# ENVIRONMENTAL PRODUCT DECLARATION

## IN ACCORDANCE WITH EN 15804+A2 & ISO 14025

Concrete roof tiles – Palema S-Stein and Mecklenburger

Benders Deutschland GmbH

**EPD HUB, HUB-5164**
Published on 30.01.2026, last updated on 30.01.2026, valid until 30.01.2031

Life Cycle Assessment study has been performed in accordance with the requirements of EN 15804, EPD Hub PCR version 1.2 (24 Mar 2025) and JRC characterization factors EF 3.1.

Created with One Click LCA

# GENERAL INFORMATION

## MANUFACTURER

| | |
|---|---|
| **Manufacturer** | Benders Deutschland GmbH |
| **Address** | Gewerbestrasse 10, DE-18299 Laage, Germany |
| **Contact details** | info.de@benders.se |
| **Website** | https://www.benders.se/de-de/ |

## EPD STANDARDS, SCOPE AND VERIFICATION

| | |
|---|---|
| **Program operator** | EPD Hub, hub@epdhub.com |
| **Reference standard** | EN 15804:2012+A2:2019/AC:2021 and ISO 14025 |
| **PCR** | EPD Hub Core PCR Version 1.2, 24 Mar 2025<br>EN 16757 Product Category Rules for concrete and concrete elements |
| **Sector** | Construction product |
| **Category of EPD** | Third party verified EPD |
| **Scope of the EPD** | Cradle to gate with options, A4-B1, and modules C1-C4, D |
| **EPD author** | Sofia Bender |
| **EPD verification** | Independent verification of this EPD and data, according to ISO 14025:<br>o Internal verification þ External verification |
| **EPD verifier** | Magaly Gonzalez Vazquez as an authorized verifier for EPD Hub |

This EPD is intended for business-to-business and/or business-to-consumer communication. The manufacturer has the sole ownership, liability, and responsibility for the EPD. EPDs within the same product category but from different programs may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804 and if they are not compared in a building context.

## PRODUCT

| | |
|---|---|
| **Product name** | Concrete roof tiles – Palema S-Stein and Mecklenburger |
| **Additional labels** | All forms and colors in the Palema and Mecklenburger range. Coated and natural. |
| **Product reference** | - |
| **Place(s) of raw material origin** | Germany and EU |
| **Place of production** | Laage, Germany |
| **Place(s) of installation and use** | Germany |
| **Period for data** | Calendar year 2024 |
| **Averaging in EPD** | Multiple products |
| **Variation in GWP-fossil for A1-A3 (%)** | - 8% |
| **A1-A3 Specific data (%)** | 89,9 |

## ENVIRONMENTAL DATA SUMMARY

| | |
|---|---|
| **Declared unit** | 1 ton |
| **Declared unit mass** | 1000 kg |
| **Mass of packaging** | 4,51 kg |
| **GWP-fossil, A1-A3 ($kgCO_2e$)** | 150 |
| **GWP-total, A1-A3 ($kgCO_2e$)** | 145 |
| **Secondary material, inputs (%)** | 6,03 |
| **Secondary material, outputs (%)** | 80 |
| **Total energy use, A1-A3 (kWh)** | 418 |
| **Net freshwater use, A1-A3 ($m^3$)** | 1,58 |

# PRODUCT AND MANUFACTURER

## ABOUT THE MANUFACTURER

Benders Deutschland GmbH is a part of the Benders group which is a Swedish family-owned company, that develops, produces, and markets competitive, high-quality products and services for the construction and civil engineering sectors. Benders operates in several different business areas and is one of the market-leading producers of concrete and natural stone products in the Nordic countries. Benders Deutschland GmbH is certified according to ISO 90001:2015 and ISO 14001:2015.

## PRODUCT DESCRIPTION

The products included in this study are all products produced at Benders Deutschland GmbH in Laage. Included are all forms and colors of concrete roof tiles and concrete accessories/fittings in the Palema and Mecklenburger range, coated and natural. The products have similar concrete recipes. Based on annual production volumes, a production-weighted average product is presented, representing all included product variants.

All environmental impact results in modules A1–A3 are averaged accordingly. Some of the products do not contain surface coating and may therefore exhibit approximately 8 % lower GWP values (A1–A3) compared to the declared average product.

The declared product group consists of concrete roof tiles intended for use as external roof covering for pitched roofs and wall cladding in residential and commercial buildings. All included products fulfil the same primary function of providing durable and weather-resistant protection against rain, snow, and frost, while contributing to the structural integrity and aesthetic appearance of the roof. Variations within the product group relate to tile shape, surface finish (coated or uncoated), and color, without affecting the intended functional application of the products. The declared results represent average environmental impacts for the product group.

Concrete roof tiles are manufactured from sand, water, cement, iron oxide pigments for coloring, small amounts of concrete admixture and in some cases a polymer and water-based surface treatment. Production and testing follow European standards EN 490 and EN 491, ensuring compliance with CE marking requirements. The tiles undergo controls for frost resistance, watertightness, and mechanical strength. When installed with original accessories, the roof covering is guaranteed for 30 years.

This LCA study includes the provision of all materials, transportation, energy and emission flows, and end of life processing of product. All industrial processes from raw material acquisition and pre-processing, production, product distribution and installation and end-of-life management are included. The production of capital equipment, construction activities, and infrastructure, maintenance and operation of capital equipment, personnel-related activities, energy and water use related to company management and sales activities are excluded. Further information can be found at: https://www.benders.se/de-de/

## PRODUCT RAW MATERIAL MAIN COMPOSITION

| Raw material category | Amount, mass % | Material origin |
|---|---|---|
| Metals | - | - |
| Minerals | 99,6 | Germany |
| Fossil materials | 0,4 | EU |
| Bio-based materials | - | - |

## BIOGENIC CARBON CONTENT

Product's biogenic carbon content at the factory gate.

| | |
|---|---|
| Biogenic carbon content in product, kg C | 0 |
| Biogenic carbon content in packaging, kg C | 1,57 |

## FUNCTIONAL UNIT AND SERVICE LIFE

| | |
|---|---|
| Declared unit | 1 ton |
| Mass per declared unit | 1000 kg |
| Functional unit | - |
| Reference service life | 50 years |

## SUBSTANCES, REACH - VERY HIGH CONCERN

The product does not contain any REACH SVHC substances in amounts greater than 0,1 % (1000 ppm).

# PRODUCT LIFE-CYCLE

## SYSTEM BOUNDARY

This EPD covers the life-cycle modules listed in the following table.

| Product stage | | | Assembly stage | | Use stage | | | | | | | End of life stage | | | | Beyond the system boundaries | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D | | |
| x | x | x | x | x | x | ND | ND | ND | ND | ND | ND | x | x | x | x | | x | |
| Raw materials | Transport | Manufacturing | Transport | Assembly | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | Deconstruction/ demolition | Transport | Waste processing | Disposal | Reuse | Recovery | Recycling |

*Modules not declared = ND. Modules not relevant = MNR*

## MANUFACTURING AND PACKAGING (A1-A3)

The environmental impacts considered for the product stage cover the manufacturing of raw materials used in production as well as packaging materials and other ancillary materials. Also, fuels used by machines, and handling of waste formed in the production processes at the manufacturing facilities are included in this stage. The study also considers the material losses occurring during the manufacturing processes as well as losses during electricity transmission.

A market-based approach is used in modelling the electricity mix utilized in the factory.

The concrete mixture consists of cement, locally sourced aggregates, water, iron oxide and concrete admixtures (A1). The raw materials are transported by truck from suppliers located within 6,5 and 670 km aways of the production site, minimizing transport-related impacts. (A2).

The mixture is extruded into aluminum or steel molds. Before extrusion, the molds are mechanically coated with release oil to prevent the mixture from sticking. The roof tiles are then stacked on trolleys to be hardened in a curing chamber at approximately 35°C and 90% humidity for about one day. Tiles with surface treatment are painted before and after curing. After hardening, the tiles are removed from the molds, loaded onto pallets, and packed with plastic. Material losses during production are estimated at approximately 2%, based on internal factory data (A3).

The energy used in the manufacturing process consists of district heating and electricity generated from natural gas (A3). Manufacturing waste is managed responsibly: concrete waste is recycled as filling material by local contractors approximately 20 km away (A3).

The use of green energy in manufacturing is demonstrated through contractual instruments (GOs, RECs, etc.), and its use is ensured throughout the validity period of this EPD.

## TRANSPORT AND INSTALLATION (A4-A5)

Transportation impacts occurred from final products delivery to construction site (A4) cover fuel direct exhaust emissions, environmental impacts of fuel production, as well as related infrastructure emissions.

The transport distance is defined according to the PCR. Average distance of transportation from production plant to building site is assumed as 100 km and the transportation method is assumed to be lorry. Vehicle capacity utilization volume factor is assumed to be 100 % which means full load. It may vary but as role of transportation emissions in total results is small, the variety in load is assumed to be negligible. Empty returns are not considered as it is assumed that return trips are used by the transportation company to serve the needs of other clients. Transportation does not cause losses as products are fastened properly.

Production loss at installation is assumed negligible as the products are delivered ready made from the factory. The roof tiles are installed using manpower and installation materials, such as bolts, is negligible. Environmental impacts from installation into the building include generation of waste packaging materials (A5) and release of biogenic carbon dioxide from wood pallets.

The average transport distance to the waste facility is estimated at 50 km, using a lorry as the most common mode of transport.

The wood pallet is recycled (32%), incinerated (30%) and landfilled (38%) according to EUROSTAT, https://ec.europa.eu/eurostat/databrowser/view/env_waspac__custom_8519174/default/table?lang=en.

The plastic is recycled (40%), incinerated (37%) and landfilled (23%) according to Debunking Efficient Recovery: The Performance of EU s "Incineration Facilities, 2023" https://zerowasteeurope.eu/wp-content/uploads/2023/01/Debunking-Efficient-Recovery-Full-Report-EN.docx.pdf.

## PRODUCT USE AND MAINTENANCE (B1-B7)

Carbon dioxide uptake through carbonation is a natural chemical process in which part of the $CO_2$ released during cement calcination is reabsorbed by concrete when exposed to air. This typically occurs during the product's use phase and at end-of-life. (B1)

The concrete roof tiles have an assumed reference service life of 50 years and do not require replacement within this period. The product is a passive building component and does not require energy or water during use. No maintenance, repair, or refurbishment with relevant environmental impact is required; therefore, no impacts are declared for modules B2–B7.

## PRODUCT END OF LIFE (C1-C4, D)

End-of-life treatment takes place at regional construction and demolition (C&D) waste facilities in Germany.

Concrete roof tiles are dismantled with the building and collected as a separate mineral waste fraction (100%). Demolition energy is modelled as diesel used by construction machinery. Using 10 kWh/m² (Bozdağ & Seçer, 2007)) and mass-based allocation (~1,000 kg/m²), the demolition energy attributed to the tiles is 0.01 kWh per kg of product. (C1).

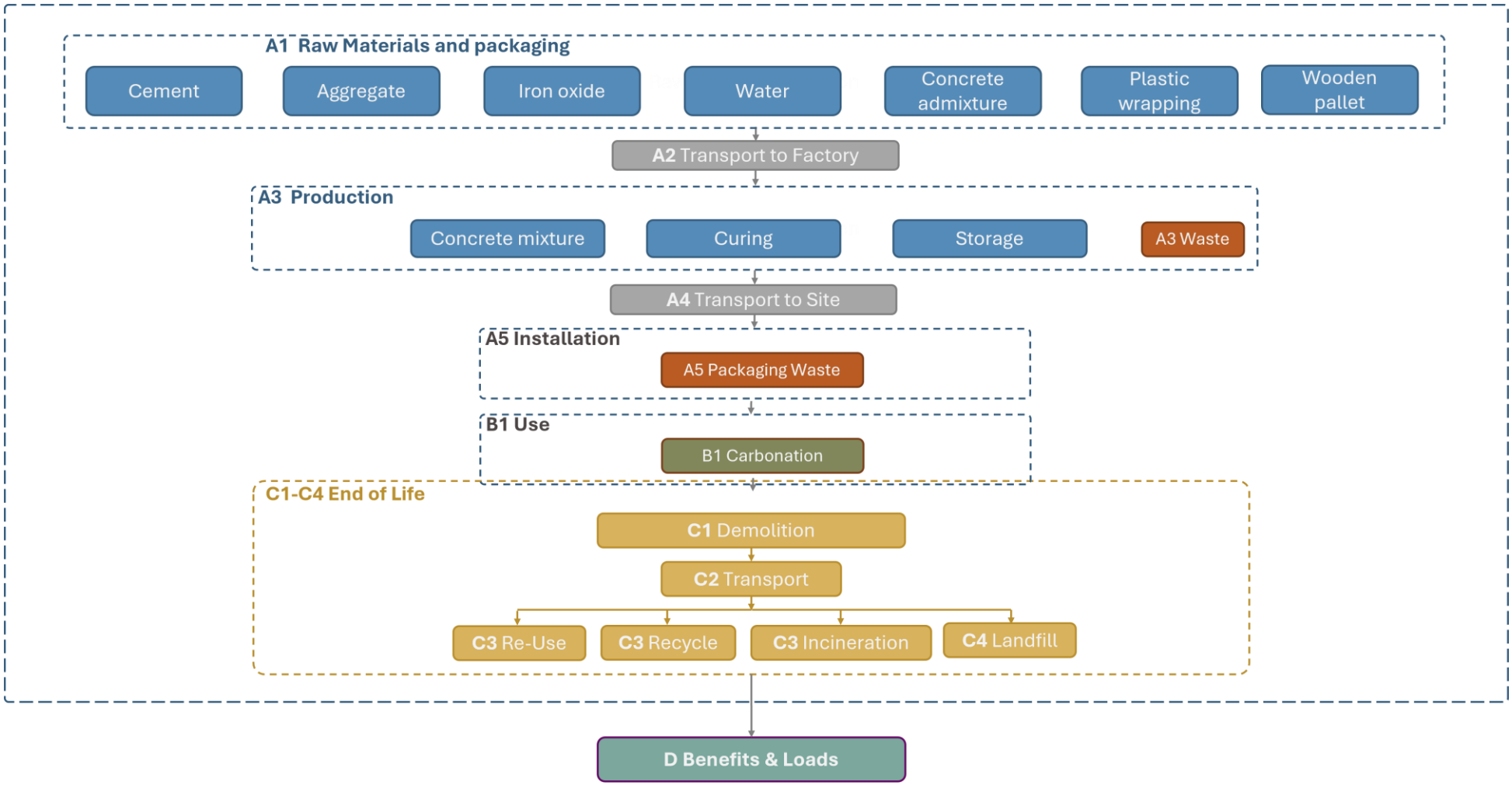
After dismantling, tiles are transported by lorry to a nearby C&D facility, assuming an average transport distance of 50 km within Germany (C2).

At the facility, the tiles are crushed and processed into secondary mineral aggregate for road and civil engineering use. An 80% recycling rate is assumed (Betoniteollisuus ry, 2020), with negligible processing losses (C3). The remaining 20% is disposed of in inert landfill (C4). These scenarios are considered representative of current German practice.

Module D accounts for the potential benefits of material recycling after completion of modules C1–C4. Credits are based on the net recycled output, excluding any recycled content already included in module A1. Recycled concrete is assumed to substitute primary crushed gravel in German infrastructure applications, with benefits calculated as avoided primary production minus recycling processing impacts. Background data are taken from Ecoinvent 3.10.

Module D also includes packaging waste treatment according to EU scenarios, providing credit for recycled plastic packaging, while wood packaging shows no net benefit. The end-of-life scenarios (C1–C4) and potential reuse, recovery, and recycling (D) described in this EPD are currently in use and reflect the most likely and representative practices for the product's lifecycle. All substitution assumptions reflect typical and current recovery practices in Germany.

# MANUFACTURING PROCESS



# LIFE-CYCLE ASSESSMENT

## CUT-OFF CRITERIA

The study does not exclude any modules or processes which are stated mandatory in the reference standard and the applied PCR. The study does not exclude any hazardous materials or substances. The study includes all major raw material and energy consumption. All inputs and outputs of the unit processes, for which data is available for, are included in the calculation. There is no neglected unit process more than 1% of total mass or energy flows. The module specific total neglected input and output flows also do not exceed 5% of energy usage or mass.

The production of capital equipment, construction activities, and infrastructure, maintenance and operation of capital equipment, personnel-related activities, energy and water use related to company management and sales activities are excluded.

This LCA study includes the provision of all materials, transportation, energy and emission flows, and end of life processing of product. All industrial processes from raw material acquisition and pre-processing, production, product distribution and installation and end-of-life management are included.

In module A3, due to lack of data, some materials are excluded but they do not exceed the 1% cut-off criteria. The excluded materials are cast release oil (<0,01%) which is used in the production process only in very small amounts and have a negligible impact on the emissions of the product.

The production of capital equipment, construction activities, and infrastructure, maintenance and operation of capital equipment, personnel-related activities, energy and water use related to company management and sales activities are excluded.

## VALIDATION OF DATA

Data collection for production, transport, and packaging was conducted using time and site-specific information, as defined in the general information section on page 1 and 2. Upstream process calculations rely on generic data as defined in the Bibliography section. Manufacturer-provided specific and generic data were used for the product's manufacturing stage. The analysis was performed in One Click LCA EPD Generator, with the 'Cut-Off, EN 15804+A2' allocation method, and characterization factors according to EN 15804:2012+A2:2019/AC:2021 and JRC EF 3.1.

## ALLOCATION, ESTIMATES AND ASSUMPTIONS

Allocation is required if some material, energy, and waste data cannot be measured separately for the product under investigation. All allocations are made according to the reference standards and the applied PCR. In this study, allocation has been done in the following ways:

| Data type | Allocation |
|---|---|
| **Raw materials** | No allocation |
| **Packaging material** | No allocation |
| **Ancillary materials** | Not applicable |
| **Manufacturing energy and waste** | Allocated by mass or volume |

The concrete recipe was calculated with a weighted average of the most produced roof tiles. Packaging materials are weighed per pallet and extrapolated to the declared unit. Energy consumption and waste production is allocated as the information was only measured at factory level. The inputs were allocated to the studied product based on annual production volumes (mass) and done in accordance with the provisions of EN 15804+A2. The LCA study is conducted in accordance with

all methodological considerations such as performance, system boundaries, data quality, allocation procedures and decision rules to evaluate inputs and outputs.

Proxy data is used for certain materials due to their unavailability in the database.

- Module A2, A4 & C2: Vehicle capacity utilization volume factor is assumed to be 1 which means full load. It may vary but as the role of transportation emission in total results is small, the variety in load is assumed to be negligible. To be conservative, empty returns are included in this study as implemented through an average load factor in the Ecoinvent transport datapoints.

- Module A4: Transportation does not cause losses as products are packaged properly. Also, volume capacity utilization factor is assumed to be 1 for the nested packaged products. Additionally, transportation distances are assumed based on a particular scenario of customer's premises and a lorry is the assumed vehicle type used.

- Module A5: Packaging waste is declared as installation waste.
- Module C2: Transportation distance to waste handling facility is estimated as 50 km and the transportation method is assumed as lorry.

- Module C3, C4, D: 80% of concrete is sent for recycling while the remaining 20% are assumed to be landfilled. Wood pallets do not have any benefit since they are reused approximately 5 times. The packaging materials incinerated for energy recovery displace electricity and heat production, while recycled materials displace the need for virgin material production.

## PRODUCT & MANUFACTURING SITES GROUPING

| | |
|---|---|
| **Type of grouping** | Multiple products |
| **Grouping method** | Based on average results of product group - by total mass |
| **Variation in GWP-fossil for A1-A3, %** | - 8% |

This EPD covers concrete roof tiles manufactured exclusively at Benders Deutschland GmbH, Laage, Germany.

The products included in this study comprise all forms and colours of concrete roof tiles within the Palema and Mecklenburger ranges, including both coated and uncoated (natural) variants. All included products are intended for use as external roof covering for pitched roofs in residential and commercial buildings and fulfil the same primary function. Variations within the product group relate to tile shape, surface finish (coated or uncoated), and color, without affecting functional performance or intended application.

The declared environmental impacts represent a production-volume-weighted average product, based on the annual production volumes at the Laage facility. All environmental impacts in modules A1–A3 are averaged accordingly.

The averaging approach is applied due to the similarity of concrete reipes, manufacturing processes, and functional performance across the included product variants.

The declared results are representative of the average environmental performance of concrete roof tiles produced at the Laage plant within the defined product range. Some products do not contain surface coating and may therefore exhibit approximately 8 % lower GWP values (modules A1–A3) compared to the declared average product.

This EPD shall not be used for products manufactured at other sites, or for concrete roof tiles with significantly different material compositions, production processes, or surface treatments outside the defined ranges.

The averaging and declared results are valid for products manufactured at the Laage production site in Germany, reflecting German production conditions. Application of this EPD to products manufactured at other locations or under different regional conditions is not recommended.

## LCA SOFTWARE AND BIBLIOGRAPHY

This EPD has been created using One Click LCA EPD Generator for EPD Hub V3 and EPD System Verification v3.2.3. The LCA and EPD have been prepared according to the reference standards and ISO 14040/14044. The EPD Generator uses Ecoinvent v3.10.1/3.11 and One Click LCA databases as sources of environmental data. Allocation used in Ecoinvent 3.10.1/3.11 environmental data sources follow the methodology 'allocation, Cut-off, EN 15804+A2'.

A5:

- EUROSTAT, https://ec.europa.eu/eurostat/databrowser/view/env_waspac__custom_8519174/default/table?lang=en.
- "The Performance of EU Incineration Facilities, 2023" https://zerowasteeurope.eu/wp-content/uploads/2023/01/Debunking-Efficient-Recovery-Full-Report-EN.docx.pdf).

B1:

- Benders internal calculations of carbonation of roof tiles (2025).

C1-C4:

- (Bozdağ & Seçer, 2007))
- (Betoniteollisuus ry, 2020)

# ENVIRONMENTAL IMPACT DATA

*The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.*

## CORE ENVIRONMENTAL IMPACT INDICATORS – EN 15804+A2, EF 3.1

| Impact category | Unit | A1 | A2 | A3 | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GWP – total[1)] | kg $CO_2$e | 1,23E+02 | 9,78E+00 | 1,15E+01 | 1,45E+02 | 1,08E+01 | 6,52E+00 | -6,00E+01 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 9,68E+00 | 3,50E+00 | 1,25E+00 | -8,41E+00 |
| GWP – fossil | kg $CO_2$e | 1,23E+02 | 9,77E+00 | 1,72E+01 | 1,50E+02 | 1,08E+01 | 7,75E-01 | -6,00E+01 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 9,67E+00 | 3,50E+00 | 1,25E+00 | -8,40E+00 |
| GWP – biogenic | kg $CO_2$e | 9,10E-02 | 2,21E-03 | -5,73E+00 | -5,64E+00 | 2,45E-03 | 5,75E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,92E-03 | -3,57E-04 | -3,97E-04 | -3,33E-03 |
| GWP – LULUC | kg $CO_2$e | 2,47E-02 | 4,36E-03 | 7,35E-03 | 3,64E-02 | 4,84E-03 | 2,30E-04 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 3,42E-03 | 3,59E-04 | 7,14E-04 | -7,54E-03 |
| Ozone depletion pot. | kg $CFC\text{-}_{11}$e | 2,84E-06 | 1,45E-07 | 4,60E-07 | 3,45E-06 | 1,60E-07 | 2,55E-09 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,92E-07 | 5,36E-08 | 3,62E-08 | -8,41E-08 |
| Acidification potential | mol $H^+$e | 4,46E-01 | 3,33E-02 | 2,85E-02 | 5,08E-01 | 3,69E-02 | 9,09E-04 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 3,02E-02 | 3,16E-02 | 8,85E-03 | -5,00E-02 |
| EP-freshwater[2)] | kg Pe | 1,71E-02 | 7,59E-04 | 9,42E-04 | 1,88E-02 | 8,42E-04 | 4,09E-05 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 6,41E-04 | 1,01E-04 | 1,03E-04 | -2,57E-03 |
| EP-marine | kg Ne | 1,74E-02 | 1,09E-02 | 1,03E-02 | 3,87E-02 | 1,21E-02 | 9,16E-04 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,02E-02 | 1,47E-02 | 3,37E-03 | -1,16E-02 |
| EP-terrestrial | mol Ne | 7,43E-01 | 1,19E-01 | 1,12E-01 | 9,74E-01 | 1,32E-01 | 3,72E-03 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,11E-01 | 1,60E-01 | 3,68E-02 | -1,40E-01 |
| POCP ("smog")[3)] | kg NMVOCe | 2,38E-01 | 4,92E-02 | 5,11E-02 | 3,38E-01 | 5,43E-02 | 1,20E-03 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 4,74E-02 | 4,79E-02 | 1,32E-02 | -4,06E-02 |
| ADP-minerals & metals[4)] | kg Sbe | 1,40E-04 | 2,73E-05 | 2,02E-05 | 1,88E-04 | 3,02E-05 | 5,24E-07 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 3,16E-05 | 1,26E-06 | 1,98E-06 | -4,53E-05 |
| ADP-fossil resources | MJ | 8,14E+02 | 1,42E+02 | 2,90E+02 | 1,25E+03 | 1,57E+02 | 2,20E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,36E+02 | 4,58E+01 | 3,06E+01 | -1,11E+02 |
| Water use[5)] | $m^3$e depr. | 1,36E+01 | 7,01E-01 | 2,28E+00 | 1,66E+01 | 7,75E-01 | 7,10E-02 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 6,67E-01 | 1,14E-01 | 8,84E-02 | -1,18E+01 |

*1) GWP = Global Warming Potential; 2) EP = Eutrophication potential. Required characterisation method and data are in kg P-eq. Multiply by 3,07 to get PO4e; 3) POCP = Photochemical ozone formation; 4) ADP = Abiotic depletion potential; 5) EN 15804+A2 disclaimer for Abiotic depletion and Water use and optional indicators except Particulate matter and Ionizing radiation, human health. The results of these environmental impact indicators shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.*

## ADDITIONAL (OPTIONAL) ENVIRONMENTAL IMPACT INDICATORS – EN 15804+A2, EF 3.1

| Impact category | Unit | A1 | A2 | A3 | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Particulate matter | Incidence | 4,27E-06 | 9,78E-07 | 5,81E-07 | 5,83E-06 | 1,08E-06 | 1,52E-08 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 7,60E-07 | 6,85E-06 | 2,01E-07 | -7,39E-07 |
| Ionizing radiation[6)] | kBq U235e | 4,19E+00 | 1,24E-01 | 2,82E-01 | 4,59E+00 | 1,37E-01 | 6,12E-03 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,73E-01 | 2,03E-02 | 1,93E-02 | -7,47E-01 |
| Ecotoxicity (freshwater) | CTUe | 6,57E+01 | 2,00E+01 | 1,86E+01 | 1,04E+02 | 2,22E+01 | 9,21E-01 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,78E+01 | 2,52E+00 | 2,57E+00 | -2,35E+01 |
| Human toxicity, cancer | CTUh | 1,71E-07 | 1,61E-09 | 6,32E-09 | 1,79E-07 | 1,78E-09 | 1,01E-10 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,65E-09 | 3,60E-10 | 2,30E-10 | -2,20E-09 |
| Human tox. non-cancer | CTUh | 2,88E-06 | 9,18E-08 | 3,68E-08 | 3,01E-06 | 1,02E-07 | 4,93E-09 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 8,53E-08 | 5,70E-09 | 5,29E-09 | -6,56E-08 |
| SQP[7)] | - | 1,95E+02 | 1,43E+02 | 4,70E+02 | 8,08E+02 | 1,58E+02 | 2,13E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 8,08E+01 | 3,21E+00 | 6,03E+01 | -8,92E+01 |

*6) EN 15804+A2 disclaimer for Ionizing radiation, human health. This impact category deals mainly with the eventual impact of low-dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator; 7) SQP = Land use related impacts/soil quality.*

## USE OF NATURAL RESOURCES

| Impact category | Unit | A1 | A2 | A3 | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Renew. PER as energy[8)] | MJ | 3,83E+01 | 1,95E+00 | 3,74E+01 | 7,76E+01 | 2,15E+00 | -5,88E+01 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 2,35E+00 | 2,90E-01 | 2,96E-01 | -9,49E+00 |
| Renew. PER as material | MJ | 0,00E+00 | 0,00E+00 | 5,03E+01 | 5,03E+01 | 0,00E+00 | -5,03E+01 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Total use of renew. PER | MJ | 3,83E+01 | 1,95E+00 | 8,77E+01 | 1,28E+02 | 2,15E+00 | -1,09E+02 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 2,35E+00 | 2,90E-01 | 2,96E-01 | -9,49E+00 |
| Non-re. PER as energy | MJ | 7,46E+02 | 1,42E+02 | 2,65E+02 | 1,15E+03 | 1,57E+02 | -1,84E+01 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,36E+02 | 4,58E+01 | 3,06E+01 | -1,11E+02 |
| Non-re. PER as material | MJ | 0,00E+00 | 0,00E+00 | 2,50E+01 | 2,50E+01 | 0,00E+00 | -2,50E+01 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 8,66E+00 |
| Total use of non-re. PER | MJ | 7,46E+02 | 1,42E+02 | 2,90E+02 | 1,18E+03 | 1,57E+02 | -4,34E+01 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,36E+02 | 4,58E+01 | 3,06E+01 | -1,02E+02 |
| Secondary materials | kg | 6,03E+01 | 6,04E-02 | 2,27E-01 | 6,06E+01 | 6,68E-02 | 2,10E-03 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 6,22E-02 | 1,90E-02 | 7,70E-03 | 1,05E-01 |
| Renew. secondary fuels | MJ | 1,59E+02 | 7,67E-04 | 1,71E+00 | 1,61E+02 | 8,48E-04 | 1,96E-05 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 7,85E-04 | 4,97E-05 | 1,59E-04 | -7,31E-04 |
| Non-ren. secondary fuels | MJ | 1,14E+02 | 0,00E+00 | 0,00E+00 | 1,14E+02 | 0,00E+00 | 0,00E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Use of net fresh water | $m^3$ | 1,50E+00 | 2,10E-02 | 5,92E-02 | 1,58E+00 | 2,32E-02 | -5,32E-03 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,83E-02 | 3,03E-03 | 3,19E-02 | -2,80E-01 |

*8) PER = Primary energy resources.*

## END OF LIFE – WASTE

| Impact category | Unit | A1 | A2 | A3 | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hazardous waste | kg | 8,66E-01 | 2,40E-01 | 2,74E-01 | 1,38E+00 | 2,66E-01 | 1,94E-02 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 1,95E-01 | 5,10E-02 | 3,38E-02 | -7,56E-01 |
| Non-hazardous waste | kg | 1,77E+01 | 4,44E+00 | 1,45E+01 | 3,67E+01 | 4,92E+00 | 9,74E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 4,11E+00 | 6,95E-01 | 7,73E-01 | -1,77E+01 |
| Radioactive waste | kg | 1,55E-01 | 3,05E-05 | 7,96E-05 | 1,55E-01 | 3,35E-05 | 1,53E-06 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 4,30E-05 | 4,98E-06 | 4,70E-06 | -1,81E-04 |

## END OF LIFE – OUTPUT FLOWS

| Impact category | Unit | A1 | A2 | A3 | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Components for re-use | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Materials for recycling | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,48E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 8,00E+02 | 0,00E+00 | 0,00E+00 |
| Materials for energy rec | kg | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Exported energy | MJ | 0,00E+00 | 0,00E+00 | 9,15E+01 | 9,15E+01 | 0,00E+00 | 9,40E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Exported energy – Electricity | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 3,96E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Exported energy – Heat | MJ | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 5,45E+00 | 0,00E+00 | ND | ND | ND | ND | ND | ND | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |

# SCENARIO DOCUMENTATION DATA SOURCES

**Manufacturing energy scenario documentation**
1. Electricity production, natural gas, combined cycle power plant, Germany, Ecoinvent, 0.47 kgCO2e/kWh

2. District heating from natural gas, Germany, GaBi, 0.17 kgCO2e/kWh
3. Diesel, burned in building machine, World, Ecoinvent, 0.10 kgCO2e/MJ

**Transport scenario documentation - A4 (Transport resources)**
1. Market for transport, freight, lorry >32 metric ton, EURO5, 100 km

**Transport scenario documentation A4**

| Scenario parameter | Value |
|---|---|
| Capacity utilization (including empty return) % | 100 |
| Bulk density of transported products | 0,00E+00 |
| Volume capacity utilization factor | <1 |

**Installation scenario documentation - A5 (Installation waste)**
1. Treatment of waste wood, untreated, sanitary landfill, Ecoinvent, 1.52 kg

2. Exported Energy: Electricity, Ecoinvent, 2.68 MJ

3. Treatment of waste wood, post-consumer, sorting and shredding, Ecoinvent, Materials for recycling, 1.28 kg

4. Exported Energy: Thermal, Ecoinvent, 3.68 MJ

5. Treatment of waste wood, untreated, municipal incineration, Ecoinvent, 1.2 kg

6. Exported Energy: Electricity, Ecoinvent, 1.28 MJ

7. Treatment of waste polyethylene, for recycling, unsorted, sorting, Ecoinvent, Materials for recycling, 0.204 kg

8. Treatment of waste polyethylene, municipal incineration, Ecoinvent, 0.189 kg

9. Exported Energy: Thermal, Ecoinvent, 1.765 MJ

10. Treatment of waste polyethylene, sanitary landfill, Ecoinvent, 0.117 kg

**Use stages scenario documentation - C1-C4 (Data source)**
1. Treatment of waste concrete, not reinforced, recycling, Ecoinvent, Materials for recycling, 800.0 kg

2. Treatment of waste concrete, inert material landfill, Ecoinvent, 200.0 kg

| Scenario information | Value |
|---|---|
| Scenario assumptions e.g. transportation | 50 km by lorry |

# THIRD-PARTY VERIFICATION STATEMENT

EPD Hub declares that this EPD is verified in accordance with ISO 14025 by an independent, third-party verifier. The project report on the Life Cycle Assessment and the report(s) on features of environmental relevance are filed at EPD Hub. EPD Hub PCR and ECO Platform verification checklist are used.

EPD Hub is not able to identify any unjustified deviations from the PCR and EN 15802+A2 in the Environmental Product Declaration and its project report.

EPD Hub maintains its independence as a third-party body; it was not involved in the execution of the LCA or in the development of the declaration and has no conflicts of interest regarding this verification.

The company-specific data and upstream and downstream data have been examined as regards plausibility and consistency. The publisher is responsible for ensuring the factual integrity and legal compliance of this declaration.

The software used in creation of this LCA and EPD is verified by EPD Hub to conform to the procedural and methodological requirements outlined in ISO 14025:2010, ISO 14040/14044, EN 15804+A2, and EPD Hub Core Product Category Rules and General Program Instructions.

Verified tools

Tool verifier: Magaly Gonzalez Vazquez

Tool verification validity: 27 March 2025 - 26 March 2028

Magaly Gonzalez Vazquez as an authorized verifier for EPD Hub Limited 30.01.2026

VERIFIED ISO 14025