



INTRODUCTION:

■ **Energetically modified cements** (EMCs) are a class of cements made from pozzolans (e.g. fly ash, volcanic ash, pozzolana), silica sand, blast furnace slag, or Portland cement (or blends of these ingredients). The term "energetically modified" arises by virtue of the mechano-chemistry process applied to the raw material, more accurately classified as "high energy ball milling" (HEBM) that deliver high-impact kinetics to cause the required low-energy transformation in the material being processed. This causes, amongst others, a thermodynamic transformation in the material to increase its chemical reactivity. For EMCs, the HEBM process used is a unique form of specialised vibratory milling discovered in Sweden and applied only to cementitious materials. Despite its "high energy" label, HEBM is extremely effective in delivering its aims. It is tremendously energy efficient, so that processes can liberate significant energy savings.

By improving the reactivity of pozzolans, their strength-development rate is increased when cast into concrete mixes. This allows for compliance with modern product-performance requirements ("technical standards") for concretes and mortars. In turn, this allows for the replacement of Portland cement in the various mixes. This has a number of benefits to their long-term qualities. Finally, the enhanced reactivity delivered by EMC Volcanics means that for the first time, volcanic materials can be compared with GGBFS (a by-product of blast furnace steel production). All told, by way of example, 95% of the U.K.'s ready mix concrete market can now be fully served with concretes of such low embodied CO₂ that they will likely deliver 'Net Zero' across their full lifecycles (please see the section on "Carbonation" below).

LCA INFORMATION:

Name and location of production site(s): EMC California, located in the Riverside–San Bernadino MSA ("Riverside MSA"), California, U.S.A.

Type: This self-declared EPD without formal PCR is stated in accordance with ISO 14044, using also the sources referenced at page 5.

Date and norms used: 2023. See References at page 5. Given Calgreen's innovations dated August 2023 ([here](#)), this EPD also uses EN references.

Declared unit: The declared unit is one metric tonne (1,000 kg) of EMC Volcanics made in California per the company's patents and trade secrets.

Reference service life: Not relevant due to the cradle-to-gate boundary conditions.

Source information used: (i) Built Environment Carbon Database Version 1.0 for assorted EPD examples (carbon.becd.co.uk); (ii) "Annual Fleet Fuel Study", NACFE, December 2022: truckingefficiency.org/annual-fleet-fuel-studies; (iii) "Green Freight Handbook", Environmental Defense Fund, 2014 (scsc/GreenFreight/EDF-Green-Freight-Handbook.pdf); (iv) Energy density of U.S. truck diesel fuel: U.S. DOT, 2023 (bts.gov/content/energy-consumption-mode-transportation); (v) Average Class-8 tractor mass: U.S. DOE, 2010 (energy.gov/eere/vehicles/fact-620-april-26-2010-class-8-truck-tractor-weight-component); and (vi) Axle-weight limits: Caltrans, 2023 (dot.ca.gov/programs/traffic-operations/legal-truck-access/weight-limitation).

Goal and scope: Per §3.1 ISO 14044 ([here](#)), a lifecycle comprises "consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal". This EPD evaluates the environmental impacts of producing one (1) tonne of EMC made from volcanic materials from cradle-to-gate sourced from the Riverside MSA, California across LCA boundaries A1-A3 only, since the three criteria of EN 15804 are met for the exclusion of stages B1-B7, C1-C4 and D (however, please see the section on "Carbonation" below).

Production: Production is for one process only per the system boundaries identified in the diagram on page 3, which is self-explanatory. No by-products occur during production. Hence, there is no need for allocations for by-products. This assessment does not include the following:

- ◆ Capital equipment production;
- ◆ Equipment maintenance;
- ◆ Human labour and employee transport.

ADDITIONAL INFORMATION:

Carbonation: Cement carbonation is a reaction removing CO₂ from the air, which occurs mainly on the surface of hydrated (*i.e.*, cured) cement-based products. While on the one hand, concrete applications are designed according to strict codes to ensure that carbonation does not lead to the corrosion of structural reinforcements, nonetheless it is accepted and uncontroversial science that such carbonation reduces the overall Global Warming Impact (GWP) of cementitious products over their whole life.

The amount of CO₂ removed by carbonation will depend on the type of the concrete's application and its treatment after its useful life. This can be increased by crushing the spent concrete after demolition, by which the surface area in air contact can be significantly enhanced. Academic research confirms crushed volcanic materials also exhibit carbonation using alternative (*i.e.*, additional) pathways due to their high silicate content. Moreover, the effect of volcanics in concrete can deliver a much enhanced effect: "the CO₂ uptake capacity was found to generally increase with the amount of volcanic ash substitution." For further information, please visit our website [here](#).

PRODUCT INFORMATION:



■ **EMC Volcanics:** An EMC made from volcanic material (Luleå, Sweden, 2020).

Product name: EMC Volcanics (tradenname: CemPozz-NP).

Product description: Cement is a vital and important material used in building and civil engineering construction. It is a finely ground powder. Mixed with water, it forms a paste that sets, hardens, and adheres to other materials. After hardening, it retains its strength even underwater. most commonly known as "Portland cement", it is used as the main raw material in the production of concrete, mortar, grouts and plasters. Its purest forms are classed as Types I, II and III per ASTM C150-05. In these, ~90–95% is a synthetic compound called "clinker". Per the U.S. Portland Cement Association's EPD, U.S. average clinker content is 92.2% ([here](#)). Clinker is formed by burning a mix of minerals—principally limestone—in a two-stage strongly endothermic process that is highly energy-intensive, powered in the form of energy-dense fossil fuels. The need for extremely high combustion temperatures, combined with the CO₂ driven-off from the limestone, means clinker production is highly carbon intensive.

Producing a tonne of Type I, II or III cement puts out about a tonne of CO₂. Collectively, the Portland cement industry releases billions of tonnes of CO₂ annually, overwhelmingly caused by clinker production. Further, absent the wholesale introduction of so-called carbon capture systems, plus the required transport networks and long-term storage devices (CCS), such is the nature of clinker's production that it will likely remain unabated for the foreseeable future, if not beyond. In any event, CCS systems will only add to clinker's already significant—and costly—energy overhead.

Zero CO₂ Outputs



Low Energy Use Electrification

■ **EMC Technology:** offers an exceptionally rare 'trinity' usually reserved only for renewables...

In contrast to the above, EMC Volcanics produce no direct CO₂ emissions during production. Production is 100% electric, giving rise to an energy-mix that can be supplied 100% by renewables. The process-energy needs are a small fraction of the needs of clinker production. There is no requirement for CCS. No water is used during production whatsoever. There is no waste during production.

Added into concrete mixes to replace (*i.e.*, to substitute-out) significant portions of Portland cement, EMC Volcanics will deliver superb results in a wide range of application-types in the built environment: construction works, ready-mixed concrete production and a wide variety of concrete products that may also require temperature-controlled curing. The enhanced performance benefits of EMC Volcanics are several, including an increased resistance to chloride attack and ASR. Further details are available separately upon request.

SYSTEM DIAGRAM:

The scope of this study is “Gradle to gate” covering the product stage only (modules A1-A3 in the Table below), since the product fulfils the three conditions required by EN 15804:2012+A2:2019, excluding modules C1-C4 and D. These are:

- ◆ The product or material is physically integrated with other products during installation so they cannot be physically separated from them at end of life;
- ◆ The product or material is no longer identifiable at end of life as a result of a physical or chemical transformation process;
- ◆ The product or material does not contain biogenic carbon.

Product Stage			Construction Stage	Use Stage								End-of-life Stage				Resource Recovery
Raw Materials Supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-contruction and demolition	Transport	Waste processing for reuse, recovery and/or recycling	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

■ KEY: X = included ND = Not Declared

LCA Boundaries A1–A3 | Riverside California

All in Kg CO2-e/tonne EMC Volcanics

----- Boundaries

A1

A2

A3



Mineral Extraction

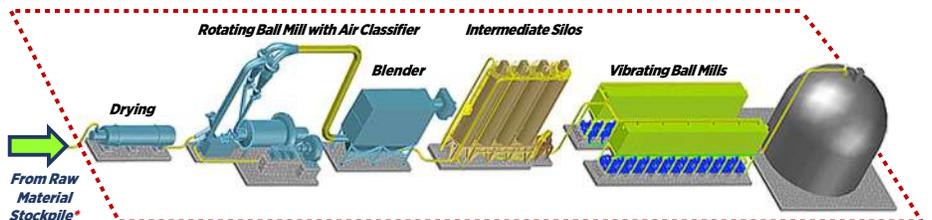
0.92



Trucking
Destination Conveying*

Logistics

3.2



EMC Processing

0.00*

* Assuming renewable-source electricity

SOURCE MATERIAL:



■ **Example:** Typical raw material deposits at source within the Riverside MSA, California (photo: Dr. Vladimir Ronin).

The Riverside MSA comprises a major rail hub in Barstow. This EPD assumes source material located in the Riverside MSA and a 20-mile round trip from mining source to the facility. There are several candidate sources that could fulfil this descriptor. Hence, for A2 purposes, the impact of such variations are likely trivial. In common across all candidates, the raw material is typically loose and of zero to minor agglomeration, of size 0-60mm (75% >1mm). Typical chemical composition is as follows (all values in %), to account for 99.95% by mass:

◆ SiO ₂	71.76
◆ Al ₂ O ₃	13.69
◆ K ₂ O	4.31
◆ Na ₂ O	2.44
◆ Fe ₂ O ₃	2.14
◆ CaO	1.75
◆ MgO	0.07
◆ TiO ₂ + SO ₃ + P ₂ O ₅	<0.4
◆ Loss of Ignition	3.39



■ **Detail:** Loose Californian raw material. Fully-processed EMC Volcanics, ready-to-use.

The EMC process does not cause any chemical reaction. Hence, a raw material's nascent chemical-composition remains unchanged.

As a general principle, all materials are tested according to specifications to meet the needs of the user base. This will engage ongoing testing processes carried out to E.U. and U.S. norms – both internally in our own labs and also externally in qualified third-party material-testing labs.

TOXICITY AND DUST CONTROL:

The facilities will comply with the U.S. environmental protection agency (EPA) regulations, monitor and report the emissions to air during the manufacturing process as per EPCRA §313 Toxic Release Inventory reporting (www.epa.gov/toxics-release-inventory-tri-program). It is unlikely EMC Volcanics will contain any substance of concern, whether or not trace amounts. There will likely be no Mica, and at worst only limited amounts of crystalline silica and feldspars. Air pollution abatement equipment will comprise low temperature baghouses, cartridge filters and bin vents. More information about safety handling is set out in our illustrative Safety Data Sheet (SDS), available separately upon request.

ENVIRONMENTAL INFORMATION:

Potential environmental impact and resource use (per functional/declared unit)		
Indicator	Unit	Total A1-A3
GWP-total	kg CO₂ eq.	4.12E+00
GWP-fossil	kg CO ₂ eq.	4.12E+00
GWP-biogenic	kg CO ₂ eq.	0
GWP-luluc	kg CO ₂ eq.	0
PERE	MJ	4.59E+02
PERM	MJ	0
PERT	MJ	4.59E+02
PENRE	MJ	2.80E+01
PENRM	MJ	0
PENRT	MJ	2.80E+01
ENERGY-total	MJ	4.80E+02

■ **Acronyms:** **GWP-total** = total Global Warming Potential; GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; **ENERGY-total** = total energy (all uses).

Additional indicators (per metric tonne)		
Indicator	Unit	Total A1-A3
CC	kg CO ₂ eq.	0
CWRS	kg CO ₂ eq.	0
CWNRS	kg CO ₂ eq.	0

■ **Acronyms:** CC = Emissions from calcination and removals from carbonation; CWRS = Emissions from combustion of waste from renewable sources used in production processes; CWNRS = Emissions from combustion of waste from non-renewable sources used in production processes.

REFERENCES:

- ◆ ASTM C618-22 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- ◆ ASTM C1157 / C1157M Standard Performance Specification for Hydraulic Cement.
- ◆ EN 15804:2012+A2:2019 Sustainability of construction works – EPDs: Core rules for construction products.
- ◆ EN 16908:2017 Cement and building lime EPDs Product category rules complementary to EN 15804.
- ◆ ISO 14020:2000 Environmental labels and declarations – General principles.
- ◆ ISO 14021:2016 Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling).
- ◆ ISO 14025:2006 Environmental labels and declarations Type III declarations – Principles and procedures.
- ◆ ISO 14040:2006 Environmental management, Life Cycle Assessment Principles and framework.
- ◆ ISO 14044:2006 Environmental management Life cycle assessment Requirements and guidelines.
- ◆ ISO 21930:2017 Sustainability in buildings & civil engineering works – Core rules for EPDs of construction products and services.

IDENTIFICATION/CONTACT INFORMATION:

Owner of the EPD: EMC Development AB | Luleå, Sweden | NATO-NCAGE identifier: ayx0n ([here](#)) | SAM identifier D3M1SZMJFMJ7.

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Description of the organisation: Building materials manufacturer.

Product group classification: UN CPC 3744 (CPC, v.2.1, [here](#)).

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Unless stated otherwise, "tons" means U.S. short tons; "tonnes" means metric tons.

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