Tiles & Bricks Europe

/ Ceramics, quality for life /

INTERNAL GUIDANCE DOCUMENT ON TBE PCR FOR CLAY CONSTRUCTION PRODUCTS

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1. Introduction

All products generate impacts on the environment. Those impacts can take place at any phase of the production, transport, use or end-of-life of a product. All these stages together refer to the *life cycle* of a product. Construction products can generate environmental impacts from the moment raw materials are extracted, throughout the transport, manufacturing process, use phase until the end- of-life (see Figure 1). Because of the long lifespan of ceramic construction products, TBE strongly recommends to take into account the whole life cycle of a product in the EPD. This approach is named cradle-to-grave. The methodology to calculate the potential environmental impacts of the whole life cycle of a product, service and system is denominated Life Cycle Assessment (LCA).

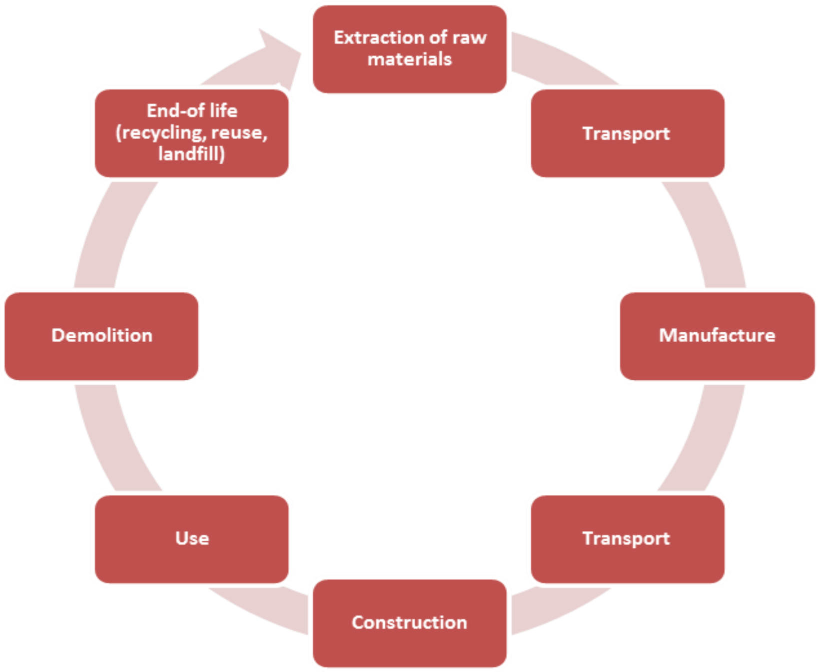

Figure 1- Life Cycle of a construction product

LCA is a tool to assess and quantify the potential environmental impacts by collecting and characterising the inputs (product, material or energy flow that enters a unit process) and outputs (product, material or energy flow that leaves a unit process) in different processes of the product's life cycle. A LCA study is carried out in accordance with the international standard ISO 14040 series. To develop an EPD, TBE strongly recommends to use the European standard EN 15804:2012 + A2:2019 which is also based on these ISO standards.

→ **The objective of this document is to provide the manufacturers of clay construction products, i.e. clay bricks, blocks, pavers and roof tiles, in all European Union (EU) Member States, with guidance for the development of Environmental Product Declarations (EPDs) of clay construction products based on a cradle-to-grave LCA approach according to EN 15804:2012 + A2:2019.**

EPDs can be used for different purposes. EPDs provide the manufacturer a good understanding of the types and causes of impacts related with their product and where in the product supply chain their major life cycle impact takes place. On the other hand, designers are often requesting EPDs of construction products that can be used as input for assessing the environmental performance of buildings.

The TBE PCR for clay construction products sets harmonised guidelines and rules for the creation of a type III EPD of clay construction products and is based on the European horizontal harmonised standard, *EN 15804:2012 + A2:2019 - Sustainability of construction works – EPDs – Core rules for the product category of construction products*, which was developed in CEN/TC 350 "Sustainability of construction works".

This TBE internal document provides guidance on the basic principles that are described in the TBE PCR for the development of EPDs for clay construction products.

Moreover, if a manufacturer of clay construction products intends to develop an EPD for clay construction products then he/she is advised to contact the national and/or European associations and use the TBE PCR.

2. Terminology

When an EPD for a construction product is being developed, a number of specific terms and definitions are frequently used. Some of these concepts are described below:

Type III Environmental Product Declaration – EPD
Type III environmental declarations are clearly described in *ISO 14025:2006 – Environmental labels and declarations – Type III environmental declarations – Principles and procedures* and are commonly known as EPDs. In short, an EPD is a standardised and LCA based tool to quantify and communicate the environmental impacts of a product or service. EPD information is articulated in modules, allowing easy organisation and expression of the environmental impacts of a product throughout its full life cycle.

Product Category Rules – PCR
PCR is a technical document that establishes specific guidelines and rules for developing type III EPDs for one or more product categories. The European standard EN 15804:2012 + A2:2019 defines the core rules for the product category of construction products. It also provides a structure to ensure that all EPDs of construction products and/or services are developed in a harmonised way.

Life cycle inventory analysis - LCI
Phase of the life cycle assessment involving the inventory being compilation and quantification of inputs and outputs for a product throughout its life cycle (ISO 14040).

Life cycle impact assessment - LCIA
Phase of LCA aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (ISO 14040).

Functional or declared unit
Quantified performance of a product system for use as a reference unit (ISO 14040).

System boundary
Set of criteria specifying which unit processes are part of a product system (ISO 14040).

Impact category
Class representing environmental issues of concern to which life cycle inventory analysis results may be assigned (ISO 14040).

Impact category indicator
Quantifiable representation of an impact category (ISO 14040).

Scenario
Collection of assumptions and information concerning an expected sequence of possible future events (EN 15804, 2019).

Waste
Substance or object which the holder discards or intends or is required to discard (EN 15804, 2019).

Reference Service Life
Service life of a construction product which is known to be expected under a particular set, i.e. a reference set, of in-use conditions and which may form the basis of estimating the service life under other in-use conditions (EN 15804, 2019).

Program operator
Body or bodies that conduct a type III environmental declaration program. Note: a program operator can be a company or a group of companies, industrial sector or trade association, public authorities or agencies or an independent scientific body or other organisation (EN 15804, 2019).

3. Basic principles

The objective of the TBE PCR is to develop common rules that should be used across Europe for developing EPDs for construction clay products. As referred in Chapter 1, the TBE PCR is based on EN 15804:2012 + A2:2019 and the EPD must have a mandatory cradle-to-grave LCA approach. The basic principles for performing an LCA study for clay construction products are described in this Chapter.

→ **The TBE PCR has been developed on the basis of EN 15804. Based on the TBE PCR, EPDs must have a mandatory cradle-to-grave LCA approach. This way it is possible to assess the potential environmental impacts of clay construction products across all life cycle stages, including raw materials, transport, manufacturing, use and end-of-life.**

→ **Cradle-to-grave EPDs assess the whole life cycle of products and could then comply with Basic Work Requirement 7 (BWR7) for construction works of the Construction Products Regulation (CPR) if EPDs become a way to implement the BWR7.**

The TBE PCR is valid for all clay product groups that are listed below:

1. Clay roof tiles and fittings;
2. Protected clay masonry units and accessories;
3. Unprotected clay masonry units and accessories;
4. Clay claddings;
5. Clay pavers and accessory clay pavers;
6. Clay blocks for construction of floor and roof systems;
7. Clay blocks for chimney;
8. Clay blocks for lintels;
9. Ceramic roof boarding sarking (unit used for the supporting structure of roof tiles, manufactured predominantly from clay or other argillaceous materials with or without sand, or other additives fired at a sufficiently high temperature to achieve a ceramic bond).
10. Clay pipes and fittings

The LCA-based information in an EPD of a clay construction product shall cover all life cycle stages of the product as indicated below and in Figure 2.

1. **Product** (Modules A1-A3): corresponds to the production of clay construction products, including all the upstream processes of the product stage.
2. **Construction process** (Modules A4 and A5): transport to the building site and installation in the building.
3. **Use** (Modules B1-B7): it corresponds to the use of clay construction products in the building, as well as maintenance, repair, replacement, refurbishment. It also includes operation- al energy and water use in the building during the product use.
4. **End-of-life** (Modules C1-C4): this stage comprises all the actions and processes related to the demolition, transport, waste processing and disposal.
5. **Module D**: this module includes the environmental benefits of reuse and recycling potential after the end of life stage.

→ **In addition to the declaration of the mandatory modules (A, C, D), TBE strongly recommends also the declaration of module B. Module B is the use stage and is key to the sector since ceramic construction products require little maintenance and replacements.**

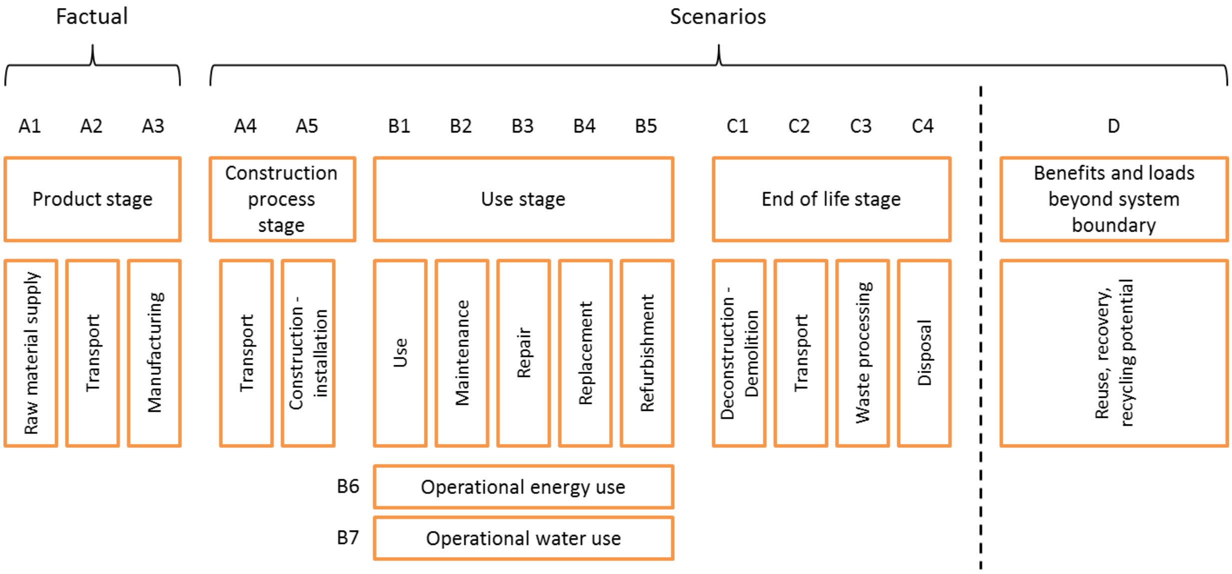

Figure 2 – Overview of the different information modules according to EN 15804

Reference service life (RSL)
RSL information to be declared in an EPD covering the use stage shall be provided by the manufacturer. Taking into account the long reference service life of the clay product (150 years), the reference study period for the building may be shorter than this period. The residual value of the clay products should be taken into account at the building level if the study period is shorter than 150 years.

→ **For clay construction products, the RSL is 150 years. Studies have shown that clay construction products stand out with their high durability and prevail with no maintenance and a life span of 150 years and more.**

Functional or declared unit
TBE recommends to use the declared unit. The declared unit of a construction clay product defines the way in which the identified functions or performance characteristics of the construction clay product are quantified. The primary purpose of the functional unit is to provide a reference by which material flows (input and output data) of construction clay product's LCA results and any other information are normalized to produce data expressed on a common basis.

→ **The declared unit is defined as: 1 tonne of clay product with an expected average reference service life of 150 years. Other units are allowed (e.g. m^2 or m^3) only if conversion factors are included in the EPD in order to make the translation towards 1 tonne in a transparent way. For possible conversion factors we refer to the Annex. The weight density (kg/m^3) should be specified in the EPD. If functional unit is being used, the intended use and the main technical properties of the clay product will have to be described in the EPD.**

Environmental impact assessment
The impact assessment shall be carried out for the following mandatory parameters describing environmental impacts, resource use, waste categories and output flows (see Table 3, 4, 6 and 7 in the PCR):

Table 3 — Core environmental impact indicators

Impact category	**Indicator**	**Unit (expressed per functional unit or per declared unit)**
Climate change – total [a]	Global Warming Potential total (GWP-total)	kg CO_2 eq.
Climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO_2 eq.
Climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO_2 eq.
Climate change - land use and land use change [b]	Global Warming Potential land use and land use change (GWP-luluc)	kg CO_2 eq.
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq.
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H^+ eq.

Eutrophication aquatic freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg PO_4 eq.
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching marine end compartment (EP-marine)	kg N eq.
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP);	kg NMVOC eq.
Depletion of abiotic resources - minerals and metals [c d]	Abiotic depletion potential for non- fossil resources (ADP-minerals & metals)	kg Sb eq.
Depletion of abiotic resources - fossil fuels [c]	Abiotic depletion for fossil resources potential (ADP-fossil)	MJ, net calorific value
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m^3 world eq. deprived

[a] The total global warming potential (GWP-total) is the sum (see C.2) of

— GWP-fossil

— GWP-biogenic

— GWP-luluc

[b] It is permitted to omit GWP-luluc as separate information if its contribution is < 5 % of GWP-total over the declared modules excluding module D.

[c] The abiotic depletion potential is calculated and declared in two different indicators:

— ADP-minerals & metals include all non-renewable, abiotic material resources (i.e. excepting fossil resources);

— ADP-fossil include all fossil resources and includes uranium.

[d] ultimate reserve model of the ADP-minerals & metals model

Table 4 — Additional environmental impact indicators

Impact category	Indicator	**Unit** (expressed per functional unit or per declared unit)
Particulate Matter emissions	Potential incidence of disease due to PM emissions (PM)	Disease incidence
Ionizing radiation, human health	Potential Human exposure efficiency relative to U235 (IRP)	kBq U235 eq.
Eco-toxicity (freshwater)	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	CTUe
Human toxicity, cancer effects	Potential Comparative Toxic Unit for humans (HTP-c)	CTUh
Human toxicity, non-	Potential Comparative Toxic Unit for humans	CTUh

cancer effects	(HTP-nc)	
Land use related impacts/ Soil quality	Potential soil quality index (SQP)	dimensionless

Table A2 6 A2 — Parameters describing resource use

Para mete r	**Unit(expressed per functional unit or per declared unit)**
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ, net calorific value
Use of renewable primary energy resources used as raw materials	MJ, net calorific value
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ, net calorific value
Use of non-renewable primary energy resources used as raw materials	MJ, net calorific value
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value
Use of secondary material	kg
Use of renewable secondary fuels	MJ, net calorific value
Use of non-renewable secondary fuels	MJ, net calorific value
Net use of fresh water	m^3

NOTE In order to identify the input part of renewable/non-renewable primary energy used as an energy carrier and not used as raw materials, the A2 indicator A2 "use of renewable/non-renewable primary energy excluding renewable/non-renewable primary energy resources used as raw materials" is considered and can be calculated as the difference between the total input of primary energy and the input of energy resources used as raw materials.

Table A2 7 A2 — Other environmental information describing waste categories

Parameter	**Unit(expressed per functional unit or per declared unit)**
Hazardous waste disposed	kg
Non-hazardous waste disposed	kg
Radioactive waste disposed	kg

→ **TBE strongly recommends to declare 'all' additional environmental impact categories in order to complete the environmental profile of the building materials. It would allow to use the EPD in every Member States.**

→ **In any case, we need to calculate both core and additional indicators.**

4. Data collection

The objective of this Chapter of the TBE guidance document is to provide guidelines on how to collect input and output data and to illustrate the nature of the information that can be collected.

In order to develop an EPD of a clay construction product, the manufacturer shall collect input and output data from its production plant and ideally insert it into a LCA software. There are several soft-wares to support LCA activities. Such softwares (SimaPro, Gabi, etc) allow LCA practitioners to quickly compile and assess the environmental impacts of products, processes or services based on a cradle-to-grave approach and its material's database is very extensive.

A1 Raw materials supply phase

For this module, the manufacturer shall collect the data regarding the extraction of clay and sand. Normally, the manufacturer only possesses information about the quantity of primary raw materials (e.g. clay and sand extracted), water and ancillary materials (colorants, pigments, glazes, englobes, etc). The producer shall collect this data that will be needed for the LCA modelling process. In this case, generic data can be used from the LCA software for this phase.

A2 Transport phase

In the A2 transport phase, the manufacturer of clay construction products shall collect data concerning the transport of raw materials (clay and sand) from the quarry to the manufacturing plant. The manufacturer shall compile information regarding:

1. The distance from the clay quarry to the plant (km);
2. Fuel type consumption of vehicle or vehicle type used for transport;
3. The truck capacity (tonnes);
4. Load (tonnes);
5. The return (empty or full).

A3 Manufacturing phase

In the A3 manufacturing phase, the producer of clay construction products shall collect data regarding the manufacturing of clay construction products.

The producer shall compile the following input data:

- √ **Raw materials**
- √ **Transport**
- √ **Electricity consumption**
- √ **Water use**
- √ **Fuel consumption for the operation of the kiln (e.g. natural gas, oil, etc)**
- √ **Ancillary materials**
- √ **Packaging products (e.g. wooden pallets, cardboard, plastic film)**

The manufacturer shall also collect the following output data:

- √ **Emissions to air**
- √ **Emissions to water**
- √ **Emissions to soil**
- √ **Waste**
- √ **Packaging waste**
- √ **Other emissions**
- √ **Co-products**
- √ **Final clay construction product**

A summary of all life cycle stages, for various clay construction products, with all modules and flows can be found below in Figure 3.

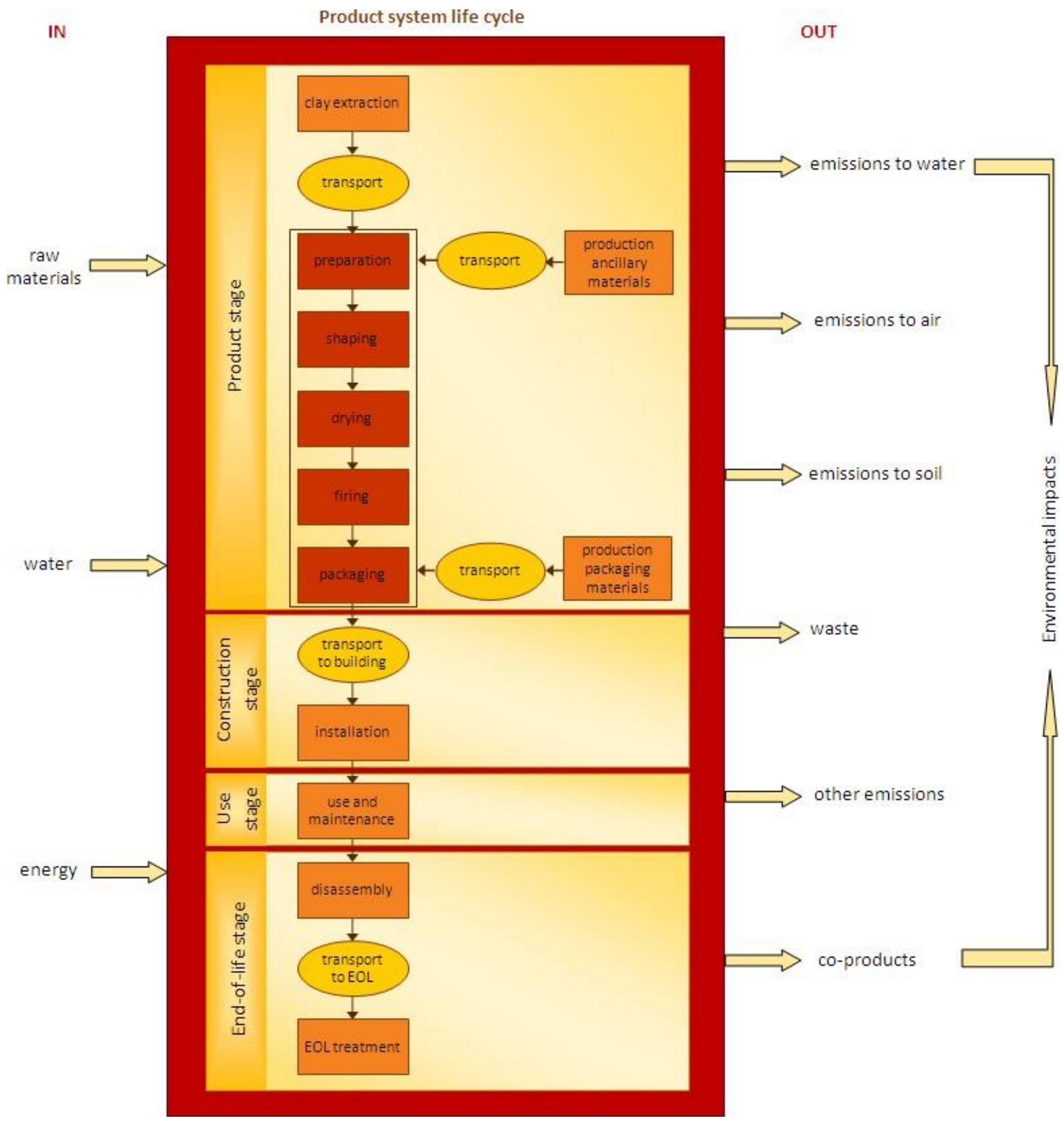

Figure 3 – System boundaries and input and output flow for the LCA of clay construction products from cradle-to-grave

5. Default scenarios

In case the manufacturer does not possess the specific data for the construction process, use and end-of-life stages (Modules A4-A5, B and C, respectively), the TBE PCR provides recommendations that will help calculating the environmental impacts of these stages. These suggestions have been compiled and are depicted in the next sections of this guidance document.

5.1 Module A4 – transport of the clay construction product from the production gate to the building site

Below is presented the methodology and example for the module A4.

The average transport distance to the customer for a product from a plant should be defined according to the methodology described in the table below if data is available.

If no specific transport distances are available, default values from national systems defined in the Table here below.

For a sectorial EPD, it is possible to provide the mean value of a representative factory. It is also possible to provide the mean value of several plants. This scenario only applies to the domestic market.

→ **If no specific transport distances are available, default values from national systems can be used as defined above.**

→ **These default values were obtained through: (1) internal national industry assessment; (2) national regulations; (3) national research studies or (4) EPD data collection.**

5.2 Module A5 – installation of clay construction product into the building

The environmental impact related to the storage of clay construction products at the construction site is considered negligible. For the treatment of packaging waste, either country specific scenarios or a European average scenario can be used. For packaging materials, the European scenario for the end of life of the package can be used as described here below if national scenarios are available. These scenarios are also applicable for the packaging waste that is generated at product stage level.

Ceramic building products
In general terms, installation of ceramic products at the building site is mainly manually and it re- quires little or negligible use of energy or water. Storage of clay products at the building site requires no special care apart from normal good health and safety site practice. The nature of the material does not create significant issues when cutting and shaping which do not produce hazardous waste. The unused products deriving from these operations can be recycled within the building site. When this is not possible, it should be counted as construction waste and the total amount shall be reported. Moreover, the default transport scenarios for the packaging waste together with the scenarios for

waste disposal should be used in the module A5. These scenarios are presented in the table here below.

5.3 Module B – use stage

Clay construction products do not generate environmental impacts during the use phase. Furthermore, construction products require no maintenance, repair, replacement, refurbishment and operational energy and water use.

→ **In general, Modules B1, B2, B3, B4, B5, B6 and B7 do not generate relevant environmental impacts and therefore they can be neglected.**

5.4 Module C1 - deconstruction, demolition stage

Both reuse and recycling are possible for construction clay products.

→ **In general, the environmental impacts generated in the module C1 are very low and hence can be ignored.**

5.5 Module C2 – transport to waste processing

As a general approach, data regarding the transportation distances of the waste are collected for each LCA onsite. However, if this information is not available the distances illustrated in the table here below can be used for clay construction product EPD development purposes.

5.6 Module C3 - waste processing for reuse, recovery and/or recycling

As a general approach, national scenarios for the end-of-life (EOL) stage should be used, if no specific data is available. However, if national EOL scenarios are also not available, it is proposed to use the European default EOL scenarios, which are presented in the table below.

5.7 Module C4 - disposal

As a general approach, national scenarios for EOL stage should be used, if no other data is available. However, if this information is not available, it is proposed to use European default EOL scenario, presented in the table below.

Table: Information modules and corresponding processes and flows

*All the modules are included, but the processes and flows do not represent an exhaustive list, being meant as orientative.

Life cycle stages	Information modules and the processes and flows corresponding to their boundaries* as per EN15804	Additional consideration for a construction clay product
A1-A3 - Product Stage	**A1, raw material extraction and processing, processing of secondary material input (e.g. recycling processes)** • A1 Extraction and processing of raw materials (e.g. mining processes – clay, sand, loam, auxiliary materials, etc.) • A1 Reuse of products or materials from a previous product system; • A1 Processing of secondary materials used as input for manufacturing the product, but not including those processes that are part of the waste processing in the previous product system; • A1 Generation of electricity, steam and heat from primary energy resources, also including their extraction, refining and transport; • A1 Energy recovery and other recovery processes from secondary fuels, but not including those processes that are part of waste processing in the previous product system; • A1-A3 processing up to the end-of-waste state or disposal of final residues including any packaging not leaving the factory gate with the product.	
	A2, transport to the manufacturer • A2 Transportation of raw materials and auxiliary materials up to the factory gate / production site and internal transport; • A1-A3 processing up to the end-of-waste state or disposal of final residues including any packaging not leaving the factory gate with the product.	
	A3, manufacturing • A3 Production of ancillary materials or pre-products;	

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A3 Manufacturing of products and co-products;
A3 Manufacturing of Packaging;
A1-A3 processing up to the end-of-waste state or disposal of final residues including any packaging not leaving the factory gate with the product.

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<tr>
<td>A4-A5 - Construction process stage</td>
<td>
A4, transportation of the clay product from manufacturer to the building site

A4 Transportation from the production gate to the construction site;
A4-A5 Storage of products, including the provision of heating, cooling, humidity control, etc.;
A4-A5 wastage of construction products (additional production processes to compensate for the loss of wastage of products);
A4-A5 waste processing of the waste from product packaging and product wastage during the construction processes up to the end-of-waste state or disposal of final residues;

In module A4, Table 7 of EN 15804 will be provided as additional technical information to specify the transport scenarios used or to support development of the scenarios at the construction site level
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A4, transportation of the clay product from manufacturer to the building site:

Below the methodology and example for module A4 is presented:

<u>Transport to the customer (Information module A4)</u>
The average transport distance to the customer for a product from a plant should be defined. If data are available, the distance to the customer can be calculated as follows:

Extract from the delivery software the quantity in term of tons delivered to each customer during a given year.
Determine the distance between the factory and every customer and explain the type of transportation.
Calculate the number of tons delivered for a certain interval, for example each 25 km, until reaching the maximum distance.
If a statistical treatment is wanted, draw a bar chart with data expressing the percentage of quantity for each interval.
Calculate the mean distance to the customer in km.

For a sector EPD, it is possible to provide the mean value of a representative factory. It is also possible to provide the mean value of several plants.

This scenario only applies to the domestic market.

Example based on the table (including a graph) below, an average transport distance of 49.5 km has been calculated (illustrative example).

Table - Illustrative example for calculation of the average transport distance
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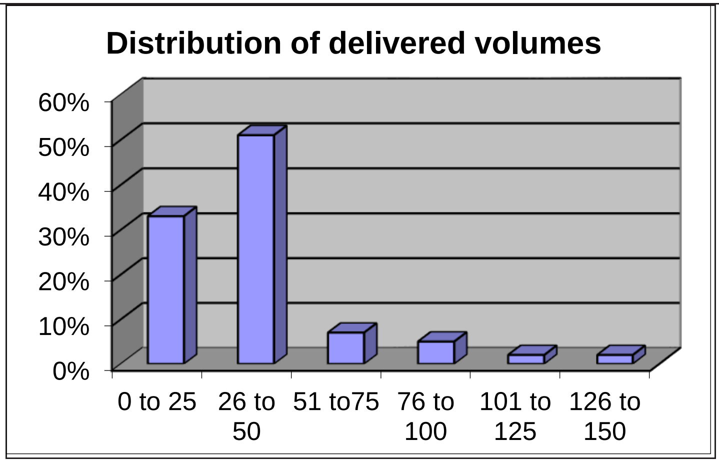

Distance in km	% of transport
0 to 25	33%
26 to 50	51%
51 to75	7%
76 to 100	5%
101 to 125	2%
126 to 150	2%

If no specific transport distances are available, default values from national systems can be used.

In addition to this methodology and example, the tables below contain information on national average transport distance.

Table: National average transportation distances

Country	Clay construction product	Distance (km)	Source and calculation method
Austria	Clay blocks	50	Internal assessment
	Facing bricks	250	
	Clay pavers	250	
	Roof tiles	150	
The Netherlands	Clay blocks	n/a	Default distance national building products according to national regulations
	Facing bricks	150	
	Clay pavers	150	
	Roof tiles	150	
Denmark	Clay blocks	50	National default distance set by the Danish Government
	Facing bricks	50	
	Clay pavers	50	
	Roof tiles	50	
UK	Clay blocks	126	Study: Carbon Footprinting of the UK Brick Industry
	Facing bricks	126	
	Clay pavers	126	
	Roof tiles	126	
France	Clay blocks	200	Source : EPD
	Facing bricks and clay slabs	150	
	Clay pavers	100	
	Roof tiles and fittings	250	

		<table><tr><td></td><td>Clay flue block for chimney</td><td>500</td><td></td></tr><tr><td rowspan="5">Switzerland</td><td>Clay blocks</td><td>50</td><td rowspan="5">Internal assessment</td></tr><tr><td>Facing bricks</td><td>50</td></tr><tr><td>Clay pavers</td><td>50</td></tr><tr><td>Roof tiles</td><td>70</td></tr><tr><td rowspan="3">Belgium</td><td>Clay blocks</td><td>72</td><td rowspan="3">Source : EPD</td></tr><tr><td>Facing bricks</td><td>103</td></tr><tr><td>Roof tiles</td><td>105</td></tr><tr><td rowspan="6">Spain</td><td>Clay blocks</td><td>120</td><td rowspan="6">Internal assessment</td></tr><tr><td>Facing bricks</td><td>250</td></tr><tr><td>Clay pavers</td><td>300</td></tr><tr><td>Roof tiles</td><td>300</td></tr><tr><td>Ceramic roofing boards</td><td>120</td></tr><tr><td>Clay blocks for construction of floor and roof systems</td><td>250</td></tr></table>
	A5, installation of the clay product into the building • A4-A5 Storage of products, including the provision of heating, cooling, humidity control, etc.; • A4-A5 wastage of construction products (additional production processes to compensate for the loss of wastage of products); • A4-A5 waste processing of the waste from product packaging and product wastage during the construction processes up to the end-of-waste state or disposal of final residues; • A5 Installation of the product into the building including manufacture and transportation of ancillary materials and any energy or water required for installation or operation of the	***A5, installation of the clay product into the building:*** *The following scenarios for Module A5 can apply as default scenarios for clay construction products:* ***General*** *With the exception of the loss of materials (construction waste) the environmental impacts of the construction phase are building specific rather than product specific. Environmental information regarding building site activities (e.g. equipment for the construction site, scaffolding, use of energy and water for handling or warehousing operations etc) should be considered within the overall environmental impact of the construction process and not*

	construction site. It also includes on-site operations to the product. *In module A5, Table 8 of EN 15804 will be provided as additional technical information to specify the construction clay product's installation scenarios describing the product's installation at the level of building.*	*addressed as part of the environmental impact of the product. Therefore these aspects are usually not declared, or declared as 'not relevant' in a product EPD.* *Impacts from the construction activities could mainly derive from:* • *Use of raw materials or ancillary materials during construction operations;* • *Fuel burning and energy use during internal transportation or; handling operations and equipment energy use;* • *Water use and waste water production (water run-off) due to the construction activities;* • *Direct emissions to air, soil and water;* • *Waste production.* ***Ceramic building products*** *If relevant information is available for a specific product, regarding the construction phase, it shall be reported. In general terms, installation of ceramic products at the building site is mainly manually and it requires little or negligible use of energy or water. Storage of clay products at the building site requires no special care apart from normal good health and safety site practice. The nature of the material does not create significant issues when cutting and shaping which do not produce hazardous waste. The unused products deriving from these operations can be recycled within the building site. When this is not possible, it should be counted as construction waste and the total amount shall be reported.* *If no specific transport distances for waste packaging are available, default values from national systems can be used.* *Table - Transportation distance to final destination for the categories wood, plastic and paper waste (Debacker W. et al., 2012)*

Type of waste	Transportation distance
Wood waste	From building site to container company or waste processor
	38 km
	From container company to final destination
	Wood pallets return to the factory gate

<table>
<tr><td rowspan="8"></td><td rowspan="8"></td><td rowspan="4">Plastic</td><td>From building site to container company or waste processor</td></tr>
<tr><td>35 km</td></tr>
<tr><td>From container company to final destination</td></tr>
<tr><td>37 km</td></tr>
<tr><td rowspan="4">Paper and cardboard</td><td>From building site to container company or waste processor</td></tr>
<tr><td>48 km</td></tr>
<tr><td>From container company to final destination</td></tr>
<tr><td>37 km</td></tr>
<tr><td rowspan="3">B1-B7 - Use stage</td><td>B1, use or application of the installed clay product
• B1 Use of the installed product in terms of any emissions to the environment (not covered by B2-B7)</td><td colspan="2"></td></tr>
<tr><td>B2, maintenance
• B2 The production and transportation of any component and ancillary products used for maintenance, including cleaning;
• B2 Transportation of any waste from maintenance processes or from maintenance related transportation;
• B2 The end-of-life processes of any waste from transportation and the maintenance process, including any part of the component and ancillary materials removed.</td><td colspan="2">B2, maintenance:
Ceramic building products require no maintenance during the use phase and therefore no impacts are declared during the maintenance phase.</td></tr>
<tr><td>B3, repair
• B3 Repair process of the repaired part of a component including:
1) the production of the repaired part of a component and of ancillary materials;
2) use of related energy and water;
3) the production and transport aspects and impacts of any wastage of materials during the repair process;</td><td colspan="2">B3, repair:
Basically ceramic building products require no repairing during the use phase and therefore no impacts should be declared in module B3.</td></tr>
</table>

	• B3 The transportation of the repaired part of component and ancillary materials, including production aspects and impacts of any waste of materials during the repair related transportation; • B3 The-end-of-life processes of any waste from transportation and the repair process, including the part of the component and ancillary materials removed.	
	B4, replacement • B4 The production of the components and of ancillary materials used for replacement; • B4 Replacement process, including related water and energy use and the production aspects and impacts of any waste of materials used during the replacement process; • B4 The transportation of the component and ancillary materials used for replacement, including production aspects and impacts of any losses of material damaged during transportation; • B4 The end-of-life processes of any losses suffered transportation and the replacement process, including the components and ancillary materials removed.	***B4, replacement:*** *Ceramic building products require no replacing during the use phase and therefore no impacts should be declared in module B4.*
	B5, refurbishment • B5 The production of the components and ancillary materials used for refurbishment; • B5 Refurbishment process and related water and energy use including production aspects and impacts of any waste of materials used during the refurbishment process; • B5 The transportation of the component and ancillary materials used for refurbishment, including production aspects and impacts of any losses during transportation; • B5 The end-of-life processes of any losses suffered during transportation and the refurbishment process, including the components and ancillary materials removed.	***B5, refurbishment:*** *Ceramic building products require no refurbishment during the use phase and therefore no impacts should be declared in module B5.*
	B6, operational energy use (e.g. operation of heating system and other building related installed services);	***B6, operational energy use:*** *This module is not relevant for construction clay products.*
	B7, operational water use	***B7, operational water use:***

		This module is not relevant for construction clay products.
C1-C4 – End-of-life stage	**C1, de-construction, demolition** • C1 deconstruction, including dismantling or demolition, of the product from the building, including initial on-site sorting of the materials;	***C1, de-construction, demolition:*** *Taking into account the long reference service life of the clay product (150 years), the reference study period for the building may be shorter than this period. Note: the residual value avoided environmental impact of the clay products should be taken into account on the building level in an additional scenario in EN 15978 when the structure or part of a building remains if the study period is shorter than 150 years.*
	C2, transport to waste processing • C2 transportation of the discarded product as part of the waste processing, e.g. to a recycling site and transportation of waste e.g. to final disposal;	***C2, transport to waste processing:*** *As a general approach, the transportation distances of the waste are available in national scenarios. If such a scenario is not available, the table below can be used. for clay construction product EPD development purposes. The data concerning the transportation of construction and demolition waste from building site to its final destination are taken from ASRO (2008).* *Table: Distance to final destination for the inert waste category with EPD information module* **Transportation distance** | **Module** *From building site to container company or waste processor* *39 km* | *module C for 100% clay products* *From container company to final destination* *23 km* | *module C for 5% clay products, module D for 95% clay products* *In accordance with EN 15804:2012, waste must be taken into account in module C until the end-of-waste boundary is reached. For the part of clay products that is recycled, this boundary lies at the recycling plant (crushing, etc.). For the part that is not recycled, the entire trajectory to the landfill should be taken into account.*
	C3, waste processing for reuse, recovery and/or recycling • C3 waste processing e.g. collection of waste fractions from the deconstruction and waste processing of material flows intended for reuse, recycling and energy recovery. Waste processing shall be modelled and the elementary flows shall be included in the	***C3, waste processing for reuse, recovery and/or recycling:*** *As a general approach, national scenarios for the end-of-life (EOL) stage should be used, if no other data is available. However, if this information is not available, it is proposed to use the European default EOL scenario available, presented in the Table below.*

Table: Distance to final destination for the inert waste category with EPD information module

Transportation distance	*Module*
From building site to container company or waste processor	
39 km	*module C for 100% clay products*
From container company to final destination	
23 km	*module C for 5% clay products, module D for 95% clay products*

		inventory. Materials for energy recovery are identified based on the efficiency of energy recovery with a rate higher than 60 % without prejudice to existing legislation. Materials from which energy is recovered with an efficiency rate below 60% are not considered materials for energy recovery.

Table: European EOL scenarios for clay products

EOL scenario	Proportion (%)
Recycling and re-use	70
Landfilling	30

The table below provides an example of EOL scenario based on national statistics used in Denmark.

Table: EOL example for clay products used in Denmark

EOL scenario	Proportion (%)
Recycling and re-use	99
Landfilling	1

Source: Waste statistics of Denmark, 2010 (Minister of Environment, based on the 2007 and 2008 data)

The table below provides an example of EOL national scenario for ceramic products used in the Netherlands.

Table: EOL example for clay products used in the Netherlands

EOL scenario	Proportion (%)
Recycling and re-use	99
Landfilling	1

The table below provides an example of EOL scenario based on national statistics used in Germany.

Source: http://www.kreislaufwirtschaft-bau.de/Arge/KWB_8.pdf (2010 report) http://www.kreislaufwirtschaft-bau.de/Arge/Summary.pdf (English summary)

Table: EOL example for clay products used in Germany

EOL scenario	***Proportion (%)***
Recycling and re-use	*95.9*
Landfilling	*4.1*

Table: EOL example for clay products used in France

Re-use	*Recycling*	*Inert landfill*
20%	*75%*	*5%*

C4, disposal

- C4 waste disposal including physical pre-treatment and management of the disposal site.

4, disposal: *As a general approach, national scenarios for the end-of-life (EOL) stage should be used, if no other data is available. However, if this information is not available, it is proposed to use European default EOL scenario, presented in the Table presented in C3. Examples of national scenarios are presented in the tables under C3.*

MODULE D

D, Benefits and loads beyond the product system boundary, information module

- D, reuse, recovery and/or recycling potentials, expressed as net impacts and benefits.

D, Benefits and loads beyond the product system boundary
For the calculation procedures and examples, we refer to the section below.

5.8 Module D

Module D declares the "design for reuse, recycling and recovery" concept for buildings by indicating the potential benefits of avoided future use of primary materials and fuels while taking into account the loads associated with the recycling and recovery processes beyond the system boundary.

In the TBE PCR for clay construction products, some specific examples for calculating Module D are given (see explanations after Annex D):

1. Demolished masonry units that can be crushed (recycling process) and used as secondary raw material in the production of masonry units;
2. Demolition bricks that can be recycled towards raw material for another application: roadwork and concrete aggregates;
3. Roof tiles that are reused after the deconstruction stage.

Please mind that the percentages given in the examples below are based on real examples but can be different for individual manufacturers. The percentages and amounts are only given to help with understanding how the calculations works.

The end of life formulae for module D given in Annex D of EN 15804:2012+A2:2019 are applied in these examples. The formulae are informative and in case of different interpretations between Annex D of the standard and the main text of the standard, it is the text of the standard which prevails on the information in Annex D of the standard. The formula given to calculate the **specific loads and benefits beyond the system boundary per unit of output for module D per output flow leaving the system boundary** ($e_{module\ D}$) is as follows:

$$\boldsymbol{e_{module\ D} = e_{module\ D1} + e_{module\ D2} + e_{module\ D3} + e_{module\ D4}}$$

Where,

$e_{module\ D1}$	=	specific loads and benefits related to the export of secondary materials
$e_{module\ D2}$	=	specific loads and benefits related to the export of secondary fuels
$e_{module\ D3}$	=	specific loads and benefits related to the export of energy as a result of waste incineration (for $R_1 < 60\%$ and $R_1 > 60\%$),
$e_{module\ D4}$	=	specific loads and benefits related to the export of energy as a result of landfilling (e.g. conversion of landfill gas to electricity).

In all examples of this annex there are only loads and benefits related to the export of secondary materials, therefore the formula above can be reduced to: $\boldsymbol{e_{module\ D} = e_{module\ D1}}$, where:

$$\boldsymbol{e_{module\ D1} = \sum_i \left(M_{MR\ out}|_i - M_{MR\ in}|_i\right) \cdot \left(E_{MR\ after\ EoWout}\Big|_i - E_{VMSub\ out}|_i \cdot \frac{Q_{R\ out}}{Q_{Sub}}\Big|_i\right)}$$

Where,

$M_{MR\ out}$	=	amount of material exiting the system that will be recovered (recycled and reused) in a subsequent system (i.e. recovery/recycling rate at end-of-life)
$M_{MR\ in}$	=	amount of input to the product system that has been recovered (recycled and reused) from a previous system (determined at the system boundary) (i.e. recycled content)
$E_{MR\ after\ EoWout}$	=	specific emissions and resources consumed per unit of analysis arising from material recovery (recycling and reusing) processes of a subsequent system after the end-of-waste state
$E_{VMSub\ out}$	=	specific emissions and resources consumed per unit of analysis arising from acquisition and pre-processing of the primary material, or average input material if primary material is not used, from the cradle to the point of functional equivalence where it would substitute secondary material that would be used in a subsequent system
$\frac{Q_{R\ out}}{Q_{Sub}}$	=	quality ratio between outgoing recovered material (recycled and reused) and the substituted material

In the following examples $e_{module\ D}$ is calculated with only the formula above to calculate $e_{module\ D1}$, as in the examples only the main ceramic product is considered. In case of a full LCA in which also packaging materials and fixations are considered or a ceramic construction product that is combined with other materials, such as insulation, other parts of the $e_{module\ D}$ formula have to be calculated too if applicable. In addition, the examples are taken from the current practice, in case of future developments where for instance the ceramic waste could be incinerated than the respective part of the $e_{module\ D}$ formula should also be applied.

Insight into the difference between the way of calculating module D now compared to the previous version of this PCR

In the EN 15804+A1 standard, that was the basis for the previous version of the PCR for TBE, there was no formula indicated to model module D. However, for more clarity of how the instructions of the text were to be applied, the first version of the PCR for TBE included a formula developed and given as an example of how module D can be calculated. The respective formula is presented below:

Net benefit$_{\text{impact indicator}}$ = **RR * (Ev' – Er') – RC* (Ev – Er)**

Where,

RC = recycled content (should be considered per kg, to be consistent with the new approach) > equivalent with $M_{MR\ in}$ of the new formula

RR = Recycling rate end-of-life (should be considered per kg, to be consistent with the new approach) > equivalent with $M_{MR\ out}$ of the new formula

Ev = Impacts of material virgin production

Er = Impacts of material secondary production

Ev' = Impacts of substituted material virgin production

Er' =	Impacts of substitute material secondary production

In this context we could equate $\boldsymbol{E_{VMSub\ out}}$ with **(Ev' – Er')** and $\boldsymbol{E_{MR\ after\ EoWout}}$ with **(Ev – Er)**.

For an easier comparison of the old and new way, in a simplified version, the two approaches are compared below:

- New formula: (a-b)*(x-y) = ax-by-(ay-bx)
- Old formula: ax-by

Where,

a = $M_{MR\ out}$ in the new formula or RR in the old formula
b = $M_{MR\ in}$ in the new formula or RC in the old formula
x = $E_{VMSub\ out}$ in the new formula or (Ev' – Er') in the old formula
y = $E_{MR\ after\ EoWout}$ in the new formula or (Ev – Er) in the old formula

1. Demolished masonry units that can be crushed (recycling process) and used as secondary raw material in the production of masonry units

In this case, it is assumed that crushed masonry units coming from the demolition of the building are used as opening agent to replace primary raw materials in the manufacturing of an equivalent masonry unit.

For the production of a declared unit of 1 ton of clay bricks, a share of 10% of crushed bricks (100 kg) is used at the production stage (A1), replacing raw clay/sand.

This secondary material comes from the recycling of clay construction waste.

In fact, 1 declared unit (1 ton) of clay bricks can generate up to 75% (750 kg) of secondary material that could be used as input in a following life cycle (see Figure 4).

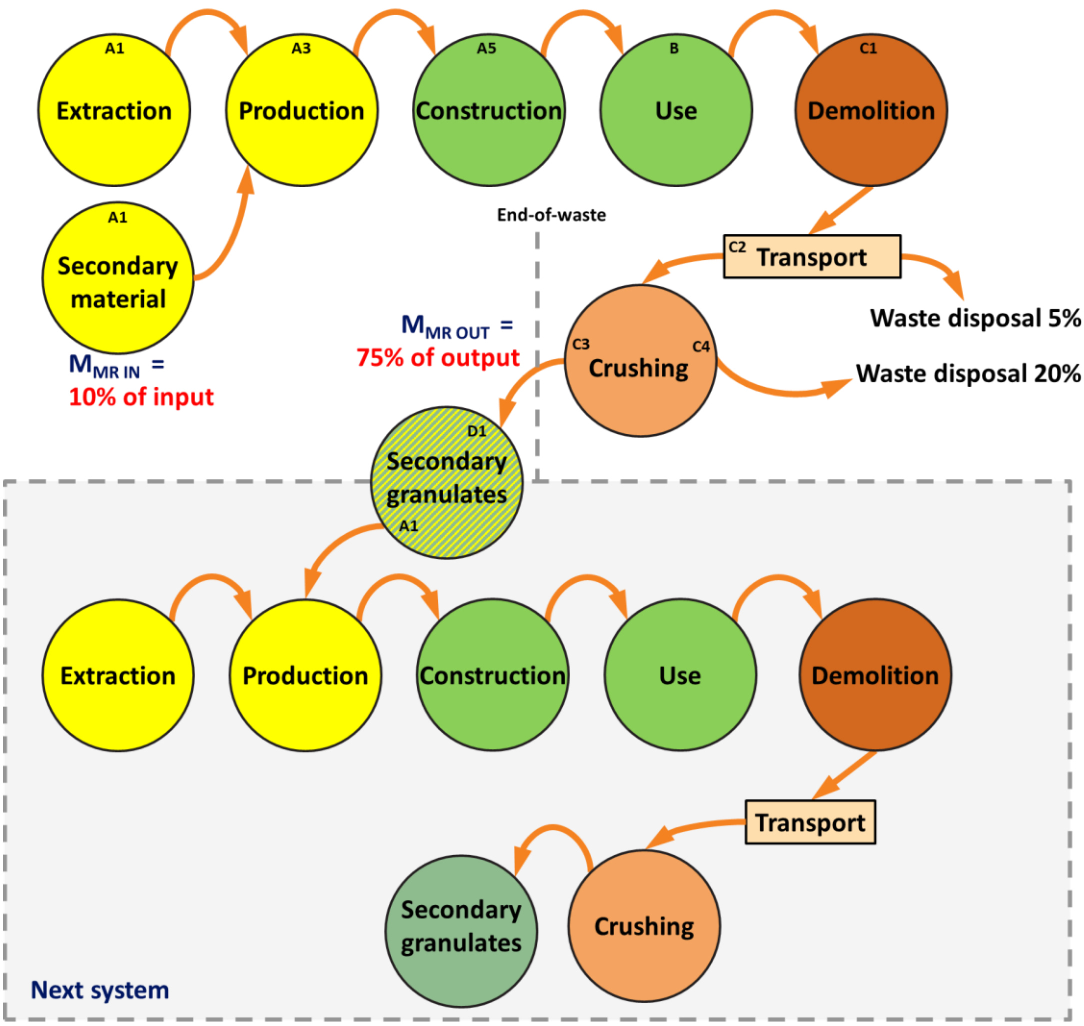

Figure 4: Visual representation of the recycling process for demolished masonry that is crushed and used as secondary raw material in the production of masonry units

Considering the environmental impact indicator Global Warming Potential (GWP), module D of example 1 can be calculated as follows:

$$e_{module\ D\ GWP} = (0.75 - 0.1) \cdot 1\ ton \cdot \left(E_{MR\ after\ EoWout\ GWP} - E_{VMSub\ out\ GWP} \cdot \frac{Q_{R\ out}}{Q_{Sub}}\right)$$

2. Demolition bricks that can be recycled towards raw material for another application: roadwork and concrete aggregates

In example 1, recycled bricks were used to substitute secondary raw materials for the production of bricks. In example 2, the used bricks are intended for other applications. Different fields of application are already technically used today. The purpose of example 2 is to show that crushed clay bricks can be used in roadwork or in the production of concrete aggregates.

<u>Example 2a:</u>
Application: roadwork

A study carried out by Mueller and Stark (2002) showed that recycled clay bricks can have a range of different applications, including embankments, fills, and roads (see Figure 5). In example 2a, after the demolition stage, the clay brick is crushed and then applied to roadwork.

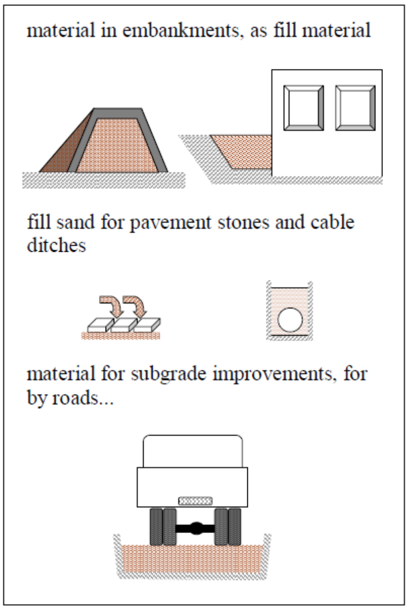

Figure 5: Examples for the application of clay masonry construction and demolition waste in unbound systems (source: Mueller and Stark, 2002)

In example 2a, a recycling rate of 95% is considered and no recycled content. For a declared unit of 1 ton of masonry unit this results in a (net) production of 950 kg of secondary granulates for roadwork (see Figure 6).

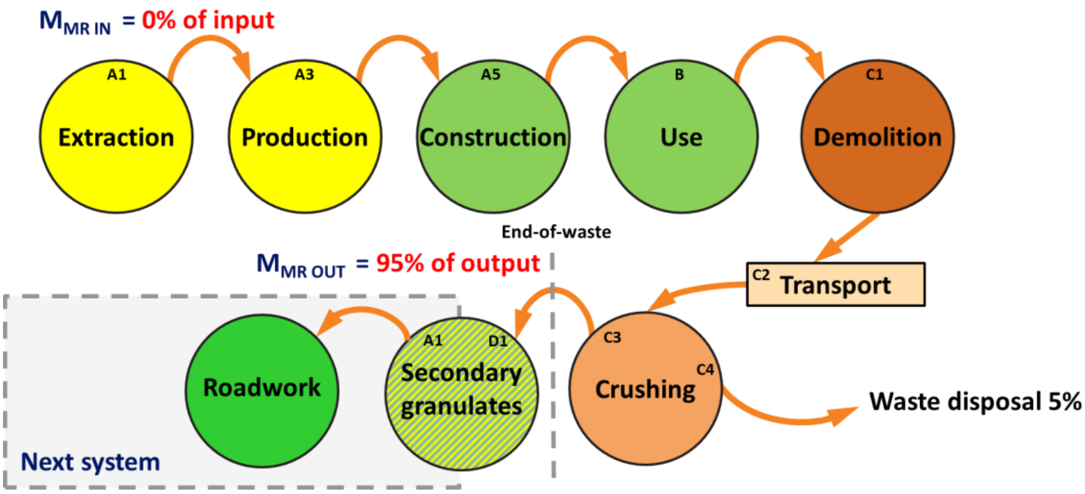

Figure 6: Demolished clay bricks which are recycled and used as raw material in road works

Example 2b
Application: concrete aggregates

In example 2b, after the demolition stage, the brick masonry is crushed and then used in the production of new concrete mixtures (Figure 6 also applies for this example but instead of 'roadwork' in the last shape of the process it would be 'new concrete'). A range of scientific studies have shown that crushed brick masonry can be used as a replacement for normal weight coarse aggregate (Kesegić et al., 2008, and Cavalline and Weggel, 2013).

In certain cases, prior to the demolition of the brick masonry wall, elements like sheetrock, acoustical tile, roof material and other interior building components are removed in order to minimize the impurities in the brick masonry aggregate (Cavalline and Weggel, 2013).

In this example 2b a recycling rate of 95% is considered and no recycled content. For a declared unit of 1 ton of masonry unit this results in a (net) production of 950 kg of secondary granulates for concrete aggregates.

Considering the environmental impact indicator Global Warming Potential (GWP), module D of Example 2a and 2b can be calculated as follows:

$$e_{module\ D\ GWP} = (0.95 - 0) \cdot 1\ ton \cdot \left(E_{MR\ after\ EoWout\ GWP} - E_{VMSub\ out\ GWP} \cdot \frac{Q_{R\ out}}{Q_{Sub}}\right)$$

3. Roof tiles that are reused after the deconstruction stage

Because of the long service life and appreciated appearance, roof tiles are often reused in practice (in this example ceramic pavers could also be used instead of roof tiles). Used roof tiles are removed during the end-of-life of a building and transported to a storage site or immediately reused in a new building. Module D indicates the potential benefits of avoided use of new produced roof tiles (i.e. $E_{VMSub\ out}$) while taking into account the loads associated with the transport and possible needed cleaning processes beyond the system boundary (i.e. $E_{MR\ after\ EoWout}$).

Example 3 considers a reuse rate of 90% of roof tiles with no recycled content. For a declared unit of 1 ton of roof tiles this results in a (net) production of 900 kg of reused roof tiles for a building (see Figure 7).

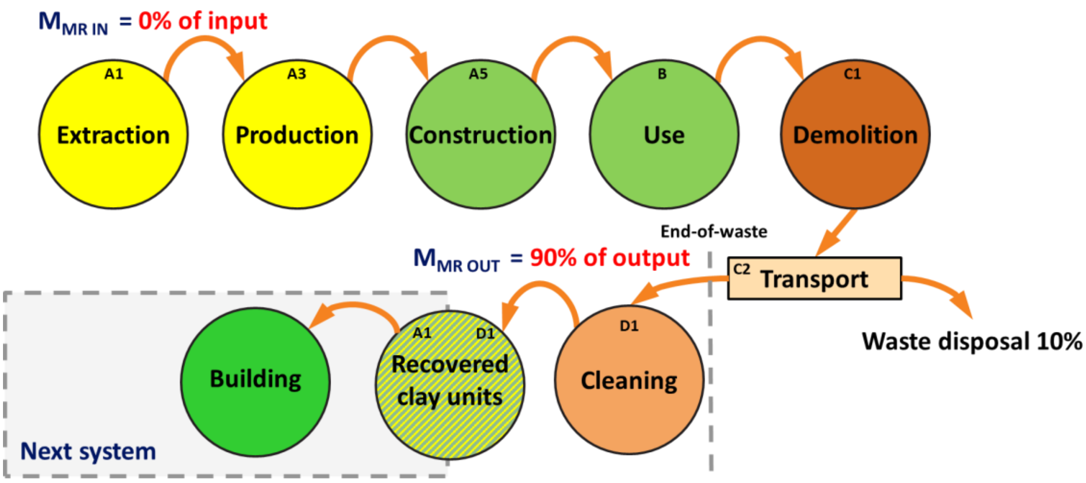

Figure 7: Reused roof tiles after the deconstruction stage

Considering the environmental impact indicator Global Warming Potential (GWP), module D of example 3 can be calculated as follows:

$$e_{module\ D\ GWP} = (0.90 - 0) \cdot 1\ ton \cdot \left(E_{MR\ after\ EoWout\ GWP} - E_{VMSub\ out\ GWP} \cdot \frac{Q_{R\ out}}{Q_{Sub}}\right)$$

6. About TBE

Tiles & Bricks Europe represents industry associations and companies from 22 European Union Member States plus Norway, Russia and Switzerland. The association promotes the interests of the clay brick and tile industry in Europe. It provides a forum for its members to exchange information on technical development, sustainable construction, climate change, resource efficiency and other emerging issues.

TBE, founded in Zurich in 1952, is a full member of Cerame-Unie, the European Ceramic Industry Association.

Our products

Clay bricks, blocks, roof tiles and pavers are durable, affordable and provide comfortable, safe and healthy homes to millions of people. They combine traditional architectural heritage with innovative and future-oriented construction methods. Clay products offer valuable solutions to save energy and reduce greenhouse gas emissions in the building sector.

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