CONCRETE MASONRY & HARDSCAPES ASSOCIATION

Environmental Product Declaration **for**

Concrete Masonry Units

as Manufactured by Members of

Concrete Masonry & Hardscapes Association (CMHA)

Concrete Masonry and Hardscapes Association

The Concrete Masonry & Hardscapes Association (CMHA) represents a unification of the Interlocking Concrete Pavement Institute (ICPI) and National Concrete Masonry Association (NCMA). CMHA is a trade association representing US and Canadian producers and suppliers in the concrete masonry and hardscape industry, as well as contractors of interlocking concrete pavement and segmental retaining walls. CMHA is the authority for segmental concrete products and systems, which are the best value and preferred choice for resilient pavement, structures, and living spaces. CMHA is dedicated to the advancement of these building systems through research, promotion, education, and the development of manufacturing guides, design codes and resources, testing standards, and construction practices. CMHA members are committed to producing concrete masonry units that contribute to resilient and sustainable communities.

ENVIRONMENTAL IMPACTS (A1-A3 Cradle-to-Gate)

Declared Product: Concrete Masonry Units
Declared Unit: 1 m^3 of concrete formed into manufactured concrete masonry units (CMU)

	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	208	232	241	360	244	395	286
Acidification Potential (kg SO2-eq)	0.83	0.74	0.78	1.73	1.04	1.93	1.70
Eutrophication Potential (kg N-eq)	0.36	0.40	0.41	0.55	0.42	0.53	0.46
Smog Formation Potential (kg O3-eq)	16.3	14.7	14.8	23.8	22.5	26.6	40.3
Ozone Depletion Potential (kg CFC-11-eq)	6.94E-06	7.19E-06	7.18E-06	2.76E-05	7.03E-06	3.04E-05	6.77E-06

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

General Information

This cradle-to-gate Environmental Product Declaration (EPD) covers US industry average concrete masonry units (CMU) as manufactured by members of Concrete Masonry and Hardscapes Association (CMHA) and other industry producers. The Life Cycle Assessment (LCA) was prepared in conformity with ISO 21930, ISO 14025, ISO 14040, and ISO 14044, the UL product category rules (PCR) and ASTM General Program Instructions. This EPD is intended for business-to-business (B-to-B) audiences.

Table 1. Concrete Masonry Unit (CMU) Products Applicable to this EPD

NW1	Normal Weight CMU with density of 125.0 pcf or greater. Compressive Strengths of 2,000 to 3,240 psi [f'm = 2,000 psi]*	ASTM C90, Concrete Masonry Unit, Loadbearing
NW2	Normal Weight CMU with density of 125.0 pcf or greater. Compressive Strengths of greater than 3,250 to 4,490 psi [f'm = 2,500 psi]*	
NW3	Normal Weight CMU with density of 125.0 pcf or greater. Compressive Strengths of 4,500 psi or greater [f'm = 3,000+ psi]*	
MW-M	Medium Weight CMU with density of 105.0 to 124.9 pcf; Containing manufactured lightweight aggregate - expanded shale, clay or slate. Compressive Strengths of 2,000 to 3,240 psi [f'm = 2,000 psi]*	
MW-N	Medium Weight CMU with density of 105.0 to 124.9 pcf; Containing natural aggregates such as pumice, scoria or limestone as well as those from byproducts of other processes such as expanded slag or bottom ash. Compressive Strengths of 2,000 to 4,490 psi [f'm = 2,000 to 2500 psi]*	
LW-M	Lightweight CMU with density of 104.9 pcf or less; Containing manufactured lightweight aggregate - expanded shale, clay or slate. Compressive Strengths of 2,000 to 4,490 psi [f'm = 2,000 to 2500 psi]*	
LW-N	Lightweight CMU with density of 104.9 pcf or less; Containing natural aggregates such as pumice or scoria as well as those from byproducts of other processes such as expanded slag or bottom ash. Compressive Strengths of 2,000 to 3,240 psi [f'm = 2,000 psi]*	

*f'm is the specified compressive strength of masonry. CMU with the listed compressive strengths comply with the corresponding assembly f'm value when used with Type M or S mortar.

Declaration Comparability Limitation Statement

Environmental declarations from different programs (ISO 14025) may not be comparable. EPDs are comparable only if they use the same PCR (or sub-category PCR where applicable), include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works. This PCR allows EPD comparability only when the same functional requirements between products are ensured and the requirements of ISO 21930:2017 §5.5 are met. However, variations and deviations are possible. Example of variations: different LCA software and background LCI datasets may lead to different results for the life cycle stages declared.

General Program Instructions	ASTM Program Operator for Product Category Rules (PCRs) and Environmental Product Declarations (EPDs), General Program Instructions. Version 8.0, revised April 29, 2020.
Reference PCR	Part B: Concrete Masonry and Segmental Concrete Paving Product EPD Requirements, March 2022. V1.1
The sub-category PCR review was conducted by:	Jack Geibig, Ecoform, LLC, Terrie Boguski, Harmony Environmental, LLC, Christine Subasic, P.E., LEED AP, Consulting Architectural Engineer
Markets of Applicability	United States
EPD Type	Industry-Average EPD From CMHA manufacturer's facilities
Declared Unit	One cubic meter (m^3) of concrete formed into manufactured concrete products
EPD Scope	Cradle-to-Gate
Year(s) of Reported Manufacturer Primary Data	1/2/2022 - 1/1/2023
LCI Database(s)	Ecoinvent, USLCI, US-EI
LCIA Methodology	TRACI 2.1 v1.04
This declaration was independently verified in accordance with ISO 14025:2006. The UL Environment "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report," v3.2 (December 2018), in conformance with ISO 21930:2017, serves as the core PCR, with additional considerations from the USGBC/UL environment Part A Enhancement (2017). □ internal ☑ external	Thomas P. Gloria (t.gloria@industrial-ecology.com) Industrial Ecology Consultants
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by	Climate Earth Inc. 137 Park Place, Suite 204 Pt Richmond, CA 94801 415-391-2725; support@climateearth.com
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by	Thomas P. Gloria (t.gloria@industrial-ecology.com) Industrial Ecology Consultants
Date of Issue	August 9, 2024 (valid for 5 years until August 8, 2029)
ASTM Declaration Number	EPD-766
LCA/EPD Developer Climate Earth, Inc. 137 Park Place, Suite 204 Pt Richmond, CA 94801 415-391-2725 https://www.climateearth.com	

Participating Manufacturers

Thirty-five Manufacturing facilities, of which 33 are CMHA members, are included in the study.

	Producer	Address	City	State	ZIP
	Barnes & Cone	5894 Court St.	Syracuse	NY	13206
	Basalite Concrete Products	1801 South Rollie Ave.	Fort Lupton	CO	80621
	Best Block - Midwest Block	12901 St. Charles Rock Rd.	Bridgeton	MO	63044
	Block - Lite Co., Inc.	3900 E. Industrial Dr.	Flagstaff	AZ	86004
	Boxley Materials	15418 West Lynchburg Salem Tpk.	Blue Ridge	VA	24064
	Consumers Concrete Corp Wyoming	1505 Burlingame Ave.	Wyoming	MI	49519
	County Materials Corporation	205 North St.	Marathon	WI	54448
	Ernest Maier - Bladensburg	4700 Annapolis Rd.	Bladensburg	MD	20710
	Ernest Maier - Millsboro	30243 Millsboro Hwy.	Millsboro	DE	19966
	Fizzano Bros Concrete Products Inc	1776 Chester Pk.	Crum Lynne	PA	19022
	Fizzano Bros Concrete Products Inc	Trevose & Sterner Mill Rd.	Trevose	PA	19053
	Fizzano Bros Concrete Products Inc	201 S Phoenixville Pk.	Malvern	PA	19355
	Hi-Way Concrete Products*	2746 Cranberry Hwy.	Wareham	MA	2571
	Jandris Block	202 High St.	Gardner	MA	01140
	Johnson Concrete Company - Lexington	218 Klumac Rd.	Salisbury	NC	28144
	Johnson Concrete Company - Willow Spring	1401 NC-42	Willow Spring	NC	27592
	Kings Material	650 12th Ave. SW	Cedar Rapids	IA	52404
	Lee Building Products - Murfreesboro	700 Ordway St.	Murfreesboro	TN	37133
	Lee Building Products – New Albany	6000 Grantline Rd.	New Albany	IN	47150

	Producer	Address	City	State	ZIP
	Lee Building Products - Louisville	12906 Old Henry Rd.	Louisville	KY	40223
	Mutual Materials	605 119th Ave.	Bellevue	NE	98005
	Nitterhouse Products LLC	859 Cleveland Ave.	Chambersburg	PA	17201
	Oldcastle APG - Charlotte	333 N. Greene St.	Greensboro	NC	27401
	Oldcastle APG Mid-Atlantic Richmond	1231 Willis Rd.	Richmond	VA	23225
	Oldcastle Georgia Masonry Supply	125 Industrial Park Cir.	Lawrenceville	GA	30046
	Oldcastle Northfield Block	3400 Bungalow Rd.	Morris	IL	60450
	Oldcastle Preferred Materials, Inc.	4636 Scarborough Dr.	Lutz	FL	33559
	Palumbo Block Co., Inc.*	365 Dover Furnace Rd.	Dover Plains	NY	12522
	Piedmont Block Company	P.O. Box 1037	Salisbury	NC	28145
	R. Ducharme Inc.	451 McKinstry Ave.	Chicopee	MA	(0)1020
	RCP Block & Brick	8240 Broadway	Lemon Grove	CA	91945
	Taylor Concrete Products	20475 Old Rome State Rd.	Watertown	NY	13601
	Texas Best Block Alleyton	2088 FM 949	Alleyton	TX	78935
	Texas Best Block San Antonio	2233 Ackerman Rd.	San Antonio	TX	78219
	Willamette Graystone LLC	3700 Frankling Blvd.	Eugene	OR	97403

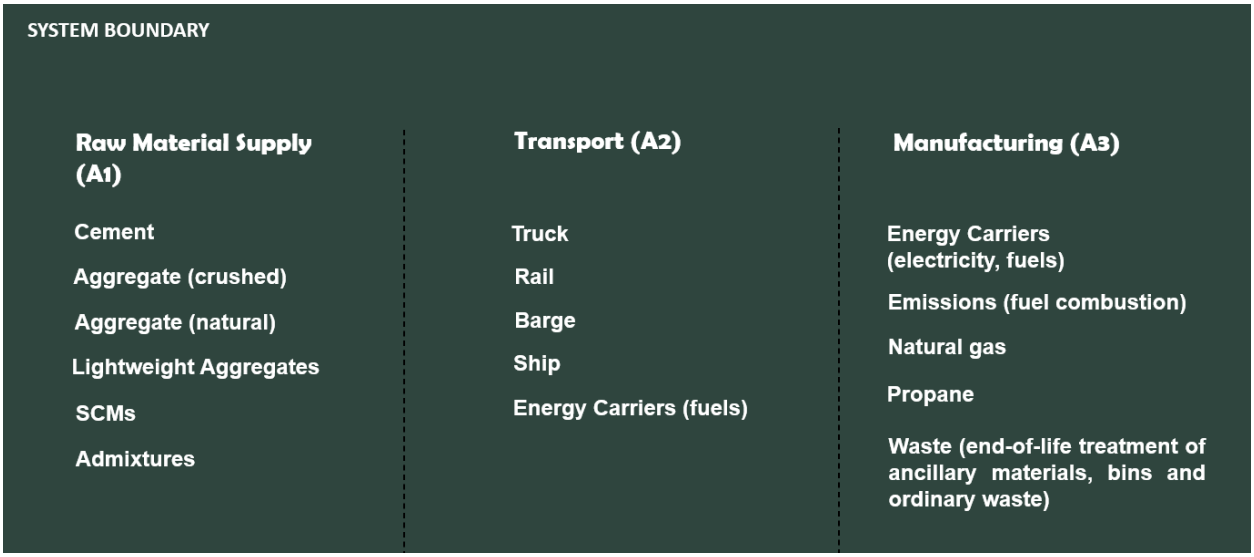
*Non-member of CMHA as of publication of this report.

System Boundary

This EPD is a cradle-to-gate EPD covering A1-A3 stages of the life cycle.

PRODUCTION Stage (*Mandatory*)			CONSTRUCTION Stage		USE STAGE					END-OF-LIFE Stage			
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction/ Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**
X	**X**	**X**	**MND**	**MND**	**MND**	**MND**	**MND**	**MND**	**MND**	**MND**	**MND**	**MND**	**MND**
Note: MND = module not declared; X = module included.													

The production stages and primary unit processes included in the study by product stage are:



Relevant Information for product stages not included in system boundary (A4-C4):
Other products not included in assessment needed for the product to serve intended function in the construction work can include mortar, grout, and reinforcement for concrete masonry products;
Typical end of life treatment is unknown but can include landfill or crushing and then re-use as a recycled aggregate or as road base;
The reference service life for concrete masonry is 75 years.

Material Content

The industry-average material content by input material for the seven product types studied here is derived from the weighted average based on production volume of all plants contributing to the study.

Table 2. **Material Properties of CMU Products**

	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Compressive Strength (psi)	2,000-3,240	3,250-4,490	4,500 or greater	2,000-3,240	2,000-4,490	2,000-4,490	2,000-3,240
Compressive Strength (MPa)	13.8-22.3	22.3-31.0	>31	13.8-22.3	13.8-31.0	13.9-31.0	13.8-22.3
Raw Materials / % of total mass							
Crushed/Natural Aggregate	91.9%	90.0%	89.4%	61.5%	82.2%	48.3%	53.5%
Lightweight Aggregate	0.0%	0.0%	0.0%	28.0%	6.9%	39.0%	33.6%
Cement	7.8%	10.0%	10.3%	10.5%	11.0%	12.3%	12.9%
Portland Cement	6.5%	7.3%	5.8%	7.3%	6.3%	10.5%	2.4%
Portland Limestone Cement	1.3%	2.8%	4.5%	3.3%	4.7%	1.8%	10.5%
Total SCM	0.3%	0.0%	0.3%	0.0%	0.0%	0.3%	0.0%
Admixtures	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Cut-Off

Items excluded from system boundary include:

- post-production processing operations such as grinding, burnishing, prefacing, or other similar operations.
- production, manufacture and construction of manufacturing capital goods and infrastructure.
- production and manufacture of production equipment, delivery vehicles, and laboratory equipment.
- personnel-related activities (travel, furniture, and office supplies); and
- energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

Allocation Procedure

Allocation follows the requirements and guidance Part A: Life Cycle Assessment Calculation Rules and Report Requirements, section 3.3.

The product category rules for this EPD recognize fly ash, silica fume and slag as recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a concrete material input.

Data Quality

The data quality requirements specified in UL PCR: 2020 were followed. This section describes the data quality achieved in relation to ISO 14044:2006 requirements.

- Precision: Primary data on their production of block CMU was collected through measurement and calculation. To ensure accuracy, the plant gate-to-gate data were individually validated.
- Time: Manufacturing Data is from 2022-2023.
- Geography: Process from US producers.
- Completeness: Process includes raw materials, energy, and ancillary and packaging materials. All transportation of raw materials and packaging, consumption of energy and water, transportation of wastes and end-of-life treatment of wastes are included.
- Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in Climate Earth software
- Reliability: Data based on 35 plants located in the USA. Study has undergone a critical review.

Declaration of environmental indicators derived from cradle-to-gate LCA
Declared Unit: 1 m^3 of concrete formed into manufactured concrete masonry units (CMU)

Table 3. **A1-A3 Impact results; product type: NW1 (1 m^3 of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	1.76E+02	2.39E+01	8.68E+00	2.08E+02	2.06E+02	2.50E+01
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	5.03E-06	1.13E-09	1.90E-06	6.94E-06	6.63E-06	1.77E-06
Eutrophication potential (EP)	kg N e	2.15E-01	1.88E-02	1.32E-01	3.65E-01	3.58E-01	3.50E-02
Acidification potential of soil and water sources (AP)	kg SO2 e	4.00E-01	3.14E-01	1.17E-01	8.31E-01	8.01E-01	1.79E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	7.35E+00	7.94E+00	9.69E-01	1.63E+01	1.30E+01	5.12E+00
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	5.20E-05	0.00E+00	2.55E-06	5.46E-05	5.61E-05	1.18E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	2.84E+02	3.84E+02	3.59E+02	1.03E+03	1.03E+03	3.14E+02
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	3.90E+01	0.00E+00	2.24E+02	2.63E+02	1.45E+02	2.53E+02
Renewable primary resources as material, (RPRM)**	MJ, NCV	4.71E-02	0.00E+00	0.00E+00	4.71E-02	2.20E-02	5.84E-02
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	9.96E+02	3.84E+02	4.82E+02	1.86E+03	1.81E+03	3.18E+02
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	1.38E+00	0.00E+00	0.00E+00	1.38E+00	6.43E-01	1.71E+00
Consumption of fresh water	m3	3.41E+00	0.00E+00	2.35E-01	3.64E+00	3.58E+00	4.21E-01
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	8.05E+01	0.00E+00	0.00E+00	8.05E+01	2.16E+01	7.74E+01
Renewable secondary fuels, (RSF)**	MJ, NCV	9.99E+00	0.00E+00	0.00E+00	9.99E+00	9.60E+00	1.50E+00
Non-renewable secondary fuels (NRSF)**	MJ, NCV	9.63E+01	0.00E+00	0.00E+00	9.63E+01	9.25E+01	1.45E+01
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.39E-03	0.00E+00	0.00E+00	2.39E-03	2.44E-03	3.69E-04
Non-hazardous waste disposed**	kg	5.41E+01	0.00E+00	1.32E+00	5.55E+01	5.45E+01	2.34E+01
High-level radioactive waste**	m3	2.72E-04	0.00E+00	1.03E-07	2.72E-04	1.27E-04	3.37E-04
Intermediate and low-level radioactive waste**	m3	1.52E-07	0.00E+00	5.58E-07	7.09E-07	6.70E-07	3.72E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	7.87E-01	0.00E+00	8.37E-01	1.62E+00	1.25E+00	7.69E-01
Materials for energy recovery**	kg	0.00E+00	0.00E+00	7.98E-03	7.98E-03	0.00E+00	3.87E-02
Recovered energy exported from the product system**	MJ	7.07E-02	0.00E+00	0.00E+00	7.07E-02	0.00E+00	1.62E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	8.38E+01	0.00E+00	0.00E+00	8.83E+01	8.49E+01	1.33E+01
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-17.5	-17.5		

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.
** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.
- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Table 4. **A1-A3 Impact results; product type: NW2 (1 m³ of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	2.10E+02	1.50E+01	3.33E+00	2.32E+02	2.17E+02	2.88E+01
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	5.52E-06	6.35E-10	1.67E-06	7.19E-06	7.12E-06	1.07E-06
Eutrophication potential (EP)	kg N e	2.41E-01	1.08E-02	1.48E-01	4.00E-01	4.03E-01	8.59E-02
Acidification potential of soil and water sources (AP)	kg SO2 e	4.40E-01	1.80E-01	1.21E-01	7.42E-01	8.11E-01	1.31E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	8.15E+00	4.61E+00	1.91E+00	1.47E+01	1.58E+01	2.77E+00
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	5.59E-05	0.00E+00	3.49E-06	5.94E-05	5.57E-05	1.59E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	4.32E+02	2.15E+02	3.29E+02	9.76E+02	1.01E+03	3.26E+02
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	3.99E+01	0.00E+00	2.46E+02	2.86E+02	9.52E+01	2.09E+02
Renewable primary resources as material, (RPRM)**	MJ, NCV	4.63E-02	0.00E+00	0.00E+00	4.63E-02	0.00E+00	6.79E-02
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	1.09E+03	2.15E+02	4.21E+02	1.73E+03	1.86E+03	2.63E+02
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	1.35E+00	0.00E+00	0.00E+00	1.35E+00	0.00E+00	1.99E+00
Consumption of fresh water	m3	3.16E+00	0.00E+00	2.07E-01	3.37E+00	3.20E+00	2.98E-01
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	5.12E+01	0.00E+00	0.00E+00	5.12E+01	1.86E+01	5.02E+01
Renewable secondary fuels, (RSF)**	MJ, NCV	1.17E+01	0.00E+00	0.00E+00	1.17E+01	9.88E+00	1.58E+00
Non-renewable secondary fuels (NRSF)**	MJ, NCV	1.13E+02	0.00E+00	0.00E+00	1.13E+02	9.53E+01	1.52E+01
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.77E-03	0.00E+00	8.96E-03	1.17E-02	2.34E-03	1.11E-01
Non-hazardous waste disposed**	kg	5.15E+01	0.00E+00	8.70E-01	5.24E+01	5.73E+01	2.61E+01
High-level radioactive waste**	m3	2.67E-04	0.00E+00	4.75E-08	2.67E-04	1.11E-07	3.92E-04
Intermediate and low-level radioactive waste**	m3	1.03E-07	0.00E+00	4.45E-07	5.48E-07	5.38E-07	2.47E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	8.63E-01	0.00E+00	8.02E-01	1.66E+00	2.43E+00	2.10E+00
Materials for energy recovery**	kg	0.00E+00	0.00E+00	2.17E-03	2.17E-03	0.00E+00	1.24E-02
Recovered energy exported from the product system**	MJ	1.07E-01	0.00E+00	0.00E+00	1.07E-01	0.00E+00	1.70E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	1.03E+02	0.00E+00	0.00E+00	1.03E+02	8.75E+01	1.39E+01
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-21.6	-21.6		

*. Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.
** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.
- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Table 5. **A1-A3 Impact results; product type: NW3 (1 m^3 of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	2.20E+02	1.45E+01	6.25E+00	2.41E+02	1.79E+02	3.45E+02
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	5.70E-06	6.11E-10	1.47E-06	7.18E-06	5.97E-06	8.40E-06
Eutrophication potential (EP)	kg N e	2.52E-01	1.06E-02	1.47E-01	4.09E-01	3.11E-01	4.88E-01
Acidification potential of soil and water sources (AP)	kg SO2 e	4.59E-01	1.77E-01	1.43E-01	7.79E-01	5.68E-01	9.59E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	8.42E+00	4.56E+00	1.86E+00	1.48E+01	1.10E+01	1.75E+01
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	9.81E-05	0.00E+00	2.71E-06	1.01E-04	3.77E-05	2.47E-04
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	4.32E+02	2.07E+02	3.82E+02	1.02E+03	5.27E+02	2.22E+03
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	4.57E+01	0.00E+00	2.73E+02	3.19E+02	6.27E+01	5.25E+02
Renewable primary resources as material, (RPRM)**	MJ, NCV	1.91E-01	0.00E+00	0.00E+00	1.91E-01	0.00E+00	6.90E-01
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	1.16E+03	2.07E+02	4.48E+02	1.81E+03	1.36E+03	2.33E+03
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	5.59E+00	0.00E+00	0.00E+00	5.59E+00	0.00E+00	2.02E+01
Consumption of fresh water	m3	3.11E+00	0.00E+00	2.09E-01	3.32E+00	1.36E+00	3.86E+00
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	2.82E+01	0.00E+00	0.00E+00	2.82E+01	1.93E+01	5.10E+01
Renewable secondary fuels, (RSF)**	MJ, NCV	1.22E+01	0.00E+00	0.00E+00	1.22E+01	9.36E+00	1.65E+01
Non-renewable secondary fuels (NRSF)**	MJ, NCV	1.17E+02	0.00E+00	0.00E+00	1.17E+02	9.01E+01	1.59E+02
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.89E-03	0.00E+00	7.26E-03	1.01E-02	2.30E-03	4.60E-02
Non-hazardous waste disposed**	kg	5.66E+01	0.00E+00	1.64E+00	5.83E+01	1.26E+00	1.02E+02
High-level radioactive waste**	m3	1.10E-03	0.00E+00	3.44E-08	1.10E-03	4.75E-08	3.98E-03
Intermediate and low-level radioactive waste**	m3	1.06E-07	0.00E+00	3.03E-07	4.09E-07	1.78E-07	7.12E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	7.92E-01	0.00E+00	1.02E+00	1.81E+00	1.15E-01	5.52E+00
Materials for energy recovery**	kg	0.00E+00	0.00E+00	8.22E-04	8.22E-04	0.00E+00	1.58E-02
Recovered energy exported from the product system**	MJ	1.54E-01	0.00E+00	0.00E+00	1.54E-01	0.00E+00	4.79E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	1.05E+02	0.00E+00	0.00E+00	1.07E+02	8.27E+01	1.46E+02
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-22.0	-22.0		

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Table 6. **A1-A3 Impact results; product type: MW-M (1 m³ of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	3.19E+02	2.81E+01	1.31E+01	3.60E+02	3.67E+02	4.42E+01
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	2.45E-05	1.29E-09	3.09E-06	2.76E-05	2.60E-05	3.78E-06
Eutrophication potential (EP)	kg N e	3.34E-01	2.19E-02	1.96E-01	5.52E-01	5.11E-01	1.50E-01
Acidification potential of soil and water sources (AP)	kg SO2 e	1.25E+00	3.65E-01	1.17E-01	1.73E+00	1.66E+00	1.66E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	1.31E+01	9.28E+00	1.43E+00	2.38E+01	2.35E+01	3.05E+00
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	5.57E-05	0.00E+00	5.03E-06	6.07E-05	6.02E-05	6.42E-06
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	2.29E+03	4.36E+02	4.22E+02	3.15E+03	2.80E+03	6.93E+02
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	1.06E+02	0.00E+00	2.05E+02	3.11E+02	4.59E+02	2.51E+02
Renewable primary resources as material, (RPRM)**	MJ, NCV	6.33E-02	0.00E+00	0.00E+00	6.33E-02	6.08E-02	2.09E-02
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	2.98E+03	4.36E+02	5.91E+02	4.01E+03	3.93E+03	4.26E+02
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	1.85E+00	0.00E+00	0.00E+00	1.85E+00	1.78E+00	6.11E-01
Consumption of fresh water	m3	2.75E+00	0.00E+00	3.00E-01	3.05E+00	3.25E+00	5.68E-01
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	7.58E+01	0.00E+00	0.00E+00	7.58E+01	2.10E+01	9.00E+01
Renewable secondary fuels, (RSF)**	MJ, NCV	1.03E+01	0.00E+00	0.00E+00	1.03E+01	1.04E+01	1.12E+00
Non-renewable secondary fuels (NRSF)**	MJ, NCV	9.94E+01	0.00E+00	0.00E+00	9.94E+01	1.00E+02	1.07E+01
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.44E-03	0.00E+00	0.00E+00	2.44E-03	2.49E-03	2.79E-04
Non-hazardous waste disposed**	kg	4.19E+01	0.00E+00	1.32E+00	4.32E+01	5.93E+01	2.83E+01
High-level radioactive waste**	m3	3.65E-04	0.00E+00	1.24E-07	3.65E-04	3.51E-04	1.20E-04
Intermediate and low-level radioactive waste**	m3	4.86E-07	0.00E+00	8.42E-07	1.33E-06	1.36E-06	4.02E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	7.28E-01	0.00E+00	5.97E-01	1.32E+00	1.07E+00	1.02E+00
Materials for energy recovery**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy exported from the product system**	MJ	1.08E-01	0.00E+00	0.00E+00	1.08E-01	0.00E+00	1.63E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	9.18E+01	0.00E+00	0.00E+00	9.12E+01	9.18E+01	9.86E+00
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-19.2	-19.2		

*. Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Table 7. **A1-A3 Impact results; product type: MW-N (1 m^3 of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	2.06E+02	3.62E+01	2.06E+00	2.44E+02	2.59E+02	3.28E+01
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	5.35E-06	1.42E-09	1.68E-06	7.03E-06	7.02E-06	1.26E-06
Eutrophication potential (EP)	kg N e	2.38E-01	2.85E-02	1.52E-01	4.19E-01	4.85E-01	7.30E-02
Acidification potential of soil and water sources (AP)	kg SO2 e	4.27E-01	4.91E-01	1.17E-01	1.04E+00	8.52E-01	5.02E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	7.76E+00	1.32E+01	1.52E+00	2.25E+01	1.75E+01	1.50E+01
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	6.44E-05	0.00E+00	2.64E-06	6.70E-05	6.63E-05	5.56E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	5.83E+02	4.81E+02	3.12E+02	1.38E+03	1.81E+03	5.26E+02
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	4.04E+01	0.00E+00	1.17E+02	1.57E+02	1.80E+02	8.61E+01
Renewable primary resources as material, (RPRM)**	MJ, NCV	8.14E-02	0.00E+00	0.00E+00	8.14E-02	7.11E-02	1.94E-01
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	1.08E+03	4.81E+02	3.97E+02	1.96E+03	2.09E+03	3.62E+02
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	2.38E+00	0.00E+00	0.00E+00	2.38E+00	2.08E+00	5.67E+00
Consumption of fresh water	m3	1.83E+00	0.00E+00	1.70E-01	2.00E+00	2.01E+00	8.56E-01
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	4.72E+02	0.00E+00	0.00E+00	4.72E+02	2.32E+01	5.69E+02
Renewable secondary fuels, (RSF)**	MJ, NCV	1.16E+01	0.00E+00	0.00E+00	1.16E+01	1.22E+01	2.41E+00
Non-renewable secondary fuels (NRSF)**	MJ, NCV	1.12E+02	0.00E+00	0.00E+00	1.12E+02	1.18E+02	2.33E+01
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.74E-03	0.00E+00	1.27E-03	4.01E-03	3.05E-03	2.23E-03
Non-hazardous waste disposed**	kg	3.89E+01	0.00E+00	8.58E-02	3.90E+01	1.99E+00	3.41E+01
High-level radioactive waste**	m3	4.70E-04	0.00E+00	4.42E-08	4.70E-04	4.10E-04	1.12E-03
Intermediate and low-level radioactive waste**	m3	9.20E-08	0.00E+00	4.33E-07	5.25E-07	5.39E-07	3.11E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	6.02E-01	0.00E+00	1.09E+00	1.69E+00	1.17E+00	2.35E+00
Materials for energy recovery**	kg	0.00E+00	0.00E+00	6.46E-03	6.46E-03	0.00E+00	1.83E-01
Recovered energy exported from the product system**	MJ	2.14E-01	0.00E+00	0.00E+00	2.14E-01	3.37E-01	2.28E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	1.00E+02	0.00E+00	0.00E+00	1.03E+02	1.08E+02	2.14E+01
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-20.9	-20.9		

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Table 8. **A1-A3 Impact results; product type: LW-M (1 m^3 of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	3.62E+02	3.03E+01	2.91E+00	3.95E+02	4.02E+02	4.76E+01
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	2.87E-05	1.34E-09	1.73E-06	3.04E-05	3.32E-05	7.02E-06
Eutrophication potential (EP)	kg N e	3.68E-01	2.42E-02	1.41E-01	5.33E-01	5.01E-01	9.78E-02
Acidification potential of soil and water sources (AP)	kg SO2 e	1.44E+00	4.03E-01	9.21E-02	1.93E+00	1.95E+00	3.81E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	1.47E+01	1.03E+01	1.58E+00	2.66E+01	2.43E+01	6.49E+00
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	5.23E-05	0.00E+00	3.55E-06	5.58E-05	5.51E-05	1.01E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	2.53E+03	4.54E+02	2.92E+02	3.28E+03	3.48E+03	7.60E+02
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	2.53E+03	4.54E+02	2.92E+02	3.28E+03	2.56E+02	2.03E+02
Renewable primary resources as material, (RPRM)**	MJ, NCV	4.00E-02	0.00E+00	0.00E+00	4.00E-02	4.79E-02	3.29E-02
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	3.40E+03	4.54E+02	3.74E+02	4.23E+03	4.48E+03	7.77E+02
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	1.17E+00	0.00E+00	0.00E+00	1.17E+00	1.40E+00	9.64E-01
Consumption of fresh water	m3	2.68E+00	0.00E+00	2.13E-01	2.89E+00	2.94E+00	2.25E-01
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	2.56E+01	0.00E+00	0.00E+00	2.56E+01	2.03E+01	1.02E+01
Renewable secondary fuels, (RSF)**	MJ, NCV	1.10E+01	0.00E+00	0.00E+00	1.10E+01	1.08E+01	1.02E+00
Non-renewable secondary fuels (NRSF)**	MJ, NCV	1.06E+02	0.00E+00	0.00E+00	1.06E+02	1.04E+02	9.83E+00
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.62E-03	0.00E+00	1.43E-02	1.69E-02	2.61E-03	1.11E-01
Non-hazardous waste disposed**	kg	5.45E+01	0.00E+00	1.03E+00	5.55E+01	6.15E+01	2.56E+01
High-level radioactive waste**	m3	2.31E-04	0.00E+00	4.46E-08	2.31E-04	2.77E-04	1.90E-04
Intermediate and low-level radioactive waste**	m3	5.50E-07	0.00E+00	4.12E-07	9.62E-07	9.24E-07	4.65E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	9.28E-01	0.00E+00	5.13E-01	1.44E+00	1.10E+00	1.00E+00
Materials for energy recovery**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy exported from the product system**	MJ	5.18E-02	0.00E+00	0.00E+00	5.18E-02	0.00E+00	1.46E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	9.62E+01	0.00E+00	0.00E+00	9.71E+01	9.52E+01	9.03E+00
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-20.1	-20.1		

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Table 9. **A1-A3 Impact results; product type: LW-N (1 m^3 of concrete)**

Impact Assessment	Unit	Weighted Average				Median	STDEV.S
		A1	A2	A3	Total A1-A3		
Global Warming Potential (GWP)*	kg CO_2 e	1.94E+02	8.67E+01	5.48E+00	2.86E+02	2.74E+02	2.93E+01
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	5.11E-06	3.58E-09	1.66E-06	6.77E-06	6.56E-06	1.00E-06
Eutrophication potential (EP)	kg N e	2.20E-01	6.90E-02	1.67E-01	4.56E-01	4.67E-01	7.65E-02
Acidification potential of soil and water sources (AP)	kg SO2 e	3.96E-01	1.19E+00	1.18E-01	1.70E+00	1.64E+00	5.44E-01
Formation potential of tropospheric ozone (POCP)	kg O_3 e	7.21E+00	3.18E+01	1.26E+00	4.03E+01	3.57E+01	1.59E+01
Resource Use							
Abiotic depletion potential for non-fossil mineral resources (ADPelements)**	kg Sb eq	6.87E-05	0.00E+00	2.15E-06	7.09E-05	5.93E-05	2.27E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	5.65E+02	1.21E+03	3.13E+02	2.09E+03	1.79E+03	6.41E+02
Renewable primary energy resources as energy (fuel), (RPRE)**	MJ, NCV	3.64E+01	0.00E+00	1.32E+02	1.68E+02	1.37E+02	8.66E+01
Renewable primary resources as material, (RPRM)**	MJ, NCV	1.07E-01	0.00E+00	0.00E+00	1.07E-01	5.68E-02	7.40E-02
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	1.00E+03	1.21E+03	4.11E+02	2.63E+03	2.61E+03	4.68E+02
Non-renewable primary resources as material (NRPRM)**	MJ, NCV	3.12E+00	0.00E+00	0.00E+00	3.12E+00	1.66E+00	2.17E+00
Consumption of fresh water	m3	1.60E+00	0.00E+00	1.56E-01	1.76E+00	1.62E+00	2.84E-01
Secondary Material, Fuel and Recovered Energy							
Secondary Materials, (SM)**	kg	5.07E+01	0.00E+00	0.00E+00	5.07E+01	2.03E+01	2.91E+01
Renewable secondary fuels, (RSF)**	MJ, NCV	1.09E+01	0.00E+00	0.00E+00	1.09E+01	1.05E+01	2.05E+00
Non-renewable secondary fuels (NRSF)**	MJ, NCV	1.05E+02	0.00E+00	0.00E+00	1.05E+02	1.01E+02	1.97E+01
Recovered energy, (RE)**	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows							
Hazardous waste disposed**	kg	2.53E-03	0.00E+00	0.00E+00	2.53E-03	2.52E-03	5.12E-04
Non-hazardous waste disposed**	kg	3.39E+01	0.00E+00	4.43E-01	3.44E+01	5.31E+01	2.45E+01
High-level radioactive waste**	m3	6.16E-04	0.00E+00	5.13E-08	6.16E-04	3.28E-04	4.27E-04
Intermediate and low-level radioactive waste**	m3	5.84E-08	0.00E+00	4.78E-07	5.36E-07	5.73E-07	2.21E-07
Components for reuse**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling**	kg	2.94E-01	0.00E+00	8.34E-01	1.13E+00	1.82E+00	2.06E+00
Materials for energy recovery**	kg	0.00E+00	0.00E+00	2.29E-02	2.29E-02	1.58E-02	1.78E-01
Recovered energy exported from the product system**	MJ	3.12E-01	0.00E+00	0.00E+00	3.12E-01	2.89E-01	1.93E-01
Carbon Emissions and Uptake*							
Calcination Carbon Emissions	kg CO_2 e	9.59E+01	0.00E+00	0.00E+00	9.63E+01	9.31E+01	1.81E+01
Carbonation Carbon Removals Natural Carbon Sequestration over 28 days	kg CO_2 e			-20.0	-20.0		

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation. Details on natural carbon sequestration can be found in the supplemental information section.

** Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

Interpretation

The material extraction (A1) product stage dominates most of the potential environmental impacts with cement contributing the greatest percentage of impacts in this stage. This EPD was calculated using industry average cement data. Cement LCIA impacts can vary depending upon manufacturing process, efficiency, and fuel source by as much as 50% for some environmental impact categories. Cement manufacturing process, efficiency and fuel source accounts for as much as 40% of impact across the LCIA results of the concrete mixes included in this EPD and thus manufacturer-specific cement impacts could result in variation of as much as 20%.

Life cycle impact assessment (LCIA) results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks (ISO 14044, ISO 14040). EPDs are comparable only if they comply with ISO 21930 (2017), use the same, sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

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Supplemental Information

Natural Carbon Sequestration

Although dry-cast and wet-cast concrete are produced using the same basic constituent materials, the resulting products differ in their final composition. Notably, dry-cast concrete is comprised of interconnected voids that are absent from wet-cast concrete. This relatively open structure of dry-cast concrete allows carbon dioxide to easily penetrate the dry-cast matrix. Coupled with the configuration of concrete masonry units (CMU), consisting of relatively thin face shells and webs, this results in significantly higher natural carbonation rates of CMU compared to wet-cast concrete.

The data for Natural Carbon Sequestration in this EPD are based on research started in 2020 and published at the ASTM Masonry Symposium in 2022 *(Walloch, Craig, et al. (2022). Conceptual Test Protocols for Measuring Carbon Sequestration of Manufactured Dry-Cast Concrete Products. Masonry Symposium: Advancing Masonry Technology. ASTM International*). This research included nine sets of CMU solicited from producers located throughout the United States to represent the range of typical CMU production across the U.S. The units were stored outside without protection until the designated curing interval had been reached, at which time a coupon sample was saw-cut from the face shell of the unit. While uncontrolled, this storage condition was intentional to simulate the environmental exposure conditions the units would see in service, which in turn influences the rate of carbonation. The annual weather conditions in northern Virginia were considered a representative average weather pattern for North America, being on neither extreme of precipitation nor temperature.

The carbon sequestration levels of CMU aged 28 days to 6 months were determined with Thermogravimetric Analysis (TGA) and reported in the reference paper. Preparation and testing protocols as well as raw material background compensation procedures are also detailed in the ASTM reference paper. The reported Global Warming Potential (GWP) values reported in the A1-A3 impact results for the various product types (Tables 3 – 9) in this EPD include the natural carbon sequestration achieved in the first 28 days post-production, which captures a representative A1-A3 boundary condition. Based on the average of the nine sets in the ASTM study, the carbon naturally sequestered over the first 28 days post-production is equivalent to 21% of the calcination carbon emissions. Applying this factor, Table S1 below summarizes the cradle-to-gate A1-A3 Global Warming Potential (GWP) including the calcination carbon emissions and the natural carbon sequestration over 28 days for the product types in this EPD as reported in Tables 3 – 9.

Table S1: A1-A3 Global Warming Potential (GWP)

		Product Type						
Impact Assessment	Unit	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	kg CO_2 e	208	232	241	360	244	395	286
Calcination Carbon Emissions	kg CO_2 e	84	103	105	96	96	92	100
Carbonation Carbon Removals Natural Carbon Sequestration at 28 days	kg CO_2 e	-18	-22	-22	-20	-20	-19	-21

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation.

Sampling and testing of each set of units in the original study has continued after the ASTM paper publication in 2022. The sets were tested 2 years after production. The average natural carbonation sequestration of the sets following 2 years of exposure is equivalent to 49% of the calcination carbon emissions. Applying this factor, Table S2, below, summarizes Global Warming Potential (GWP) after 2 years of service including the calcination carbon emissions and the natural carbon sequestration for the product types in this EPD after 2 years of service. This data can be incorporated into Whole Building Life Cycle Analysis for the use module, B1, depending on the exposure of the CMU to atmospheric carbon dioxide.

Table S2: Global Warming Potential (GWP) after 2 Years of Service

		Product Type						
Impact Assessment	Unit	NW1	NW2	NW3	MW-M	MW-N	LW-M	LW-N
Global Warming Potential (GWP)*	kg CO_2 e	185	204	212	333	217	369	258
Calcination Carbon Emissions	kg CO_2 e	84	103	105	96	96	92	100
Carbonation Carbon Removals Natural Carbon Sequestration at 2 years	kg CO_2 e	-41	-50	-51	-47	-47	-45	-49

* Both calcination carbon emissions and natural carbon sequestration within 28 days of manufacture (which is considered as part of the A3 module for CMU production) are included in the Global Warming Potential (GWP) calculation.

Carbon sequestration continues after 2 years and will be able to be incorporated into Whole Building Life Cycle Analysis for the use module, B1, as additional test data becomes available from industry.