Cement Association of Canada | Association Canadienne du Ciment

AN ENVIRONMENTAL PRODUCT DECLARATION

FOR GENERAL USE (GU) & PORTLAND-LIMESTONE (GUL) CEMENTS

The Cement Association of Canada (CAC) is pleased to present this Canadian and CAC member regionalized industry average environmental product declaration (EPD) for general use (GU) and portland-limestone (GUL) cements. This EPD was developed in compliance with CAN/CSA-ISO 14025 and is verified by ASTM International.

The EPD includes life cycle assessment (LCA) results for the production stage or cradle-to-gate manufacture of GU and GUL cements as produced in three regions of Canada by CAC members in 2020. It is intended for business-to-business communication.

For more information about [Cement Association of Canada], please go to [www.cement.ca].

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GU and GUL Cements

ASTM CERTIFICATION PAGE

This document is a Type III industry-average Environmental Product Declaration (EPD) describing portland cement (GU) and portland-limestone (GUL) cements produced in 3 regions of Canada by Cement Association of Canada (CAC) members. The results of the underlying LCA are computed with the *North American (N.A.) version of the Global Cement and Concrete Association (GCCA) Industry EPD tool for cement and concrete* [4]. This tool and the underlying LCA model and database have been previously verified to conform to the prevailing sub-product category rule (PCR) [11], ISO 21930:2017 (the core PCR) [10] as well as ISO 14025:2006 [7], ISO 14040/44:2006 Amd: 2020 LCA standards [7], [8] and ASTM International's General Program Instructions [1].

This EPD is certified by ASTM to conform to the Sub-Product Category Rule (PCR) as well as to the requirements of ISO 14025 and ISO 21930. This EPD is intended for business-to-business audiences.

DECLARATION HOLDER	Cement Association of Canada 502-350 Sparks Street Ottawa, ON, K1R 7S8 Phone: (613) 236-9471 Link (URL): http://www.cement.ca This declaration is valid for all CAC member companies manufacturing GU and GUL cements. The complete list of CAC Members is available at https://cement.ca/about-cac/our-members/
DECLARATION NUMBER	EPD #452
PRODUCT GROUP AND NAME	Cement, UN CPC 3744
DECLARED PRODUCT AND UNIT	General use (GU) and portland-limestone (GUL) cements – one metric tonne
REFERENCE PCR	NSF Product Category Rule for *Preparing an Environmental Product Declaration for Portland, Blended Hydraulic, Masonry, Mortar, and Plastic (Stucco) Cements*. V3.2, September 2021.
PROGRAM OPERATOR	ASTM International 100 Barr Harbor Drive West Conshohocken, PA, USA 19428-2959 www.astm.org
DATE OF ISSUE AND VALIDITY PERIOD	04-21-2023 – 5 YEARS

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EPD VERIFICATION This EPD was independently verified by ASTM in accordance with ISO 14025 and the reference PCR:	Tim Brooke ASTM International 100 Barr Harbor Drive PO Box C700 West Conshohocken PA 19428-2959, USA cert@astm.org Thomas P. Gloria, Ph. D. Industrial Ecology Consultants 35 Bracebridge Rd. Newton, MA External X
NOTES	The EPD results are computed using the *N.A. version of GCCA Industry EPD tool for Cement and Concrete* v4.0 (https://concrete-epd-tool.org).
EPD Prepared by:	Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, Ontario, Canada K1P 5G8 info@athenasmi.org www.athenasmi.org

ABOUT THE CEMENT ASSOCIATION OF CANADA

The Cement Association of Canada (CAC) is the voice of Canada's cement manufacturers. The industry provides a reliable, domestic supply of cement required to build Canada's communities and critical infrastructure. The CAC and its members are committed to the environmentally responsible manufacturing of cement and concrete products. This EPD demonstrates the Cement Association of Canada's commitment to transparently sharing the environmental footprint of major cement products produced by its members in various regions of the country. In support of the study, primary LCI data were collected to produce portland cement (Type GU) and portland-limestone cement (Type GUL) for the reference year 2020. The cement plant study sample included all CAC member facilities (13 plants) producing grey cements:

- Eastern Region (QC and NS): 4 Facilities
- Central Region (ON): 5 facilities
- Western Region (AB and BC): 4 Facilities

PRODUCT DESCRIPTION AND APPLICABLE STANDARDS

Cement is primarily used as one ingredient in the production of concrete. Concrete is used in a myriad of building and civil engineering works. Table 1 below presents the related standards for the two cement products covered under this EPD.

Table 1: EPD Cement Products

Product Name	Applicable Standards	Type
Portland Cement	CSA A3001 & ASTM C150, ASTM C1157, AASHTO M85	Type GU / Type I[a)]
Portland-Limestone Cement	CSA A3001 & ASTM C595, ASTM C1157, AASHTO M240	Type GUL / Type IL[b)]

Note [a,b)]: U.S. cement type designations

Definitions

Hydraulic cement — a type of cement that sets and hardens through a chemical reaction with water and is capable of setting and hardening under water (CSA A23.1). Blended hydraulic cement, portland cement, portland-limestone cement, mortar cement, and masonry cement are examples of hydraulic cement.

Cement, portland: a product obtained by pulverizing clinker consisting essentially of hydraulic calcium silicates, to which the various forms of calcium sulphate, up to 5% limestone, water, and processing additions may be added at the option of the manufacturer (CSA A3001).

Cement, portland-limestone: a product obtained by intergrinding portland cement clinker and limestone, to which the various forms of calcium sulphate, water, and processing additions may be added at the option of the manufacturer (CSA A3001).

In Canada, CSA recognizes six types of portland cement under Standard A3001, as follows:

Type GU: General use cement
Type MS: Moderate sulphate resistant cement
Type MH: Moderate heat of hydration cement
Type HE: High early strength cement
Type LH: Low heat of hydration cement, and
Type HS: High sulphate resistant cement.

CSA 3001 defines Type GU, as a general-purpose portland cement suitable wherever the special properties of other types are not required.

In Canada, CSA recognizes four types of portland-limestone cement under Standards A3001 and A23.1, as follows,

Type GUL: General use cement
Type MHL: Moderate heat of hydration cement
Type HEL: High early strength cement, and
Type LHL: Low heat of hydration cement.

U.S.A. cement type designation for GU and GUL are Types I and IL, respectively. ASTM C150 defines Type I, as portland cement for use when the special properties specified for any other type is not required. ASTM C595 defines Type IL, as portland-limestone cement with up to 15% limestone permitted. Canada is a major supplier of cements to the U.S.A.

Product Standards

Applicable product standards for portland cement (Type GU) and portland-limestone cement (Type GUL), UN CPC 3744, include:

Portland cement:

- CSA A3001 – Cementitious Materials for Use in Concrete
- ASTM C150 – Standard Specification for Portland Cement
- ASTM C1157 – Standard Performance Specification for Hydraulic Cement
- AASHTO M85 – Standard Specification for Portland Cement (Chemical and Physical)

Portland-limestone cement:

- CSA A3001 – Cementitious Materials for Use in Concrete
- CSA A23.1 – Concrete Materials and Methods of Concrete Construction
- ASTM C595 – Standard Specification for Blended Hydraulic Cements
- ASTM C1157 – Standard Performance Specification for Hydraulic Cement
- AASHTO M240 – Standard Specification for Blended Hydraulic Cement

Material Content

Table 2 below presents the material content of GU and GUL cements as calculated on a regional production weighted per cent basis (%).

Table 2: Average Material Content for 1 metric ton (1,000 kg) of GU and GUL, percentage basis

	TYPE GU %			TYPE GUL %		
Material Inputs	**West**	**Central**	**East**	**West**	**Central**	**East**
Clinker	91	91	93	84	84	87
Limestone	3	4	2	9	11	8
Gypsum (including anhydrites)	6	5	5	6	5	5
Processing aids	<1	<1	<1	1	<1	<1
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

DECLARED UNIT

The declared unit for this study is the production of one metric ton (1 t) of portland cement awaiting delivery to a customer. The cement is either packaged and stored on pallets or housed unpackaged in silos and ready for bulk transport.

SYSTEM BOUNDARY

This EPD describes GU and GUL cement production from cradle-to-gate, as depicted in Figure 1. This includes all modules (A1-A3) of the Production stage, as defined by the PCR. Specifically, Production stage modules capture the following aspects of the life cycle:

Extraction and processing of raw materials to produce cement and packaging where applicable(A1);
Transportation of raw materials and packaging from source to cement production site (A2);
Consumption of energy and water required to produce cement (A3);
Emissions and wastes generated from producing cement(A3);
Transportation of wastes from cement production to end-of-life (A3); and
End-of-life of wastes generated during cement production (A3).

The Construction, Use and End-of-life stages are excluded from the scope of the PCR and therefore from the impact results provided by this EPD.

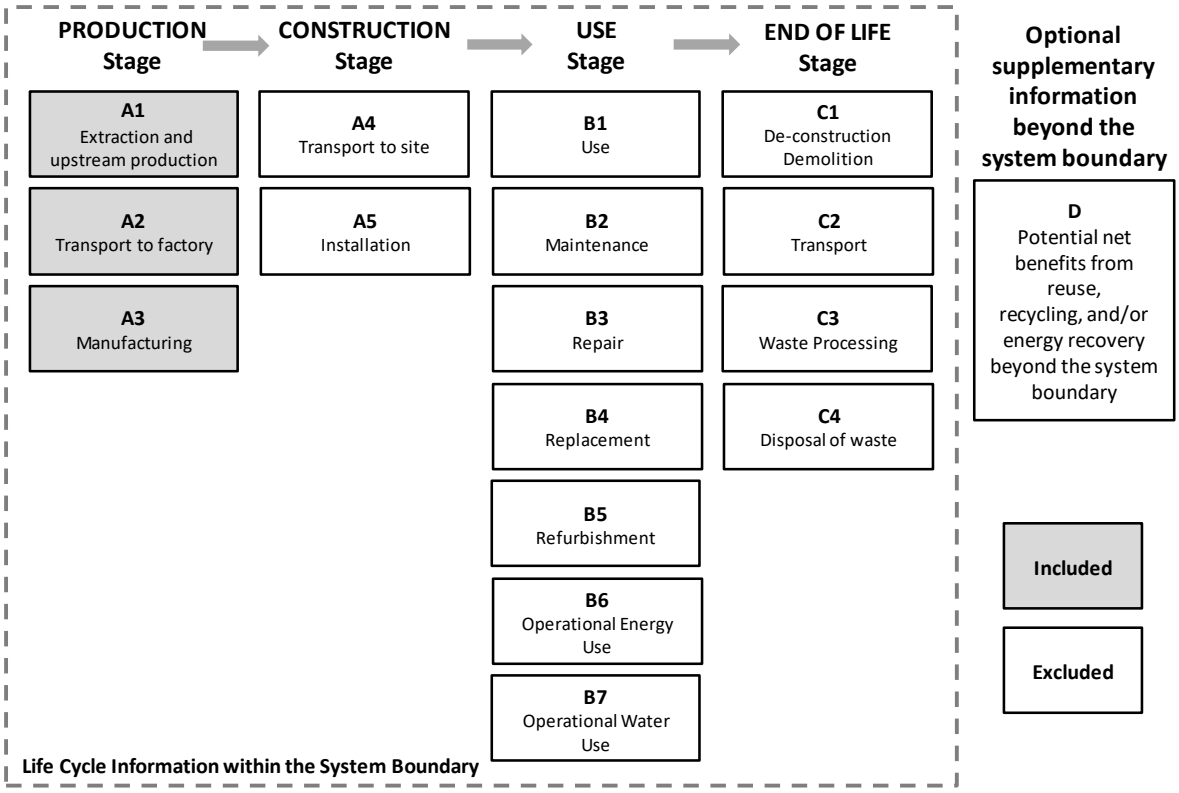

Figure 1. Boundary of the industry-average cement production processes.

EXCLUSIONS AND CUT-OFF CRITERIA

Several items are excluded from the foreground life cycle inventories (LCIs) used in the LCA. These relate specifically to operations at cement production plants:

Capital equipment and infrastructure. These are expected to contribute negligibly (<1%) to the total impact of cement production given the long lifetime of these items and high output of cement over this period.

Personnel-related activities, such as travel, furniture and office supplies. (Energy and water use related to on-site office operations, such as company management and sales activities, are included.)

These two categories of items are included in upstream processes (e.g., electricity generation) where they are captured in the background data used in the LCA underlying GCCA Industry EPD tool.

The cut-off criteria as per NSF PCR, Section 7.1.8 [11] and ISO 21930, 7.1.8 [9] were followed. Per ISO 21930, 7.1.8, all input/output data required were collected and included in the LCI modelling. No substances with hazardous and toxic properties that pose a concern for human health and/or the environment were identified in the framework of this EPD.

ALLOCATION APPROACH

Allocation of inventory flows and subsequently environmental impact is relevant when assets are shared between product systems. The allocation method prescribed by the PCR is applied in the underlying LCA. The sub-category PCR recognizes fly ash, furnace bottom ash, bypass dust, mill scale, polluted soils, spent catalyst, aluminum oxide waste, silica fume, granulated blast furnace slag, iron rich waste, cement kiln dust (CKD), flue gas desulfurization (FGD) gypsum, calcium fluoride rich waste and postconsumer gypsum as recovered materials and thus, the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a cement material input. Further, used tires, plastics, solvents, used oil and oily waste, coal/carbon waste, roofing asphalt, household refuse-derived waste, non-hazardous liquid waste, industrial sludge, and agricultural waste are considered non-renewable and/or renewable secondary fuels. Only the materials, water, energy, emissions, and other elemental flows associated with reprocessing, handling, sorting and transportation from the point of the generating industrial process to their use in the production process are considered. All emissions from combustion at the point of use are considered. For co-products, no credit is considered, and no allocation is applied. See the LCA model and LCA database reports of the *N.A. version of GCCA's Industry Tool for EPDs of cement and concrete for more information* [3], [4].

DATA QUALITY REQUIREMENTS AND ASSESSMENT

Data Quality Requirements	Description
Technology Coverage	Data represents the prevailing technology in use at CAC member facilities. Whenever available, for all upstream and core material and processes, North American typical or global average industry LCI datasets were utilized as captured in the GCCA EPD Tool. *Technological representativeness is characterized as "high".*
Geographic Coverage	The geographic region considered is Canada and various sub-regions – west, central and east. *Geographical representativeness is characterized as "high".*
Time Coverage	Regional activity (primary) data are representative of 2020 calendar year (12 months). - limestone extraction, - clinker production, - GU and GUL cement manufacturing, - In-bound/out-bound transportation data - primary data collected for quarry sites and cement manufacturing plants. *Temporal representativeness is characterized as "high".*
Completeness	All relevant, specific processes, including inputs (raw materials, energy and ancillary materials) and outputs (emissions and production volume) were considered and modeled in the GCCA Tool to complete the production profile for GU and GUL cement products. CAC member plants report various emissions to the National Pollution Release Inventory. These data for 2020 were drawn on in the completion of this project report. The completeness of the foreground process chain in terms of process steps is rigorously assessed.

Data Quality Requirements	Description
Consistency	To ensure consistency, cross checks of the energy demand and the calculated raw meal to clinker ratio against ranges reported in the WBCSD Cement Sustainability Initiative, Cement CO_2 and Energy Protocol, v3.1 December, 2013 were conducted [13]. The LCA team conducted mass and energy balances at the facility level and selected process levels to maintain a high level of consistency
Reproducibility	External reproducibility is not strictly possible as the source LCI data and subsequent LCA background reports are confidential.
Transparency	Activity datasets are disclosed in the project LCI compilation, and the background reports generated by the GCCA Tool.
Uncertainty	A *sensitivity check* was conducted relative to the PCA industry average [12]. The variation across significant inputs were found to be well within the expected range and hence, there is high degree of confidence in the results.

LIMITATIONS

This EPD represents regional industry average performance for CAC members producing GU and GUL cements. It considers only cement plants located in Canada. Results may not adequately represent cement production systems that differ greatly from those captured by the data used in the underlying LCA.

This EPD is a declaration of potential environmental impact and does not support or provide definitive comparisons of the environmental performance of specific products. Only EPDs prepared from cradle-to-grave life cycle results and based on the same function and reference service life and quantified by the same functional unit can be used to assist purchasers and users in making informed comparisons between products.

The EPD provided here in and the underlying LCA conform to the NSF Product Category Rule for Preparing an Environmental Product Declaration for Portland, Blended Hydraulic, Masonry, Mortar, and Plastic (Stucco) Cements. EPDs of cements that follow a different PCR may not be comparable.

LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. Further, LCA offers a wide array of environmental impact indicators, and this EPD reports a collection of those, as specified by the PCR.

In addition to the impact results, this EPD provides several metrics related to resource consumption and waste generation. These data are informational as they do not provide a measure of impact on the environment. Further, severalLCA impact categories and inventory items are still emerging or under development and can have high levels of

uncertainty that preclude international acceptance pending further development. Use caution when interpreting results for these categories – identified with an "*"in Tables 3 and 4.

SUPPLEMENTARY INFORMATION REGARDING LCA METHODOLOGY

Additional information regarding databases and impact methodologies used for conducting the LCA for this EPD can be found in the *LCA core model and LCA database reports of the N.A. version of GCCA's Industry EPD Tool for Cement and Concrete* [4], [5] (see demo.gcca.quantis.solutions/)

LIFE CYCLE ASSESSMENT RESULTS

The cradle-to-gate (A1 to A3) EPD results for producing one metric ton of GU cement are presented in Table 3.

Table 3. Production stage EPD Results for General Use (GU) portland cement.

Impact category and inventory indicators	Unit	West	Central	East
Global warming potential, GWP 100, IPCC 2013	kg CO_2 eq	796	854	898
Ozone depletion potential, ODP	kg CFC-11 eq	1.92E-05	1.83E-05	1.54E-05
Acidification potential, AP	kg SO_2 eq	0.85	0.44	0.53
Eutrophication potential, EP	kg N eq	0.56	0.53	0.37
Smog formation potential, SFP	kg O_3 eq	6.41	5.51	6.68
Abiotic depletion potential for non-fossil mineral resources, ADP elements*	kg Sb eq	1.12E-04	1.22E-04	2.65E-04
Abiotic depletion potential for fossil resources, ADP fossil*	MJ LHV	4005	4212	3419
Renewable primary resources used as an energy carrier (fuel), RPR_E*	MJ LHV	258	237	567
Renewable primary resources with energy content used as material, RPR_M*	MJ LHV	0.00	<1	<1
Non-renewable primary resources used as an energy carrier (fuel), $NRPR_E$*	MJ LHV	4014	4231	3419
Non-renewable primary resources with energy content used as material, $NRPR_M$*	MJ LHV	0.00	<1	<1
Secondary materials, SM*	kg	119.7	67.3	40.5
Renewable secondary fuels, RSF*	MJ LHV	115	155	87.15
Non-renewable secondary fuels, NRSF*	MJ LHV	356	10	432
Net use of freshwater, NFW*	m^3	1.09	1.39	2.28
Hazardous waste disposed, HWD*	kg	0.01	0.02	0.001
Non-hazardous waste disposed, NHWD*	kg	0.07	5.56	0.24
High-level radioactive waste, conditioned, to final repository, HLRW* Intermediate- and low-level radioactive waste, conditioned, to final repository, ILLRW* **x**[1)]	kg	1.79E-07	2.64E-07	1.15E-07
Components for re-use, CRU*	kg	0.19	0.00	0.00

Impact category and inventory indicators	Unit	West	Central	East
Materials for recycling, MFR*	kg	0.00	0.40	0.31
Materials for energy recovery, MER*	kg	0.00	0.00	0.00
Recovered energy exported from the product system, EE*	MJ LHV	0.00	0.00	0.00
Additional Inventory Parameters for Transparency				
Global warming potential - biogenic, GWP_{bio}*	kg CO_2 eq	1.49	0.25	0.37
Emissions from calcination*	kg CO_2 eq	475	475	493
Emissions from combustion of waste from renewable sources*	kg CO_2 eq	0.06	0.14	0.04
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq	32.35	3.36	41.16

1) x – Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.

*) Use caution when interpreting results for these categories

Table 4. Production stage EPD Results for General Use (GUL) portland-limestone cement.

Impact category and inventory indicators	Unit	West	Central	East
Global warming potential, GWP 100, IPCC 2013	kg CO_2 eq	732	798	864
Ozone depletion potential, ODP	kg CFC-11 eq	1.69E-05	1.78E-05	1.59E-05
Acidification potential, AP	kg SO_2 eq	0.79	0.42	0.57
Eutrophication potential, EP	kg N eq	0.44	0.49	0.47
Smog formation potential, SFP	kg O_3 eq	6.19	5.37	7.07
Abiotic depletion potential for non-fossil mineral resources, ADP elements*	kg Sb eq	1.12E-04	1.21E-04	2.69E-04
Abiotic depletion potential for fossil resources, ADP fossil*	MJ LHV	3607	3982	3401
Renewable primary resources used as an energy carrier (fuel), RPR_E*	MJ LHV	334	232	548
Renewable primary resources with energy content used as material, RPR_M*	MJ LHV	0.00	1.32	0.00
Non-renewable primary resources used as an energy carrier (fuel), $NRPR_E$*	MJ LHV	3616	4001	3402
Non-renewable primary resources with energy content used as material, $NRPR_M$*	MJ LHV	0.00	<1	0.00
Secondary materials, SM*	kg	112.4	62.8	38.2
Renewable secondary fuels, RSF*	MJ LHV	108	144	82
Non-renewable secondary fuels, NRSF*	MJ LHV	334	9	408
Net use of freshwater, NFW*	m^3	1.41	1.57	2.21
Hazardous waste disposed, HWD*	kg	0.01	0.02	0.001
Non-hazardous waste disposed, NHWD*	kg	0.07	5.35	0.24

Impact category and inventory indicators	Unit	West	Central	East
High-level radioactive waste, conditioned, to final repository, HLRW* Intermediate- and low-level radioactive waste, conditioned, to final repository, ILLRW* **x**[1)]	kg	1.77E-07	1.95E-07	1.13E-07
Components for re-use, CRU*	kg	0.18	0.00	0.00
Materials for recycling, MFR*	kg	0.00	0.37	0.29
Materials for energy recovery, MER*	kg	0.00	0.00	0.00
Recovered energy exported from the product system, EE*	MJ LHV	0.00	0.00	0.00
Additional Inventory Parameters for Transparency				
Global warming potential - biogenic, GWP_{bio}*	kg CO_2 eq	1.72	0.10	0.57
Emissions from calcination*	kg CO_2 eq	444	443	464
Emissions from combustion of waste from renewable sources*	kg CO_2 eq	0.06	0.13	0.03
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq	30.18	3.13	38.8

[1)] x – Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.
*) Use caution when interpreting results for these categories

INTERPRETATION

Based on the GU and GUL EPD results calculated with the GCCA Industry EPD Tool for cement and concrete, the following conclusions could be reached. The Manufacturing module (A3) drives most of the potential environmental impacts. Manufacturing impacts are primarily driven by energy use (electricity and thermal fuels) used during the pyroprocessing of limestone in the production of clinker. Clinker content in cement similarly defines the relative environmental profile of the final cement products. Raw material extraction (A1) is the second largest contributor to the Production stage EPD results, followed by raw material transportation (A2).

ADDITIONAL ENVIRONMENTAL INFORMATION

Air pollution abatement equipment used at PCA members cement facilities may consist of any mix of the following technologies: high and low temperature baghouses, bin vents, drum filters, dry filters, cartridge filters, precipitators, water sprinklers for dust control, Selective non-catalytic reduction (SNCR), Selective catalytic reduction (SCR), wet scrubbers, dry scrubbers (dry sorbent injection, DSI), Activated Carbon Injection (ASI), and Regenerative Thermal Oxidizer (RTO).

It is also noted that about a third of the plants package some of their cements, the majority bulk load their cements for sale.

REFERENCES

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