An Industry Average Environmental Product Declaration for Slag Cement

SCA
SLAG CEMENT ASSOCIATION

ASTM INTERNATIONAL
Helping our world work better

An Environmental Product Declaration (EPD)
In accordance with ISO 14025 and ISO 21930

About this EPD

This is an industry average cradle-to-gate environmental product declaration for slag cement as produced and distributed by Slag Cement Association members. The life cycle assessment was prepared according to ISO 14025:2006, ISO 21930:2017 (the core PCR) and the NSF product category rules for Slag Cement (subcategory PCR). This environmental product declaration (EPD) is intended for business-to-business audiences.

General Summary

EPD Commissioner and Owner

Slag Cement Association (SCA)
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: 847-977-6920
Link (URL): www.slagcement.org
info@slagcement.org

Each SCA member company provided both LCI and meta-data for the 2019/2020 calendar or fiscal year (12 months). SCA members operate more than 30 facilities in the USA and Canada including granulation, grinding and slag cement bulk distribution terminals. SCA members, with the inclusion of their Canadian holdings and affiliates, produce and ship over 95% of the slag cement consumed in the USA and Canada. A complete list of SCA member companies can be found here https://www.slagcement.org/home/membercompanies.aspx

The owner of the declaration is liable for the underlying information and evidence.

SCA Members

Argos USA Corporation
3015 Windward Plaza, Suite 300
Alpharetta, GA 30005
Member Link (URL): https://www.argos-us.com

Ash Grove Cement Company
11011 Cody, Suite 300.
Overland Park, KS 66210
Member Link (URL): http://www.ashgrove.com/

CEMEX USA
10100 Katy Freeway, Suite 300
Houston, TX, 77043, USA
Member Link (URL): https://www.cemexusa.com

Holcim (US) Inc.
24 Crosby Drive
Bedford, MA 01730
Holcim (Canada) Inc.
2300 Steeles Avenue West, 4th Floor
Concord, Ontario L4K 5X6
Member Link (URL): www.holcim.com

Lafarge North America
8700 West Bryn Mawr Avenue, Suite 300
Chicago, IL 60631
Member Link (URL):
http://www.lafarge-na.com/wps/portal/na
Eastern Canada - Main Office
Lafarge Canada Inc.
6509 Airport Road
Mississauga, ON L4V 1S7

Lehigh Cement Co.
300 E. John Carpenter Freeway
Irving, TX 75062
Member Link (URL): http://www.lehighhanson.com/home.aspx

St. Marys Cement a Votorantim Cimentos Company
55 Industrial St
Toronto, Ontario, M4G 3W9
Member Link (URL): http://www.stmaryscement.com/saintmaryscementinc/

OZINGA
19001 Old LaGrange Road
Mokena, IL 60448, US
Member Link (URL): https://ozinga.com

Skyway Slag Cement
5960 Berkshire Lane, Suite 900
Dallas, TX 75225
Member Link (URL): http://www.skywaycement.com

Product Group and Name	*Slag Cement, UN CPC 3744, UNSPSC Code 30111601.*

An Environmental Product Declaration (EPD)
In accordance with ISO 14025 and ISO 21930

Product Definition	Slag cement, UN CPC 3744 and UNSPSC Code 30111601, is defined as granulated blast-furnace slag that has been ground to cement fineness, with or without additions, and is a hydraulic cement [2].
Product Category Rules (PCR)	NSF International, Product Category Rules for Preparing an Environmental Product Declaration for Slag Cement, v2.0, December 2020 [2].
Date of Issue & Validity Period	07/30/2021 – 5 years
Declared Unit	1 metric ton of slag cement

EPD and Project Report Information

Program Operator	ASTM International
Declaration Number	EPD 245
Declaration Type	Cradle-to-gate (modules A1 to A3). Industry average.
Applicable Countries	United States and Canada
Product Applicability	Slag cement is a supplementary cementitious material (SCM) typically used in concretes and mortars to replace a portion of the portland cement in, and augment the performance of, concrete and mortars.
Content of the Declaration	This declaration follows Section 9; Content of an EPD, NSF International, Product Category Rules for Preparing an Environmental Product Declaration for Slag Cement, v2.0, December 2020 [2].
This EPD was independently verified by ASTM in accordance with ISO 14025 and the reference PCR: Internal External X	Tim Brooke ASTM International 100 Barr Harbor Drive, PO Box C700 West Conshohocken PA 19428-2959, USA cert@astm.org
The Project Report	An Industry Average Cradle-to-Gate Life Cycle Assessment of Slag Cement for the USA and Canadian Markets, July 2021.
LCA report and EPD Prepared by: Athena Sustainable Materials Institute	Lindita Bushi, PhD, Jamie Meil & Grant Finlayson Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, Ontario, Canada K1P 5G8 info@athenasmi.org www.athenasmi.org

An Environmental Product Declaration (EPD)
In accordance with ISO 14025 and ISO 21930

The EPD project report was independently verified by in accordance with ISO 14025, ISO 14040/44, and the reference PCR by:	Thomas P. Gloria, PhD, Industrial Ecology Consultants 35 Bracebridge Rd. Newton, MA

PCR Information

Program Operator	NSF International
Reference PCR	Product Category Rules for Preparing an Environmental Product Declaration for Slag Cement, v2.0, December 2020 [2].
PCR review was conducted by:	Thomas P. Gloria, PhD (Chair), Industrial Ecology Consultants, t.gloria@industrial-ecology.com Dr Michael Overcash, Environmental Clarity Mr. Bill Stough, Bill Stough, LLC

Product Description

Slag cement, UN CPC 3744, is defined in ASTM C125 as granulated blast-furnace slag that has been ground to cement fineness, with or without additions, and that is a hydraulic cement [2]. Slag cement is a supplementary cementitious material (SCM). Iron blast furnace slag (BFS) is a waste material of pig iron production and as such is categorized as a "recovered material" [2]. To transform iron BFS, so it can be used as a SCM in concrete and mortars, it is first rapidly quenched with water to form granules known as Granulated Blast Furnace Slag (GBFS). It then undergoes dewatering, crushing of oversized material only (if applicable), and storage at the granulating facilities. GBFS is then shipped to the grinding facilities where it undergoes dewatering/drying (if applicable), iron removal from slag granules (if applicable), crushing (if applicable), grinding, and packaging (if applicable). The slag cement is then stored onsite in a terminal or moved off-site to another distribution terminal.

Material Content and Standards

Inputs	Quantity (%)
Slag Granules	99.4%
Gypsum	0.3%
Synthetic Gypsum	0.2%
Cement Kiln Dust	0.1%
Grinding Aids	<0.1%
Total	100%

Applicable Standards:
As an SCM in concrete:
- *ASTM C989/C989M, Standard Specification for Slag Cement for Use in Concrete and Mortars*
- *AASHTO M 302, Standard Specification for Slag Cement for Use in Concrete and Mortars*
- *CSA A3001, Cementitious Materials for Use in Concrete*
- *ASTM C125 Standard Terminology Relating to Concrete and Concrete Aggregates*

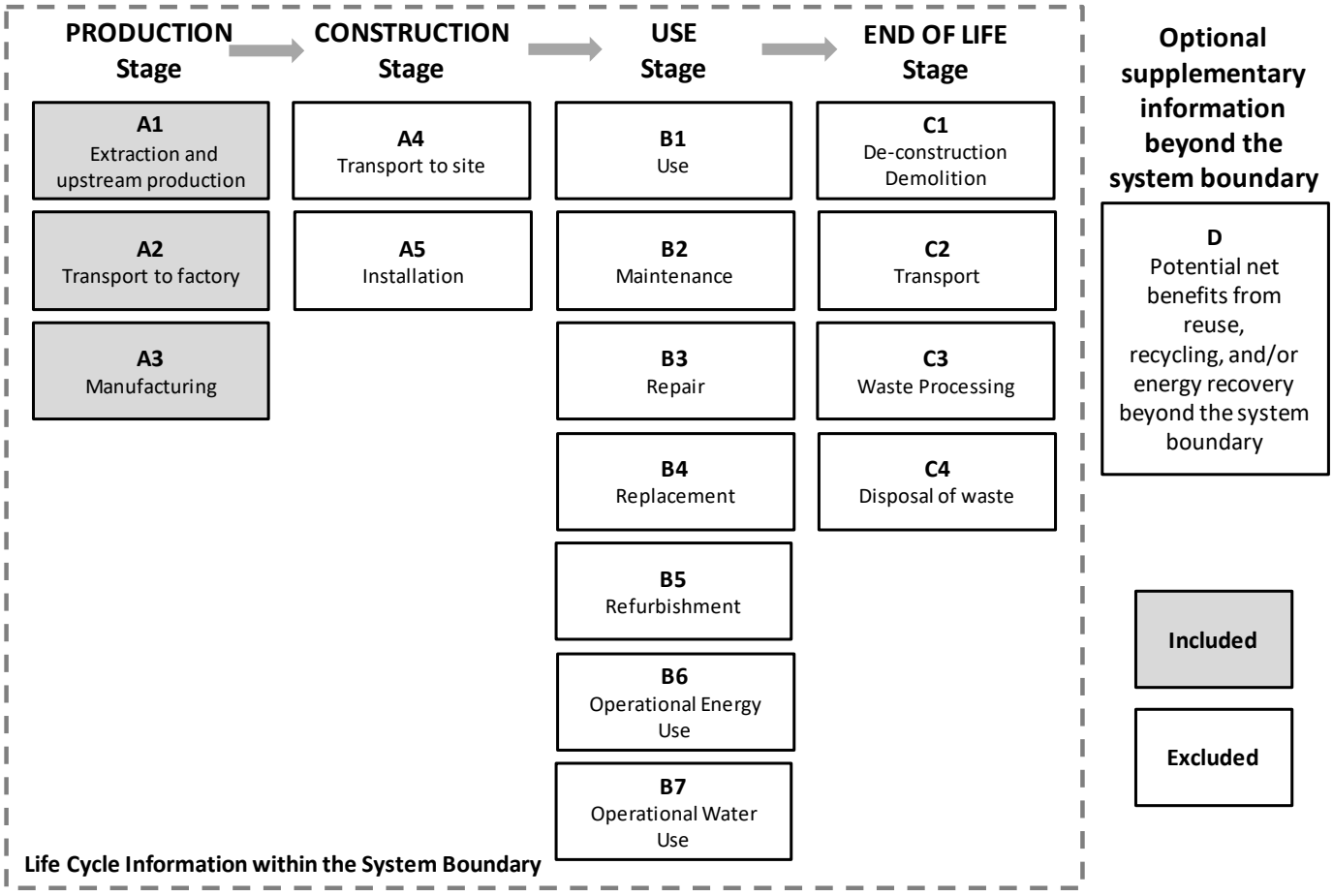
As a constituent of blended cement
- *ASTM C595/C595M, Standard Specification for Blended Hydraulic Cements*
- *AASHTO M 240M/M 240, Standard Specification for Blended Hydraulic Cements*
- *ASTM C219, Standard Terminology Relating to Hydraulic Cement.*

Declared Unit

The declared unit is one metric ton (1000 kg) of slag cement.

System Boundary

This EPD is a cradle-to-gate EPD covering the *production stage* (A1-A3) as depicted in the figure below. The production stage includes extraction and recovery of raw materials (cradle) through the manufacture of slag cement 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.



Items *excluded* from the system boundary include:

- 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

Cut-off Criteria
The cut-off criteria as per NSF PCR, Section 7.1.8 [2] and ISO 21930, 7.1.8 [3] were followed. Per ISO 21930, 7.1.8 [3], 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. Any facility specific data gaps for the 2019/2020 calendar or fiscal year (12 months) (e.g., amounts of lubricants) were filled in with generic facility, company, or industry data.

Data Collection
Gate-to-gate input/output flow data were collected for the following processes for the 2019/2020 calendar or fiscal year (12 months):

- Iron blast furnace slag granulation, slag cement manufacture and distribution terminal operations.

These data were collected from 21 SCA member facilities from three discrete regions (East, Midwest, and West NA), to represent the US and Canadian industry average geographic mix. These 21 facilities (3 granulating, 12 grinding and 7 off-site distribution terminals) were deemed representative of the specific processes and the SCA's membership. In total, these 21 facilities operated by the 9 SCA company members (Argos, Ash Grove Cement Company, Cemex, Holcim US, Lafarge Canada, Lehigh Cement Company, St Mary's Cement Group, Skyway Cement Company and Ozinga) completed LCI questionnaires representing 100% of member operated granulating facilities, 75% of their grinding facilities and 86% of all shipments via off-site terminal operations. In addition, around 33% of the total North American slag cement was shipped through off-site terminals. All LCI data were averaged on the annual production basis across facilities.

Allocation Rules

Allocation follows the requirements and guidance of ISO 14044 Clause 4.3.4 [5], NSF PCR [2], and ISO 21930 section 7.2 [3]. The sub-category PCR recognizes iron blast furnace slag as a recovered material In addition, and in keeping with the NSF PCR for Portland, Blended, Masonry and Plastic (Stucco) Cements [6], this study also recognizes cement kiln dust (CKD) and flue gas desulfurization (FGD) 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 material input.

Several SCA members grind slag at their cement plants and thus produce slag cement as well as a number of other portland cements and as such plant specific generic formulations for one (1) metric ton of slag cement was used to model and calculate the required formulation materials and other inputs/outputs. LCI modeling did consider the plant specific manufacturing yields. "Mass" was used as the physical parameter for allocating flows between slag cement and other co-products to calculate the input energy flows (e.g., electricity, natural gas, diesel), packaging materials, freshwater consumption, process emissions to air, water and land and waste flows (if applicable).

Data Quality Requirements and Assessment

Data Quality Requirements	Description
Technology Coverage	Data represents the prevailing technology in use at SCA member facilities. Whenever available, for all upstream and core material and processes, North American typical or average industry LCI datasets were utilized. *Technological representativeness is characterized as "high".*
Geographic Coverage	The geographic region considered is U.S. and Canada. The geographic coverage of all LCI databases and datasets is provided in the LCA background report. *Geographical representativeness is characterized as "high".*
Time Coverage	Primary activity data are representative of 2019/2020 calendar or fiscal year (12 months). - Granulation, - Grinding, - Terminal operations, and - In-bound/out-bound transportation data - Generic data: the most appropriate LCI datasets were used as found in the ecoinvent v.3.6 database for US and global, December 2019 and US LCI Database. *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 complete production profile for all facilities. The relevant background materials and processes were taken from the US LCI Database ecoinvent v 3.6 LCI database for US, and modeled in SimaPro software v.9.1.1.1, September 2021. The completeness of the cradle-to-gate process chain in terms of process steps is rigorously assessed for the slag cement product systems and documented in the LCA background report.
Consistency	To ensure consistency, the facility specific LCI modeling for the slag cement production used the same LCI modeling structure, which consisted of input material and intermediate products, 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, slag cement product 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 *SCA_Athena LCI database* developed in SimaPro, 2021. A high level of transparency is provided throughout the LCA background report as the LCI profile is presented for each process as well as major upstream inputs. Key primary (manufacturer averaged) and secondary (generic) LCI data sources are similarly summarized in the LCA background report Annexes. External reproducibility is possible as a high level of transparency is provided throughout the project report.

Transparency	Activity and LCI datasets are transparently disclosed in the project report, including data source.
Uncertainty	A *sensitivity check* was conducted to assess the reliability of the EPD 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 both a *sensitivity and Monte Carlo analysis.*

Life Cycle Impact Assessment Results

This section summarizes the *production 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 are calculated based on 1 metric ton of slag cement type as manufactured and distributed by Slag Cement Association members. *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 [4], [5]. Further, a number of LCA 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 "*"* [2].

EPDs based on cradle-to-gate and cradle-to-gate with options information modules shall not be compared. Further, EPDs based on a declared unit shall not be used for comparisons [2]. Environmental declarations from different programs may not be comparable [7]. EPDs are comparable only if they comply with ISO 21930, use the same, sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works [3].

Production stage EPD Results for one metric ton of Slag Cement

Impact category and inventory indicators	Unit	A1, Extraction and upstream production	A2, Transport to factory	A3, Manufacturing	Total
Global warming potential, GWP 100[1)], AR5	kg CO_2 eq	1.8	62.7	82.6	**147.0**
Ozone depletion potential, ODP[2)]	kg CFC-11 eq	2.9E-07	1.4E-05	1.0E-05	**2.4E-05**
Smog formation potential, SFP[2)]	kg O_3 eq	0.19	33.1	4.28	**37.6**
Acidification potential, AP[2)]	kg SO_2 eq	8.7E-03	1.7	2.6E-01	**2.0**
Eutrophication potential, EP[2)]	kg N eq	2.9E-03	0.08	2.4E-01	**0.33**
Abiotic depletion potential for non-fossil mineral resources, ADP elements[3)]*	kg Sb eq	1.7E-06	2.4E-06	6.8E-05	**7.2E-05**

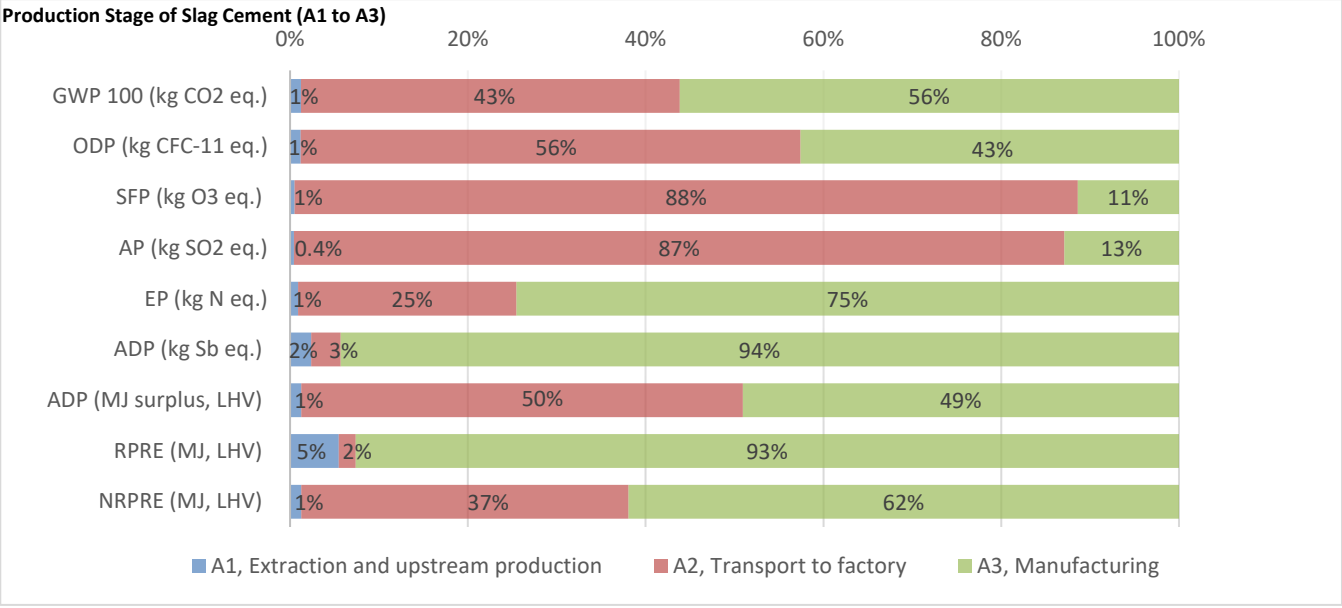
Abiotic depletion potential for fossil resources, ADP fossil[2)]	MJ surplus LHV	3.1	123.7	122.2	**249.0**
Renewable primary resources used as an energy carrier (fuel), RPR_E*	MJ LHV	3.0	1.0	50.6	**54.6**
Renewable primary resources with energy content used as material, RPR_M[4)]*	MJ LHV	0	0	0	**0**
Non-renewable primary resources used as an energy carrier (fuel), $NRPR_E$*	MJ LHV	28	815.4	1,371	**2,214**
Non-renewable primary resources with energy content used as material, $NRPR_M$[4)]*	MJ LHV	0	0	0	**0**
Secondary materials, SM[4)]*	kg	997.9	0	0.0	**997.9**
Renewable secondary fuels, RSF[4)]*	MJ LHV	0	0	0	**0**
Non-renewable secondary fuels, NRSF[4)]*	MJ LHV	0	0	0	**0**
Recovered energy, RE[4)]*	MJ LHV	0	0	0	**0**
Consumption of freshwater, FW[4)]	m^3	0.003	0	0.019	**0.023**
Hazardous waste disposed, HWD[4)]*	kg	2.9E-03	0	4.0E-04	**0.003**
Non-hazardous waste disposed, NHWD[4)]*	kg	3.0E-05	0	4.9E-02	**0.049**
High-level radioactive waste, conditioned, to final repository, HLRW[4)]*	m^3	6.9E-09	0	2.3E-07	**2.4E-07**
Intermediate- and low-level radioactive waste, conditioned, to final repository, ILLRW[4)]*	m^3	1.1E-07	0	2.8E-06	**7.4E-06**
Components for re-use, CRU[4)]*	kg	0	0	0	**0**
Materials for recycling, MR[4)]*	kg	0	0	0.15	**0.15**
Materials for energy recovery, MER[4)]*	kg	0	0	0	**0**
Recovered energy exported from the product system, EE[4)]*	MJ LHV	0	0	0	**0**
Additional Inventory Parameters for Transparency					
Emissions from calcination	kg CO_2 eq	0	0	0	**0**
Biogenic CO_2, reporting the removals and emissions associated with biogenic carbon content contained within biobased products	kg CO_2 eq	0	0	0	**0**

Table Notes:
[1)] Calculated as per U.S EPA TRACI v2.1, with IPCC 2013 (AR 5), SimaPro v 9.1.1.1 [10].
GWP 100, excludes biogenic CO_2 removals and emissions associated with biobased products; 100-year time horizon GWP factors are provided by the IPCC 2013 Fifth Assessment Report (AR5), TRACI v2.1 with AR5, v1.05 [10].
[2)] Calculated as per U.S EPA TRACI v2.1, SimaPro v 9.1.1.1 [10].
[3)] ADP elements is calculated as per CML-IA Baseline v3.05, SimaPro v 9.1.1.1 [10].
[4)] Calculated as per ACLCA ISO 21930 Guidance [11].

LCA Interpretation

Figure below provides a contribution analysis for the slag cement production stage results delineated by information module (in %).

- **A1** Extraction and upstream production accounts for 1% of the GWP, and is a minor contributor to the overall results (varying between 1% and 5%).
- **A2** Transport is a significant contributing activity. It is largely responsible for smog formation and acidification effects and a significant contributor to ozone depletion. Next to A3 Manufacturing, Transport is responsible for a significant use of non-renewable energy.
- **A3** Manufacturing generally contributes the largest share of the potential impact category results – excluding smog formation and acidification, module A3 accounts for between 43% and 94% across all indicators, including 56% of global warming potential and 62% of non-renewable fossil energy consumption.



Additional Environmental Information

Quality and Environmental Management Systems

In general, SCA member manufacturing facilities follow the ISO 14001 environmental management system, ISO 9001 quality management system or other in-house quality control systems.

Health Protection Manufacture

The OSHA standards are applicable and followed.
- U.S. Department of Labor, Occupational Safety & Health Administration (OSHA),
29 CFR, PART 1910 Occupational Safety and Health Standards.
(https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910)
No additional health protection measures extending beyond mandatory occupational safety measures for commercial operations are required.

Environmental Protection and Equipment

The SCA member manufacturing facilities comply with the regional (US and Canadian) environmental protection requirements, monitor and report the emissions to air during the manufacturing process as per the following:
- EPCRA Section 313 Toxic Release Inventory Reporting (U.S)
(http://www.ecy.wa.gov/epcra/section313.html)
- The Canadian National Pollutant Release Inventory (NPRI) reporting
(http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1)

Pollution abatement equipment typically used in the slag cement manufacturing facilities are as follows: fabric filter – high temperature (baghouse), fabric filter- low temperature (baghouse), bin vent filter, dry filter, cartridge filter, precipitator, and water sprinkler for dust control.

References

1. ASTM C989/ C989M, Standard Specification for Slag Cement for Use in Concrete and Mortars.
2. NSF International, Product Category Rules for Preparing an Environmental Product Declaration for Slag Cement, v2.0, December 2020.
3. ISO 21930:2017 Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services.
4. ISO 14040:2006/Amd 1:2020 Environmental management - Life cycle assessment - Principles and framework.
5. ISO 14044:2006/Amd1:2017/Amd2:2020 Environmental management - Life cycle assessment - Requirements and guidelines.
6. NSF International, Product Category Rule Environmental Product Declarations, PCR for Portland, Blended, Masonry, Mortar, and Plastic (Stucco) Cements, V3.1, September 2020.
7. ISO 14025:2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.
8. ISO 14021:2016 Environmental labels and declarations -- Self-declared environmental claims (Type II environmental labelling).

9. ASTM. (2020). General Program Instructions, Version: 8.0. ASTM Program Operator for Product Category Rules (PCR) and Environmental Product Declarations (EPDs).
10. PRé 2019.SimaPro LCA Software v9.1.1.1, June 2021. https://simapro.com/, accessed 06-2021.
11. 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 , accessed 06-2021.
12. LEED v4, Building Design and Construction Guide (BD+C), MR Credit: Building Product Disclosure and Optimization - Environmental Product Declarations, Option 2 Multi-attribute optimization (1 point). https://www.usgbc.org/node/2616376?return=/credits/new-construction/v4/material-%26amp%3B-resources, accessed 06-2021.
13. LEED v4.1 July 2019, Building Design and Construction Guide (BD+C), Getting started guide for beta participant, MR Credit: Building Product Disclosure and Optimization - Environmental Product Declarations, Option 2 Multi-attribute optimization (1 point), pg.170. https://new.usgbc.org/leed-v41, https://leeduser.buildinggreen.com/credit/NC-v4.1/MRc2#tab-credit-language, accessed 06-2021.
14. U.S. EPA, Emissions & Generation Resource Integrated Database (eGRID). https://www.epa.gov/egrid, accessed October 2020.