ENVIRONMENTAL PRODUCT DECLARATION

Vitro Architectural Glass Flat Glass Products

This EPD was not written to support comparative assertions. Even for similar products, differences in declared unit, use and end-of-life stage assumptions and data quality may produce incomparable results. It is not recommended to compare EPDs with another organization, as there may be differences in methodology, assumptions, allocation methods, data quality such as variability in data sets and results of variability in assessment software tools used.

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Declaration Number:
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Program Operator: ASTM International
Company: Vitro Architectural Glass

ASTM INTERNATIONAL
www.astm.org

Architectural Glass
www.VitroGlazings.com

PCR Reference: NSF GANA *Product Category Rule (PCR) for Flat Glass - UNCPC 3711*
PCR review was conducted by: Jack Geibig (Chair), Ecoform, ncss@nsf.org
Declared Unit: 1 metric tonne of flat glass maintained for a 30-year reference service life (RSL)

Declaration Information

Product Information

Product Name: Vitro Architectural Flat Glass

Product Definition: Vitro manufactures flat glass at Carlisle, Pennsylvania; Wichita Falls, Texas; and Fresno, California.

This Environmental Product Declaration is valid for the following uncoated Vitro Glass products:

- Clear glass
- ***Starphire***® low-iron glass
- ***Acuity***™ low-iron glass
- ***Solarphire***® glass
- ***Atlantica***® glass (tinted)
- ***Azuria***® glass (tinted)
- ***Graylite***® ***II*** glass (tinted)
- ***Optiblue***® glass (tinted)
- ***Optigray***® glass (tinted)
- ***Pacifica***® glass (tinted)
- ***Solarblue***® glass (tinted)
- ***Solarbronze***® glass (tinted)
- ***Solargray***® glass (tinted)
- ***Solexia***® glass (tinted)

Declaration Type: Business-to-business

Period of Validity: This declaration is valid for a period of five years from the date of publication.

Geographic Scope: This declaration is valid for Vitro Glass products sold worldwide.

Product Application and/or Characteristics

This declaration is valid for all Vitro Glass clear, low-iron and uncoated tinted glass products that have been manufactured and/or delivered to customers in their unfinished, unprocessed, annealed state. This declaration does not apply to Vitro Glass products that have been coated or heat-treated or that have undergone other forms of secondary processing.

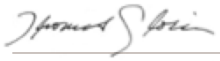
Annealed Vitro Glass products are intended primarily for interior and exterior applications for commercial and residential building projects, but may also be specified for a limited range of industrial applications, including solar power collection and others. Optical, thermal and mechanical properties for all products are available at VitroGlazings.com or by calling 855-VTRO-GLS (887-6457).

Content of the Declaration

- Product definition and physical building-related data
- Details of raw materials and material origin
- Description of how the product is manufactured
- Data on usage condition, unusual effects and end-of-life phase
- Life Cycle Assessment (LCA) results

Verification

This LCA was independently verified in accordance with ISO 21930, ISO 14025, and the reference PCR by:

Name	Date
	7/25/17

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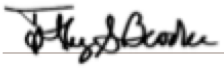
This declaration was independently verified in accordance with ISO 14025 and the reference PCR by:

Name	Date
	7/25/17

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EPD Summary

This document is a Type III environmental product declaration by Vitro Architectural Glass that is certified by ASTM International (ASTM) as conforming to the requirements of ISO 14025. ASTM has determined that the LCA information fulfills the requirements of ISO 14044 in accordance with the instructions listed in the referenced product category rules (PCR). The intent of this document is to further the development of environmentally compatible and sustainable construction methods by providing comprehensive environmental information related to potential impacts in accordance with international standards.

This EPD was not written to support any comparative assertions. Even for similar products, differences in declared unit, use and end-of-life assumptions, and data quality may produce incomparable results. It is not recommended to compare EPDs with another organization, as there may be differences in assumptions, methodology, allocation methods, and data quality such as variability in datasets and results of variability in assessment software tools.

Scope and Boundaries of the Life Cycle Assessment

The LCA was performed according to ISO 14040 following the requirements of the ASTM EPD Program Instructions and referenced PCR.

System Boundary: Cradle-to-gate
Allocation Method: Cut-off approach
Declared Unit: 1 metric tonne of flat glass maintained for a 30-year reference service life (RSL)

Life Cycle Assessment Results (TRACI 2.1) Vitro Architectural Flat Glass

EVALUATION VARIABLE	UNIT PER METRIC TONNE	TOTAL	RAW MATERIALS	PRODUCTION
Primary Energy, non-renewable	MJ	**19,600**	4,870	14,800
Primary Energy, renewable	MJ	**695**	227	468
Global Warming Potential	kg CO_2 eq.	**1,370**	350	1,020
Ozone Depletion Potential	kg CFC-11 eq.	**1.10E-07**	2.96E-08	8.06E-08
Acidification Potential	kg SO_2 eq.	**8.02**	0.909	7.11
Eutrophication Potential	kg N eq.	**0.461**	0.0501	0.411
Smog Formation Potential	kg O_3 eq.	**212**	16.6	195
Mineral Resource Depletion Potential (ReCiPe 1.08)	kg Fe eq.	**12.3**	6.23	6.09

Additional Information

To achieve its goal of being an environmentally responsible company, Vitro Glass has re-engineered manufacturing processes at its glass plants to minimize energy production, improve air and water quality, and cut waste.

For example, Vitro Glass's Wichita Falls, Texas plant recently was cited as a national model for water reclamation and recycling, due to a $1.9 million project that diverts treated non-potable wastewater from the city's wastewater treatment facility to Vitro Glass's seven glass-cooling towers. The project, which was implemented during extreme drought conditions in 2014 and 2015, has reduced potable water consumption at the glass plant by more than 50 million gallons per year since 2014 (Source: Water Environment & Reuse Foundation, Final Report, Feb. 2017).

Vitro Glass also was the first U.S. glass manufacturer to have its products recognized by the *Cradle to Cradle Certified*™ Products Program and has maintained that certification ever since. To meet the *Cradle to Cradle Certified* Product Standard, Vitro Glass has undergone a thorough audit of the materials used in the formulation and production of its glass products, the processes used to manufacture them, and the company's commitment to a Global Code of Ethics. The certification was awarded based on the following five criteria: *Material Health*, *Material Reutilizatio*n, *Renewable Energy & Carbon Management*, *Water Stewardship* and *Social Fairness*.

Vitro Glass equips its glass-making plants with extensive systems to recover and store discarded (or scrap) glass known as cullet, a valuable feedstock that reduces procurement of virgin materials and the amount of energy consumed during the glass-melting process. Greater than 99 percent of the unused glass the company manufactures is reutilized in production.

Vitro Glass ships many of its glass products on reusable steel racks, which has reduced the amount of disposal packaging that accompanies them by 65 percent.

1. Product

1.1 Description of Company

Vitro Architectural Glass (Vitro Glass) is a leading glass manufacturer with an extensive portfolio of flat and processed glass products engineered for commercial and residential buildings, and industrial applications. The company operates manufacturing facilities in Carlisle, Pennsylvania; Wichita Falls, Texas; Salem, Oregon; and Fresno, California. Flat glass is produced exclusively at the Carlisle, Wichita Falls and Fresno facilities.

1.2 Product Under Study

The declared products submitted for evaluation are uncoated and unprocessed flat glass products, as defined by NSF GANA *Product Category Rule (PCR) for Flat Glass - UNCPC 3711*, manufactured by Vitro Architectural Glass. Flat glass is a clear, sheet glass produced from soda-lime silicates, along with metal-oxide materials that are used in the creation of tinted glasses. The products are commonly used for windows, glass doors and walls. The declared glass products are available in a range of thicknesses and treatment options. While designed for a wide range of commercial, institutional and residential building applications, the thicknesses selected for this declaration are representative primarily of commercial building applications.

Colored or tinted glasses are primarily the same composition as clear glass with minor adjustments to account for the addition of colorants. All batch materials and the associated energy to produce a product with them have been accounted for in this declaration.

This declaration covers a range of float glass products manufactured by Vitro Glass:

- Clear glass
- ***Starphire***® glass
- ***Acuity***™ low-iron glass
- ***Solarphire***® glass
- ***Atlantica***® glass
- ***Azuria***® glass
- ***Graylite***® ***II*** glass
- ***Optiblue***® glass
- ***Optigray***® glass
- ***Pacifica***® glass
- ***Solarblue***® glass
- ***Solarbronze***® glass
- ***Solargray***® glass
- ***Solexia***® glass

The following life cycle stages are evaluated:

- **Material Extraction and Pre-Processing** — Covers raw material extraction and processing, along with inbound transport of materials to glass production facility.
- **Production** — Relates to the manufacture of glass from primary materials, as well as materials used in packaging. This stage ends when the final glass product exits the production line and is stored onsite.
- **Packaging and Storage** — Addresses onsite storage of glass products before they leave the facility to be delivered to the end-user or fabricator. This life cycle stage is not associated with any potential environmental impacts.

1.3 Product Use and Application

Vitro Glass products are intended primarily for interior and exterior applications for commercial and residential building projects. They typically are processed into coated, heat-treated or laminated glass products and/or assembled into multi-pane insulating glass units (IGUs) specified by architects, glazing contractors and other building professionals for finished homes and buildings. Flat glass products also may be used for a limited range of industrial applications, including solar power collection and others.

The product-use life cited for this declaration is defined as 30 years per NSF GANA *Product Category Rule (PCR) for Flat Glass - UNCPC 3711*.

1.4 Technical Data

Optical, thermal and mechanical properties for all Vitro Glass products are available at www.VitroGlazings.com or by calling 855-VTRO-GLS (887-6457).

1.5 Placing on the Market

The products considered in this EPD conform to the following technical specifications for float glass products (dependent on location):

- *ASTM C 1036: Standard Specification for Flat Glass*; and/or
- *EN 572: Glass in Building. Basic soda-lime silicate glass products. Float glas*s; and/or
- *Malaysia – MS 1135: Specification for Float Glass and Polished Plate*

Vitro Architectural Glass is certified to ISO 9001:Quality Management System.

1.6 Properties of Declared Product as Delivered

Vitro Glass products are sold according to the dimensions specified by the user. In the case of pre-cut glass, products are sold in packs in these common dimensions:

- 1.80 m x 2.13 m (72” x 84”)
- 1.83 m x 2.44 m (72” x 96”)
- 2.44 m x 3.30 m (96” x 130”)
- 3.30 m x 5.18 m (130” x 204”)

1.7 Base and Ancillary Materials

Float glass is primarily made from a blend of silica, soda ash, dolomite, metal compounds and recycled cullet glass. Table 1 shows the production-weighted average composition of float glass manufactured by Vitro Glass.

Table 1: Material composition of float glass

MATERIAL	MASS [%]	RENEWABLE	NON-RENEWABLE	RECYCLED
Silica sand	59.8		x	
Naturally mined soda ash	18.1		x	
Dolomite	13.7		x	
Limestone	6.3		x	
Caustic soda	1.2		x	
Sodium sulfate	0.6		x	
Metal compounds	0.2		x	
Carbocite #1	<0.1		x	
Sodium nitrate	<0.1		x	

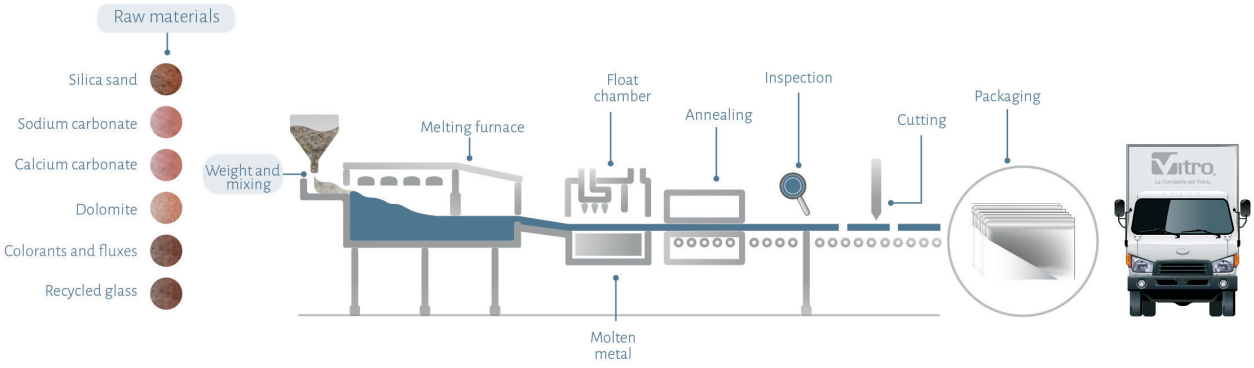
Starphire® glass and tinted glasses are similar in composition to clear glass, but may include adjustments to trace elements for melting and coloring purposes.

1.8 Flat Glass Manufacturing

The manufacturing process described in this declaration includes facility inputs and outputs for manufacturing 1 metric tonne of float glass and includes inbound transport of packaging.

The glass manufacturing process begins when raw materials, including sand, soda ash, limestone, dolomite and other minor ingredients, arrive at a Vitro Glass manufacturing facility. As materials are batched and fed into the furnace, they react to form a ribbon of liquid glass. The glass ribbon flows through the furnace into a float bath canal where the material begins to harden atop a bath of liquid tin. Stretch machines, located at the hot end of the float bath, alter the thickness and width of the glass as it moves toward the exit of the furnace. Cooling to about 866 K (1,100 degrees F), the glass is lifted out of the liquid tin and on to conveyor rolls, then fed into an annealing lehr. The lehr cools the glass at a controlled rate to achieve proper stresses for easy and accurate cutting. As the glass exits the lehr, is it cooled to room temperature by open air fans and inspected for flaws prior to cutting.

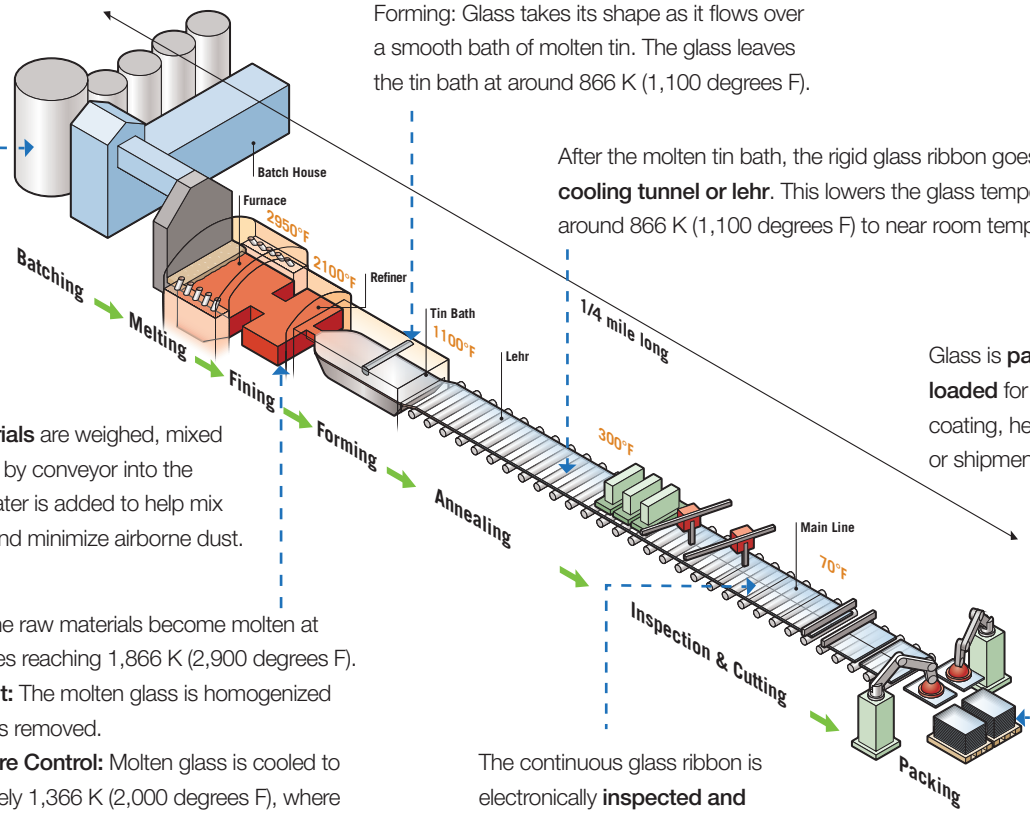
Flat Glass Production Process



Flat Glass Process

Forming: Glass takes its shape as it flows over a smooth bath of molten tin. The glass leaves the tin bath at around 866 K (1,100 degrees F).

After the molten tin bath, the rigid glass ribbon goes through the **cooling tunnel or lehr**. This lowers the glass temperature from around 866 K (1,100 degrees F) to near room temperature.



Glass is **packed and loaded** for off-line coating, heat-treating or shipment.

Raw materials are weighed, mixed and moved by conveyor into the furnace. Water is added to help mix the batch and minimize airborne dust.

Melting: The raw materials become molten at temperatures reaching 1,866 K (2,900 degrees F).
Refinement: The molten glass is homogenized and bubbles removed.
Temperature Control: Molten glass is cooled to approximately 1,366 K (2,000 degrees F), where the viscosity is ready for the tin float bath.

The continuous glass ribbon is electronically **inspected and cut** to the appropriate size.

Vitro Architectural Glass is certified to ISO 9001:Quality Management System.

1.9 Environment and Health during Manufacturing

Vitro Glass was the first U.S. glass manufacturer to have its products recognized by the *Cradle to Cradle Certified*™ Products Program and has maintained that certification ever since. To meet the *Cradle to Cradle Certified* Product Standard, Vitro Glass has undergone a thorough audit of the materials used in the formulation and production of its glass products, the processes used to manufacture them and the company's commitment to a Global Code of Ethics. The certification was awarded based on the following five criteria: *Material Health*, *Material Reutilization*, *Renewable Energy & Carbon Management*, *Water Stewardship* and *Social Fairness*.

Pre-Consumer Recycling

Vitro Glass equips its glass-making plants with extensive systems to recover and store discarded (or scrap) glass known as cullet, a valuable feedstock that reduces procurement of virgin materials and the amount of energy consumed during the glass-melting process. Greater than 99 percent of the unused glass Vitro Glass manufactures is reutilized in production.

Packaging

Vitro Glass ships many of its glass products on reusable steel racks, which has reduced the amount of disposal packaging that accompanies them by 65 percent.

Water Conservation

Vitro Glass's Wichita Falls, Texas plant was cited as a national model for water reclamation and recycling due to a $1.9 million project that diverts treated non-potable wastewater from the city's wastewater treatment facility to Vitro Glass's seven glass-cooling towers. The project, which was implemented during extreme drought conditions in 2014 and 2015, has reduced potable water consumption at the glass plant by more than 50 million gallons per year since 2014. (Source: Water Environment & Reuse Foundation, Final Report, Feb. 2017).

1.10 Product Processing/Installation

Vitro Architectural Glass should be installed according to industry standards and according to all applicable building codes in the given jurisdiction.

1.11 Packaging

Glass products are packaged on reusable steel racks and stretch-wrapped for delivery. Vitro Glass requests that customers return steel racks for reuse and encourages proper disposal/recycling of stretch wrap in accordance with local guidelines.

1.12 Condition of Use

Vitro Glass products are intended primarily for interior and exterior applications for commercial and residential building projects. They are typically processed into coated, heat-treated or laminated glass products and/or assembled into multi-pane IGUs specified by architects, glazing contractors and other building professionals for finished buildings. Flat glass products also may be used for a limited range of industrial applications, including solar power collection and others.

1.13 Environment of Health during Use

The system boundaries for the analysis encompass a "cradle-to-gate" scope. Environmental impacts of product in use phase are excluded from this declaration, per NSF GANA *Product Category Rule (PCR) for Flat Glass - UNCPC 3711*.

1.14 Extraordinary Effects

To meet the *Cradle to Cradle Certified* Product Standard, Vitro Glass has undergone a thorough audit of the materials used in the formulation and production of its glass products, the processes used to manufacture them and the company's commitment to a Global Code of Ethics. The certification was awarded based on the following five criteria: *Material Health*, *Material Reutilizatio*n, *Renewable Energy & Carbon Management*, *Water Stewardship* and *Social Fairness*.

1.15 Re-use Phase

Vitro Glass products offer multiple options for reuse and repurposing after deconstruction, including use as an aggregate in concrete and asphalt applications. When finely ground, recycled float glass also can be used as a partial replacement for cement in concrete.

Broken glass (cullet) also is a valuable feedstock in the production of glass, as it greatly reduces demand for virgin materials. The use of cullet also reduces the melting temperature for batch materials, which further diminishes energy consumption.

Glass is considered a technical nutrient and is heavily recycled. The Glass Association of North America (GANA) has produced an informational bulletin titled "Recyclability of Architectural Glass Products" (DD 04-0114). Vitro Glass has several managers and technical personnel serving as active members and in leadership roles for GANA.

1.16 Disposal

Glass is not regarded as a hazardous material, so it may be disposed via typical, non-hazardous waste stream classifications and disposable routes; nevertheless, Vitro Glass encourages recycling of all glass products due to their ease of reuse and reuse versatility.

1.17 Further Information

For further information about Vitro Architectural Glass products, visit VitroGlazings.com.

2. LCA: Calculation Rules

2.1 Declared Unit

The declared unit being evaluated for flat glass, as specified by the GANA PCR for Flat Glass, is 1 metric tonne of glass, maintained for a 30-year period.

2.2 System Boundary

The system boundaries for the analysis encompass a “cradle-to-gate” scope (i.e., raw materials extraction and processing, inbound transport of materials and glass production). As is typical for LCA studies, impacts associated with the construction of capital equipment (such as production equipment in the manufacturing stage) and with human labor and employee commutes are not included within system boundaries. Use and end-of-life stages are excluded as well, as mandated by the PCR.

2.3 Assumptions

Due to limitations in data availability, many assumptions were made in allocating important manufacturing inputs and outputs including electricity, process materials and natural gas consumption between flat and processed glass products. The allocation approaches taken may therefore overestimate the environmental burden for uncoated glass production, as many of these inputs and outputs were allocated entirely to uncoated glass production.

2.4 Cut-off Criteria

No cut-off criteria had to be applied within this study. The system boundary was defined based on relevance to the goal of the study. For the processes within the system boundary, all available energy and material flow data have been included in the model. In cases where no matching Life Cycle Inventories (LCI) are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts.

2.5 Background Data

Regional and national averages for fuel inputs, electricity grid mixes, materials, transportation and disposal methods were obtained from the GaBi 2017 database. Documentation for all GaBi datasets can be found at www.gabi-software.com/support/gabi/gabi-6-lci-documentation/.

2.6 Data Quality

A variety of tests and checks were performed throughout the project to ensure the high quality of the completed LCA. Checks included an extensive review of the LCA model, as well as the background data used.

Data included first-hand company manufacturing data in combination with consistent background LCI information from the GaBi 2017 databases.

2.7 Period Under Review

The data are representative of Vitro Glass's float glass production data for the year 2015.

2.8 Allocation

Where manufacturing inputs, such as electricity use, were not sub-metered, they were allocated by mass, area, or by expert judgment.

2.9 Comparability

A comparison or an evaluation of EPD results is only possible if all results to be compared were created using the same background data and according to the same guidelines, including EN 15804 (CEN, 2013) and the PCR. Additionally, the building context and product-specific performance characteristics should be taken into account.

3. LCA: Results

3.1 Results

LCA results are presented per the declared unit (1 metric tonne of float glass). Note that, at this point, the reported impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. Life Cycle Impact Assessment (LCIA) results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins or risks.

Table 2: Emissions LCI results for float glass, per declared unit (1 metric tonne)

TYPE	FLOW	UNIT	UNCOATED: RAW MATERIALS	UNCOATED: PRODUCTION	TOTAL
Emissions to air	SOx	kg	-	1.11E+00	**1.11E+00**
	NOx	kg	6.28E-01	7.85E+00	**8.47E+00**
	CO_2	kg	3.29E+02	9.55E+02	**1.28E+03**
	Methane	kg	6.99E-01	2.32E+00	**3.02E+00**
	Nitrous oxide	kg	1.05E-02	7.66E-03	**1.82E-02**
	CO	kg	1.89E-01	5.95E-01	**7.84E-01**
	NMVOCs	kg	7.45E-02	2.01E-01	**2.76E-01**
	Fe	kg	5.61E-05	4.10E-04	**4.66E-04**
	PM (total)	kg	5.02E+00	2.33E+00	**7.35E+00**
Water usage and emissions to water	Water consumption	m^3	1.13E+03	1.98E+03	**3.12E+03**
	PO_4^{3-}	kg	4.98E-04	5.08E-04	**1.01E-03**
	NO^{3-}	kg	9.72E-03	1.86E-02	**2.83E-02**
	Dioxin	kg	2.13E-18	1.28E-17	**1.49E-17**
	Arsenic	kg	1.78E-12	1.08E-05	**1.08E-05**
	Lead	kg	1.18E-04	3.87E-04	**5.06E-04**
	Mercury	kg	7.00E-07	2.11E-06	**2.80E-06**
	Cadmium	kg	4.26E-05	1.21E-04	**1.64E-04**
	Chromium	kg	7.78E-03	3.02E-02	**3.80E-02**

Table 3: Energy usage LCI results for float glass, per declared unit (1 metric tonne)

FLOW	UNIT	UNCOATED: RAW MATERIALS	UNCOATED: PRODUCTION	TOTAL
PERE	MJ	2.27E+02	4.14E+02	**6.41E+02**
Hydro	MJ	6.15E+01	7.92E+01	**1.41E+02**
Solar	MJ	8.83E+01	1.09E+02	**1.97E+02**
Wind	MJ	6.80E+01	1.72E+02	**2.40E+02**
Biomass	MJ	-	1.56E+00	**1.56E+00**
PERM	MJ	-	5.42E+01	**5.42E+01**
PERT	MJ	2.27E+02	4.68E+02	**6.95E+02**
PENRE	MJ	4.82E+03	1.48E+04	**1.96E+04**
Fossil fuel	MJ	4.49E+03	1.41E+04	**1.86E+04**
Nuclear	MJ	3.31E+02	6.54E+02	**9.85E+02**
PENRM	MJ	-	4.89E+01	**4.89E+01**
PENRT	MJ	4.87E+03	1.48E+04	**1.96E+04**
SM	MJ	-	-	
RSF	MJ	-	-	-
NRSF	MJ	-	-	-

Table 4: Wastes and outputs LCI results for uncoated glass, per declared unit (1 metric tonne)

FLOW	UNIT	UNCOATED: RAW MATERIALS	UNCOATED: PRODUCTION	TOTAL
Hazardous waste disposed	kg	3.82E-06	5.46E-06	**9.28E-06**
Non-hazardous waste disposed	kg	1.98E+01	1.19E+01	**3.17E+01**
Radioactive waste disposed	kg	1.30E-01	2.56E-01	**3.87E-01**
Components for re-use	kg	-	-	-
Materials for recycling	kg	-	1.18E+01	**1.18E+01**
Materials for energy recovery	kg	-	-	-
Exported energy	MJ	-	-	-

Table 5: LCIA results for float glass products per declared unit (1 metric tonne)

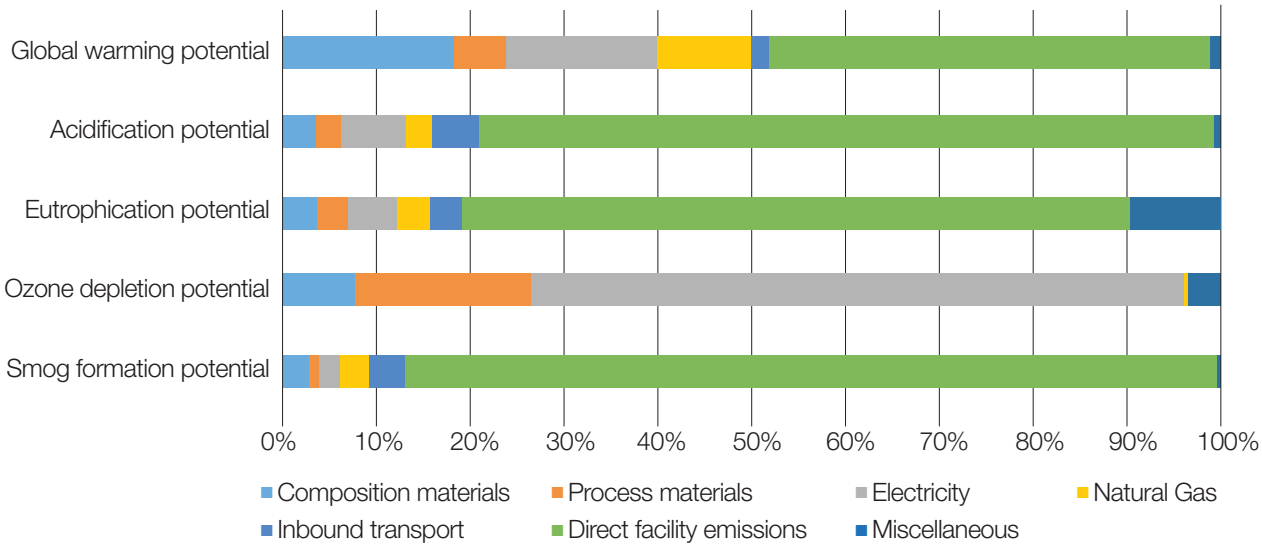
IMPACT CATEGORY	UNIT	UNCOATED: RAW MATERIALS	UNCOATED: PRODUCTION	TOTAL
CML 2001 (January 2016)				
GWP	[kg CO_2 eq.]	3.52E+02	1.02E+03	**1.37E+03**
ODP	[kg CFC-11 eq.]	2.78E-08	7.57E-08	**1.03E-07**
AP	[kg SO_2 eq.]	8.30E-01	5.82E+00	**6.65E+00**
EP	[kg $(PO_4)^{3-}$ eq.]	1.04E-01	1.08E+00	**1.18E+00**
POCP	[kg ethene eq.]	4.86E-02	3.62E-01	**4.11E-01**
ADPe	[kg Sb eq.]	3.04E-03	3.80E-04	**3.42E-03**
ADPf	[MJ]	4.54E+03	1.41E+04	**1.87E+04**
TRACI 2.1				
GWP	[kg CO_2 eq.]	3.50E+02	1.02E+03	**1.37E+03**
ODP	[kg CFC-11 eq.]	2.96E-08	8.06E-08	**1.10E-07**
AP	[kg SO_2 eq.]	9.09E-01	7.11E+00	**8.02E+00**
EP	[kg N eq.]	5.01E-02	4.11E-01	**4.61E-01**
POCP	[kg O_3 eq.]	1.66E+01	1.95E+02	**2.12E+02**
ADPe	[kg Fe eq., per ReCiPe 1.08]	6.23E+00	6.09E+00	**1.23E+01**
ADPf	[MJ]	5.79E+02	1.91E+03	**2.49E+03**

4. LCA: Interpretation

The analysis results represent the cradle-to-gate environmental performance of both uncoated and processed glass products. For a better understanding of the results and impact drivers for the production of uncoated glass, the environmental performance is further broken down in Figure 1 (pg. 18), according to the following criteria:

- **Composition materials** — Upstream impacts associated with extraction and pre-processing of materials used in glass composition, including silica sand, dolomite, pigments, etc.
- **Process materials** — Upstream impacts associated with extraction and pre-processing of process materials like oxygen, hydrogen, nitrogen, tin bath, etc.
- **Electricity** — Impacts associated with generating electricity in relevant manufacturing facility regions
- **Natural gas** — Impacts associated with natural gas production for use in the furnace
- **Inbound transport** — Ship, rail and truck transport of raw materials to the manufacturing facilities
- **Direct emissions** — Emissions reported by facilities
- **Miscellaneous** — Impacts associated with manufacturing waste, packaging materials, water usage and onsite transport

Figure 1: Relative contributions of manufacturing inputs and outputs for uncoated glass production (TRACI 2.1)



Direct-reported emissions drive many impact categories, including global warming potential, acidification potential, eutrophication potential and smog formation potential. This is due to direct emissions of carbon dioxide, sulfur oxides, nitrogen oxides and non-methane VOCs. Global warming potential also has significant contribution from CO_2 emissions associated with natural soda production, electricity consumption (particularly at the Wichita Falls and Carlisle facilities), and natural gas production. Ozone depletion potential is driven primarily by electricity consumption, specifically from the nuclear-heavy Carlisle electricity grid. Though process materials represent a less-significant portion of overall impacts, they do account for a non-negligible amount of global warming potential and ozone depletion potential impacts. This is primarily attributed to the use of gaseous oxygen as a process material.

5. Additional Environmental Information

Vitro Architectural Glass conserves natural resources through several initiatives aligned to its Sustainability Model. Aiming to create a positive influence in the economic, social and environmental aspects within a framework of responsible corporate management, Vitro Glass will continue to develop and maintain processes to ensure the company's presence enhances the communities in which it operates.

The sustainability and potential health impacts of materials can be disclosed in a number of ways. Multiple programs have been, and continue to be, developed that outline the data collection and reporting methodologies for disclosure. Some of these programs include, but are not limited to:

- *Cradle to Cradle Certified* Product Standard (C2C)
- GreenScreen® for Safer Chemicals (GS)
- Pharos Chemical & Material Library & Building Product Library (BPL)
- HPD Collaborative's (HPDC) Health Product Declaration (HPD)
- International Living Future Institute's (ILFI) Declare
- Global Harmonized System (GHS) for Safety Data Sheets (SDS)

Vitro Glass utilizes *Cradle to Cradle Certification* in conjunction with Safety Data Sheets (SDS) and Living Building Challenge's Red List as the most comprehensive methods of disclosing the sustainability and material health impacts of its products. Vitro Glass will continue to monitor the programs listed above, as well as new initiatives.

Vitro Glass publicly available data, industry-accepted values and information are provided in the documents below:

- *Cradle to Cradle Certification* and Material Health Certificate
- Technical Document 143 – Material Ingredient Disclosure
- VitroGlazings.com
- Vitro Glass Education Center
- Vitro Corporate Sustainability Report

Additional information is available at VitroGlazings.com or by calling 1-855-VTRO-GLS (877-6457).

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Cradle to Cradle Certified™ Product Standard administered by the Cradle to Cradle Products Innovation Institute: *c2ccertified.org*

Cradle to Cradle Certified™ Product Standard administered by the Cradle to Cradle Products Innovation Institute: *c2ccertified.org* and STD Certificate_ Standard: *http://www.c2ccertified.org/resources/detail/material-health-certificate-standard*

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Vitro Glass Education Center: *GlassEd.vitroglazings.com*

Water Environment & Reuse Foundation, Final Report, Feb. 2017

7. Contact Information

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