NATURAL STONE INSTITUTE

Industry-wide Type III EPD

Exterior Dimension Stone Cladding

Natural stone is an easy solution to many green building goals. It is nearly complete as a building material in its natural state as mother nature does most of the manufacturing. It is a single-ingredient natural material that emits no VOCs. Its durability allows stone to perform impeccably in commercial & residential applications, interior or exterior.

Participating manufacturers:

Coldspring
Colorado Stone Quarries
Continental Cut Stone
Delgado Stone Distributors
Freshwater Stone
Independent Limestone Company
Polycor
Quality Stone
Royal Bedrock
Russell Stone
Stony Creek Quarry
Vermont Quarries
Vetter Stone

UNDERWRITTEN BY NATURAL STONE FOUNDATION

Performance dashboard

Features & functionality

Panel sizes vary based on size and soundness of the block yielded by the quarry

Veneer units are precut, prefinished and delivered to job sites ready to install

Surface finishes vary from rough split face and bed to panels with polished face and sawn bed

Installation methods include adhered or anchored

Stone types include granite, limestone, marble, quartzite, sandstone, serpentine, slate, soapstone, and travertine

Visit NSI for more product information

Environment & materials

Emits no VOCs, and poses no health hazards

Quarries and processing facilities are located across N. America, making shipping distances never too far

Can be refinished and recycled with endless opportunities for reuse after initial service life

Scrap stone used as fill on premises, kept onsite for reclamation, or crushed as aggregates used in construction

No periodic cleaning needed during entire service life

Select natural stone products have qualified for one or more of the following certifications, rating systems, and disclosures:

Sustainable Stone Certified

Dimension Stone Design Manual

Health Product Declaration (HPD)

MasterFormat® 04 41, 04 42, 04 43, 04 43 16, 09 75

For specification information, refer to:
Dimension Stone Design Manual
Natural Stone Sustainability Standard
Natural Stone Catalogue
For spec help, contact us or call 440.250.9222

See LCA, interpretation & rating systems

SM Transparency Report (EPD)™

VERIFICATION	LCA
3rd-party reviewed	✔
	Transparency Report (EPD)
3rd-party verified	✔

Validity: 2022/11/01 – 2027/10/31
Decl #: NSI – 20221101 – 003

This environmental product declaration (EPD) was externally verified, according to ISO 21930:2017, SM Part A, and ISO 14025:2006, by Jack Geibig, President, Ecoform.

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ecoform CLEAN PRODUCT INNOVATIONS

SUMMARY

Reference PCR
ULE PCR Part B: Cladding Product Systems EPD requirements v2.0, 2021

Regions; system boundaries
North America; Cradle to grave

Functional unit / reference service life:
1 m² of installed stone cladding; 75 years

LCIA methodology: TRACI 2.1

LCA software; LCI database
SimaPro Developer 9.4
EcoInvent 3.8, US-EI 2.2

LCA conducted by: Sustainable Minds

Public LCA:
Industry wide Life Cycle Assessment of Natural Stone Cladding for NSI

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LCA results & interpretation

Exterior Dimension Stone Cladding

Life cycle assessment

Scope and summary

○ Cradle to gate ○ Cradle to gate with options ✔ **Cradle to grave**

Product description

Stone cladding is applied to a building exterior to separate it from the natural environment and provide an outer layer to the building. It not only provides a control to weather elements but also a durable, aesthetically pleasing building appearance. Natural stone makes up 100% of the total mass of natural stone cladding, and the different stone types included in this study are granite, marble, quartzite, limestone, and sandstone. It is used in commercial, residential, and public sector buildings.

Functional unit

The functional unit is one square meter of installed natural stone cladding for a service life of 75 years. The natural stone cladding product system is an industry-average product, i.e., the product profile represents the weighted average of NSI's natural stone cladding based on NSI's industry-average quarrying of stone specific to cladding and also includes the industry-average production of cladding. The product system in this study also includes the ancillary materials used in the installation of the product – mortar and masonry connectors. Materials needed to meet functional unit are:

Natural stone - 83.28 kg per m^2
Mortar - 4.88 kg per m^2
Masonry connectors - 0.62 kg per m^2
Water - 1.00 liters per m^2

Manufacturing data

The data for all stone products were collected from NSI members covering a period of two years: January 2019 to December 2020. Data for quarry operations were collected from twelve NSI quarry members covering 36 quarries across North America. The participant quarries in this study are Coldspring, Delgado Stone Distributors, Freshwater Stone, Independent Limestone Company, Polycor, Quality Stone Corporation, Royal Bedrock Inc., Russell Stone Products, Stony Creek Quarry, Vermont Quarries Corporation, and Vetter Stone Company.

After the stone is extracted from the quarry, it goes to a processing facility. Stone processor operations data were collected from six NSI member processors covering 17 facilities across North America. Cladding products were produced at all facilities which submitted data but one processor. The participant processors in this study producing cladding are Delgado Stone Distributors, Polycor, Russell Stone Products, Vetter Stone Company, and Continental Cut Stone. NSI resources and other literature data were used to develop estimates or assumptions for other upstream or downstream activities where necessary.

Industry-wide results calculation methodology

Based on data provided by the participating natural stone processors, limestone and granite represented much of natural stone cladding at 56.72% and 36.18%, respectively. Marble cladding covered 0.13% of the market share, while the rest (6.97%) was from other natural stones (including quartzite and sandstone).

For quarry data, an average inventory per kg of stone quarried for each stone category (granite, limestone, marble, and other natural stone) was developed, and later a weighted inventory per kg of stone quarried was generated using the quarry production share of each stone type among the participant quarries. After that, the inventory per kg of stone quarrying specific to stone cladding was developed using the market distribution of natural stone cladding by stone type as collected from participant stone processing facilities (56.72% limestone, 36.18% granite, 0.13% marble, and 6.97% other natural stone).

Similarly, the inventory for one square meter of processed stone cladding was developed. An average inventory per square meter of stone processed for each stone category (granite, limestone, marble, and other natural stone) was developed, and later a weighted inventory per square meter of stone processed was generated using the production share of each stone type using the stone processing share of each stone type among the participant processors. After that, the inventory per square meter of stone processing specific to cladding was developed using the market distribution of natural stone cladding (56.72% limestone, 36.18% granite, 0.13% marble, and 6.97% other natural stone).

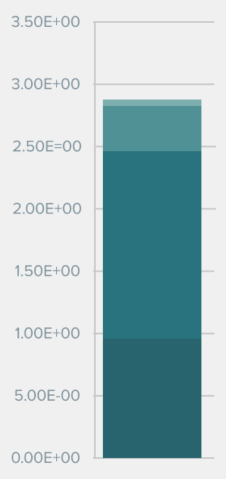
Data quality

Primary data was collected for a time period of two years, which represents typical operations of quarry and processors across North America. Inventory data is considered to have a good precision and provide a representative depiction of the industry average. Data is also considered to be complete, as no know flows are deliberately excluded from this analysis other than those defined to be outside of the system boundary.

Material composition greater than 1% by weight

FLOW	MASS PERCENTAGE
Natural stone	100%

Total impacts by life cycle stages [mPts/per func unit]



LIFE CYCLE STAGE	MPTS/FUNC. UNIT
Raw material supply and transport	9.56E-01
Manufacturing (Stone processing)	1.51E+00
Construction	3.72E-01
End of life	5.49E-02

What's causing the greatest impacts

All life cycle stages

For the natural stone cladding product, the cradle-to-gate stage (A1-A3) dominates the results for all impact categories. This study assessed a multitude of inventory and environmental indicators. In addition to the six major impact categories (global warming potential, ozone depletion, acidification, smog, eutrophication, and fossil fuel depletion), additional impact categories have also been included. These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined, and LCA should continue making advances in their development. However, the EPD users shall not use additional measures for comparative purposes. LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Overall results are consistent with expectations for stone cladding's life cycles, with most of the impacts being generated during cradle-to-gate stages, as cladding is not associated with energy consumption during its use stage.

The primary finding, across the environmental indicators, was that the cradle-to-gate stage dominates the impacts mainly due to the energy consumed at the quarries and processing plants. The processor operations (A3) stage is the highest contributor to most of the impact categories followed by the quarry operations (A1). In some of the impact categories, quarry operations make the highest contribution, followed by the processor operations stage. The cradle-to-gate stage (A1-A3) contributes to ~65% of the total impacts in all impact categories except for ozone depletion. The transportation of stone from quarries to processing plants, transportation of cladding from processing plants to the installation sites, and the use of mortar during installation also generate significant impacts in the overall life cycle impacts of stone cladding.

Quarry operations and transport to processors

Impacts generated at quarries (A1) are mainly because of the use of grid electricity and fuels in the quarries. Other material inputs generate little impact in comparison to the electricity and fuel consumed. The transportation of stone from quarries to processing plants also generates significant impacts in numerous impact categories.

Processor operations and transport to building sites

Manufacturing operations at processing plants make up the greatest share of all impact categories except for ozone depletion. Energy consumed at processors (both electricity and fuels) is responsible for the majority of impacts, while other material inputs have an insignificant contribution. The transportation of stone cladding manufactured in processor plants to the building sites also makes a significant impact on the overall life cycle impacts of natural stone cladding.

Other life cycle stages

Use of mortar during installation also generates significant impacts in the overall life cycle impacts of stone cladding. Under normal operating conditions, stone cladding will not require any cleaning. Due to the nature of natural stone, it is anticipated that the stone cladding products will last for the lifetime of the building. The reference service life (RSL) thus meets an ESL of 75 years, and cladding will need no replacements during its service life. The use stage, thus, is not relevant. End-of-life stages have lower contributions to the total life cycle impacts.

Variation analysis

A variation analysis was performed to study the environmental impacts variation between natural stone cladding from different stone types. Results were generated for both quarry operations and processor operations specific to various stone types (granite, limestone, marble, and other natural stone). One of the major parameters that influences the results is the amount of stone that needs to be quarried to produce one square meter of stone cladding, which varies per stone type.

The variation between weighted average, minimum, and maximum LCIA results is greater than 20% for all the impact categories. This is attributed to varying quarry and processor operations used by different quarries and processors.

Sensitivity analysis

Based on NSI's expert judgement, it was assumed that energy consumed for the processing of a square meter of stone cladding matches the average energy consumed for processing of different stone products. A sensitivity analysis was performed to check the robustness of the results when the energy consumed during processing is varied by +/-20% from the estimate used in this study. The resulting variation in the total life cycle impacts is less than 10%, implying that the system is not sensitive to this assumed value.

How we're making it greener

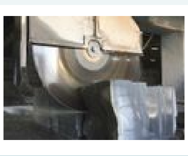
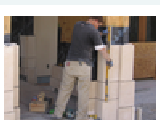
The natural stone industry is committed to making sure our inherently eco-friendly building material is produced efficiently and responsibly. Through the Natural Stone Sustainability Standard we have defined metrics for responsible production in the following categories:

- Energy
- Water
- Chemicals
- Land reclamation & adaptive reuse
- Site management
- Transportation
- Social governance
- Human health & safety
- Excess process materials
- Solid waste
- Innovation

Companies have the opportunity to third-party verify compliance with these metrics. As the industry's leader in education, the Natural Stone Institute is also striving to build awareness about best practices for sustainability among all quarriers and fabricators globally.

See how we make it greener

LCA results

LIFE CYCLE STAGE	RAW MATERIAL SUPPLY AND TRANSPORT	MANUFACTURING	CONSTRUCTION	USE	END OF LIFE
Information modules: Included (X) | Excluded* (MND) Stages B1-B7, C1, and C3 though included, have no associated activities. *Module D is excluded.	**A1 Quarry operations**	**A3 Processor operations**	**A4 Stone transport to building sites**	**B1 Use**	**C1 Deconstruction**
	A2 Transport to processors		**A5 Installation**	**B2 Maintenance**	**C2 Waste Transport**
				B3 Repair	**C3 Waste processing**
				B4 Replacement	**C4 Disposal**
				B5 Refurbishment	
				B6 Operational energy use	
				B7 Operational water use	
					

SM Single Score

Learn about SM Single Score results

Impacts of 1 square meter of installed natural stone cladding	9.56E-01 mPts	1.51E+00 mPts	3.72E-01 mPts	0 mPts	5.49E-02 mPts
Materials or processes contributing >20% to total impacts in each life cycle stage	Energy consumed during stone quarrying (electricity and fuels).	Energy consumed during stone processing (electricity and fuels).	Truck transportation and use of ancillary materials (mainly mortar) for installation..	NA	Waste transport to end of life centers.

TRACI v2.1 results per functional unit

LIFE CYCLE STAGE	Unit	A1-A2 QUARRY OPERATIONS AND TRANSPORT	A3 PROCESSOR OPERATIONS	A4-A5 STONE TRANSPORT TO BUILDING SITES	B1-B7 USE	C1-C4 END-OF-LIFE
Ecological damage						
Impact category	Unit					
Acidification	kg SO_2 eq	7.48E-02	6.39E-02	3.07E-02	0	4.47E-03
Eutrophication	kg N eq	7.45E-03	9.05E-03	2.70E-03	0	5.77E-04
Global warming	kg CO_2 eq	8.50E+00	1.29E+01	8.89E+00	0	1.28E+00
Ozone depletion	kg CFC-11 eq	5.02E-07	6.21E-07	9.97E-07	0	2.54E-07
Human health damage						
Impact category	Unit					
Carcinogenics	CTU_h	2.10E-07	4.56E-07	2.86E-08	0	5.25E-10
Non-carcinogenics	CTU_h	8.73E-07	1.06E-06	4.88E-07	0	4.65E-08
Respiratory effects	kg $PM_{2.5}$ eq	6.51E-03	1.64E-02	2.34E-03	0	3.25E-04
Smog	kg O_3 eq	2.20E+00	1.47E+00	6.08E-01	0	1.20E-01
Additional environmental information						
Impact category	Unit					
Fossil fuel depletion	MJ surplus	1.57E+01	1.72E+01	1.19E+01	0	2.62E+00
Ecotoxicity	CTU_e	46.5 %	41.4 %	10.1 %	0 %	2.0

See the additional content required by the ULE PCR Part B for cladding product systems on page 4 of the **Transparency Report PDF**.

References

LCA Background Report
NSI Natural Stone Cladding LCA Background Report (public version), NSI 2022; SimaPro Analyst 9.4; Ecoinvent 3.4 and US ecoinvent (US -EI 2.2) database; TRACI 2.1

ISO 21930:2017 serves as the core PCR along UL Part A.

ULE PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements v3.2
December, 2018. Technical Advisory Panel members reviewed and provided feedback on content written by UL Environment and USGBC. Past and present members of the Technical Advisory Panel are listed in the PCR.

ULE PCR Part B: Cladding Product Systems EPD requirements v2.0
April 2021. PCR review conducted by: Jim Mellentine (Thrive ESG); Christopher White (NIST), Ph.D.; and Philip S. Moser, P.E.(MA) (Simpson Gumpertz & Heger).

UL Environment General Program Instructions v2.5, March 2021 (available upon request)

ISO 14025, "Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services"

Download PDF SM Transparency Report, which includes the additional EPD content required by the UL Environment PCR.

SM Transparency Reports (TR) are ISO 14025 Type III environmental declarations (EPD) that enable purchasers and users to compare the potential environmental performance of products on a life cycle basis. Environmental declarations from different programs (ISO 14025) may not be comparable. Comparison of the environmental performance of Cladding Product Systems using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase. Full conformance with the PCR for stone cladding allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible.
Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared

Rating systems

The intent is to reward project teams for selecting products from manufacturers who have verified improved life-cycle environmental performance.

LEED BD+C: New Construction | v4 - LEED v4
Building product disclosure and optimization
Environmental product declarations

- ✔ Industry-wide (generic) EPD — ½product
- ○ Product-specific Type III EPD — 1 product

LEED BD+C: New Construction | v4.1 - LEED v4.1
Building product disclosure and optimization
Environmental product declarations

- ✔ Industry-wide (generic) EPD — 1 product
- ○ Product-specific Type III EPD — 1.5 product

Collaborative for High Performance Schools National Criteria
MW C5.1 – Environmental Product Declarations

- ✔ Third-party certified type III EPD — 2 points

Green Globes for New Construction and Sustainable Interiors
Materials and resources

- ✔ NC 3.5.1.2 Path B: Prescriptive Path for Building Core and Shell
- ✔ NC 3.5.2.2 and SI 4.1.2 Path B: Prescriptive Path for Interior Fit-outs

BREEAM New Construction 2018
Mat 02 - Environmental impacts from construction products
Environmental Product Declarations (EPD)

- ✔ Industry--average EPD — .5 points
- ○ Multi-product specific EPD — .75 points
- ○ Product-specific EPD — 1 point

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3rd-party reviewed	✔
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North America; Cradle to grave
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1 m^2 of installed stone cladding; 75 years
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How we make it greener

Exterior Dimension Stone Cladding

Expand all

See LCA results by life cycle stage

RAW MATERIAL ACQUISITION

Usable material vs excess process material ratios vary at each quarry and at times the excess exceeds the usable. It is important to know that excess process materials are almost always reclaimed or recycled. It is extremely uncommon for any stone to be diverted to a landfill. The Natural Stone Institute is working with their quarrier members to identify ways to make use of this excess and educate the industry about techniques and product lines that can effectively improve quarry yield.

The design community can also help with this issue. Most natural stone's have a specific set of characteristics for the most desirable pieces. For example, limestone is generally either buff or gray in color. The blocks that are variegated, containing both buff and gray hues, are less desirable. If design teams are more accepting of natural variation in the material, then there is more usable material, and less excess, available from the source.

TRANSPORTATION

Using stone from local sources is the single biggest opportunity to reduce its embodied carbon. Since natural stone is a heavy material, the environmental impacts for transporting it end up being the most significant accrual of carbon. Natural stone is sourced world-wide and each deposit has unique aesthetic and performance characteristics so this is not always avoidable. Be sure to understand the distances between the quarry, the fabrication facility, and sometimes the distribution centers. In most North American operations the quarry is within miles of the fabrication facility. However, some natural stone producers will take advantage of lower labor costs in other countries and ship the stone large distances to be fabricated and then back again.

MANUFACTURING

To ensure the health and safety of our workforce, water is used during quarrying and fabrication to reduce dust and heat. Recycling this water is both environmentally responsible and economical. It is very common for stone facilities to recycle over 85% of the water used in their facilities.

There are a large variety of sizes and finishes that are commonly used for natural stone cladding. Design teams can help to reduce energy consumption in the following ways:

- Appreciate natural color and pattern variations.
- Understand how finishes are achieved and additional work that may be required on edges or adjacent surfaces.
- Optimize panel sizes based on block availability.
- Reduce thickness if possible.
- Avoid complex geometries such as radiuses and solid corners.
- Consult an expert for guidance on the most sustainable ways of achieving your desired aesthetic.

USE AND END OF LIFE

There are endless opportunities for natural stone to be refinished, reused, and recycled.

Since it is durable and full-bodied, the surface of the material can be removed, revealing a 'clean slate' free of any sealers or contaminants, freeing them of centuries of pollutants, preserving the historical integrity of the project, and eliminating the need for new construction.

Because of these capabilities, stone rarely reaches an end to its potential service life. When an owner chooses to replace natural stone, it can be removed and altered into an entirely new product and reinstalled in a new location.

There are also stone companies that have 'take-back' programs, to divert the stone from a landfill back to a quarry to be used as part of their land reclamation plan. If stone does end up in a construction landfill, there will be no toxic chemicals seeping into the earth as the material degrades. It simply returns to the earth, cradle to cradle.

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3rd-party reviewed	✓
	Transparency Report (EPD)
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Additional EPD content required by:
ULE PCR Part B: Cladding Product Systems EPD Requirements

Exterior Dimension Stone Cladding

Data

Background This industry-average declaration was created by collecting product data for one square meter of installed natural stone cladding.

Allocation The allocation methods used were examined according to the updated allocation rules in ISO 21930:2017. Quarry inputs and outputs were divided evenly among the quarried stone by mass, and no co-product allocation was needed. Although different stone products go through different processing steps, processor inputs and outputs were also evenly distributed between different stone products based on their production area. More resources were allocated to countertops (10%) than the average stone processing, but no adjustment was made for cladding.

Cut-off criteria for the inclusion of mass and energy flows are 1% of renewable primary resource (energy) usage, 1% nonrenewable primary resource (energy) usage, 1% of the total mass input of that unit process, and 1% of environmental impacts. The total of neglected input flows per module does not exceed 5% of energy usage, mass, and environmental impacts. The only exceptions to these criteria are substances with hazardous and toxic properties, which must be listed even when the given process unit is under the cut-off criterion of 1% of the total mass. No known flows are deliberately excluded from this declaration; therefore, these criteria have been met. Biogenic carbon is included in reported results.

Relevant technical properties

PARAMETER	VALUE	UNIT	TEST METHOD
Thickness to achieve functional unit	0.05	m	
Density	2507	kg /m^3	
Length	1.52	m	
Width	0.66	m	
Flexural strength	3.45 – 8.27	MPa	ASTM C880
Modulus of rupture	2.76 – 13.79	MPa	ASTM C99
Compressive strength	12.41 – 137.89	MPa	ASTM C170
Thermal conductivity (k-value)	1.26 – 5.38	W/mK	ASTM C518
Thermal resistance (R-value)	0.19 – 0.79	m.K/W	ASTM C518
Liquid water absorption	0.2 – 12.00	% of dry weight	ASTM C97
VOC emissions	0	µg/m^3	

Major system boundary exclusions

- Capital goods and infrastructure; maintenance and operation of support equipment;
- Manufacture and transport of packaging materials not associated with final product;
- Human labor and employee transport;
- Building operational energy and water use not associated with final product.

Major assumptions and limitations

- Natural stone other than granite, limestone, & marble are grouped together.
- Quarrying & processing inventory specific to cladding are generated using the production share of cladding by stone types among the participant processors only.
- Energy consumed for cladding stone processing is assumed to be similar to the average energy processing of all stone products.
- Gaps in materials data for participant manufacturers are filled with an average from other facilities.
- A conservative stone transport distance of 100 km is taken for stone transport from quarries to processors for the quarries with no primary transport info.

Calcination CO_2 emissions Calcination occurs during installation stage due to the use of mortar. Mortar includes cement, calcination CO_2 emissions for cement are calculated and reported separately using a carbon intensity factor of 886 CO_2 per ton of cement (Source: U.S. Cement Industry Carbon Intensities (2019)).

Hazardous waste Stone cladding does not contain substances that are identified as hazardous according to the Resource Conservation and Recovery Act (RCRA), Subtitle C.

Scenarios and additional technical information

Transport from Quarry to Processor [A2] Based on the primary data, the transport distance varies, & the weighted distance is 65 km. For quarries with no primary info, a conservative distance of 100 km via truck & trailer was assumed.

PARAMETER	VALUE	UNIT
Transport to the building site [A4]		
Vehicle type	Lorry, 16-32 ton	
Fuel type	Diesel	
Liters of fuel	0.36	l/100 km
Distance from manufacturer to installation site	301	km (weighted avg)
Capacity utilization (mass based)	100	%
Gross density of products transported	2,508	kg/m^3 (weighted avg)
Capacity utilization volume factor	1	

Installation into the building [A5]

Installation scrap assumed	5	%
Ancillary materials - Mortar Masonry connectors	 4.88 0.62	kg
Net freshwater consumption	0.001	m^3
Electricity consumption	0	kWh
Product loss per functional unit (scrap)	4.16	kg
Waste materials at the construction site before waste processing (stone scrap and packaging waste)	6.17	kg
Output materials from on-site waste processing	0	kg
Mass of packaging waste by type Plastic Cardboard Wood	 0.003 0.002 2.005	kg
Biogenic carbon contained in packaging	0.27	kg CO_2
Direct emissions to ambient air, soil and water	0	kg
VOC emissions	0	µg/m^3

Reference service life

Reference Service Life (RSL)	75	years
Declared product properties	Refer to 'Relevant technical properties' table	
Design application parameters	Outdoor applications	
Outdoor environment	Installation as recommended by the manufacturer.	
Estimated Service life (ESL)	75	years
Maintenance process information	Not necessary	
Use conditions	All conditions	

End of life [C1-C4]

Assumptions for scenario development	The product is dismantled and removed from the building manually. It is transported to a local facility where it requires no further processing before final disposition.		
Collection process	Collected separately	0	kg
	Collected with mixed construction waste	88.78	kg
Recovery	Reuse	0	kg
	Recycling (68.5%)	60.82	kg
Disposal	Landfill (31.5%)	27.97	kg
Waste transport		100	km
Final disposal		27.97	kg
Removals of biogenic carbon (excluding packaging)		0	kg CO_2

LCI dataset variability for major parameters

LCI parameter	Unit	For Quarry Operations			For Processor Operations		
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
Electricity	kWh	2.82E-02	1.28E-02	3.83E-02	2.91E+01	2.98E+01	2.03E+01
Gasoline	liters	5.10E-04	4.94E-04	3.24E-04	1.38E-01	6.51E-02	1.92E-01
Diesel	liters	9.84E-03	7.51E-03	9.78E-03	4.52E-01	4.60E-01	3.86E-01
Propane	liters	5.47E-05	6.08E-06	1.15E-04	1.30E+00	2.85E-01	2.21E+00
Natural gas	MJ	3.46E-05	NA	7.73E-05	7.50E+00	5.16E+00	9.35E+00
ANFO	kg	2.23E-04	1.15E-04	3.16E-04	NA	NA	NA
Diamond blades	kg	1.48E-04	7.06E-06	3.12E-04	3.88E-02	4.82E-03	7.07E-02
Carbide tooling	kg	1.39E-02	4.07E-07	NA	2.13E-04	3.72E-05	3.77E-04

Variation of TRACI impact categories

Impact category	Min. value	Max. value	Mean	Median
Ozone depletion	1.95E-06	3.59E-06	2.73E-06	2.78E-06
Global warming	2.33E+01	6.59E+01	3.98E+01	4.00E+01
Smog	3.23E+00	1.12E+01	5.95E+00	5.30E+00
Acidification	1.43E-01	4.20E-01	2.33E-01	2.14E-01
Eutrophication	1.52E-02	4.48E-02	2.64E-02	2.50E-02
Carcinogenics	2.15E-07	2.13E-06	9.46E-07	9.80E-07
Non-carcinogenics	1.78E-06	6.05E-06	3.31E-06	3.25E-06
Respiratory effects	1.39E-02	6.74E-02	3.79E-02	3.78E-02
Ecotoxicity	2.19E+01	8.94E+01	4.53E+01	4.43E+01
Fossil fuel depletion	3.95E+01	9.49E+01	6.09E+01	5.73E+01

LCIA results, resource use, output and waste flows, and carbon emissions & removals per m^2 of natural stone cladding

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
LCIA results (per m^2 of natural stone cladding)												
Ozone depletion	kg CFC-11 eq	1.74E-07	3.28E-07	6.21E-07	8.81E-07	1.16E-07	0	0	2.42E-07	0	1.17E-08	**2.37E-06**
Global warming	kg CO_2 eq	6.85E+00	1.65E+00	1.29E+01	4.42E+00	4.47E+00	0	0	1.22E+00	0	6.87E-02	**3.15E+02**
Smog	kg O_3 eq	2.06E+00	1.36E-01	1.47E+00	3.64E-01	2.44E-01	0	0	1.00E-01	0	2.00E-02	**4.39E+00**
Acidification	kg SO_2 eq	6.96E-02	5.16E-03	6.39E-02	1.38E-02	1.68E-02	0	0	3.81E-03	0	6.64E-04	**1.74E-01**
Eutrophication	kg N eq	6.75E-03	6.94E-04	9.05E-03	1.86E-03	9.16E-04	0	0	5.12E-04	0	6.49E-05	**1.99E-02**
Carcinogenics	CTUh	2.09E-07	6.85E-10	4.56E-07	1.84E-09	2.67E-08	0	0	5.05E-10	0	2.01E-11	**6.95E-07**
Non-carcinogenics	CTUh	8.11E-07	6.19E-08	1.06E-06	1.66E-07	3.22E-07	0	0	4.57E-08	0	7.97E-10	**2.46E-06**
Respiratory effects	kg $PM_{2.5}$ eq	6.19E-03	3.24E-04	1.64E-02	8.69E-04	1.47E-03	0	0	2.39E-04	0	8.61E-05	**2.56E-02**
Ecotoxicity	CTUe	43.8%	2.7%	41.4%	7.3%	2.8%	0%	0%	2.0%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	1.23E+01	3.36E+00	1.72E+01	9.00E+00	2.93E+00	0	0	2.48E+00	0	1.46E-01	**4.75E+01**
Resource use indicators (per m^2 of natural stone cladding)												
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	3.46E+00	3.43E-02	6.98E+01	9.21E-02	1.96E+00	0	0	2.53E-02	0	1.98E-03	**7.54E+01**
Renewable primary resources with energy content used as material	MJ, LHV	1.97E+00	0	3.66E+00	0	0	0	0	0	0	0	**5.64E+00**
Total use of renewable primary resources with energy content	MJ, LHV	5.43E+00	3.43E-02	7.35E+01	9.21E-02	1.96E+00	0	0	2.53E-02	0	1.98E-03	**8.10E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	1.02E+02	2.21E+01	2.24E+02	5.93E+01	4.16E+01	0	0	1.63E+01	0	9.64E-01	**4.66E+02**
Non-renewable primary resources with energy content used as material	MJ, LHV	5.61E-01	0	0	0	0	0	0	0	0	0	**5.61E-01**
Total use of non-renewable primary resources with energy content	MJ, LHV	1.03E+02	2.21E+01	2.24E+02	5.93E+01	4.16E+01	0	0	1.63E+01	0	9.64E-01	**4.66E+02**
Secondary materials	kg	0	0	0	0	0	0	0	0	0	0	**0**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m^3	1.52E+02	3.74E-03	1.02E+01	1.00E-02	3.10E+00	0	0	2.76E-03	0	1.69E-04	**1.66E+02**
Output flows and waste category indicators (per m^2 of natural stone cladding)												
Hazardous waste disposed	kg	1.51E-03	0	3.16E-04	0	0	0	0	0	0	0	**1.83E-03**
Non-hazardous waste disposed	kg	6.40E-02	0	4.19E-01	0	2.06E+00	0	0	0	0	2.80E+01	**3.05E+01**
High-level radioactive waste, conditioned, to final repository	kg	5.05E-03	1.80E-06	5.77E-02	4.82E-06	3.16E-04	0	0	1.33E-06	0	1.03E-07	**6.31E-02**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.54E-06	1.88E-08	1.16E-05	5.06E-08	6.48E-07	0	0	1.39E-08	0	1.09E-09	**1.59E-05**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	2.78E+02	0	2.24E+01	0	4.12E+00	0	0	0	0	6.08E+01	**3.66E+02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions and removals (per m^2 of natural stone cladding)												
Biogenic carbon removal from product	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from product	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon removal from packaging	kg CO_2	0	0	3.66E+00	0	1.83E-01	0	0	0	0	0	**3.85E+00**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	2.78E+00	0	0	0	0	0	**2.78E+00**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	1.21E+00	0	0	0	0	0	**1.21E+00**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**