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Canadian Industry-average Cradle-to-gate LCA of concrete block masonry units produced by CCMPA Members

Prepared in support of the Canadian Construction LCI (CCLCI) Project

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General Summary
This life cycle assessment (LCA) report presents industry-average results for concrete block masonry units as produced by the CCMPA. The LCA has been conducted to as part of the NRC's Canadian Construction LCI (CCLCI) project and may be used by industry to produce a Type III Environmental Product Declaration (EPD) for concrete block masonry units conforming to product standard(s) [16]. Specifically, this industry-average LCA background report (named the "The Project Report" in ISO 21930:2017 [1]) has been conducted in conformance with ISO 14040/44 standards [2], [3], and according to the requirements of ISO 21930:2017 [1], UL PCR for preparing an environmental product declaration for concrete block masonry units [7], and UL EPD program operator rules [8].

This LCA report is verified by ASTM International to conform to the requirements of ISO 14040 [2], 14044 [3], 14025 [5], and 21930 [1].

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Terms and Definitions

ISO 14040/44:2006 [2], [3] – Clause 3 Terms and Definition.

Allocation: Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems.

Comparative assertion: environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function.

Life Cycle Assessment (LCA): Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

Life Cycle Impact Assessment (LCIA): Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product.

Life Cycle Interpretation: Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations.

Life Cycle Inventory (LCI): Phase of Life Cycle Assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

Product system: Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product.

System boundary: Set of criteria specifying which unit processes are part of a product system.

Note: the term system boundary is not used in this International Standard in relation to LCIA.

Uncertainty analysis: Systematic procedure to quantify the uncertainty introduced in the results of a life cycle inventory analysis due to the cumulative effects of model imprecision, input uncertainty and data variability.

Note: Either ranges or probability distributions are used to determine uncertainty in the results.

ISO 14021:2016 [4] – Clause 7.8 Recycled content

Recovered material: Material that would have otherwise been disposed of as waste or used for energy recovery but has instead been collected and recovered as a material input, in lieu of new primary material, for a recycling or a manufacturing process.

Type III Environmental Product Declaration (EPD): Providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information

Note 1 the predetermined parameters are based on the ISO 14040 series of standards.

Note 2 the additional environmental information may be quantitative or qualitative.

Product Category Rules (PCR): Set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories.

ISO 21930:2017 [1] – Clause 3 Terms and definitions

Average data: Data based on a fully representative sample for a construction product or construction service, provided by one or more suppliers, either from their multiple plants or based on multiple similar construction products of the supplier(s).

By-product: Co-product from a process that is incidental or not intentionally produced and which cannot be avoided.

Co-product: Any of one or more products from the same unit process, but which is not the object of the assessment.

Declared unit: Quantity of a construction product for use as a reference unit in an EPD based on LCA for the expression of environmental information in information modules.

Note 1 to entry: The declared unit is used where the function and the reference scenario for the whole life cycle, on the construction works level, cannot be stated.

Information module: Compilation of data to be used as a basis for an EPD, covering a unit process or a combination of unit processes that are part of the life cycle of a product.

Life cycle: All consecutive and interlinked stages in the life of the object under consideration.

Note 1 to entry: For consideration of environmental impacts and environmental aspects, the life cycle comprises all stages, from raw material acquisition or generation from natural resources to end-of-life.

Based on UL PCR Part B: Concrete Masonry and Segmental Concrete Paving Product EPD Requirements, V1.0, November 2020. [7] – 3 Terms and definitions

Acronyms and Abbreviations

ADPf	Abiotic depletion potential for fossil resources
AP	Acidification potential
ASTM	American Society for Testing and Materials
B2B	Business-to-business
BD+C	Building Design and Construction, LEED
CFC-11	Trichlorofluoromethane
CO2	Carbon dioxide
CRU	Components for re-use
EE	Recovered energy exported from the product system
EP	Eutrophication potential
EPD	Environmental product declaration
FFD	Fossil fuel depletion
FW	Consumption of fresh water
GWP 100	Global warming potential, 100 years' time horizon
LHV	Lower heating value or net caloric value
HLRW	High-level radioactive waste, conditioned, to final repository
HWD	Hazardous waste disposed
ID+C	Interior Design and Construction, LEED
ILLRW	Intermediate- and low-level radioactive waste, conditioned, to final repository
IPCC	International Panel on Climate Change
ISO	International Organization for Standardization
kg	Kilogram
km	Kilometer
kWh	kilowatt hours
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
MC	Moisture content
MER	Materials for energy recovery
MJ	Mega joule
MR	Materials for recycling

MSF	Thousand square feet
N	Nitrogen
NAICS	North American Industry Classification System
NERC	The North American Electric Reliability Corporation
NHWD	Non-hazardous waste disposed
NPRI	Canadian National Pollutant Release Inventory
NRPRM	Non-Renewable primary energy carrier used as material
NRPRE	Non-renewable primary energy carrier used as energy
NRSF	Non-renewable secondary fuel
NSF	National Center for Sustainability Standards
O3	Ozone
ODP	Ozone depletion potential
O+M	Building Operations and Maintenance, LEED
OSHA	Occupational Safety & Health Administration
PCR	Product category rules
PM	Particulate Matter
RE	Recovered energy,
RPRM	Renewable primary energy carrier used as material
RPRE	Renewable primary energy carrier used as energy
RSF	Renewable secondary fuel
SFP	Smog formation potential
SM	Secondary material
SO2	Sulfur dioxide
TRACI	Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts
TRI	United States Toxics Release Inventory (TRI) Program
UN CPC	United Nations Central Product Classification
US EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

1 Introduction

LCA is an analytical tool used to comprehensively quantify and interpret the energy and material flows to and from the environment over the entire life cycle of a product, process, or service [2], [3]. Environmental flows include emissions to air, water, and land, as well as the consumption of energy and material resources. By including the potential impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product.

The **Canadian Construction LCI** (CCLCI) is a National Research Council Canada (NRC) project that provides individuals accounting of the energy and material flows into and out of the environment that are associated with producing construction materials, components, or assemblies in Canada. The NRC is working with the Canadian construction sector to develop industry-average life cycle inventories (LCIs), based on the surveys of a representative sample set of facilities. The LCIs are used to produce life cycle assessments (LCAs) in accordance with relevant product category rules (PCRs). The resulting LCI datasets and LCA reports are made publicly available on a web platform.

See Annex A for a detailed list of specifications for the LCIs and LCAs produced as part of the CCLCI.

This study demonstrates the CCMPA's commitment to transparently sharing the environmental footprint of concrete block masonry units produced in Canada. In support of the study, primary LCI data were collected for the production of concrete block masonry units for the reference years 2020 and 2021. The concrete block masonry units plant study sample included 15 CCMPA member companies:

- Eastern Region (ON, QC, NS, NF): 13 Facilities
- Western Region (AB, SK): 2 Facilities

To ensure representativeness, the assessment also considered the scale of operations including a mix of small, medium and large facilities, and their geographical location by census region.

2 Study Goals

2.1 Goal of the study

The CCLCI aims to support:

1. Mechanisms for reducing the environmental impact of the Canadian building sector:
    a) GoC policy for GHG emissions reductions: TBS greening government, Healthy Environment Healthy Economy;
    b) Other governmental and non-governmental policy, e.g., CoV rezoning policy, green building rating systems.
2. Competitiveness of Canadian industry:
    a) Disclosure of environmental performance;
    b) Industry benchmarking.
3. The expanded use of LCA and improvements to the practice:
    a) Publicly available, Canadian-specific LCI/LCA datasets of good data quality;
    b) Harmonization of LCI datasets across EPDs and wbLCAs ;
    c) Increased uptake of industry surveying in Canada at a reduced cost;
    d) Research.

2.2 Intended application and audience

The CCLCI is a series of publicly-available LCIs and LCA reports that provide both foreground LCIs (e.g., greenhouse gas emissions) and environmental indicator results (e.g., global warming potential). See Figure 1 for an illustration of how the project deliverables (shown green) fit into the context of LCA practice (shown grey), and feed into database applications (shown blue).

The CCLCI provides the following types of LCI/LCA datasets to LCA modelling software, LCA/EPD calculators, and wbLCA tools:

1. Industry-average LCIs of foreground processes (public)
2. Plant-specific foreground LCIs (confidential)
3. Cradle-to-gate (information modules A1-A3) industry-average LCA results for construction products (public)

The foreground LCIs come from surveying Canadian production facilities. The LCIs serve to produce either industry-average or plant specific LCAs and EPDs or contribute to an LCI database. The LCAs are modeled by connecting industry average LCI datasets with the best available or most appropriate background data, then performing life cycle impact assessment (LCIA).

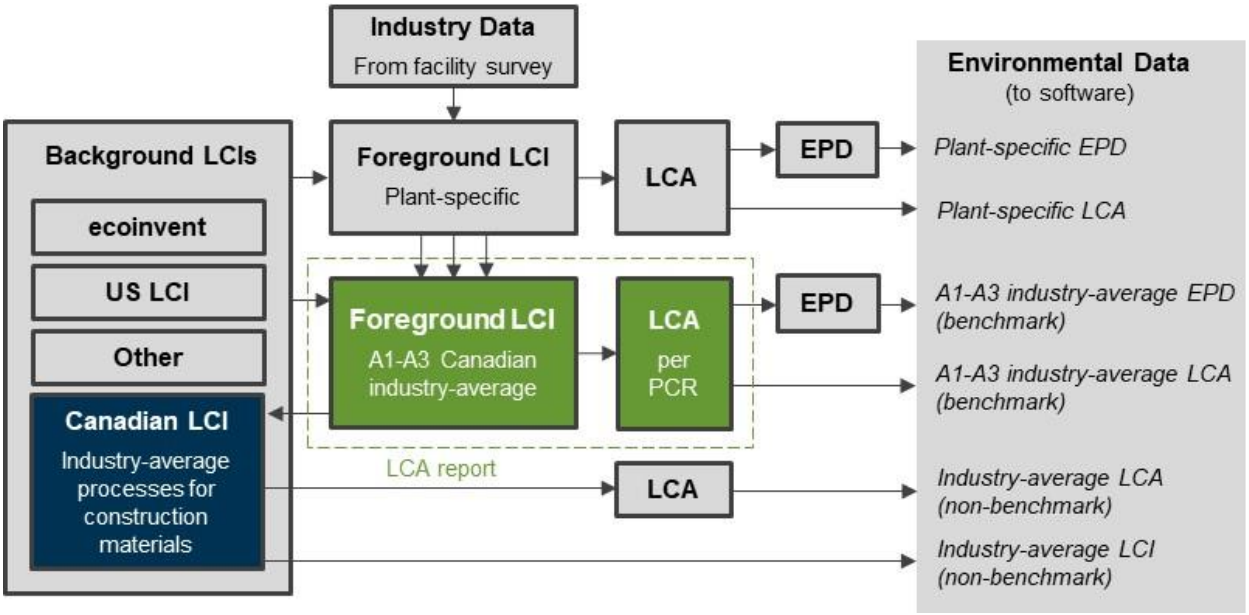


Figure 1: CCLCI project scope

The datasets may be used for the following purposes:

- Informing lower impact production and infrastructure design
- Meeting the requirements of policy
- Publicly declaring the environmental performance of building products and infrastructure
- Benchmarking Canadian industry and infrastructure
- Research

The LCA reports and datasets are intended to be used by:

- LCA practitioners
- LCA tool providers
- LCI/LCA data providers and producers
- Construction industry
- Policy-makers
- Researchers

2.3 Comparative assertions

This industry-average LCA for concrete block masonry units is not a comparative assertion. Only LCAs or EPDs prepared from cradle-to-grave life cycle results and based on the same function, Reference Service Life (RSL), quantified by the same functional unit, and meeting all the conditions for comparability listed in ISO 14025:2006 and ISO 21930:2017 can be used to compare between products [1].

Per ISO 21930, 10.1 [1], this Project Report has been made available to the verifier with the requirements on confidentiality stated in ISO 14025 [5]. This Project Report is independently verified by Thomas Gloria, Ph.D. in accordance with ISO 14025 [5], ISO 14040/44 [2], [3], and the UL PCR requirements [7].

3 Product Identification

3.1 Product description

Concrete block masonry units (UNSPSC 30131502, CSI MasterFormat Division 4-22-00 – see Figure 2) products are covered by this EPD. This EPD reports the impacts for average concrete block masonry units.

Figure 2: Example of concrete masonry unit construction

Per UL PCR [7],

A manufactured masonry unit made of concrete in which the binder is a combination of water and cementitious materials falling under CSI division 04 22 00.

3.2 Product standard

The applicable Canadian product standard for CMUs (UN CPC 3755) is CSA A165.1-04 - Concrete block masonry units.

3.3 Material content

Appendix 1 presents the mix designs as derived from the CCMPA member facilities LCI data for the reference year 2021.

4 Scope of the Study

4.1 Declared unit

The declared unit is defined as the quantity of a construction product for use as a reference unit in an EPD based on LCA for the expression of environmental information in information modules [1], [7].

Per the UL PCR, Section 7.1.3 [7], the declared unit for this LCA study is defined as: “One cubic meter (m^3) of concrete formed into manufactured concrete masonry product.” A declared unit is defined for LCAs covering the cradle-to-gate Production stage which consists of three alpha-numeric modules: A1 Extraction and upstream production; A2 Transport to factory; and A3 Manufacturing [1].

4.2 System boundary

For this Project Report, the boundary is “cradle-to-gate” or the Production stage, which includes extraction of raw materials (cradle) through the manufacture of concrete block masonry units ready for shipment (gate). Downstream activity stages - Construction, Use, End-of-life, and Optional supplementary information beyond the system boundary - are excluded from the system boundary (see Figure 3). Per UL PCR, Section 7.1.7.2 [7], the Production Stage includes the following processes:

- A1 shall include the constituents of concrete listed in UL PCR Part A Table 1;
- A2 shall assume all long-haul transport by bulk carriers (greater than 322 km (200 mi)) do not typically return empty and thus can use the US LCI dataset which includes 35% additional distance to account for this;

- A2 shall assume that all short haul transport (local trucks and dump trucks) return empty. Thus, one way transport distance shall be multiplied by (2/1.35) to reflect two way transport and eliminate the 35% additional distance included in the US LCI;

- A3 shall include transportation activities at the concrete manufacturing site;

- A3 shall include an assumption of 5% material loss unless product specific data is available and transparently reported in the project LCA report underlying the EPD;

- A3 shall include ancillary materials which include, but are not limited to, lubricating oils, engine oils, & other consumable operations equipment maintenance (OEM) products;

  A3 shall include final end of life treatment for any manufacturing waste. For example, admixture and ancillary material packaging. Concrete returned from construction sites is not included in A3; it is included in the construction process Stage A5

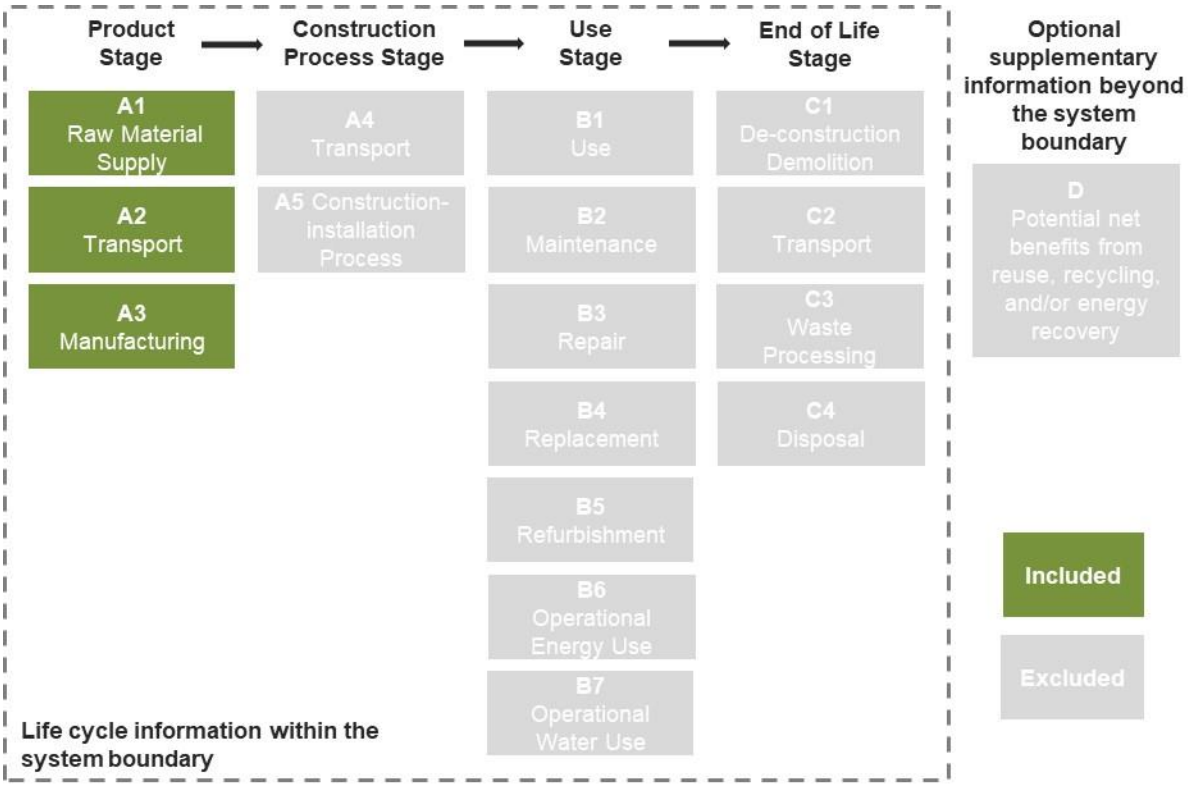


Figure 3 Common life cycle stages and their information modules for construction products [1]

Per ISO 21930, 7.1.7.2.1 [1], the system boundary with nature includes those technical processes that provide the material and energy inputs into the system and the subsequent manufacturing and transport processes up to the factory gate, as well as the processing of any waste arising from those processes.

4.3 Cut-off criteria

The cut-off criteria as per the UL PCR, Section 7.1.8 [7] and ISO 21930, 7.1.8 [1] were followed for this Project Report. Per ISO 21930, 7.1.8 [1], all input/output data required were collected and included in the LCI modelling (see Annexes A and B). No substances that are either dangerous or regulated that affect health and environment were present in the CMU block product system. Any plant-specific data gaps for the reference year 2021 e.g. input hydraulic fluids, lubricants, oils, or packaging materials were filled in with plant generic data from previous years or industry-average data.

Per the UL PCR, Section 7.1.7 [7], the Production Stage *excludes* the following processes:

- 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);
- energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

4.4 LCA software

Athena's Concrete LCA Software V2 was used to conduct the LCA modeling. This software incorporates published EPDs and data sources to calculate the A1-A3 impacts for the products that were modeled. This software was third party reviewed in February 2022 and found to be in conformance with the following relevant standards:

- (ISO). (2006a) 14025:2006 Environmental labels and declarations---Type III environmental declarations---Principles and procedures.
- ISO (2006b) 14040:2006 Life Cycle Assessment------Principles and Framework.
- ISO (2006c) 14044:2006 Environmental management---Life cycle assessment---Requirements and guidelines.
- ISO (2017) 21930:2017 Sustainability in building construction – Environmental declarations of building products

5 Life Cycle Inventory

5.1 Process descriptions

5.1.1 Cradle-to-gate product system

The cradle-to-gate weighted-average LCI models for construction products consider the three modules: A1 Extraction and upstream production, A2 Transport, and A3 Manufacturing. This section describes this system boundaries of the product systems modelled in greater detail. Figure 4 presents the Production stage system boundary for the declared concrete block masonry units product system.

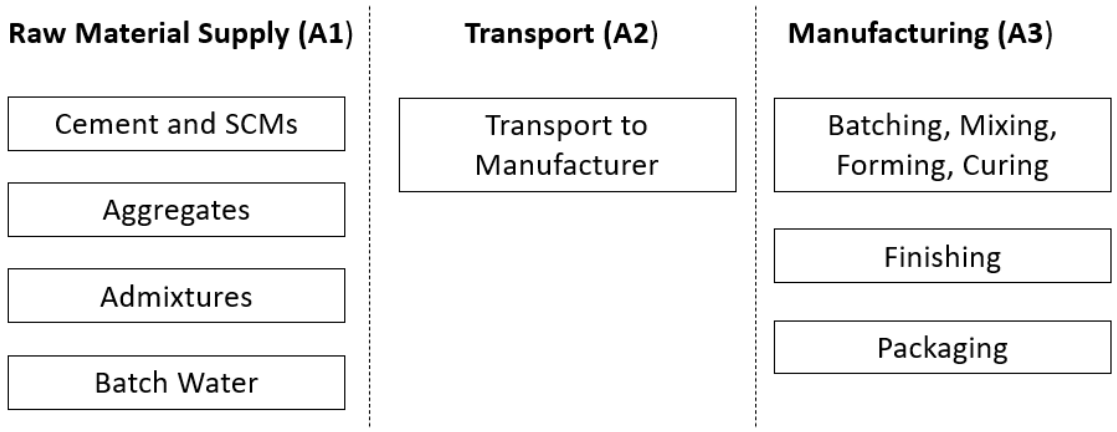


Figure 4: Cradle-to-gate system boundary of concrete block masonry units (UL PCR)

Upstream Raw Material Production (Raw Materials A1): Upstream production includes extraction, handling, and processing of the raw materials and manufactured products such as cement. The A1 module, similar to the other modules, was modeled to be as regionally representative as possible. This regionalization includes the development of custom cement data for each region based on the actual suppliers of cement at a regional level, as well as the customization of aggregate datasets to incorporate the specific electricity grids to the model.

The regional-average cement data developed for this study is based on published EPDs by each of the individual cement producers. At the time of this study, representative EPDs exist for all cement suppliers in Canada. The facility data collection included providing the specific suppliers for cement and thus region-specific weighted averages were developed to represent the average GU and GUL cement used by ready-mixed concrete producers.

Transportation of Materials to the Concrete Plant (Transport A2)- The transportation module includes the transportation of all input materials and fuels from the suppliers to the gate of the concrete plant.

Region-specific averages were calculated for cement, aggregates, SCM's, and admixtures. The calculated average transportation distance is shown in Table 1 below.

CMU Production (Manufacturing A3): CMU Production includes the batching, mixing, forming, and curing processes, as well as the finishing and packaging of the product for shipment to customers. Mix designs for "Normal Weight" and "Lightweight" CMU products were provided by manufacturers; the average mix designs for the two products are shown in Table 1.

CMU production also includes carbonation of the cement present in the final product. Recent research by Walloch et al. (in press) used thermogravimetric analysis to measure the carbon content of the constituent materials used to produce the CMU, and then again to measure carbon content post-production. The difference in these two quantities is the net CO2 sequestered by the hydrates in the block and is equal to 21 kg CO2 eq.

Table 1: Mix Designs and Material Transportation Distances

Inputs	Normal Weight CMU Ingredients (kg/m3)	Lightweight CMU Ingredients (kg/m3)	Ingredient Trucking (km)
Cement			
Portland Cement/Portland Limestone Cement	190.95	157.87	146/154
Aggregate			
Crushed Coarse Aggregate	394.57	81.12	26
Natural Coarse Aggregate	32.48	65.58	26
Crushed Fine Aggregate	308.99	0.00	43
Natural Fine Aggregate	1239.52	190.22	43
Pelletized Slag	0.00	106.56	73
Expanded Slag	0.00	818.40	38
Natural Lightweight Aggregate	0.00	248.67	43
SCMs			
Slag Cement (GGBFS)	9.74	22.23	84
Fly Ash	9.73	31.83	181
Admixtures			
Air Entrainer	0.03	0.06	1,279
Water Reducer	0.11	0.02	1,279

5.2 Data collection, representativeness, sources, and calculations

Data collection was based on an initial survey of CCMPA member facility operations. CCMPA members operate facilities in Canada producing various concrete block masonry unit products. A representative sample of 15 concrete block masonry unit plants within CCMPA membership was selected based on technical attributes, production scale and geographic location – see Annex B for a directory of CCMPA facilities that participated in the project. The 15-plant sample size represents greater than 50% of total concrete masonry unit production in Canada.

The LCI data collected was done with the expressed intent of attaining an acceptable representation of the Canadian industry-average technology mix and provincial/regional geographic representation. Foreground gate-to-gate LCI data were collected for concrete block masonry unit production for the reference year 2021. Data collection was based on customized LCI surveys which covered the following *primary data* for each facility for the 2021 reference year:

- Concrete Production
- Production Energy
- Plant Consumables
- Water Use
- Waste Produced
- Air and Water Emissions

Per ISO 21930, 5.3 [1], all facility-specific LCI data were weighted based on total annual production to calculate the weighted-average LCI profiles. All LCI data (including meta-data) were verified and benchmarked with 2021 plant-specific and/or CCMPA industry-average LCI data for each product system.

Annex C summarizes the weighted-average LCI data for the gate-to-gate foreground processes included in scope. These LCIs, along with metadata for JSON-LD, ILD, and ecoSpold2 data exchange formats can be also found in the accompanying Microsoft Excel file.

This LCA study draws on appropriate LCI datasets provided by (see Annexes C and D):

- CCMPA and its members for foreground gate-to-gate concrete block masonry units production (see Annex A); and
- North American and global LCI databases such as the U.S. National Renewable Energy Laboratory LCI database, 2014 (http://www.nrel.gov/lci/), and ecoinvent 3.4, allocation, cut-off database, 2018 (http://www.ecoinvent.org/). Both are included in the LCA software SimaPro v.9.1.

Data calculation procedures follow ISO 14044 [3] and the UL PCR for concrete block masonry units [7]. The same calculation procedures are applied throughout this LCA study. Per ISO 21930, 7.2.2 [1], when transforming the inputs and outputs of combustible material into inputs and outputs of energy, the *net calorific value* (*lower heating value*) of fuels is applied according to scientifically based and accepted values specific to the combustible material.

Per the UL PCR, Section 7.1.11 [7], SI units are used for the LCA data and results, with conversions shown in Annex E, Table 9 as necessary.

5.3 Data Quality Requirements and Assessments

Per the UL PCR, Section 7.1.9 [7], and ISO 21930, 7.1.9 [1], appropriate activity and LCI foreground and background data shall be used to model the concrete block masonry units systems. LCI data should be as representative (technologically, geographically, and time-specific), complete, consistent, reproducible and transparent as possible with regards to the goal and scope of the study [2], [3]. A detailed description of collected data and the data quality assessment regarding the UL PCR requirements [7] and ISO 14044 [3] is provided in Annex D, Table 6-8. Overall data quality is assessed based on its representativeness (technology coverage, geographic coverage, time coverage), completeness, consistency, reproducibility, transparency and uncertainty (see Table 2).

Table 2: Data Quality Requirements and Assessments

Data Quality Requirements	Description
Technology Coverage	Data represents the prevailing technology in use in Canada. Whenever available, for all upstream and core material and processes, North American typical or industry-average LCI datasets were utilized (see Annex B, Table B1 to B3). *Technological representativeness is characterized as "high".*
Geographic Coverage	The geographic region considered is Canada. The geographic coverage of all LCI databases and datasets is given in Annex B, Tables B1 to B3. *Geographical representativeness is characterized as "high".*
Time Coverage	Activity data are representative as of 2021 (see Annex A). - In-bound/ out-bound transportation data – primary data collected from 196 facilities: reference year 2021 (12 months) - Generic data: the most appropriate LCI datasets were used as found in the US LCI Database, ecoinvent v.3.4 database for US, Canada and global, 2018. *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 to provide an industry average for concrete block masonry units. The relevant background materials and processes were taken from the US LCI Database (adjusted for known data placeholders), ecoinvent v 3.4 LCI database for Canada,and modeled in SimaPro V9.1 and Athena Concrete LCA Software V2. The completeness of the cradle-to-gate process chain in terms of process steps is rigorously assessed for concrete block masonry units and documented in Section 5.1.

Data Quality Requirements	Description
Consistency	To ensure consistency, the LCI modeling of the production weighted input and output LCI data for concrete block masonry units used the same LCI modeling structure across the selected CCMPA member facilities, which consisted of input raw, secondary, facing/backing, formulation, ancillary and packaging materials, energy flows, water resource inputs, product outputs, co-products, by-products, emissions to air, water and soil, and solid and liquid waste disposal. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the facility level and selected process levels to maintain a high level of consistency.
Reproducibility	Internal reproducibility is possible since the data and the models are stored and available in Project File "CCMPA" in Athena Concrete LCA Software V2. A high level of transparency is provided throughout the report as the weighted-average LCI profile is presented for each of the declared products as well as major upstream inputs. Key foreground (manufacturer specific) and background (generic) LCI data sources are summarized in Annex D. External reproducibility is also possible as a high level of transparency is provided throughout the Project Report and LCI data and sources are summarized in Annexes C and D.
Transparency	Activity and LCI datasets are transparently disclosed in the project report, including data sources (see Annexes C and D).
Uncertainty	A *sensitivity check* was conducted to assess the reliability of the LCA results and conclusions by determining how they are affected by uncertainties in the data or assumptions on calculation of LCIA and energy indicator results. The sensitivity check includes the results of the *sensitivity analysis* (see Section 7).

5.4 Allocation Rules

Per ISO 21930, 7.2.4 [1], *Consistent allocation procedures shall be uniformly applied to similar inputs and outputs of the system under consideration. For example, the approaches of allocation to co-products or to secondary materials crossing the system boundary between product systems should use the same procedure used for co-products or to secondary material flows entering the product system.*

The CCMPA facilities produce no other co-products besides selected concrete block masonry units and as such allocation is not required. Per ISO 21930, 3 [1], a c*o-product* is defined as any of one or more products from the same unit process, but which is not the object of the assessment. As a result, plant-specific generic formulations for 1 cubic meter of the number concrete block masonry units products of interest were used to model and calculate the required input raw materials.

Per ISO 21930, 3 [1], *by-product* is defined as co-product from a process that is *incidental or not intentionally produced* and which cannot be avoided.

6 Life Cycle Impact Assessment

6.1 Impact category and inventory indicators

Per UL PCR, Section 9.5 [7], the following environmental indicators are reported as described in Table 3.

Table 3: Impact category and inventory indicators

Impact category and inventory indicators	Short	Unit (per Declared Unit)	Source of the method
Environmental impacts			
Global warming potential	GWP	kg CO_2 eq.	TRACI v2.1, July 2012 /with IPCC 2013, AR5[1)] [15]
Ozone depletion potential	ODP	kg CFC-11 eq.	TRACI v2.1, July 2012/WMO:2003 [15]
Eutrophication potential	EP	kg SO_2 eq.	TRACI v2.1, July 2012 [15]
Acidification potential	AP	kg N eq.	TRACI v2.1, July 2012 [15]
Photochemical oxidant creation potential	POCP	kg O_3 eq.	TRACI v2.1, July 2012 [15]
Use of primary resources			
Renewable primary resources used as an energy carrier (fuel)	RPR_E	MJ LHV	CED V1.10 NCV
Renewable primary resources with energy content used as material	RPR_M	MJ LHV	ACLCA ISO 21930 Guidance, 6.2 [9]
Non-renewable primary resources used as an energy carrier (fuel)	$NRPR_E$	MJ LHV	CED V1.10 NCV
Non-renewable primary resources with energy content used as material	$NRPR_M$	MJ LHV	ACLCA ISO 21930 Guidance, 6.4 [9]
Use of secondary resources			
Secondary materials	SM	kg	ACLCA ISO 21930 Guidance, 6.5 [9]
Renewable secondary fuels	RSF	MJ LHV	ACLCA ISO 21930 Guidance, 6.6 [9]
Non-renewable secondary fuels	NRSF	MJ LHV	ACLCA ISO 21930 Guidance, 6.7 [9]
Recovered energy	RE	MJ LHV	ACLCA ISO 21930 Guidance, 6.8 [9]
Abiotic depletion potential for fossil resources			
Abiotic depletion potential, surplus	ADP surplus	MJ, surplus	TRACI 2.1, July 2012 [15]
Abiotic depletion potential, LHV	ADP LHV	MJ, LHV	CML-baseline, V3.02
Consumption of freshwater resources			
Consumption (or net use) of freshwater	FW	m^3	ACLCA ISO 21930 Guidance, 9 [9]
Waste and output flows			
Hazardous waste disposed*	HWD	kg	ACLCA ISO 21930 Guidance, 10.1 [9]
Non-hazardous waste disposed	NHWD	kg	ACLCA ISO 21930 Guidance, 10.2 [9]
High-level radioactive waste, to final repository	HLRW	kg or m^3	ACLCA ISO 21930 Guidance, 10.3 [9]
Intermediate- and low-level radioactive waste, to final repository	ILLRW	kg or m^3	ACLCA ISO 21930 Guidance, 10.4 [9]
Components for reuse	CRU	kg	ACLCA ISO 21930 Guidance, 10.5 [9]

Impact category and inventory indicators	Short	Unit (per Declared Unit)	Source of the method
Materials for recycling	MR	kg	ACLCA ISO 21930 Guidance, 10.6 [9]
Materials for energy recovery	MER	kg	ACLCA ISO 21930 Guidance, 10.7 [9]
Recovered energy exported from the product system	EE	kg	ACLCA ISO 21930 Guidance, 10.8 [9]
Additional inventory parameters for transparency			
Removals and emissions associated with biogenic carbon content of the bio-based product	GWP_{BC}	kg CO_2 eq.	ISO 21930:2017, Clause 7.2.7 [1]
Emissions from calcination and removals from carbonation	GWP_{CC}	kg CO_2 eq.	ISO 21930:2017, Clause 7.2.8 [1]
Removals and emissions associated with biogenic carbon content of the bio-based packaging	GWP_{BP}	kg CO_2 eq.	ISO 21930:2017, Clause 7.2.7 [1]

*Hazardous waste defined by Resource Conservation and Recovery Act (RCRA), Subtitle 3 per UL PCR Part A.

6.2 LCA results for EPD

This section summarizes the product stage life cycle impact assessment (LCIA) results including resource use and waste generated metrics based on the cradle-to-gate life cycle inventory inputs and outputs analysis. The results in Table 4a and Table 4b are calculated based on 1 cubic meter of concrete block masonry units and the results are attached to this document. *It should be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks [2], [3].*

Table 4a: LCA Results for Normal Weight and Lightweight CMU – East Canada Region

Impact category and inventory indicators	Unit	East Region: Normal Weight CMU - GU Cement w/ Average SCM Content (Industry Default)	East Region: Normal Weight CMU - GUL Cement w/ Average SCM Content	East Region: Light Weight CMU - GU Cement w/ Average SCM Content (Industry Default)	East Region: Light Weight CMU - GUL Cement w/ Average SCM Content
Environmental impacts					
GWP	kg CO_2 eq.	205.38	190.58	176.54	164.16
ODP	kg CFC-11 eq.	7.78E-04	6.26E-06	6.43E-04	5.34E-06
EP	kg N eq.	0.16	0.16	0.13	0.13
AP	kg SO_2 eq.	1.10	1.12	1.01	1.03
POCP	kg O_3 eq.	13.30	14.34	12.44	13.30
Use of primary resources					
RPR_E	MJ, NCV	109.32	119.98	91.38	99.79
RPR_M	MJ, NCV	0.00	0.00	0.00	0.00
$NRPR_E$	MJ, NCV	1945.25	1897.74	1781.83	1739.40
$NRPR_M$	MJ, NCV	0.00	0.00	0.00	0.00
Use of secondary resources					
SM	kg	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	8557.89	8555.64	1351.17	1349.30
RE	MJ, NCV	0.00	0.00	0.00	0.00
Abiotic depletion potential					
ADPf	MJ, LHV	1003.46	976.85	943.75	918.80
ADPe	kg Sb	0.00	0.00	0.00	0.00
Consumption of freshwater resources					
FW	m^3	2.45	2.48	2.34	2.37
Waste and output flows					
HWD	kg	0.00	0.00	0.01	0.01
NHWD	kg	190.17	248.20	157.28	205.26
HLRW	m^3	3.07E-07	3.07E-07	5.40E-08	5.40E-08
ILLRW	m^3	3.70E-07	3.70E-07	1.96E-07	1.96E-07
CRU	kg	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency					
GWP_{CALC}	kg CO_2 eq.	74.46	83.50	61.56	69.03
GWP_{CARB}	kg CO_2 eq.	-21.00	-21.00	-21.00	-21.00

Table 4b: LCA Results for Normal Weight and Lightweight CMU – West Canada Region

Impact category and inventory indicators	Unit	West Region: Normal Weight CMU - GU Cement w/ Average SCM Content (Industry Default)	West Region: Normal Weight CMU - GUL Cement w/ Average SCM Content	West Region: Light Weight CMU - GU Cement w/ Average SCM Content (Industry Default)	West Region: Light Weight CMU - GUL Cement w/ Average SCM Content
Environmental impacts					
GWP	kg CO2 eq.	251.64	232.28	213.94	197.93
ODP	kg CFC-11 eq.	6.87E-06	6.93E-06	5.83E-06	5.88E-06
EP	kg N eq.	0.81	0.79	0.66	0.65
AP	kg SO2 eq.	1.07	1.01	0.98	0.93
POCP	kg O3 eq.	15.37	13.87	14.12	12.88
Use of primary resources					
RPRE	MJ, NCV	37.49	58.65	32.62	50.11
RPRM	MJ, NCV	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2219.30	2132.73	2005.07	1933.47
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00
Use of secondary resources					
SM	kg	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	88.35	79.88	91.52	84.51
RE	MJ, NCV	0.00	0.00	0.00	0.00
Abiotic depletion potential					
ADPf	MJ, LHV	1440.83	1384.32	1295.57	1248.84
ADPe	kg Sb	0.00	0.00	0.00	0.00
Consumption of freshwater resources					
FW	m3	2.30	2.30	2.26	2.25
Waste and output flows					
HWD	kg	0.00	0.00	0.01	0.01
NHWD	kg	52.28	47.24	43.28	39.11
HLRW	m3	2.87E-09	2.87E-09	9.73E-09	9.73E-09
ILLRW	m3	1.56E-07	1.56E-07	1.65E-07	1.65E-07
CRU	kg	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00
EE	kg	0.00	0.00	0.00	0.00
Additional inventory parameters for transparency					
GWPCALC	kg CO2 eq.	91.13	80.66	75.34	66.69
GWPCARB	kg CO2 eq.	-21.00	-21.00	-21.00	-21.00

7 Interpretation

Interpretation is the phase of LCA in which the findings from the inventory analysis and the impact assessment are brought together and significant issues are identified and considered in the context of the *study goal and scope* [2]. In addition, the study's completeness, consistency of all applied information, and sensitivity to key assumptions or parameters as they relate *to the goal and scope of the study* are evaluated. Lastly, the interpretation phase ends by drawing conclusions, stating the study's limitations, and making recommendations [3].

7.1 Identification of the Significant Issues

Contribution analysis is an analytical method used to support the interpretation of LCA results and to facilitate the comprehension and the reader's understanding of the environmental profile.

Figures 5a -6b shows the percent contribution of the raw materials production (A1), transportation (A2) and RMC manufacturing core processes (A3) for the global warming potential (GWP) impact indicator and Non-renewable primary energy consumed as energy (NRPRE) inventory metric. Global warming potential and non-renewable energy were selected as representative indicators as it is generally understood that the primary driver of impacts in the ready-mix concrete product system is the consumption of energy resources in the production of the cement, the transport of high-mass materials to the ready-mix producer, as well as the emissions from cement calcination that is incorporated in the A1 GWP impacts.

Figure 5a: Contribution Analysis by Information Module, GWP Indicator, Eastern Region

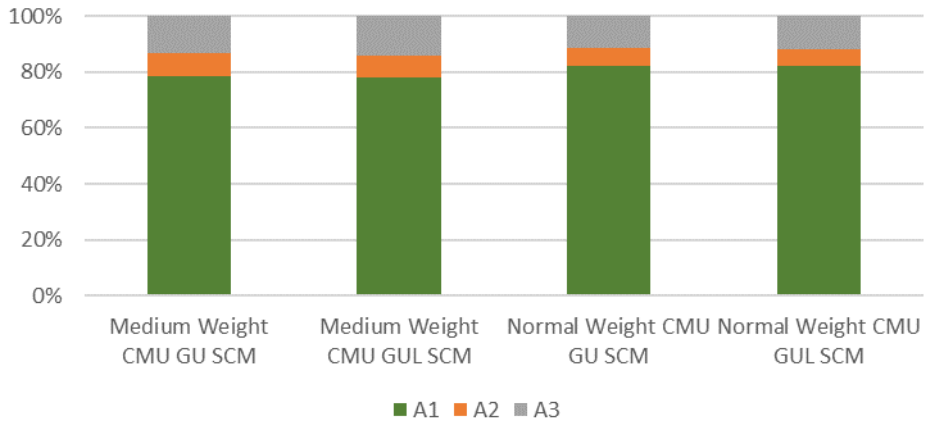


Figure 5b: Contribution Analysis by Information Module, NRPRE Indicator, Eastern Region

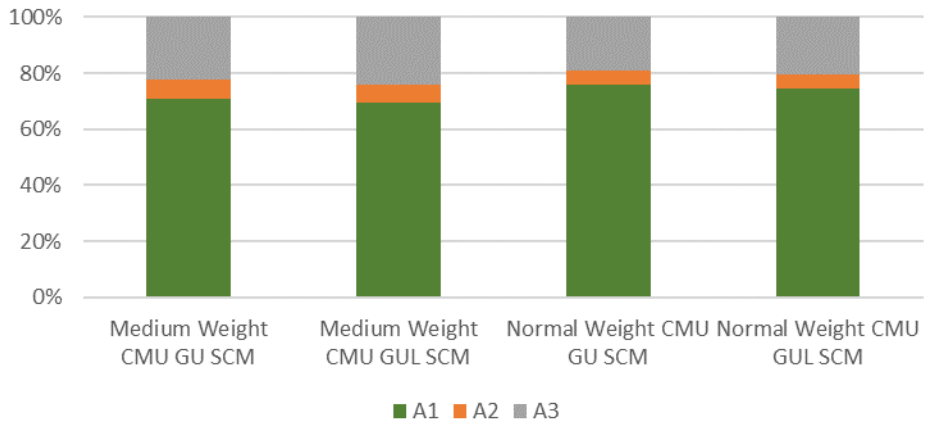
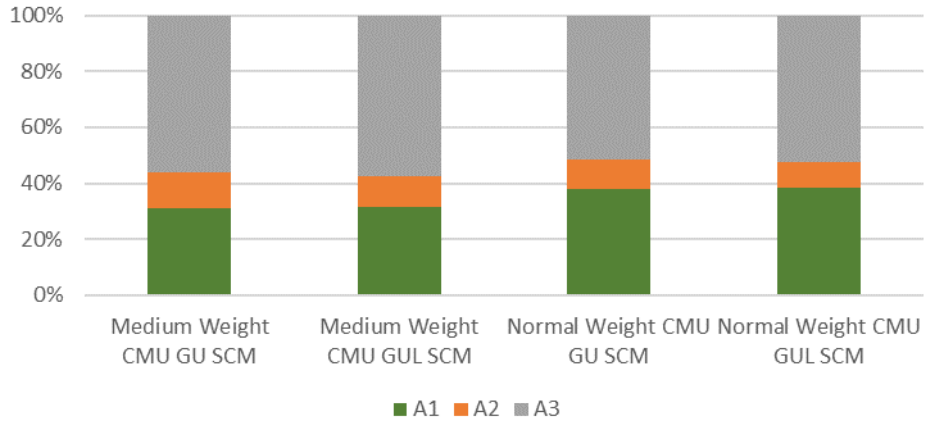
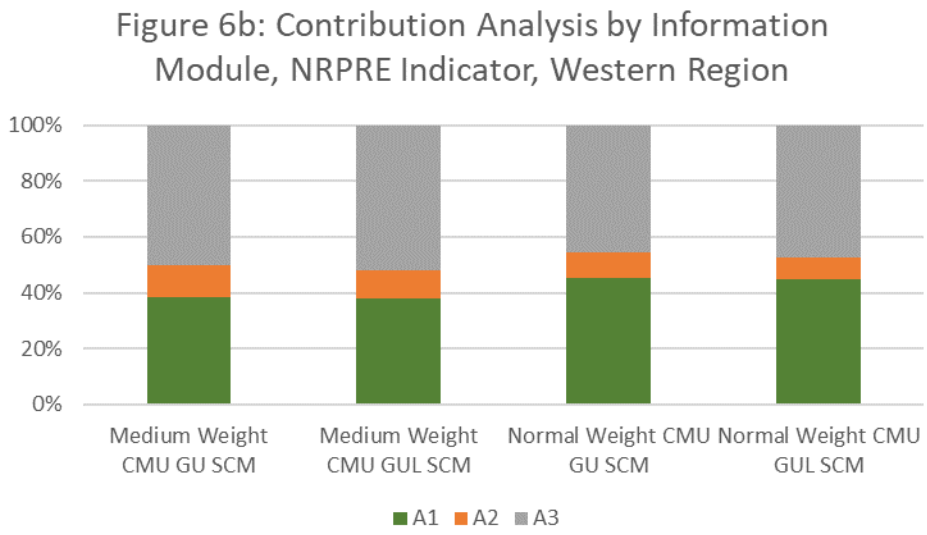


Figure 6a: Contribution Analysis by Information Module, GWP Indicator, Western Region





The contribution analysis confirms our understanding of the concrete impacts. Overall, upstream materials production (A1) accounts for the largest proportion of the GWP (69% to 82%). The raw materials production is also a significant contributor to non-renewable energy use (31%-45%) while the facility operations cause the greatest proportion of impacts in both regions (45%-57%).

The difference between the GWP contribution and the NRPRE contribution is attributable to two factors. The first factor is that the upstream cement production includes carbon dioxide process emissions from calcination. This skews the GWP contribution in A1 relative to the energy use. The second factor is that the A3 module includes carbonation which causes negative GWP, further reducing the GWP in this module relative to A1.

7.2 Completeness, Consistency, and Sensitivity Checks

Evaluating the study's completeness, consistency and sensitivity helps to establish and enhance confidence in, and the reliability of, the results of the LCA study, including the significant issues identified in the first element of the interpretation [3].

The objective of the ***completeness check*** is to ensure that all relevant information and data needed for the interpretation are available and complete [3]. The product systems were checked for data completeness. All input and output data were found to be complete and no gaps were identified at information modules A1, A2 and A3 (see Appendix C and D tables).

The objective of the ***consistency check*** is to determine whether the assumptions, methods, models and data are consistent with the goal and scope of the study [3]. Through a rigorous process, consistency was ensured between the ready mixed concrete product systems in terms of calculation rules, methods, models, and data quality, including data source, time-related coverage, technology, and geographical coverage (see Section 5). Table 6-8 summarizes the data quality assessment conducted in the framework of this LCA study.

To assess how factors such as *uncertainties in data*, and assumptions would affect the reliability of the results and conclusions, a ***sensitivity check*** or ***sensitivity analysis*** may be undertaken. In lieu of sensitivity analysis for this project, we have instead provided a wide range of product variations per strength class and as such the variability between and within products is covered under the range of results that are presented.

7.3 Limitations and Recommendations

For best interpretation and appropriate use of the LCA results, it is important to state the inherent ***limitations*** and assumptions of the LCA technique. LCA addresses "potential environmental impacts" and does not predict absolute or precise environmental impacts due to (a) the relative expression of potential environmental impacts to a reference unit, (b) the integration of environmental data over space and time, (c) the inherent uncertainty in modeling of environmental impacts, and (d) the fact that some possible environmental impacts are clearly future impacts [2].

Limitations include the fact that this study does not report all the environmental impacts caused by, for example, emissions that might impact human and/or ecosystem health. In order to assess the local impacts of product manufacturing on human health, land use and local ecology, additional analysis is required.

This project reports the results of an industry wide 'cradle-to-gate' LCA of ready mixed concrete in order to establish industry benchmarks. No environmental claim regarding the superiority or equivalence of concrete relative to a competing product that performs the same function is implied. This LCA does not make any statements that the products covered or worse than any other product. LCIA results are only relative expressions of potentials and do not predict actual impacts, the exceeding of thresholds, safety margins or risks,

8 Declaration Type and Product Average Declaration

The type of EPD that may be based on this Project Report is defined as:

- A "*Cradle-to-gate*" EPD for concrete block masonry units covering the *Production stage* (information modules A1 to A3) and is intended for use in *Business-to-Business* communication.

CCMPA EPD for concrete block masonry units falls under the description:

- *An average product EPD, as an average from several CCMPA manufacturers' facilities*

(in this case, CCMPA member manufacturers as listed under "CCMPA Member Companies Corporate Locations").

9 Declaration Comparability Limitation Statement

The following ISO 21930 statement indicates the comparability limitations of EPDs produced using this report and intent to avoid any market distortions or misinterpretation of EPDs based on the UL PCR for concrete block masonry units [7]:

> *- Only EPDs prepared from cradle-to-grave life cycle results and based on the same function, RSL, quantified by the same functional unit, and meeting all the conditions for comparability listed in ISO 14025:2006 and ISO 21930:2017 can be used to comparison between products*.

10 Explanatory Material

For any explanatory material, regarding this CCMPA LCA for concrete block masonry units, please contact the National Research Council Canada.

National Research Council Canada

1200 Montreal Rd Building M-58

Ottawa, ON K1A 0R6

Robert.Cooney@nrc-cnrc.gc.ca (Project Manager, LCA^2 Initiative)

11 References

[1] ISO 21930:2017 Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services.

[2] ISO 14040:2006 Environmental management - Life cycle assessment - Principles and framework.

[3] ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines.

[4] ISO 14021:2016 Environmental labels and declarations -- Self-declared environmental claims (Type II environmental labelling).

[5] ISO 14025:2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.

[6] ISO 14048:2002. Environmental management — Life cycle assessment — Data documentation format.

[7] UL PCR Part B: Concrete Masonry and Segmental Concrete Paving Product EPD Requirements, V1.0, November 2020.

[8] UL PCR Part A: Product Category Rule (PCR) Guidance for Building-Related Products and Services, Part A Life Cycle Assessment Calculation Rules and Report Requirements; UL 10010,Version 3.2

[9] ACLCA 2019, Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017. The American Centre for Life Cycle Assessment. May, 2019. https://aclca.org/aclca-iso-21930-guidance/

https://aclca.org/wp-content/uploads/ISO-21930-Final.pdf

[10] Athena Concrete LCA Software, V2. January 2022.

[11] European Commission - Joint Research Centre - Institute for Environment and Sustainability (2010). *International Reference Life Cycle Data System (ILCD) Handbook - Nomenclature and other conventions*. https://eplca.jrc.ec.europa.eu/uploads/MANPROJ-PR-ILCD-Handbook-Nomenclature-and-other-conventions-first-edition-ISBN-fin-v1.0-E.pdf

[12] U.S. Environmental Protection Agency (2019). *The Federal LCA Commons Elementary Flow List: Background, Approach, Description and Recommendations for Use*. https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=347251&Lab=NRMRL

[13] Executive Office of the President, Office of Management and Budget (2017*). North American Industry Classification System.*https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf

[14] U.S. Environmental Protection Agency (2016). *Guidance on Data Quality Assessment for Life Cycle Inventory Data.* https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=321834

[15] U.S. Environmental Protection Agency (2012). Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) TRACI version 2.1. https://nepis.epa.gov/Adobe/PDF/P100HN53.pdf

[16] Construction Standards Institute (CSI) (2012). OmniClass: A Strategy for Classifying the Built Environment. Table 22 Work Results. https://www.csiresources.org/standards/omniclass

[17] Walloch et al: (in press) Conceptual Test Protocols for Measuring Carbon Sequestration of Manufactured Dry-Cast Concrete Products.

Annex A: CCLCI Project Specifications

This annex is a set of guidelines that shall be applied to the LCI/LCA datasets of construction products developed as part of the CCLCI project.

The objective of this annex is to establish consistent rules to ensure:

- Project deliverables can be used to meet the goals of the CCLCI.
- LCAs are of good quality, are verifiable, and transparently report LCI datasets and environmental indicator results.

General

1) The LCA shall meet the CCLCI goals described in Section 2.
2) The LCA shall be completed in accordance with a North American PCR that is based on the core rules of ISO 21930:2017 [1][1].
3) The LCA shall be third-party reviewed for conformance with the relevant PCR and ISO 21930: 2017.
4) The NRC shall review the LCA report and LCI for conformance with the requirements of this annex.

Scope

5) The system boundary shall cover the production stage of construction materials, information modules A1-A3; other modules may be considered if required by the PCR or to conform to best-practice.

Data quality goals

6) Technlogical Representativeness: the LCA shall be representative of industry-average manufacturing (module A3) of construction products. Process design, operating conditions, material quality, and process scale shall be considered when selecting a sample set of facilities that is representative of industry-average[2].
7) Geographic Representativeness: the LCA shall be representative of Canadian industry. The best available geographic representation shall be reported, in principle according to the following hierarchy: Provincial → Regional → National (see Figure 7 for default geographic classifications). The LCA should not be representative of non-Canadian geographies, nor mixes of Canadian and non-Canadian materials production.
8) Temporal Representativeness: the LCA shall be based on the survey data of the most current available calendar or fiscal year and shall be no less than two years old. Survey data from different time periods shall not be aggregated.

[1] Note: EPD requirements are outside the scope of the CCLCI project.

[2] See the EPA's *Guidance on Data Quality Assessment for Life Cycle Inventory Data* [14] for further information on the four criteria.

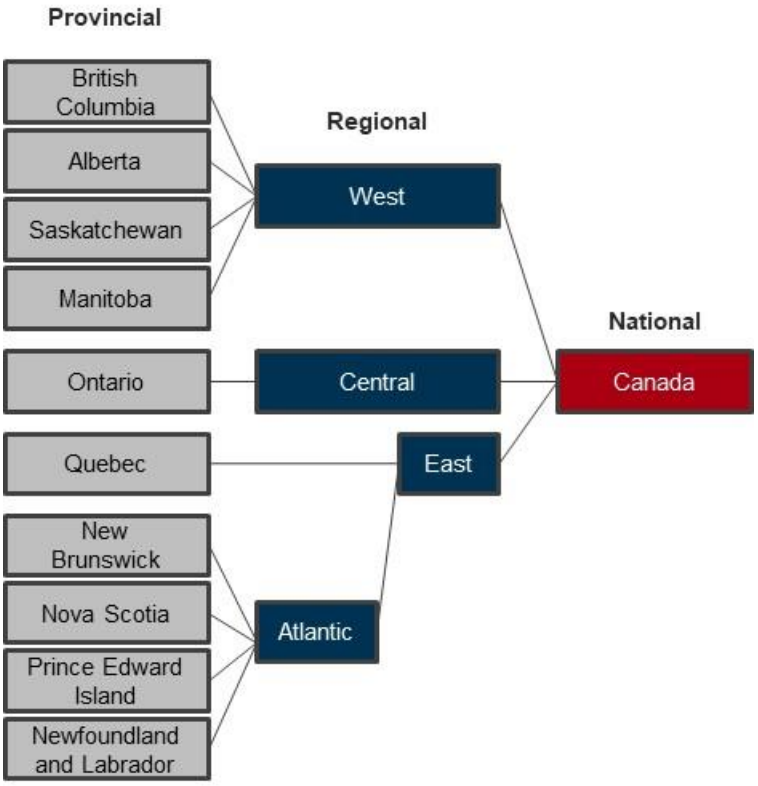


Figure 7: Geographic representation hierarchy for LCIs

Life Cycle Inventory

9) The LCA shall be based on new foreground LCI datasets derived from industry survey information. The survey information shall in principle include the largest sample set of facilities available and/or feasible that meets data quality requirements, and shall not be less than 3 facilities from different entities in a geographic division[3].
10) Foreground LCIs shall:
11) In principle be broken down into appropriate gate-to-gate processes in unallocated format for each major transformation process within the operational control of the construction product manufacturers. Aggregation of foreground LCIs from two or more gate-to-gate processes may be performed; aggregation of foreground and background LCIs should not be performed.
12) Account for all relevant technosphere and elementary flows and at minimum, include all flows required to calculate the mandatory environmental indicators.
    a. Meet the minimum metadata requirements of ISO 14048 [2], and ILCD[4], ecoSpold2[5], and JSON-LD[6] data exchange formats;

[3] Note: data providers are encouraged to use customized survey tools/software for surveying.

[4] See https://eplca.jrc.ec.europa.eu/LCDN/downloads/ILCD_Format_1.1_Documentation/ILCD_FlowDataSet.html for ILCD format fields

[5] An html file of ecoSpold2 format fields can be downloaded here: https://www.ecoinvent.org/data-provider/data-provider-toolkit/ecospold2/ecospold2.html#2089

[6] See http://greendelta.github.io/olca-schema/ for JSON-LD format fields.

b. Include an applicable 6-digit *North American Industry Classification System* (NAICS) number and associated NAICS title [13].
c. Include an applicable "Level 3" (8-digit) OmniClass Table 22 (MasterFormat) number and associated title [16][7]
d. Have technosphere flows named in accordance with the US LCI database convention, otherwise in accordance with ILCD nomenclature [11].
e. Have elementary flows named in accordance with the *Federal LCA Commons Elementary Flow List: Background, Approach, Description and Recommendations for Use* [12].
f. Include a data quality assessment (DQA) in accordance with the EPA's *Guidance on Data Quality Assessment for Life Cycle Inventory Data* [14].

13) Background LCI data with the best data quality, and/or data deemed most appropriate, and/or are required by the relevant PCR shall be selected for use, and by default should come from the most current version of the ecoinvent database.
14) Background LCIs may be adjusted to i) better reflect the applicable time period, technology, or geography, or ii) for the purpose of calculating mandatory environmental indicators. Adjustments shall be described in the LCA report.
15) The data source and representativeness (technological, temporal, and geographic) of each background LCI dataset shall be evaluated and reported.

LCIA method & environmental indicators

16) The LCA shall at minimum report all mandatory environmental indicators, per ISO 21930:2017. A rationale shall be provided for indicators that are not assessed.
17) Life cycle impact assessment (LCIA) shall at minimum be performed using the TRACI v2.1 method [15].
18) Non-LCIA inventory metrics shall be calculated in accordance with *ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017* [9].

Interpretation

19) Appropriate contribution, dominance, and sensitivity analyses shall be performed.
20) When relevant, the module A1-A3 global warming potential contribution of the following sources/sinks shall be evaluated:
    - Biogenic carbon;
    - Carbonation; and
    - Land use change.

Reporting

21) The LCA shall be reported based on the NRC LCA report template.
22) The LCI and associated metadata shall be reported according to the NRC LCI template.

[7] Note: this metadata requirement is only applicable to processes that describe finished construction products.

Annex B: CCMPA Plant Directory

Basalite Concrete Products
8650 130th Street
Surrey, British Columbia
V3W 1G1
www.basalite.com

locations: Surrey, British Columbia

Brampton Brick Limited
225 Wanless Drive
Brampton, Ontario
L7A 1E9
www.bramptonbrick.com

locations: Brampton, Ontario; Brockville, Ontario

Brown's Concrete Products Ltd.
3075 Herold Drive
Sudbury, Ontario
P3E 6K9
www.brownsconcrete.com

locations: Sudbury, Ontario

Canal Block
3562 Nugent Road
Port Colborne, Ontario
L3K 5V5
www.canalblock.com

locations: Port Colborne, Ontario

Casey Concrete Ltd
96 Park Street
Amherst, Nova Scotia
B4H 2M8
www.caseyltd.ca

locations: Amherst, Nova Scotia

Century Concrete Products Ltd 2016
4170 Midland Ave
Scarborough, Ontario
M1V 4S6
www.centuryconcrete.ca

locations: Scarborough, Ontario

Day & Campbell Limited
1074 Upper Wellington Street
Hamilton, Ontario
L9A 3S6
www.daycampbell.com

locations: Hamilton, Ontario

Cindercrete Products Ltd.
P.O. Box 306
Hwy #1 East
Regina, Saskatchewan
S4P 3A1
www.cindercrete.com

locations: Regina, Saskatchewan

Concrete Products
260 East White Hills Road
P.O. Box 8056 STN 'A'
St. John's, Newfoundland
A1B 3M7
www.newcrete.ca

locations: St. John's, Newfoundland

Expocrete, an Oldcastle company
#38, 53016 HWY 60
Acheson, Alberta
T7X 5A7
www.expocrete.com

locations: Acheson & Edmonton, Alberta; Winnipeg, Manitoba

Newtonbrook Block
2665 Aurora Road
P.O. Box 69
Gormley, Ontario
L0H 1G0
www.newtonbrook.com

locations: Whitchurch-Stouffville, Ontario

Niagara Block Inc.
5000 Montrose Road
Niagara Falls, Ontario
L2H 1K5
www.niagarablock.com

locations: Niagara Falls, Ontario

Richvale-York Block Inc.
1298 Clarke Road
London, Ontario
N5V 3B5
www.richvaleyork.com

locations: Gormley, Ontario**;** London, Ontario

Santerra Stonecraft
5115 Rhodes Drive
Windsor, Ontario
N8N 2M1
www.santerrastonecraft.com

locations: Windsor, Ontario

Shaw Brick
1 Shaw Dr
P.O. Box 2130
Lantz, Nova Scotia
B2S 3G4
www.shawbrick.com

locations: Fredericton, New Brunswick; Lantz, Nova Scotia

Simcoe Block (1979) Ltd.
207 Tiffin Street
Barrie, Ontario
L4M 4T2
www.simcoeblock.com

locations: Barrie, Ontario

VJ Rice Concrete Limited
1 Rice Road
Bridgetown, Nova Scotia
B0S 1C0
http://www.riceconcrete.ca/

locations: Bridgetown, Nova Scotia

Annex C: Life Cycle Inventories

Table 5: Gate-to-gate unallocated inputs/outputs for 1 m3 of concrete masonry units production

Inputs/Outputs	Data Reference	Units	Canadian Average Facility Flows per 1 m3
Production			
Reference Flow		m3	1.00
Energy Inputs			
Purchased Electricity - Used at Plant	A3-1	kWh	33.12
Natural Gas - Used at Plant	A3-2	m3	14.15
Fuel Oil - Used at Plant	A3-3	l	0.18
Diesel - Used at Plant	A3-3	l	1.15
Gasoline - Used at Plant	A3-4	l	0.12
LPG (Liquified Propane Gas) - Used at Plant	A3-5	l	0.07
Diesel - Used in Fleet	A3-3	l	1.15
Ancillary Material Inputs			
Grease	A3-7	kg	0.02
Oil and Lubricants	A3-7	kg	0.06
Water Consumption			
Total Water Use	A1-9	l	424.54
Waste			
Hazardous Solid Waste	A3-6	kg	0.00
Non-Hazardous Solid Waste	A3-7	kg	0.31

Annex D: Data Sources

Table 6: Datasets used in the A1 Module of this LCA

Flow Ref.	Materials	LCI Data Source	Year / Region	Data Quality Assessment
A1-1	GU and GUL Cement *ASTM C150, C595, C1157*	Calculated based on EPD data for specific suppliers	2021-2022 Canada	• Technology: very good • Time: very good • Geography: very good • Completeness: very good • Reliability: very good
A1-2	Fly Ash *ASTM C618*	None, no incoming burden, only transport is considered	N/A	• N/A • Recovered material
A1-3	Silica Fume *ASTM c1240*	None, no incoming burden, only transport is considered	N/A	• N/A • Recovered material
A1-4	Slag Cement *ASTM C989*	Slag Cement Association EPD of North America Slag Cement (2021)	2021 North America	• Technology: very good • Time: very good • Geography: very good • Completeness: very good • Reliability: very good
A1-5	Crushed Aggregates *coarse and fine* *ASTM C33*	ecoinvent 3.4: "Gravel, crushed {RoW}| production | Cut-off, U" (2018) Modified foreground process with region-specific electricity grid.	2001 World/ Regional	• Technology: very good • Time: poor • Geography: good • Completeness: very good • Reliability: very good
A1-6	Natural Aggregates *coarse and fine* *ASTM C330*	ecoinvent 3.4: "Gravel, round {RoW}| gravel and sand quarry operation | Cut-off, U" (2018) Modified foreground process with region-specific electricity grid.	2001 World/ Regional	• Technology: very good • Time: poor • Geography: good • Completeness: very good • Reliability: very good
A1-7	Pelletized Slag	Slag Cement Association EPD of North America Slag Cement, Module A1 (2021)	2021 North America	• Technology: very good • Time: very good • Geography: very good • Completeness: very good • Reliability: very good

Flow Ref.	Materials	LCI Data Source	Year / Region	Data Quality Assessment
A1-8	Admixtures *ASTM C494*	EFCA EPDs for Air Entrainers, Plasticisers and superplasticisers, Hardening Accelerators, Set Accelerators, Water Resisting Admixtures, and Retarders (2015) [8] Non-supported LCIA indicators estimated – adjusted using TRACI equivalents	2015 EU	• Technology: very good • Time: very good • Geography: fair • Completeness: good • Reliability: very good
A1-9	Batch and Wash Water *ASTM C1602*	ecoinvent 3.4: Tap water {RoW}| market for | Cut-off, U (2018) [18] Modified foreground process with Canada average electricity grid	2011 World/ USA	• Technology: very good • Time: good • Geography: good • Completeness: very good • Reliability: very good

Table 7: Datasets used in the A2 Module of this LCA

Flow Ref.	Process	LCI Data Source	Year / Region	Data Quality Assessment
A2-1	Road	USLCI 2014: Transport, combination truck, short-haul, diesel powered/tkm/RNA (2014) [13]	2010 USA	• Technology: very good • Time: good • Geography: very good • Completeness: very good • Reliability: very good
A2-2	Rail	USLCI 2014: Transport, train, diesel powered /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A2-3	Ocean	USLCI 2014: Transport, ocean freighter, average fuel mix /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A2-4	Barge	USLCI 2014: Transport, barge, average fuel mix /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good

Table 8: Datasets used in the A3 Module of this LCA

Flow Ref	Process	LCI Data Source	Year / Region	Data Quality Assessment
A3-1	Electricity	ecoinvent 3.4: Electricity, low voltage {XX}| market for | Cut-off, U (2018) [18] Modeled based on provincial-specific electricity grids	2015 USA	• Technology: very good • Time: very good • Geography: very good • Completeness: very good Reliability: very good
A3-2	Natural Gas	USLCI 2014: Natural Gas, combusted in industrial boiler /US U (2014)	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-3	Diesel	USLCI 2014: Diesel, combusted in industrial equipment /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good Reliability: very good
A3-4	Gasoline	USLCI 2014: Gasoline, combusted in equipment /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-5	Liquefied Propane Gas	USLCI 2014: Liquefied petroleum gas, combusted in industrial boiler /US U (2014) [13]	2007 USA	• Technology: very good • Time: fair • Geography: very good • Completeness: very good • Reliability: very good
A3-6	Hazardous Solid Waste,	ecoinvent 3.4: Hazardous waste, for incineration {RoW}| treatment of hazardous waste, hazardous waste incineration | Alloc Rec, U (2018) [18] Modified foreground process with Canada average electricity grid	2011 World/ USA	• Technology: very good • Time: good • Geography: good • Completeness: very good • Reliability: very good
A3-7	Non-Hazardous Solid Waste	ecoinvent 3.4: Inert waste {RoW}| treatment of, sanitary landfill | Alloc Rec, U (2018) [18] Modified foreground process with United States average electricity grid	2011 World/ USA	• Technology: very good • Time: good • Geography: good • Completeness: very good • Reliability: very good

Annex E: Other Data Tables

Table 9: Conversion factors

Convert from	To	Multiply by
Metric ton	Short ton	1.10231
Kilogram (kg)	Pound (lb)	2.20462
Litre	Gallons	0.26417
Cubic meter (m^3)	Cubic foot (ft^3)	35.3147
Kilometer (km)	Mile (mi)	0.62137
tkm	ton-mile	0.68495
Meter (m)	Foot (ft)	3.28084
MJ	British Thermal Unit (BTU)	947.817

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