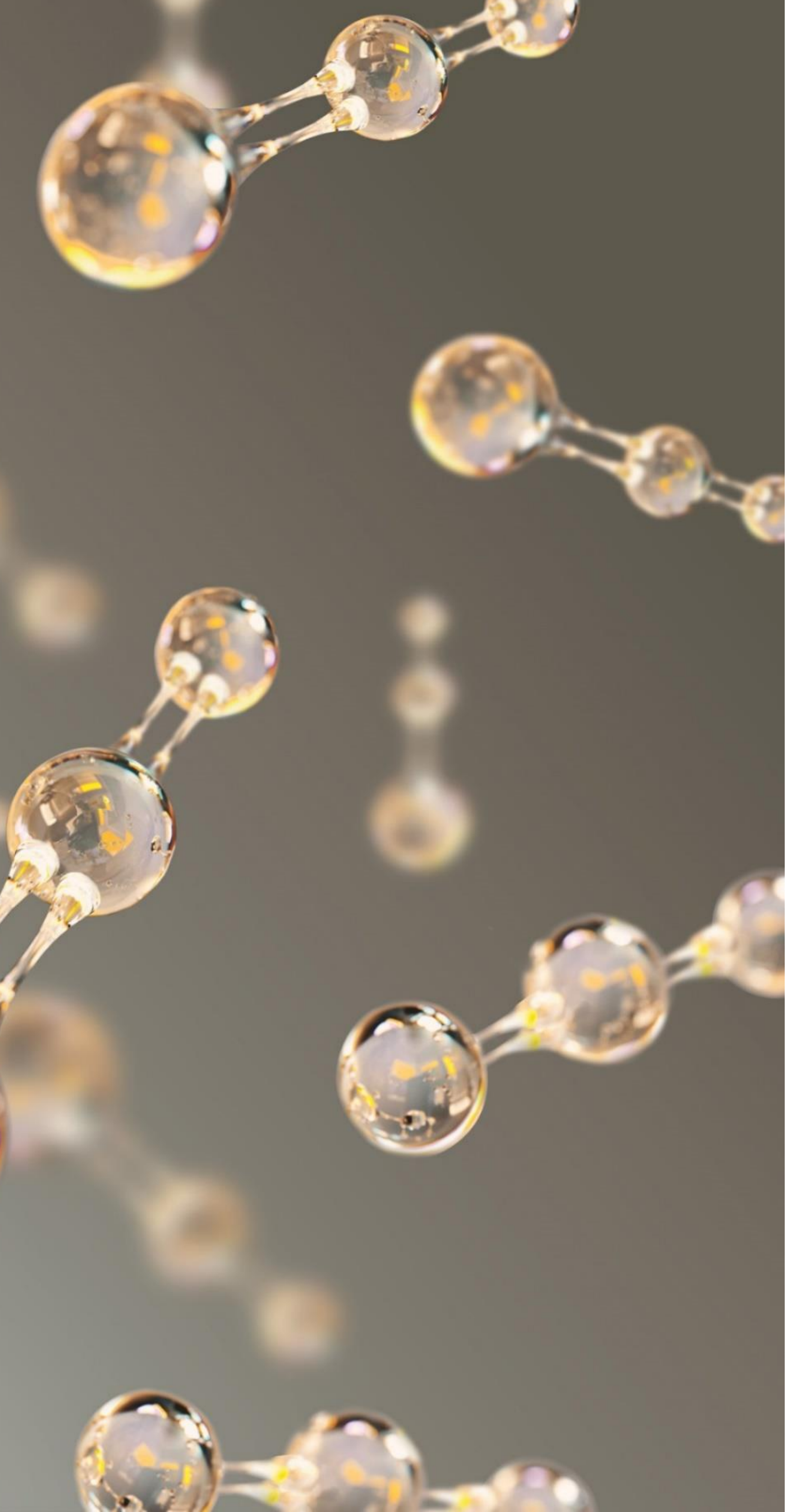

ENVIRONMENTAL PRODUCT DECLARATION

IN ACCORDANCE WITH EN 15804+A2 & ISO 14025 / ISO 21930

O·C·O® TECHNOLOGY

CARBON:CAPTURED®

Manufactured LimeStone (M-LS)

EPD HUB, EPDHUB-0193

Publishing date 25 November 2022, last updated date 25 November 2022, valid until 25 November 2027

Created with One Click LCA

GENERAL INFORMATION

MANUFACTURER

Manufacturer	O.C.O Technology Ltd
Address	Norfolk House, High Street, Brandon, Suffolk, IP27 0AX
Contact details	info@oco.co.uk
Website	www.oco.co.uk

EPD STANDARDS, SCOPE, AND VERIFICATION

Program operator	EPD Hub, hub@epdhub.com
Reference standard	EN 15804+A2:2019 and ISO 14025
PCR	EPD Hub Core PCR version 1.0, 1 Feb 2022
Sector	Construction product
Category of EPD	Third party verified EPD
Scope of the EPD	Gradle to gate
EPD author	Dr. Peter Gunning, Head of Research & Development, O.C.O Technology Ltd
EPD verification	Independent verification of this EPD and data, according to ISO 14025: ☐ Internal certification ☑ External verification
EPD verifier	N.C, as an authorized verifier acting for EPD Hub

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	Manufactured LimeStone (M-LS)
Additional labels	N/A
Product reference	N/A
Place of production	Brandon, Avonmouth and Leeds
Period for data	01/10/2019 to 30/10/2020
Averaging in EPD	Multiple factories
Variation in GWP-fossil for A1-A3	19.12 %

ENVIRONMENTAL DATA SUMMARY

Declared unit	1 tonne
Declared unit mass	1000 kg
GWP-fossil, A1-A3 (kgCO2e)	-47.1
GWP-total, A1-A3 (kgCO2e)	-45.7
Secondary material, inputs (%)	37.6
Secondary material, outputs (%)	0.0
Total energy use, A1-A3 (kWh)	163.0
Total water use, A1-A3 (m3e)	0.952

PRODUCT AND MANUFACTURER

ABOUT THE MANUFACTURER

O.C.O Technology has developed a Carbon Capture and Utilisation (CCU) process to treat and stabilise thermal residues, and in turn valorise them into sustainable construction products such as carbon neutral* aggregate. With the unique use of carbon dioxide within its treatment process, O.C.O is amongst the top companies in the world for permanent carbon capture in a commercialised process. O.C.O Technology is a genuine 'World's First', on many fronts and has attracted interest from both the UK Government and the international community.

PRODUCT DESCRIPTION

Manufactured LimeStone (M-LS) is an artificial rock composed of accelerated carbonation stabilised thermal residue, sand, and cement. For use in masonry units, concrete, asphalt, hydraulically bound mixtures, and unbound mixtures. Typical density 1100±100kg/m^3. Compressive strength

>5N/mm^2. Certified to BS EN 13055-1 (Lightweight aggregates - Lightweight aggregates for concrete, mortar, and grout), and BS EN 13242 (Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction).

The product achieves a global warming potential value of -49.1kg per tonne of M-LS (according to EN 15804+A1, CML / ISO 21930).

**The carbon storage associated with the M-LS product is managed in Puro Registry for carbon removal credits and is only available by separate negotiation with O.C.O*

PRODUCT RAW MATERIAL MAIN COMPOSITION

Raw material category	Amount, mass- %	Material origin
Metals	0	N/A
Minerals	63.26	UK
Fossil materials	9.25	UK
Bio-based materials	0	N/A
Water	13.09	UK
Carbonation	14.40	UK

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	0

FUNCTIONAL UNIT AND SERVICE LIFE

Declared unit	1 tonne
Mass per declared unit	1000 kg
Functional unit	N/A
Reference service life	N/A

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	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND		
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 = MND. 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 the production. 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.

M-LS (Manufactured LimeStone) is artificial rock manufactured by reacting carbon dioxide with industrial process residues. Many wastes react naturally with carbon dioxide. If the conditions are carefully controlled, this natural reaction can be accelerated, taking place in minutes rather than months or years. This results in the formation of calcium carbonate (limestone). The primary reaction is represented in figure 1.

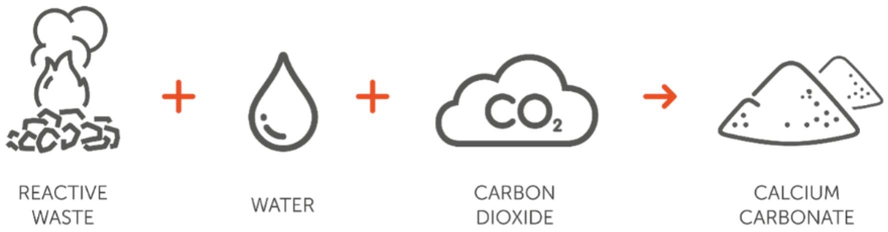

Figure 1: Basic accelerated carbonation reaction

The process is a genuine Carbon Capture and Utilisation (CCU) process. During the process, significant volumes of carbon dioxide are permanently captured as stable carbonates. The process has further benefit in the valorisation of thermal wastes as construction products. At the three commercial facilities operated by O.C.O in the UK, carbonated thermal wastes are blended with binders and fillers and then pelletised to form a rounded aggregate (M-LS or Manufactured-LimeStone) that has many applications in construction.

The finished M-LS has captured more carbon dioxide than is emitted in its manufacture, resulting in a carbon neutral aggregate*. A typical M-LS sample is shown in figure 2.

**The carbon storage associated with the M-LS product is managed in Puro Registry for carbon removal credits and is only available by separate negotiation with O.C.O*

Figure 2. Typical M-LS sample

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.

This EPD does not cover modules A4-A5.

PRODUCT USE AND MAINTENANCE (B1-B7)

This EPD does not cover the use phase. Air, soil, and water impacts during the use phase have not been studied.

PRODUCT END OF LIFE (C1-C4, D)

This EPD does not cover modules C1-C4, or D. M-LS is never used alone in any application; it is always physically integrated with other materials (such as virgin and recycled aggregate and cement), meaning that they cannot be physically separated nor specifically identified at end of life. It is non-organic and therefore does not include biogenic carbon in biomass.

MANUFACTURING PROCESS

M-LS is manufactured using a multiple stage process designed to stabilise and valorise industrial thermal residues as a useful construction product (see figure 3).

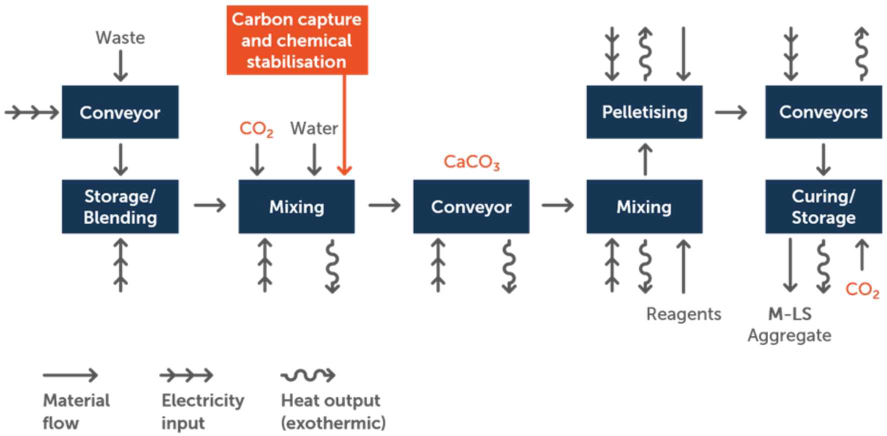

Figure 3: Manufacturing process

Thermal residue arriving on site is stored in silos before being blended with material from other sources. The blended residue passes through a mixing stage where CO_2 and water are added to achieve chemical stabilisation. The resulting calcium carbonate ($CaCO_3$) mixture undergoes a second mixing stage where additional reagents are added. Finally, the combined mixture undergoes pelletising to form the rounded product. Further CO_2 naturally combines with the product whilst it undergoes curing and storage on site. The technology is adaptable to a wide variety of thermal residues including those arising from biomass, energy from waste, cement manufacture, steel and aluminium production, paper manufacture, and wastewater treatment. The reaction promotes rapid solidification and improves mechanical properties and modification of contaminant mobility (see figure 4). Carbonation results in a reduction in porosity due to the formation of voluminous calcium carbonate in the pore space. This aids the retention of contaminants through improved physical containment. Crystals of calcium carbonate join in an interlocking lattice, forming an unimpaired bond between grains.

Figure 4: Solidification/Stabilisation Processes

The carbonation reaction results in chemical stabilisation which improves contaminant retention. Under optimum conditions the rate of heavy metal release can be reduced by up to several orders of magnitude. This is due to precipitation of metals as low solubility carbonates, the formation of solid solutions in the precipitated calcium carbonate, and sorption onto crystal surfaces.

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.

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 done as per the reference standards and the applied PCR. In this study, allocation has been done in the following ways:

Data type	Allocation
Raw materials	Allocated by mass or volume
Packaging materials	Not applicable
Ancillary materials	Not applicable
Manufacturing energy and waste	Allocated by mass or volume

This 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. All estimations and assumptions are given below.

Module A2

Vehicle capacity utilisation volume factor is assumed to be 1 which means full load. In reality, it may vary but as the role of transportation emission in the total results is small, the variety in load is assumed to be negligible. Empty returns are not considered as it is assumed that a return trip is used by the transportation company to serve the needs of other clients. Defra figures used for the transportation of factory waste to landfill/recycling (https://www.gov.uk)

Module A3

The manufacturing process of M-LS utilises Accelerated Carbonation Technology to start a carbonation process in which carbon dioxide is captured and permanently fixed in the product. This process is an intrinsic part of the manufacturing process, taking place much faster than it would do naturally and continuing whilst the product is in stockpiles prior to use by O.C.O customers in the manufacture of blocks and blended aggregate. The extent of carbonation that can take place with the blend of materials used is identified by stoichiometric analysis. To ensure that carbonation has been considered completely and fully accounted for in this EPD, it is based on the assumption that all carbonation takes place during the module A3 manufacturing phase. Carbonation is determined by a stoichiometric calculation using the chemical composition of the raw materials acting as CO_2 sinks (thermal residues and cement). The composition is determined by X-Ray Fluorescence (XRF) to obtain the proportions of participating elements (calcium, sodium, potassium, and sulfur). An equation developed by Steinour (Steinour, H.H. 1959. Some effects of carbon dioxide on mortars and concrete: a discussion. J. Amer. Concrete Inst. 30, 905-907) is applied to calculate the total carbon capacity of the raw materials. A correction factor is applied to act as buffer for incomplete carbonation of the materials (Gunning, P.J., Hills, C.D., and Carey, P.J. (2010). Accelerated carbonation treatment of industrial wastes. Waste Management, 30, 1081– 1090). The method has previously been used and verified for PAS2050 and BS EN 15804+A2 carbonation calculation purposes.

The chemical reaction that takes place during the formation of the aggregate is exothermic and there will be a direct heat emission to the atmosphere. The direct heat emission is estimated to be 9.33 kWh per tonne. This emission is not included in the EPD indicator results. As part of the chemical reaction a small amount of ammonia gas will also be released to the atmosphere. Ammonia release is less than 4e-6%, which is four orders of magnitude below the minimum reporting threshold of 0.1%.

Allocation used in Ecoinvent 3.6 environmental data sources follows the methodology ‘allocation, cut-off by classification’. This methodology is in line with the requirements of the EN 15804 - standard.

AVERAGES AND VARIABILITY

The basic raw material (APCr) varies through time from each supplier and between different suppliers, therefore the recipe mix must be adjusted on an ongoing basis at all sites as part of the quality control process. This results in the ranges of input material seen in the product raw material composition table. These varied inputs will have related impacts on the GWP of the final product. This EPD has been calculated from the production volumes across all three sites over a 12-month period and reports an accurate average over that period. The variation in GWP-fossil for A1-A3 has been calculated by creating separate EPD for each site and then calculating the difference between them as a percentage of the average.

Type of average	Multiple factories
Averaging method	Averaged by shares of total mass
Variation in GWP-fossil for A1-A3	19.12 %

LCA SOFTWARE AND BIBLIOGRAPHY

This EPD has been created using One Click LCA EPD Generator. The LCA and EPD have been prepared according to the reference standards and ISO 14040/14044. Ecoinvent and One Click LCA databases were used as sources of environmental data.

ENVIRONMENTAL IMPACT DATA

CORE ENVIRONMENTAL IMPACT INDICATORS – EN 15804+A2, PEF

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_2e	-5,52E1	6,64E0	2,82E0	-4,57E1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
GWP – fossil	kg CO_2e	-5,65E1	6,64E0	2,82E0	-4,71E1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
GWP – biogenic	kg CO_2e	1,33E0	4,64E-3	1,37E-3	1,33E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
GWP – LULUC	kg CO_2e	1,82E-2	2,04E-3	2,54E-3	2,27E-2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Ozone depletion pot.	kg CFC_{-11}e	3,08E-6	1,55E-6	3,89E-7	5,02E-6	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Acidification potential	mol H^+e	2,17E-1	2,74E-2	1,93E-2	2,64E-1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
EP-freshwater[2)]	kg Pe	1,21E-3	5,49E-5	5,98E-5	1,33E-3	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
EP-marine	kg Ne	5,51E-2	8,15E-3	6,89E-3	7,01E-2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
EP-terrestrial	mol Ne	6,43E-1	9,01E-2	7,66E-2	8,1E-1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
POCP (“smog”)[3)]	kg NMVOCe	1,62E-1	2,9E-2	1,99E-2	2,11E-1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
ADP-minerals & metals[4)]	kg Sbe	4,84E-4	1,2E-4	5,48E-6	6,09E-4	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
ADP-fossil resources	MJ	3,88E2	1,03E2	5,93E1	5,5E2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Water use[5)]	m^3e depr.	8,82E0	3,83E-1	6,45E-2	9,27E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

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	2,85E1	1,3E0	7,78E0	3,76E1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Renew. PER as material	MJ	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Total use of renew. PER	MJ	2,85E1	1,3E0	7,78E0	3,76E1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Non-re. PER as energy	MJ	3,88E2	1,03E2	5,93E1	5,5E2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Non-re. PER as material	MJ	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Total use of non-re. PER	MJ	3,88E2	1,03E2	5,93E1	5,5E2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Secondary materials	kg	3,76E2	0E0	0E0	3,76E2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Renew. secondary fuels	MJ	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Non-ren. secondary fuels	MJ	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Use of net fresh water	m^3	9,19E-1	2,11E-2	1,22E-2	9,52E-1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

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	1,52E0	1,02E-1	1,4E-1	1,76E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Non-hazardous waste	kg	5,36E1	1,08E1	2,02E0	6,64E1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Radioactive waste	kg	1,89E-3	7,04E-4	4,53E-4	3,05E-3	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

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	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Materials for recycling	kg	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Materials for energy rec	kg	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Exported energy	MJ	0E0	0E0	0E0	0E0	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

ENVIRONMENTAL IMPACTS – EN 15804+A1, CML / ISO 21930

Impact category	Unit	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Global Warming Pot.	kg CO_2e	-5,84E1	6,58E0	2,78E0	-4,91E1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Ozone depletion Pot.	kg $CFC_{-11}e$	2,64E-6	1,23E-6	3,77E-7	4,25E-6	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Acidification	kg SO_2e	1,64E-1	1,39E-2	1,46E-2	1,93E-1	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
Eutrophication	kg $PO_4{}^3e$	5,3E-2	2,85E-3	3,75E-3	5,96E-2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
POCP ("smog")	kg C_2H_4e	6,58E-3	8,54E-4	5,03E-4	7,94E-3	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
ADP-elements	kg Sbe	4,84E-4	1,2E-4	5,48E-6	6,09E-4	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
ADP-fossil	MJ	3,88E2	1,03E2	5,93E1	5,5E2	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

VERIFICATION STATEMENT

VERIFICATION PROCESS FOR THIS EPD

This EPD has been verified in accordance with ISO 14025 by an independent, third-party verifier by reviewing results, documents and compliancy with reference standard, ISO 14025, and ISO 14040/14044, following the process and checklists of the program operator for:

- This Environmental Product Declaration
- The Life-Cycle Assessment used in this EPD
- The digital background data for this EPD

Why does verification transparency matter? Read more online.

This EPD has been generated by One Click LCA EPD generator, which has been verified and approved by the EPD Hub.

THIRD-PARTY VERIFICATION STATEMENT

I hereby confirm that, following detailed examination, I have not established any relevant deviations by the studied Environmental Product Declaration (EPD), its LCA and project report, in terms of the data collected and used in the LCA calculations, the way the LCA-based calculations have been carried out, the presentation of environmental data in the EPD, and other additional environmental information, as present with respect to the procedural and methodological requirements in ISO 14025:2010 and reference standard.

I confirm that the company-specific data has been examined as regards plausibility and consistency; the declaration owner is responsible for its factual integrity and legal compliance.

I confirm that I have sufficient knowledge and experience of construction products, this specific product category, the construction industry, relevant standards, and the geographical area of the EPD to carry out this verification.

I confirm my independence in my role as verifier; I have not been involved in the execution of the LCA or in the development of the declaration and have no conflicts of interest regarding this verification.

Neena Chandramathy, as an authorized verifier acting for EPD Hub Limited
25.11.2022

VERIFIED ISO 14025