Pozzotive® Screening LCA – Pre-Production

Beacon Falls, CT Production Facility

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Abbreviations

The following abbreviations are used throughout the report:

A1	Raw Material supply module of product stage of an EPD
A2	Transportation module of product stage of an EPD
A3	Manufacturing module of product stage of an EPD
ACLCA	American Center for Life Cycle Assessment
$ADP_{elements}$	Abiotic Depletion Potential for non-fossil mineral resources
ADP_{fossil}	Abiotic Depletion Potential for fossil resources
AP	Acidification Potential
CED	Cumulative Energy Demand
CFC-11 e	Trichlorofluoromethane equivalence
CO_2 e	Carbon Dioxide equivalence
DQA	Data Quality Assessment
EP	Eutrophication Potential
EPD	Environmental Product Declaration
GWP	Global Warming Potential
ISO	International Organization for Standardization
Kg	Kilogram
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LHV	Lower Heating Value
m^3	Cubic Meter
MJ	Mega Joule
MRF	Municipal Recycling Facility
N e	Nitrogen equivalence
NCV	Net Caloric Value
NERC	North American Electricity Reliability Council
NPCC	Northeast Power Coordinating Council
$NRPR_E$	Non-renewable primary resources as energy (fuel)
$NRPR_M$	Non-renewable primary resources as material
NRSF	Non-renewable secondary fuels
nrE	Depletion of non-renewable energy resources
O_3 e	Ozone equivalence
ODP	Ozone Depletion Potential
PCR	Product Category Rule
POCP	Photochemical Ozone Creation Potential
RE	Recovered energy
RPR_E	Renewable primary energy resources as energy (fuel)
RPR_M	Renewable primary resources as material
RSF	Renewable secondary fuels
SM	Secondary Material
SO_2 e	Sulfur Dioxide equivalence
tkm	Tonne kilometer
TRACI	Tool for the Reduction and Assessment of Chemical and other environmental Impacts
WBCSD	World Business Council for Sustainable Development
WP	Windowpane

Executive Summary

Urban Mining Northeast (UMNE) is a licensed regional producer of Pozzotive®, a high performance postconsumer pozzolan and functional industrial filler. Using patented technology, UMNE is able to use any type of post-consumer glass, and turn it into a fine powder like substance, Pozzotive®. Pozzotive® is used in a multitude of applications including concrete products, paints, coatings, adhesives, polymers, elastomers and many others. The goal of this study is the quantify the GHG reduction potential of incorporating Pozzotive® into a concrete mix designs' environmental product declaration (EPD). This is the first phase of a three-part project which culminates with a product-specific, Type III Environmental Product Declaration (EPD) for Pozzotive® using 12 months of actual production data.

Uban Mining is nearing completion of a new production facility to manufacture Pozzotive® in Beacon Falls, CT. Utilizing engineering estimates of material, energy and waste flows, this study calculates twenty five environmental impacts that are required to be reported on concrete EPDs (see Table 3). The GWP impacts of one metric tonne of Pozzotive® is 56 kg CO_2e. This compares to the US industry average GWP for Portland cement of 1,040 kg CO_2e. Pozzotive® has 95% less impacts than the industry average Portland cement.

Utilizing these pre-production screening LCA results, this study also calculated the GWP of a concrete mix design produced by US Concrete/Eastern Concrete at their Broadway plant located in Jersey City, NJ. This analysis used the Climate Earth EPD Generator, part of the CarbonClarity suite of applications for the concrete materials industry, to calculate the mix's EPD values with Broadway's actual verified data. Results show a 42.2% reduction in GWP for the 9,000 PSI mix with a 56-day set that replaces 50% of the cement with Pozzotive®.

Two items to bear in mind as you utilize these results are:

- Most manufacture specific cement EPD's are less than the industry average. We are seeing GWP numbers around 800 kg CO_2e.
- The results of this study are based on engineering estimates of material, waste, and energy flows. Actual production flows will change the results.

While this study is intended for business-to-business (B-to-B) audiences evaluating the use of Pozzotive® in concrete mix designs, we have also included some additional study results to help Urban Mining understand the details of their GWP value. See Figure 3 and Tables 5-6. This information will help focus investments in equipment and processes to reduce your final EPD's GWP impacts.

Screening LCA

General Information

Commissioner of the LCA study: Urban Mining Northeast (https:// http://urbanminingne.com/about.htm)

External practitioner of the LCA study: Laurel McEwen, Climate Earth (laurel.mcewen@climateearth.com)

Date of report: May 11, 2020

Goal and scope definition

Goal

The goal of this life cycle assessment (LCA) study is to provide cradle to gate pre-production estimated impacts of a new ground glass pozzolan product, Pozzotive®, produced at a new production facility in Beacon Falls, CT. Utilizing these results, the GWP of five concrete mix designs will be calculated to determine the potential reduction in GWP when cement is replaced with Pozzotive®. This study is intended for business-to-business (B-to-B) audiences evaluating the use of Pozzotive® in concrete mix designs.

This is the first phase of a three-part project which culminates with a product-specific, Type III Environmental Product Declaration (EPD). Since the ultimate goal is to produce an EPD based on 12 months of production data this study considered the following standards: ISO 14040 (ISO 14040, 2006), 14044 (ISO 14044, 2006), 21930 (ISO 21930, 2017), PCR for Concrete (NSF International, 2019).

Scope

This study is cradle-to-gate.

Product system

The product system investigated by this study is Pozzotive® produced at:

105 Breault Rd, Beacon Falls, CT 06403

Pozzotive® meets the following specification: ASTM C1866/C1866M-20, Ground-Glass Pozzolan for Use in Concrete

Declared Unit

The declared unit used in this study is 1 metric tonne Pozzotive®.

System boundary

This study captures following life cycle product stages (as illustrated in Figure 1):

- **A1 – Raw Material Supply** (upstream processes): Extraction, handling, and processing of the materials (including fuels) used in the production of Pozzotive®.
- **A2 – Transportation:** Transportation of these materials from the supplier to the 'gate' of the Beacon Falls plant.
- **A3 – Manufacturing** (core processes): The energy used to operate the Beacon Falls plant.

PRODUCTION Stage (*Mandatory*)			CONSTRUCTION Stage		USE Stage					END-OF-LIFE Stage			
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction/ Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4

Figure 1: Life-cycle stages and modules

The main processes included in the system boundary are illustrated in Figure 2.

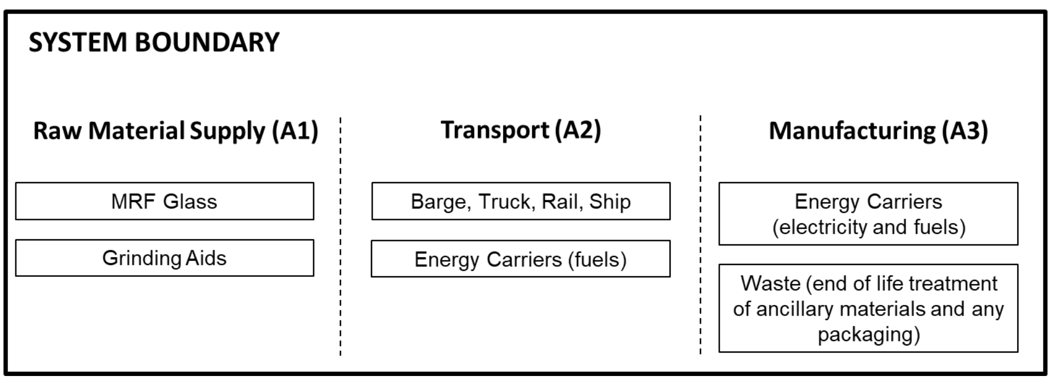

Figure 2: System Boundary for study

Electricity impacts are calculated based on North American Electricity Reliability Council (NERC) 2014 resource mix for the Northeast Power Coordinating Council (NPCC) region. The resource mix for NPCC region is: 38.5% Natural Gas, 15.3% Hydro, 3.6% Coal, 36.8% Nuclear, 2.7% Wind, 1.6% Wood Chips, 1.5% Oil with a GWP of 0.29 kg CO2e/kWh.

The following cradle-to-gate life cycle stages are excluded from the primary product stages:

1. Production, manufacture, and construction of manufacturing capital goods and infrastructure
2. Production and manufacture of production equipment, delivery vehicles and laboratory equipment
3. Personnel-related activities (travel, furniture, and office supplies)
4. Energy and water use related to company management and sales activities, which that may be located either within the factory site or at another location

Allocation procedure

This study follows the rules of ISO 14044, 2006 section 4.3.4, avoiding allocation wherever possible, and when allocation cannot be avoided, partitioning impacts based on physical causality. For recycled materials, allocation follows the "polluter pays principle"[1].

Cutoff criteria

All inputs and outputs to a unit process have been included in the calculation, for which data are available. Data gaps have been filled by conservative assumptions with average or generic data. Any assumptions for such choices have been documented. When data was not reasonably available, the following cutoff criteria were used:

- Mass | If a flow is less than 1% of the cumulative mass of the model flows, it may be excluded, provided its environmental relevance is minor.
- Energy | If a flow is less than 1% of the cumulative energy of the system model, it may be excluded, provided its environmental relevance is minor.
- Environmental relevance | Material and energy flows known or expected to have the potential to cause environmentally relevant emissions into air, water, or soil related to the environmental indicators of the PCR shall be included unless justification for exclusion is documented.
- The total of neglected input flows shall be a maximum of 5% of energy usage and mass.

Excluded flows in this study include: maintenance parts, ancillary materials such as oils, lubricants and greases consumed during the annual operation of the plant. It is assumed that these flows will be less than 1% of the cumulative mass of the model flows.

[1] The process of waste processing shall be assigned to the product system that generates the waste until the end-of-waste state is reached.

Impact categories and methodology

The life cycle impact categories used in this study replicate those required in the Concrete PCR (NSF International, 2019). Table 1 lists all indicators and Life Cycle Inventory (LCI) metrics along with the characterization models used.

Table 1. Category indicators, reported units, abbreviation, and characterization models used

Life Cycle Impact Assessment Indicator	Units	Characterization Models
Global warming potential (GWP)	kg CO_2 e	TRACI 2.1 V1.04 (EPA, 2016)
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	
Eutrophication potential (EP)	kg N e	
Acidification potential of soil and water sources (AP)	kg SO_2 e	
Formation potential of tropospheric ozone (POCP)	kg O_3 e	
Life Cycle Inventory Metrics	**Units**	
Resource Use		
Abiotic depletion potential for non-fossil mineral resources ($ADP_{elements}$)	kg Sb e	CML-IA baseline, 2013[2]
Abiotic depletion potential for fossil resources (ADP_{fossil})	MJ, NCV	CML-IA baseline, 2013
Renewable primary energy resources as energy (fuel), (RPR_E)*	MJ, NCV	CED (LHV) v1.0, 2019[3]
Renewable primary resources as material, (RPR_M)*	MJ, NCV	LCI
Non-renewable primary resources as energy (fuel), ($NRPR_E$)*	MJ, NCV	CED (LHV) v1.0, 2019[4]
Non-renewable primary resources as material ($NRPR_M$)*	MJ, NCV	LCI
Consumption of fresh water	m^3	ReCiPe Midpoint (H) v 1.12
Secondary Material, Fuel and Recovered Energy		
Secondary Materials, (SM)*	kg	LCI+
Renewable secondary fuels, (RSF)*	MJ, NCV	LCI+
Non-renewable secondary fuels (NRSF)*	MJ, NCV	LCI+
Recovered energy, (RE)*	MJ, NCV	LCI+
Waste & Output Flows		
Hazardous waste disposed*	kg	LCI
Non-hazardous waste disposed*	kg	LCI
High-level radioactive waste*	kg	LCI
Intermediate and low-level radioactive waste*	kg	LCI
Components for reuse*	kg	LCI+
Materials for recycling*	kg	LCI+
Materials for energy recovery*	kg	LCI+
Recovered energy exported from the product system*	MJ, NCV	LCI+
Additional Inventory Parameters for Transparency		
Emissions from calcination*	kg CO_2 e	WBCSD v3.0 (2011)[5]

* Calculated in accordance with ACLCA Guidance to calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017 (ACLCA, 2019)
+ Calculated from primary data on foreground manufacturing processes

[2] Clay, Bentonite, Limestone, Gravel, Silica, Sand added to model per Table A4 in the PCR for Concrete (NSF International, 2019)
[3] CED impact categories: renewable biomass, renewable wind, solar, geothermal, renewable water
[4] CED impact categories: non-renewable, fossil, non-renewable nuclear, non-renewable biomass
[5] https://www.cement-co2-protocol.org/en/Content/Resources/Downloads/WBCSD_CO2_Protocol_En.pdf

LCIA procedure

Impacts for each unit process are calculated within SimaPro v9.0.0.41 (PRé Sustainability, 2018).

Data sources

Life cycle inventory (LCI) data used to conduct this study are the best available. Where company or supplier-specific LCI data could not be found representative processes were selected from the ecoinvent 3.5 allocation, cut-off by classification database (ecoinvent, 2018) or the USLCI database (National Renewable Energy Laboratoy, 2015).

Assumptions

LCA studies are typically based on a set of core assumptions that facilitate the modeling of the studied systems. The following assumption was made in this study:

- Municipal recycling facility (MRF) glass waste contains a blend of crushed glass along with other waste (paper, plastic, metals, organics). This study assumes a product yield of 86% from the raw feed.
- The moisture content of the MRF glass can vary from 2-10%. This study assumes a 5% moisture content.

Data quality

The quality of LCI data used in this study is evaluated based on the following characteristics:

- **Technological representativeness (technology)**: the degree to which the data reflects the actual technology(ies) used.
- **Temporal representativeness (time)**: the degree to which the information collected reflects the actual time of the study. Foreground data shall be the average of twelve consecutive months during the last five years. Background data should not be older than ten years.
- **Geographical representativeness (geography)**: the degree to which the data reflects the actual geographic location of the activity. The geographic region of the relevant life-cycle stages included in the calculation of data should be documented.
- **Completeness**: the degree to which the data are statistically representative of the relevant activity and obtained over an adequate period of time to even out normal fluctuations.
- **Reliability**: the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable

Data quality is rated *"very good"*, *"good"*, *"fair"*, or *"poor"* for characteristics of each process.

Treatment of missing data

The following lists the missing data and their treatment:

- Grinding Media – no data was available for the ceramic grinding media. Ceramic tile making process was used as a conservative placeholder.

Life Cycle Inventory

LCI Unit processes

A complete list secondary data, its source and data quality assessment (DQA) is provided in Table 2.

Table 2: Secondary data sources and data quality assessment (DQA)

Unit process name	LCI data source	Data Quality Assessment
Electricity (kWh)	ecoinvent 3.5: "Electricity, medium voltage {NPCC, US only}| market for | Cut-off, U"	**technology:** very *good* – Average technology used to produce, transmit and distribute electricity. **time:** *very good* – Data from 2014, less than ten years. **geography:** very *good* – Process describes the regional electrical grid available in the ten regional entities of the North American Electric Reliability Corporation (NERC). **completeness:** *very good* – Dataset includes electricity inputs produced and imported, transformation to medium voltage, the transmission network, direct emissions to air, electricity losses during transmission. **reliability:** *good* – Verified data partially made on assumptions.
MRF Glass	n/a – recovered material	
Grinding Media (lb)	ecoinvent 3.5: Ceramic tile {RoW}| production | Cut-off, U	Proxy Data
Propane (gal)	USLCI processes: "Liquefied petroleum gas, combusted in industrial boiler NREL/US U"	**technology:** *good* – Process represents combustion of propane in boiler. **time:** *poor* – Data is from 2008, greater than ten years **geography:** *very good - Process is from USLCI database.* **completeness:** *good* – process includes production of LPG at refinery, transportation, and combustion. **reliability:** *fair* – USLCI database has not undergone a formal validation process.
Road Transport (lbmi)	USLCI processes: "Transport, combination truck, long-haul, diesel powered/tkm/RNA" "Transport, refuse truck, diesel powered, Northeast region/tkm/RNA"	**technology:** *good* – Process represents transportation of goods in a single-unit and combination trucks. **time:** *good* – Data is from 2010, ten years **geography:** *very good* - Process is from USLCI database. **completeness:** *good* – Process includes combustion of diesel and empty backhaul. **reliability:** *fair* – USLCI database has not undergone a formal validation process.
Solid Waste to Incinerator (lb)	Ecoinvent 3.5: custom process made up of: "Disposal, plastics, mixture, 0% water, to municipal incineration/US* US-EI U" "Disposal, paper, 0% water, to municipal incineration/US* US-EI U" "Disposal, aluminium, 0% water, to municipal incineration/US* US-EI U" "Disposal, municipal solid waste, 0% water, to municipal incineration/US* US-EI U" "Disposal, steel, 0% water, to municipal incineration/US* US-EI U"	**technology:** very *good* – Average Swiss MSWI plants with electrostatic precipitator for fly ash, wet flue gas scrubber. Well applicable to modern incineration practices in Europe, North America or Japan. **time:** *poor*– Data is from 2003, greater than ten years. **geography:** *fair* – European **completeness:** very *good* – process includes waste-specific air and water emissions from incineration, auxiliary material consumption for flue gas cleaning. Short-term emissions to river water and long-term emissions to ground water from slag compartment (from bottom slag) and residual material landfill (from solidified fly ashes and scrubber sludge). Process energy demands for MSWI. **reliability:** *good* – Verified data partially made on assumptions.

Primary Data Collection

Data collection

Primary plant data consists of engineering estimated data[6] provided by Dale Hauke, Project Executive, Urban Mining CT LLC.

Allocations

Several allocations were made in this study:

- Delta's manufacturing (A3) impacts are allocated based on annual volume of Pozzotive® produced
- Transportation is allocated based on the mass of the transported material.
- The following recovered materials where used in this study: MRF Glass.

[6] See file Beacon Falls Energy and Waste Estimates 20200506.xlsx

Impact Assessment

Results for Pozzotive®

The GWP impacts for a metric tonne of Pozzotive® is 56 kg CO_2e. This compares to the US industry average GWP for Portland cement of 1,040 kg CO_2e.

Table 3: Pozzotive® cradle to gate impacts (per 1 metric tonne)

Impact Assessment	Unit	A1	A2	A3	TOTAL
Global warming potential (GWP)	kg CO_2 e	0.33	0.12	55.4	**55.9**
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	3.24E-08	4.92E-12	1.09E-05	**1.09E-05**
Eutrophication potential (EP)	kg N e	9.80E-04	9.28E-05	8.96E-02	**9.07E-02**
Acidification potential of soil and water sources (AP)	kg SO2 e	1.35E-03	1.54E-03	0.20	**0.20**
Formation potential of tropospheric ozone (POCP)	kg O_3 e	1.56E-02	3.96E-02	1.73	**1.78**
Resource Use					
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb e	2.15E-05	0.00	3.40E-06	**2.49E-05**
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	4.15	1.67	764	**770**
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ, NCV	0.23	0.00	151	**151**
Renewable primary resources as material, (RPRM)*	MJ, NCV	0.00	0.00	0.00	**0.00**
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	4.49	1.67	1,570	**1,576**
Non-renewable primary resources as material (NRPRM)*	MJ, NCV	0.00	0.00	0.00	**0.00**
Consumption of fresh water	m3	0.00	0.00	0.93	**0.93**
Secondary Material, Fuel and Recovered Energy					
Secondary Materials, (SM)*	kg	-	-	1,160	**1,160**
Renewable secondary fuels, (RSF)*	MJ, NCV	-	-	-	**-**
Non-renewable secondary fuels (NRSF)*	MJ, NCV	-	-	-	**-**
Recovered energy, (RE)*	MJ, NCV	-	-	-	**-**
Waste & Output Flows					
Hazardous waste disposed*	kg	0.00	0.00	0.00	**0.00**
Non-hazardous waste disposed*	kg	0.00	0.00	0.11	**0.11**
High-level radioactive waste*	kg	2.63E-10	0.00E+00	1.01E-06	**1.01E-06**
Intermediate and low-level radioactive waste*	kg	2.82E-09	0.00E+00	3.55E-06	**3.55E-06**
Components for reuse*	kg	-	-	0.00	**-**
Materials for recycling*	kg	-	-	0.00	**-**
Materials for energy recovery*	kg	-	-	0.11	**0.11**
Recovered energy exported from the product system*	MJ, NCV	-	-	0.00	**-**
Additional Inventory Parameters for Transparency					
Emissions from calcination and uptake from carbonation*	kg CO_2 e	0.00	0.00	0.00	**0.00**

* Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.
- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories.

The majority of Pozzotive's® impacts come from the A3 life cycle stage. Electricity from the grinding operation is the primary source of global warming potential (GWP) impacts for this stage.

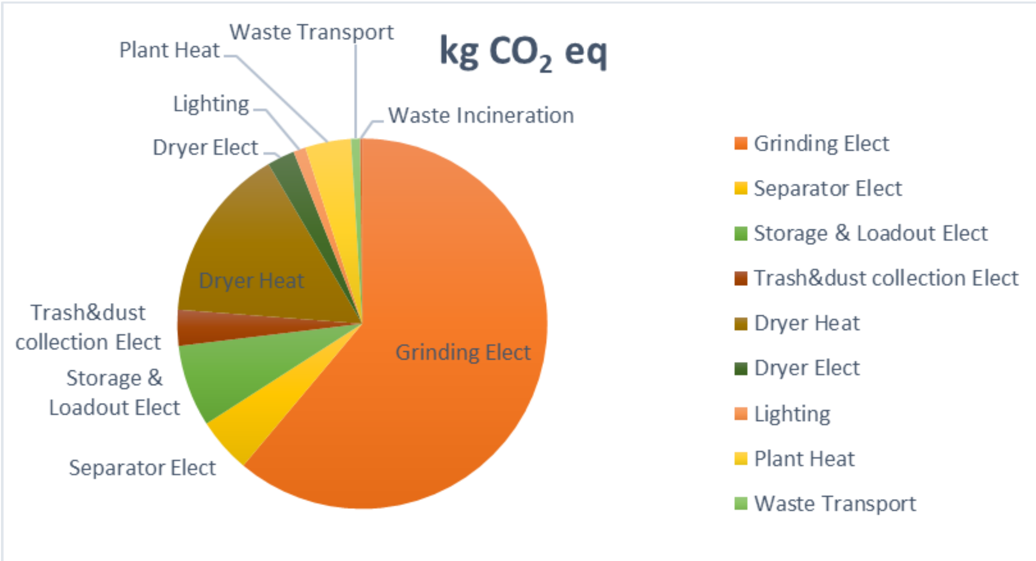

Figure 3: Percent contribution of A3 plant processes to the GWP

Results for US Concrete/Eastern Concrete mix design replacing cement with Pozzotive®

Table 4 shows a 42.2% reduction in GWP for a 9,000 PSI mix with a 56 day set that replaces 50% of the cement with Pozzotive®. This analysis includes A1-A3 concrete impacts for a mix produced at US Concrete/Eastern Concrete's Broadway Plant located in Jersey City, NJ.

Table 4: Cradle to Gate (A1-A3) GWP (kg CO2e) per cubic yard of a US Concrete/Eastern Concrete mix design with and without Pozzotive®

Mix Design/cyd			
material	**quantity**	**w/out Pozzotive**	**with Pozzotive®**
Type I/II Cement	lb	850	425
Pozzotive	lb	0	425
Sand	lb	1,150	1,150
Stone 1	lb	1,000	1,000
Stone 2	lb	700	700
Water	gal	34.7	34.7
Admix1	fl.oz	46.8	46.8
Admix2	fl.oz	17	17
Admix3	fl.oz	25.5	25.5
Global Warming Potential (kg CO_2 eq/m3)		625	361

The total reduction for mixes produced at the Broadway Plant includes both the A1 reduction from replacing cement with Pozzotive® **plus** the change in A2 impacts due to the change in shipping distances of cement and Pozzotive®.

Sensitivities

To moisture content of MRF Glass

The moisture content of the MRF glass can vary from 2-10%. This study assumes a 5% moisture content. GWP results can vary from 54-59 kg CO_2e/tonne depending on the moisture content.

Table 5: Sensitivity of Pozzotive® cradle to gate impacts (per 1 metric tonne) to moisture content of MRF glass

Impact Assessment	Unit	2% moisture	5% moisture	10% moisture
Global warming potential (GWP)	kg CO_2 e	54.0	55.9	58.9
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 e	1.09E-05	1.09E-05	1.09E-05
Eutrophication potential (EP)	kg N e	9.02E-02	9.07E-02	9.16E-02
Acidification potential of soil and water sources (AP)	kg SO2 e	0.20	0.20	0.20
Formation potential of tropospheric ozone (POCP)	kg O_3 e	1.73	1.78	1.86
Resource Use				
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	kg Sb e	2.49E-05	2.49E-05	2.49E-05
Abiotic depletion potential for fossil resources (ADPfossil)	MJ, NCV	746	770	810
Renewable primary energy resources as energy (fuel), (RPRE)*	MJ, NCV	151	151	151
Renewable primary resources as material, (RPRM)*	MJ, NCV	0.00	0.00	0.00
Non-renewable primary resources as energy (fuel), (NRPRE)*	MJ, NCV	1,552	1,576	1,617
Non-renewable primary resources as material (NRPRM)*	MJ, NCV	0.00	0.00	0.00
Consumption of fresh water	m3	1.26	0.93	0.38
Secondary Material, Fuel and Recovered Energy				
Secondary Materials, (SM)*	kg	1,160	1,160	1,160
Renewable secondary fuels, (RSF)*	MJ, NCV	-	-	-
Non-renewable secondary fuels (NRSF)*	MJ, NCV	-	-	-
Recovered energy, (RE)*	MJ, NCV	-	-	-
Waste & Output Flows				
Hazardous waste disposed*	kg	0.00	0.00	0.00
Non-hazardous waste disposed*	kg	0.15	0.11	0.05
High-level radioactive waste*	kg	1.01E-06	1.01E-06	1.01E-06
Intermediate and low-level radioactive waste*	kg	3.55E-06	3.55E-06	3.55E-06
Components for reuse*	kg	-	-	-
Materials for recycling*	kg	-	-	-
Materials for energy recovery*	kg	0.15	0.11	0.05
Recovered energy exported from the product system*	MJ, NCV	-	-	-
Additional Inventory Parameters for Transparency				
Emissions from calcination and uptake from carbonation*	kg CO_2 e	0.00	0.00	0.00

* Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude - Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories. international acceptance pending further development. Use caution when interpreting data in these categories.
- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories.

To raw feed

Pozzotive® can be made with waste windowpane (WP) glass. Compared to MRF glass, WP glass has 0.1% moisture (eliminating the need to dry the waste) and only 1.5% waste resulting in a higher product yield of 98%. When WP glass is used as the raw feed GWP results drop to 46 $kgCO_2e$/tonne.

Table 6: Sensitivity of Pozzotive® cradle to gate impacts (per 1 metric tonne) to raw feed

Impact Assessment	MRF Glass	WP Glass
Global warming potential (GWP)	55.9	45.9
Depletion potential of the stratospheric ozone layer (ODP)	1.09E-05	9.40E-06
Eutrophication potential (EP)	9.07E-02	7.72E-02
Acidification potential of soil and water sources (AP)	0.20	0.17
Formation potential of tropospheric ozone (POCP)	1.78	1.48
Resource Use		
Abiotic depletion potential for non-fossil mineral resources (ADPelements)*	2.49E-05	2.44E-05
Abiotic depletion potential for fossil resources (ADPfossil)	770	635
Renewable primary energy resources as energy (fuel), (RPRE)*	151	129
Renewable primary resources as material, (RPRM)*	0.00	0.00
Non-renewable primary resources as energy (fuel), (NRPRE)*	1,576	1,325
Non-renewable primary resources as material (NRPRM)*	0.00	0.00
Consumption of fresh water	0.93	1.35
Secondary Material, Fuel and Recovered Energy		
Secondary Materials, (SM)*	1,160	1,017
Renewable secondary fuels, (RSF)*	-	-
Non-renewable secondary fuels (NRSF)*	-	-
Recovered energy, (RE)*	-	-
Waste & Output Flows		
Hazardous waste disposed*	0.00	0.00
Non-hazardous waste disposed*	0.11	0.02
High-level radioactive waste*	1.01E-06	8.61E-07
Intermediate and low-level radioactive waste*	3.55E-06	3.04E-06
Components for reuse*	-	-
Materials for recycling*	-	-
Materials for energy recovery*	0.11	0.02
Recovered energy exported from the product system*	-	-
Additional Inventory Parameters for Transparency		
Emissions from calcination and uptake from carbonation*	0.00	0.00

* Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.
- Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete. Use caution when interpreting data in these categories.

Limitations of the results

Life cycle impact assessment (LCIA) results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

The results of this study are based on engineering estimates of material, waste, and energy flows. Actual production flows will change the results.

Several LCI data sources are older than ten years, as indicated in the data quality assessment in Table 2. These datasets, rated “poor” for temporal representativeness, were chosen due to lack of alternatives. More current data could change the results of the study.

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

- renewable primary energy resources as energy (fuel), (RPRE)
- renewable primary resources as material, (RPRM)
- nonrenewable primary resources as energy (fuel), (NRPRE)
- nonrenewable primary resources as material (NRPRM)
- secondary materials (SM)
- renewable secondary fuels (RSF)
- nonrenewable secondary fuels (NRSF)
- recovered energy (RE)
- abiotic depletion potential for non-fossil mineral resources (ADPelements)
- hazardous waste disposed
- nonhazardous waste disposed
- high-level radioactive waste
- intermediate and low-level radioactive waste
- components for reuse
- materials for recycling
- materials for energy recovery; and
- recovered energy exported from the product system.

References

ACLCA. (2019). *ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017.*

ecoinvent. (2018). *The ecoinvent Database v.3.5.* Zurich, Switzerland: The Swiss centre for Life Cycle Inventories.

EPA. (2016). *Tool for the Reduction of Assessment of Chemical and Other Environmental Impacts (TRACI).*

ISO 14040. (2006). *ISO 14040; Environmental Management - Life Cycle Assessment - Principles and Framework.*

ISO 14044. (2006). *Environmental management - Life cycle assessment - Requirements and guidelines.*

ISO 21930. (2017). *ISO 21930; Sustainability in Building Construction - Environmental Declaration of Building Products.*

National Renewable Energy Laboratoy. (2015). *U.S. Life-Cycle Inventory (LCI) database.*

NSF International. (2019). *PCR for Concrete.*

PRé Sustainability. (2018). *SimaPro Vers. 9.0.0.41.* www.pre-sustainability.com/simapro.