

The reference study period of Norwegian PCRs for building products shall always be set to 60 years. However, this may vary for construction products which are intended to be used in buildings with a different estimated service life, for example an opera house or a temporary structure. An EPD based on a c-PCR which uses the 60 year default, may also refer to the required service life of the construction works.

4.5 Summary

A PCR that provides scenarios should describe how the construction product should be documented in the EPD, in terms of intended use and application, RSL, declared functional performance and technical information.

A construction product may have several intended applications. Consequently, this may result in numerous scenarios concerning the RSL, FU or DU with options. It is therefore important to document and declare which intended uses have been included in the scenarios.

In conclusion, the c-PCR should summarise information regarding the product use and application areas, the RSL, and provide a description of scenarios from life cycle modules A4 to D. An example of the information required is provided in Table 1. The same information or an equivalent table should also be documented in the EPD with both qualitative and quantitative technical information for the various scenarios.

Table 1: prEN 16757 Sustainability of Construction Works – Environmental Product Declarations – Product Category Rules for Concrete and Concrete Elements

N.	SCENARIO	RSL	B1 – Use of the installed product [a]	B2 Maintenance	B 3 Repair	B4 Replacement [b]	B5 Refurbishment [b]	B6 – Operational energy use	B7 – Operational water use
1	Structural concrete or concrete elements for buildings (exterior)	ESL, normally 100 years	Potential emission to soil and groundwater Carbonation process	Generally no maintenance is foreseen. One-off cleaning and surface treatment may apply for elements with specific purposes (e.g. aesthetic).	Repair may be necessary in case of accidental damage to structural elements or elements with aesthetic purposes.	-	-	Energy used for operating heating and cooling systems integrated in the element **.	Water used for operating heating and cooling systems integrated in the element**.
4	Non-structural elements for buildings (interior)	half ESL, normally 50 years	Potential emission to indoor air Carbonation Process	Generally no maintenance is foreseen. One-off cleaning and surface treatment may apply for elements with specific purposes (e.g. aesthetic).	Repair may be necessary in case of accidental damage.	In case of accidental damage the element may be replaced.		Energy used for operating heating and cooling systems integrated in the element [b].	Water used for operating heating and cooling systems integrated in the element [b].
9	Elements for agricultural constructions	25 years	Potential emission to soil and groundwater Carbonation Process	Cleaning may be necessary.	–	In case of accidental damage the element may be replaced.	–	–	–

5 Module A4-A5 Construction Stage

According to NS-EN 15804, the construction stage includes provision and transport of all materials, products and energy, as well as waste processing up to an end-of-waste state or disposal of final residues during the construction process stage. The information modules also include all impacts and aspects related to any losses during this construction process stage (i.e. production, transport, waste processing and disposal of lost products and materials).

5.1 Module A4 Transport to the Construction Site

This module includes transportation from the production gate to the construction site, and includes all segments of that anticipated journey. The transport scenario should be described with precise journey descriptions, including the names of any cities or ports, as well as the country in which the city is located in, if the product is transported from outside of Norway. The route should declare whether or not the transport scenario includes storing the product at a central warehouse. If the location of the central warehouse is unknown, then Oslo is typically used as a notional point in Norway. Brussels, Belgium is used as a notional point in Europe. A description of the mode of transport, type of vehicle, vehicle capacity (%) and distance travelled (km) should be included in the LCA report and in the EPD under A4 scenario descriptions, see Table 1. Tools such as Google Maps or Sea Rates Route Explorer can be used to ascertain transport distances when specific information is incomplete. Additional information shall also include fuel or energy consumption (l/t km).

Transport to the construction site (A4) may consist of multiple scenarios, and should therefore reflect the market area(s) as defined in the product section of the EPD.
There is an 'additional Norwegian requirement' that requires the transport distance from the production site to the central warehouse to be declared. If no central warehouse is described in the transport scenario, then the transport distance from the production site to the central warehouse should be declared as 0 km.

Table 2: Example of information required for transport from place of production to user (A4)

Mode of Transport	Location	Destination	Capacity (%)	Type of Vehicle	Distance (km)	Fuel or energy consumption (l/t km)
Lorry	Factory, City	Port, City	53	Lorry >32t, EURO 4	100	0,020
Boat	Port, City	Port, City	65	Freight ship	250	-
Lorry	Port, City	Warehouse, City	53	Lorry >32t, EURO 4	100	0,020
Lorry	Warehouse, City	Building Site, City	53	Lorry 16-32t, EURO 5	50	0,044

Figure 2 details the system boundary used for transport and shows that the life cycle impacts from fuel, infrastructure and vehicle, with regards to production, operation, maintenance and disposal are included.

The transport scenario in module A4 shall consider vehicle capacity or the load factor of a vehicle. Life cycle inventory databases such as Ecoinvent typically specify an average load factor within the transport process. The assumptions used in Ecoinvent v.3.1 are shown in Figure 3.

However, it is necessary to check whether or not the generic assumptions reflect the actual load factor in the specific transport scenario. The specific information and assumptions taken in this adjustment should be documented in the EPD and the calculations should be shown in the LCA report, in order to ensure reproducible result.

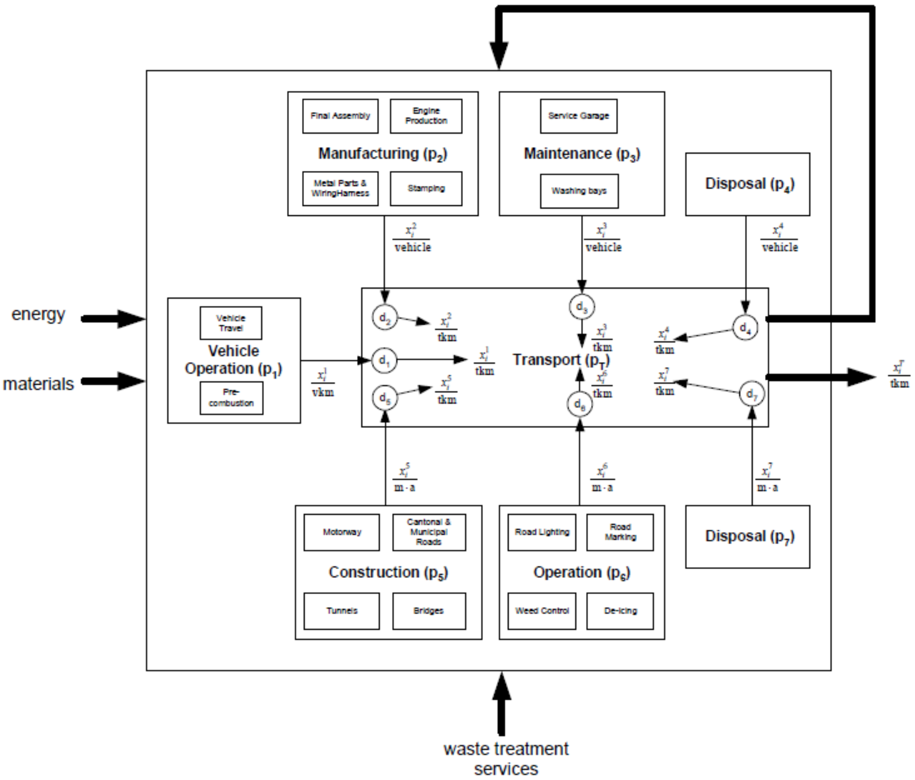

Figure 2: Principle model structure and transport components and their interrelationship

The lorry transport processes in Ecoinvent v3.1 are based on the following assumptions:

Lorry Size Class	Average Load [ton]	Gross Vehicle Weight (GVW) [ton]	Net Vehicle Weight [ton]	Max GVW [ton]	Max load [ton]
3,5 - 7,5t	0,98	4,98	4	7,5	3,5
7,5 - 16t	3,29	9,29	6	16	10
16 - 32t	5,79	15,79	10	32	22
> 32t	19,2	33,2	14	50	36
This is the size classification of the vehicle, indicating the gross weight range.	This is the average load of the lorry for that specific weight class, inclusive of the return journey.	This is the weight of the lorry and the load combined.	The net vehicle weight is found by subtracting average load from GVW.	Max GVW is taken from the upper limit of the lorry size class. For >32t, we know that max GVW on Norwegian roads is 50 tons.	Maximum load is found by subtracting net vehicle weight from max GVW.

Capacity Utilisation (%) may be calculated by dividing the average load by the maximum load.
For example, for the 16-32t lorry: 5,79/22 = 26,3%

Using these assumptions, we get the following capacity utilisations for the generic transport processes listed in Ecoinvent v3.1 above:

Lorry Size Class	Capacity Utilisation	
3,5 - 7,5t	28,0	%
7,5 - 16t	32,9	%
16-32t	26,3	%
>32t	53,3	%

Figure 3: Ecoinvent v.3.1 transport assumptions.

5.2 Module A5 Installation into the Building

This module includes the manufacture and transportation of ancillary materials, energy or water required for the installation or operation of the functional unit into the building and operation of the construction site. This includes the on-site storage of products including the provision of heating, cooling, humidity control etc., wastage of construction products (additional production process to compensate for the loss of products), waste processing of the waste from product packaging and loss material, up to the end-of-waste state or disposal of final residues.

As an example, an installed gypsum board is a gypsum board which is cut to custom size, fixed with screws and jointed to the adjacent gypsum board with jointing tape and plaster, and, if applicable, painted.

Table 3 provides default material loss factors during installation for different product groups.

Table 3: Default material loss factors during installation for different product groups

Product group	**Average loss on site during construction**	**Source**
Precast concrete	0%	-
Building boards, Gypsum plaster boards	15%	Veidekke ASA/Norgips 2001
Steel	0%	-
Windows and doors	0%	-

The scenario for installation is dependent on the application area of the product. For example, Figure 4 shows that different auxiliary materials are required to install the same window into either a brick cavity wall or a timber framed wall. It may therefore be useful to refer to product assembly or mounting instructions from the window manufacturer, in order to ascertain the resources required to install the product into the building or wall component. If the product has a SINTEF Technical Approval (SINTEF TA), then the area of application described in the SINTEF TA can be referred to.

If specific installation information is not available from the manufacturer, then guidance on the installation of construction products into buildings is available from SINTEF Building Research Design Guides (Byggforskserien).

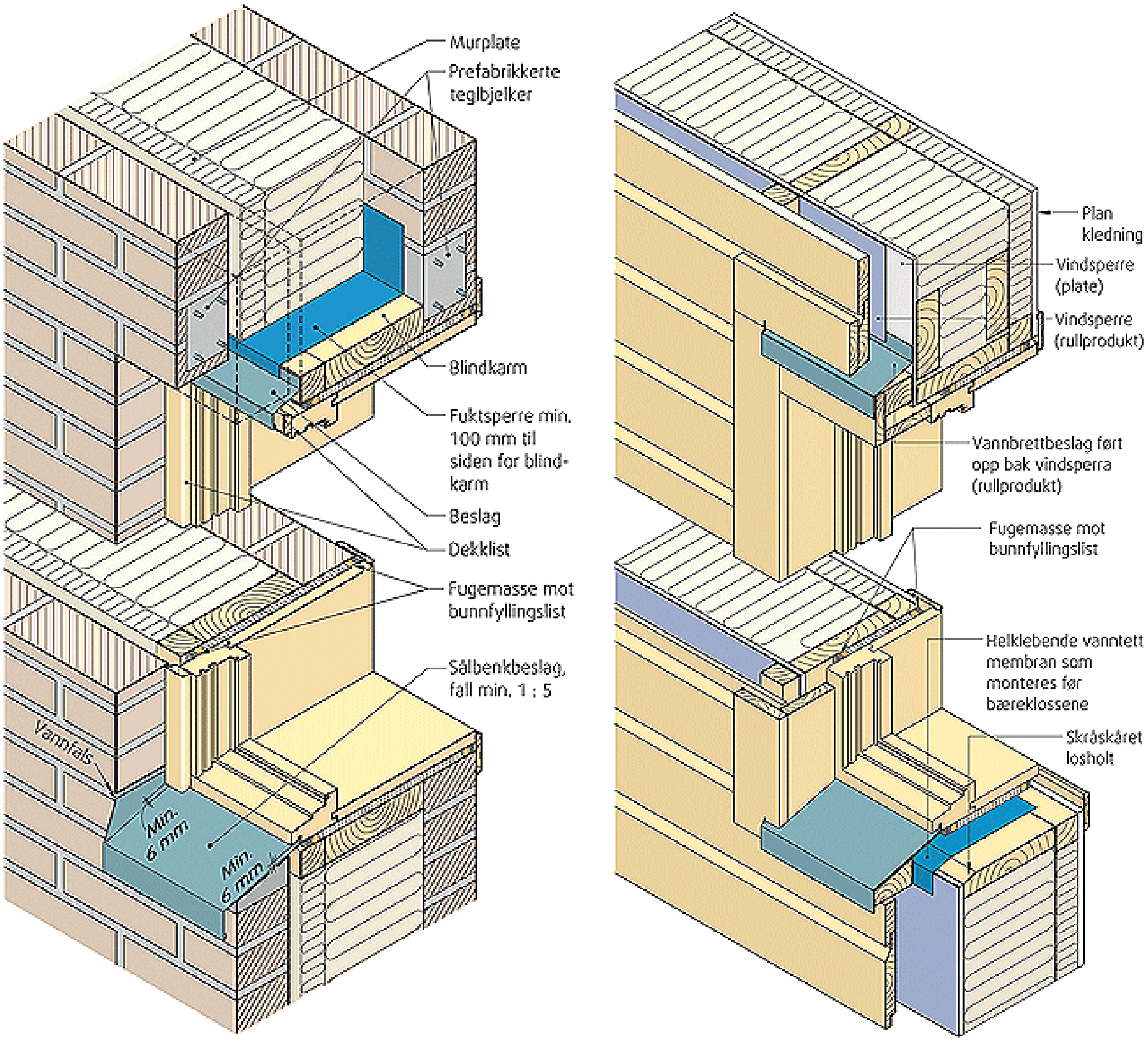

Figure 4. Installation of a window into a brick cavity wall and a timber framed wall, from SINTEF Byggforskserien 523.702 and 523.701.

All waste processing of waste from product packaging, auxiliary materials and loss materials should be taken to an end-of-waste-state or disposal of final residues within module A5. It is also worth noting that the auxiliary materials required for the installation of the product should be listed in the EPD in the material composition table, under the product description section, as additional materials. The installation scenario for module A5 should consider the following as within the system boundary:

- Auxiliary materials (kg)
- On-site water consumption (m^3)
- On-site electricity consumption (kWh)
- Other resources (kg)
- Other energy carriers (MJ)
- On-site material loss (kg / %)
- Substance output following waste treatment on-site (kg)
- Dust released to air (kg)
- VOC released to air (kg)

6 Modules B1-B7 Use Stage

According to NS-EN15804 the use stage includes provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of waste state, or disposal of final residues during this part of the use stage. The information modules also include all impacts and aspects related to losses during this part of the use stage (i.e. production, transport, waste processing and disposal of the lost products and materials).

6.1 Module B1 Use

This module includes the release of substances to the environment (air, soil and water) during normal, anticipated use. This could for example include CO_2 emissions from degradation or organic material, as well as chemical reactions to air on material surfaces, which can lead to both positive and negative impacts. One specific example includes the carbonation of exposed, non-reinforced concrete. Concrete carbonation in exposed concrete may be described in terms of negative GWP.

Emissions to indoor air are not included in the impact categories according to NS-EN 15804, but should be declared in the EPD under the 'additional Norwegian requirements - emissions to indoor environment' section. Release of any substances to the environment is typically documented in through valid horizontal standards of measurement of release of regulated dangerous substances from construction products using harmonised test methods according to the respective technical committees for European product standards. A SINTEF Technical Approval is one form of documentation that shows the product does not release any dangerous substances according to methods defined in these horizontal standards. Alternative ways of documenting and checking emissions to indoor environment include checking if the product meets M1 criteria for low emissions, or to see if the product has a GEV Emicode label (EC2, EC1 or $EC1^{plus}$).

6.2 Module B2 Maintenance

As seen in Figure 5, this module covers the combination of all planned technical and associated administrative actions during the service life to maintain the product installed in a building, so that it can perform its required functional and technical performance, as well as preserve the aesthetic qualities of the product. Such maintenance activities could include; cleaning, planned servicing, replacement or mending worn, damaged or degraded parts. Water and energy use required for cleaning shall be documented in this module, and not in modules B6 or B7.

An example of product maintenance may be demonstrated with a window, whereby the window requires regular window-washing and periodic repainting of the window's timber frame during the lifetime of the building component. The recurrence of these activities is dependent on many factors such as accessibility, quality of craftsmanship, climate and location. Therefore it is recommended to use average maintenance values (middles) from 'Byggforskserien 700.320: Intervals for maintenance and replacement of building parts' in situations where specific maintenance scenario information is unavailable.

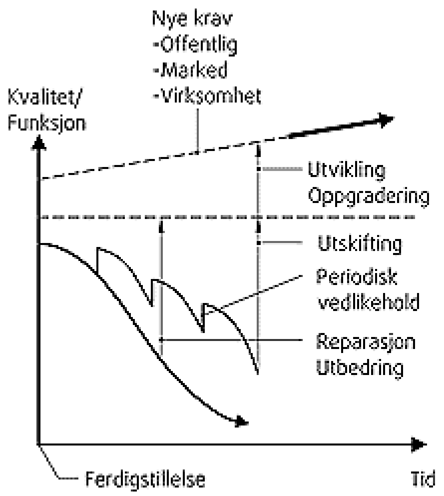

Figure 5. Quality and function of a building viewed during a lifetime perspective, from SINTEF Byggforskserien 700.320.

The system boundary for maintenance includes the production and transportation of any ancillary products used for maintenance, as well as the transport and end-of-life processes of any waste from the maintenance process to an end-of-waste-state or disposal of final residues. The maintenance scenario should consider the following as within the system boundary:

- Maintenance cycle (No. / RSL)
- Water consumption for cleaning and maintenance activities (m^3)
- Auxiliary materials (kg)
- Other resources (kg)
- Electricity consumption (kWh)
- Other energy carriers (MJ)
- Material loss (kg)

6.3 Module B3 Repair

This module covers the combination of all technical and associated administrative actions during the service life associated with corrective, responsive or reactive treatment of a product, so that it can perform its required function and technical performance, inclusive of aesthetic qualities. This includes the replacement of a broken component or part due to damage, whereas replacement of the whole element due to damage should be assigned to replacement in module B4.

In following the window analogy, the repair of broken glass in a window should be allocated under repair in module B3, whilst replacement of the whole window unit should be assigned to replacement in module B4. Furthermore, emission accounting should include the production and transportation of new glass and packaging, and all impacts due to the repair process (rubber seal, water for cleaning etc.) and the end of life stage of the glass waste and any related packaging. The repair scenario should consider the following as within the system boundary:

- Information on the repair and inspection process (description)
- Repair cycle (No. / RSL)
- Water consumption (m^3)
- Auxiliary (kg)
- Other resources (kg)
- Electricity consumption (kWh)
- Other energy carriers (MJ)
- Material loss (kg)

6.4 Module B4 Replacement

This module covers the combination of all technical and associated administrative actions associated with the return of a product to a condition in which it can perform its required function or technical performance, by replacement of a whole construction element. Replacement of a whole construction element as part of a concerted replacement programme for the building should be considered under module B5 for refurbishment.

It is recommended to use average replacement values (middles) from 'Byggforskserien 700.320: Intervals for maintenance and replacement of building parts' in situations whereby specific replacement scenario information is unavailable. It should be noted that product warranties or guarantees should not be used to estimate the service lifetime of a product, as this typically underestimates the actual performance of the product, and may lead to higher documented emissions.

The system boundary for replacement includes the production and transportation of replacement materials and packaging, all impacts due to the replacement process, the end of life of the original product, any waste from installation of the replacement product, packaging waste and waste generated from installation. The replacement scenario should consider the following as within the system boundary:

- Replacement cycle (No. / RSL)
- Electricity consumption (kWh)
- Litres of fuel (l/100km)
- Replacement of worn parts (kg)

6.5 Module B5 Refurbishment

This module covers the combination of all technical and associated administrative actions of a product associated with the return of a building or building part to a condition in which it can perform its required functions. These activities cover a concerted programme of maintenance, repair and/or replacement activity, across a significant part or whole section of the building.

The system boundary for refurbishment should reflect the type of activities taking place within the concerted programme of refurbishment, be that maintenance, repair and/or replacement. Please refer to the maintenance, repair and replacement sections of this guideline for more specific information on the system boundary.

6.6 Module B6 Energy Use to Operate Building Integrated Technical Systems

This module includes energy use during the operation of the product, together with its associated environmental aspects and impacts including processing and transport of any waste arising on site from the use of energy. Integrated building technical systems are installed to support the operation of a building, and includes technical building systems for heating, cooling, ventilation, lighting, domestic hot water and other systems for sanitation, security, fire safety, internal transport, building automation and IT communications.

CEN/TR 15615 provides guidance on the selection of standards to calculate the operational energy use of technical building systems. Tools such as SIMIEN or IDA-ICE can also be used to calculate operational energy use.

Aspects related to production, transportation and installation of the equipment shall be assigned to modules A1-A5. Energy use during maintenance, repair, replacement or refurbishment activities for the equipment shall be assigned to modules B2-B5. Aspects related to the waste processing and final disposal of equipment shall be assigned to modules C1-C4. However, life cycle impact from fuels, infrastructure and machinery production for operational energy is to be included in this module. The operational energy use scenario should consider the following as within the system boundary:

- Electricity consumption (kWh)
- Other energy carriers (MJ)
- Equipment output (kW)

6.7 Module B7 Operational Water Use by Building Integrated Technical Systems

This module covers the period from building handover to deconstruction or demolition, and includes water use during the operation of the product, together with its associated environmental impacts during the life cycle of water (production, transportation and waste water treatment). Building integrated technical systems include systems for cooling, ventilation, humidification, domestic hot water, sanitation, security, fire safety and internal transport.

The British 'Water Efficiency Calculator for New Dwellings' sets out the water calculation methodology for assessing a whole house. The calculation method is used to assess compliance against water performance targets in building regulations and in the 'Code for Sustainable Homes' assessment methodology, see Table 3. The calculation tool supplies water consumption rates for a range of building integrated technical systems, and can therefore also be used to calculate operational water use for products and systems in module B7. This is useful when specific, operational water use scenario information is lacking.

Table 3: Maximum consumption of potable water in dwellings, according to the Code of Sustainable Homes

Performance Target	Max. consumption of potable water (litres/person/day)
Building Regulations Compliance	125
Code for Sustainable Homes (Level 1/2)	120
Code for Sustainable Homes (Level 3/4)	105
Code for Sustainable Homes (Level 5/6)	80

The operational water use scenario should consider the following as within the system boundary:

- Water consumption (m^3)
- Electricity consumption (kWh)
- Other energy carriers (MJ)
- Equipment output (kW)

7 Modules C1-C4 End-of-Life

7.1 Introduction

The end-of-life stage starts from when a construction product is replaced, dismantled or deconstructed from a building until it reaches an end-of-waste state.

7.2 Developing an End-of-Life Scenario

NS-EN 15804 specifies in Section 6.3.8 that a scenario shall be realistic and representative for one of the most probable alternatives. If there are several common scenarios, then the most representative scenario, or all relevant scenarios, shall be declared. The technical information documented in Table 12 of the standard shall thus be provided for the end-of-life scenario.

CEN/TR 15941: 2010 states that the requirements for the end of life scenario are as follows: The use of generic data for scenarios describing the end-of-life stage (downstream processes) should reflect:

a) existing technology;
b) current regulations;
c) today's average practice and mix of different end-of-life treatments of the product group in the location where the process takes place.

Since CEN/TR 15942:2010 states that the mix of different end-of-life treatments of the product should be used, this contradicts the requirements laid out in NS-EN 15804 where only the most representative or all relevant scenarios shall be declared. Any PCRs based on NS-EN 15804 must be careful when citing CEN/TR 15942.

Scenarios can be developed based on statistical data. Figure 4 shows the percentage distribution between the different treatments of plastic waste from buildings and construction in Norway in 2013. Energy recovery is the most used treatment options followed by recycling.

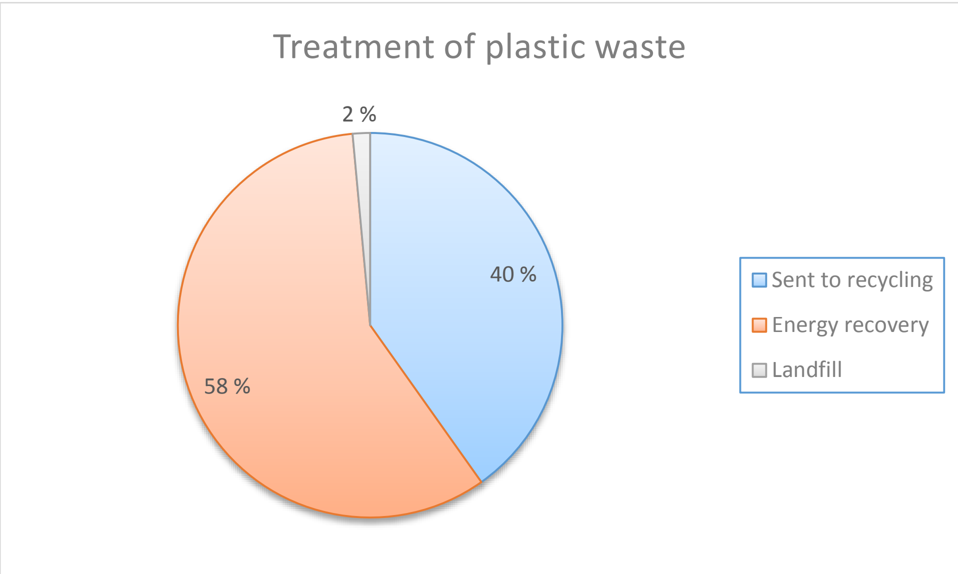

Figure 4: Treatment of plastic waste from building and construction in Norway in 2013 (Statistics Norway)

7.3 Defining the End-of-Waste State

The end-of-waste state defines which activities shall be included in the lifecycle of a construction product. It is based on the EU waste framework directive, and can be specified for individual waste fractions. Generally, a product must fulfil specific requirements, have a positive market demand, and not lead to overall adverse environmental effects. These requirements are listed as:

- a substance or object commonly used for specific purposes;
- there is an existing market or demand for the substance or object;
- the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products);
- the use will not lead to overall adverse environmental or human health impacts

Market value is often an easy indicator for when a product has reached an end-of-waste state, but it often requires additional sorting or processing before the product can be regarded to fulfil specific requirements.

Typical technical requirements can be defined for different fractions. Metal scrap has specific regulations for when an end-of-waste state has been reached. This includes, for instance, that only <2% of foreign materials can be present in metal scrap. A statement of conformity also needs to be transmitted to the next holder, in order to prove that the scrap fulfils the technical requirements. In some cases, materials for recycling require further off-site sorting, before they can be regarded to have reached an end-of-waste state.

One example is given with wood waste. Wood waste is sometimes treated with energy recovery. However, wood waste can also be recycled into a fuel. Wood pellets and briquettes have several technical requirements and standards. In general wood waste has three categories:

- Clean wood waste (e.g. packaging)
- Mixed wood waste (e.g. construction waste)
- Impregnated wood waste (e.g. CCA and creosote impregnated wood, impregnated wood that has unidentified impregnation)

EN 16485: 2014 provides two assumptions for the use of wood and wood-based construction products in an end-of-waste state:

- After sorting and chipping of post-consumer wood, if it has a positive market value and specific technical requirements are met for use as a fuel or raw material in particleboard.
- After thermal treatment of impregnated wood.

7.4 System Boundary

Figure 4 shows the system boundary of a product treated with incineration during its end-of-life scenario. It not only shows the system boundary, but also the allocation of processes in lifecycle modules C and D.

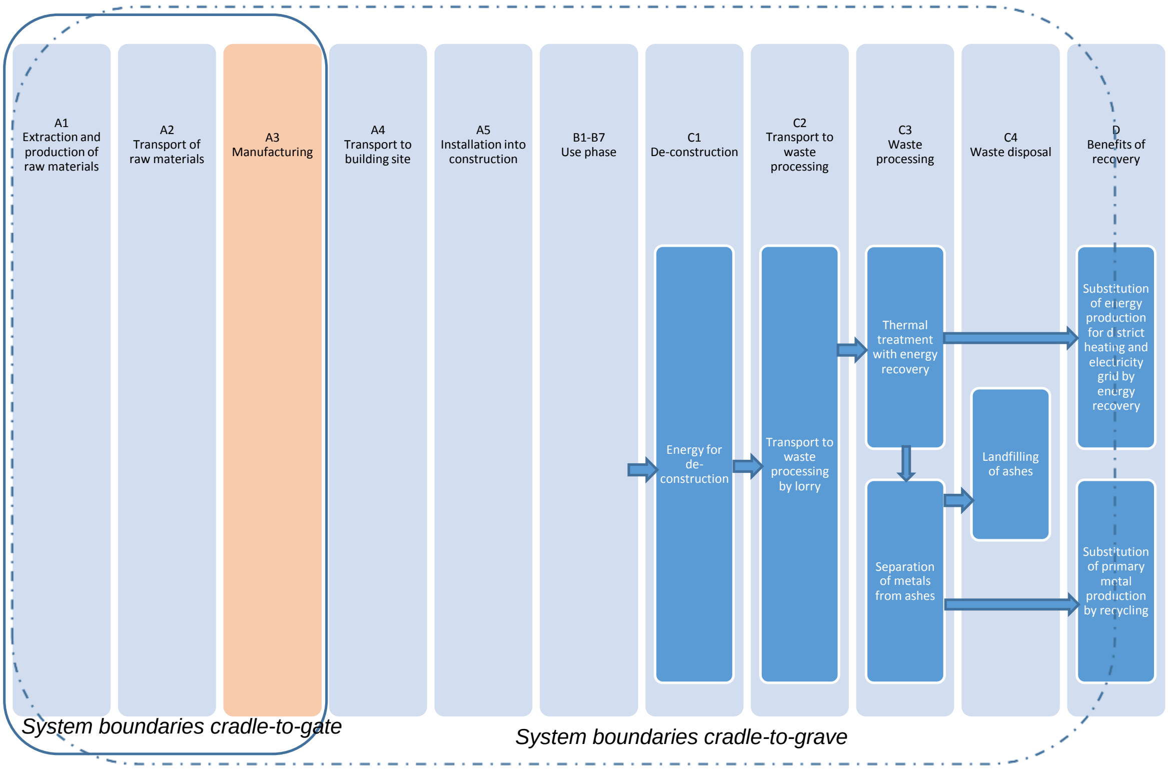

Figure 5: System boundaries for end-of-life for a product treated with thermal treatment

<u>C1 De-construction</u>

This module includes activities at the building site. It includes any processes required to make construction wastes ready for transport. This typically includes energy used for the dismantling of building parts and sorting of construction materials. If products are sold from the building site, the end-of-waste state is regarded as reached at this point.

<u>C2 Transport to Waste Processing</u>

If the end-of-waste state is not reached on-site, any transport to waste processing or disposal is included in C2.

<u>C3 Waste Processing Prior to Reuse, Recovery and Recycling</u>

This module includes processes which transform waste into a new product. For instance energy recovery is included here, when a solid waste is transformed into energy as a new product.

For materials that are recycled, waste processing could include energy used for sorting and bulk packaging. For example, paper products are sorted into several fractions before they are sold further.

<u>C4 Waste Disposal</u>

This module includes activities for the treatment of waste that does not reach an end-of-waste state. This is typically characterised by waste that is sent to landfill or incineration without, or with, low energy recovery.

8 Module D Benefits and Loads beyond the Lifecycle

Module D assesses flows that have reached an end-of-waste state, and that have benefits of avoiding other production activities. These are typically:

- Incineration of combustible materials that exports energy which can be utilised in district heating, electricity production and other industrial processes. This exported energy substitutes other energy production. This other energy production can be subtracted in module D.
- Recyclable materials such as plastics and metals can be used in new products instead of extracting virgin resources. The extraction and refinement of such materials can be subtracted in module D.

The accounting rule in module D is that only net benefits can be accounted for. Use of any secondary materials or energy should be subtracted here. Hence, if a material that consists of 50 % recycled materials is recycled, then only half of those materials are substituting the extraction and refinement of virgin materials. If a material consists of 100% recycled materials, there is no net benefit from recycling in module D. Furthermore, NS-EN 15804 specifies that module D must be consistent with today’s average technology. Therefore, today's current average energy recovery rate must be used to calculate exported energy in module D. NS-EN 15804 does not specify if the substitution shall use a marginal or average energy mix. Hence, this must be specified in the PCR.

9 Resources

CEN/TR 15941: 2010

CEN/TR 15615 (2008) Explanation of the general relationship between various European standards and the Energy Performance of Buildings Directive (EPBD) – Umbrella Document

GEV Emicode: http://www.emicode.com/en/emicode-r/categories/

Google Maps https://www.google.no/maps/

http://www.planningportal.gov.uk/buildingregulations/approveddocuments/partg/waterefficiency

NS-EN 15804: 2012 + A1: 2013 Sustainability of Construction Works - Environmental Product Declarations - Core Rules for the Product Category of Construction Products. Standard Norway, European Standard.

ISO 21931-1: 2010

Rakennustieto M1: http://m1.rts.fi/en/

Sea Rates Route Explorer https://www.searates.com/services/routes-explorer/

SINTEF Byggforskserien 700.320

SINTEF Technical Approval: http://www.sintefcertification.no/

Statistics Norway. Table 09781: Treatment of waste from construction, rehabilitation and demolition of buildings, by material and treatment (tonnes).

Spielmann, M., Bauer, C., Dones, R., Tuchschmid, M. (2007) Ecoinvent Report No.14: Transport Services. Data v2.0. Spielmann & Scholz (2005) Swiss Centre for Life Cycle Inventories, Dubendorf. Figure 4-1: Principle model structure and transport components and their interrelationship.

Veidekke ASA/Norgips (2001) Gips. Avfallsminimering og kildesortering.