ENVIRONMENTAL PRODUCT DECLARATION

Vitro Architectural Glass Processed 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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Issue Date: July 25, 2017

Valid Until: July 25, 2022

Revision 6

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Declaration Number: ASTM-EPD #062

Program Operator: ASTM International
Company: Vitro Architectural Glass

ASTM INTERNATIONAL
www.astm.org

Vitro Architectural Glass
www.VitroGlazings.com

PCR Reference: *UL Environment PCR Guidance for Building-Related Products and Services: Part B:Processed Glass EPD Requirements*
PCR review was conducted by: Jack Geibig (Chair), Ecoform, ncss@nsf.org

Declared Unit: 1 m^2 of processed glass

Declaration Information

Product Information

Product Name: Vitro Architectural Processed Glass
Product Definition: This declaration encompasses all coated and/or heat-treated glasses manufactured by Vitro Glass whether they are used monolithically (in single-pane windows) or combined with other Vitro Architectural Glass products in double- or triple-pane IGUs.

Product brands covered under this declaration are listed below. They include architectural glass products processed with coatings over clear, ultra-clear (including *Acuity*™ glass) and tinted glass substrates:

- *Solarban*® 60 solar control low-e glass
- *Solarban*® 67 solar control low-e glass
- *Solarban*® 70 solar control low-e glass (formerly Solarban® 70XL glass)
- *Solarban*® 72 solar control low-e glass
- *Solarban*® R77 solar control low-e glass
- *Solarban*® 90 solar control low-e glass
- *Solarban*® 90 solar control low-e glass
- *Solarban*® z50 solar control low-e glass
- *Solarban*® z75 solar control low-e glass
- *Solarban*® R100 solar control low-e glass
- *Sungate*® 400 passive low-e glass
- *Sungate*® 460 passive low-e glass
- *Vistacool*® subtly reflective tinted glasses
- *Solarcool*® reflective tinted glasses
- *Clarvista*® shower glass
- *Herculite*® tempered glass

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 Architectural Glass products sold worldwide.

Product Application and/or Characteristics

This declaration is valid for all architectural vacuum-coated, reflective and insulating glass unit (IGU) products manufactured by Vitro Glass for use in residential and commercial building applications. Processed Vitro Glass products are intended primarily for interior and exterior use in commercial and residential buildings. Optical, thermal andmechanical 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 withISO 14044 and the reference PCR by:

Name	Date
	7/25/17

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

Name	Date
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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 informationfulfills 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 accordancewith international standards.

Full conformance with the PCR for North American Processed Glass allows EPD comparability only when all stagesof the processed glass life cycle have been considered, which is not permitted under this PCR. However, variation and deviations are possible, as different LCA software and background Life Cycle Inventory (LCI) datasets may leadto differences in results upstream or downstream of the life cycle stages declared.

Comparison of the environmental performance of processed glass using EPD information shall be based on the product's use and impacts at the building level; therefore, EPDs may not be used for comparability purposes when not considering the building energy phase as instructed under this PCR. In addition, environmental declarations conductedunder different programs may not be comparable.

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 m^2 of processed glass products

LCA Results (TRACI 2.1) Vitro Architectural Glass Processed Glass

EVALUATION VARIABLE	UNIT PER SQUARE METER	REFLECTIVE	NON-LOW-E	DOUBLE-PANE IGU	TRIPLE-PANE IGU
Primary Energy, non-renewable	MJ	383	401	860	1,340
Primary Energy, renewable	MJ	15.8	14.6	38.8	60.6
Global Warming Potential	kg CO_2 eq.	26.5	27.6	58.7	90.9
Ozone Depletion Potential	kg CFC-11 eq.	2.22E-09	3.83E-09	1.25E-08	2.15E-08
Acidification Potential	kg SO_2 eq.	0.156	0.153	0.304	0.466
Eutrophication Potential	kg N eq.	0.00891	0.00860	0.0167	0.0255
Smog Formation Potential	kg O_3 eq.	4.07	3.81	7.21	10.9
Abiotic resource depletion potential – minerals	kg Fe eq.	0.308	0.227	5.21	10.1
Abiotic resource depletion potential – fossil fuels	MJ (surplus)	48.6	45.5	94.9	146

Additional Information

Vitro Architectural Glass coated glass products such as *Solarban*® solar control low-e glasses, *Sungate*® passive low-e glasses, *Solarcool*® reflective glasses and *Vistacool*® subtly reflective glasses are specified by architects to enhance the energy and environmental performance of buildings.

Low-e glasses are engineered with coatings that diminish solar heat gain while permitting high levels of natural light transmittance. These characteristics enable buildings and homes to consume significantly less energy for heating, cooling and artificial lighting, the largest consumers of energy in commercial buildings. In addition, studies consistently have demonstrated that high levels of daylight in buildings and visual connection to the outdoors promote human health,productivity and happiness.

Reflective glasses, which expand the range of aesthetic options available to architects, building designers and building owners, diminish solar heat gain by deflecting heat, but they do not transmit light into buildings as effectively as glasses manufactured with advanced low-e coatings.

Low-e glasses can be united with clear glass, ultra-clear glass, tinted glasses and reflective glasses in multi-pane IGUs to give architects a virtually unlimited array of aesthetic and environmental performance options.

As an environmentally responsible company, Vitro Glass has committed significant resources to re-engineering manufacturing processes at its glass plants to minimize energy production, optimize material ingredients, improve air and water quality and cut waste.

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 consumedduring 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 producer with an extensive product portfolio of float and processed glass products specified for use in architectural applications. It operates manufacturing facilities in Carlisle, Pennsylvania; Wichita Falls, Texas; Salem, Oregon; and Fresno, California. Processed glass products are produced exclusively at the Carlisle, Wichita Falls and Salem facilities.

1.2 Product Under Study

The declared products validated in this document are processed glass products manufactured by Vitro Glass that are commonly used for windows, glass doors and walls. All processed glass utilizes the upstream data included in Float Glass EPD published by Vitro Glass (ASTM-EPD #061) and verified through ASTM International against the NSF GANA*PCR for Float Glass - UNCPC 3711*.

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.

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

Table 1: Description of products under study

PRODUCT	DESCRIPTION	VITRO PRODUCTS
Reflective Glass*	Float glass coated with reflective coating	*Vistacool*® glass *Solarcool*® glass
Low-E Coated Glass	Float glass vacuum-coated with low-emissivity coating	*Solarban*® glass *Sungate*® glass
Non-Low-E Coated Glass*	Vacuum-coated float glass with non-low-emissivity coating	*Clarvista*® glass
Heat-Treated Glass	Float, low-e coated, or reflective glass heat-treated for increased durability	*Herculite*® glass (when fully tempered)
Double-Pane IGU*	An insulating glass unit assembly comprised of two "average" glass panes and one spacer. An "average" pane is comprised of a production-weighted average of uncoated, low-e coated, heat-treated, and heat-treated low-e coated glass, and is based on IGU manufacturing data, but does not represent an actual glass product produced by Vitro Glass.	
Triple-Pane IGU*	An insulating glass unit assembly comprised of three "average" glass panes and two spacers. An "average" pane is comprised of a production-weighted average of uncoated, low-e coated, heat-treated, and heat-treated low-e coated glass, and is based on IGU manufacturing data, but does not represent an actual glass product produced by Vitro Glass.	

* represents glass products for which results are presented in this study

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 manufacture of glass from primary materials, as well as materials used in packaging. This stage ends when the final glass product leaves the production line and is stored onsite.
- **Packaging and Storage —** This stage is not associated with any potential environmental impacts but includes onsite storage of glass products before they leave the facility to be delivered to the end user or fabricator.

1.3 Product Use and Application

Vacuum-coated, reflective and IGU glass products enhance the energy efficiency and appearance of homes and commercial buildings. All processed glass products listed in this declaration may be used in commercial, institutional or residential applications.

1.4 Technical Data

Vitro Architectural Glass products can be combined in a vast array of configurations in double- and triple-pane IGUs. To view a comprehensive list of configurations and related optical, thermal and mechanical performance data for each configuration, visit VitroGlazings.com or call 1-855-VTRO-GLS (887-6457) for assistance.

1.5 Placing on the Market

The products validated in this EPD conform to the following technical specifications for processed glass products (dependent on location and process):

- *ASTM C 1036: Standard Specification for Flat Glass; and/or*
- *EN 572: Glass in Building. Basic soda lime silicate glass products. Float glass; and/or*
- *Malaysia – MS 1135: Specification for Float Glass and Polished Plate; and/or*
- *ASTM C 1376: Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass; and/or*
- *CPSC 16CFR 1201: Safety Standard for Architectural Glazing Materials; and/or*
- *ANSI Z97.1; and/or*
- *EN 12898: Glass in building. Determination of the emissivity; and/or*
- *MS 2397: Coated Glass in Building - Specification*

Safety Glazing Certification Council (SGCC) certifications are available upon request.
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 dimensions specified by the user. In the case of pre-cut glass, products are sold in packs with 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")

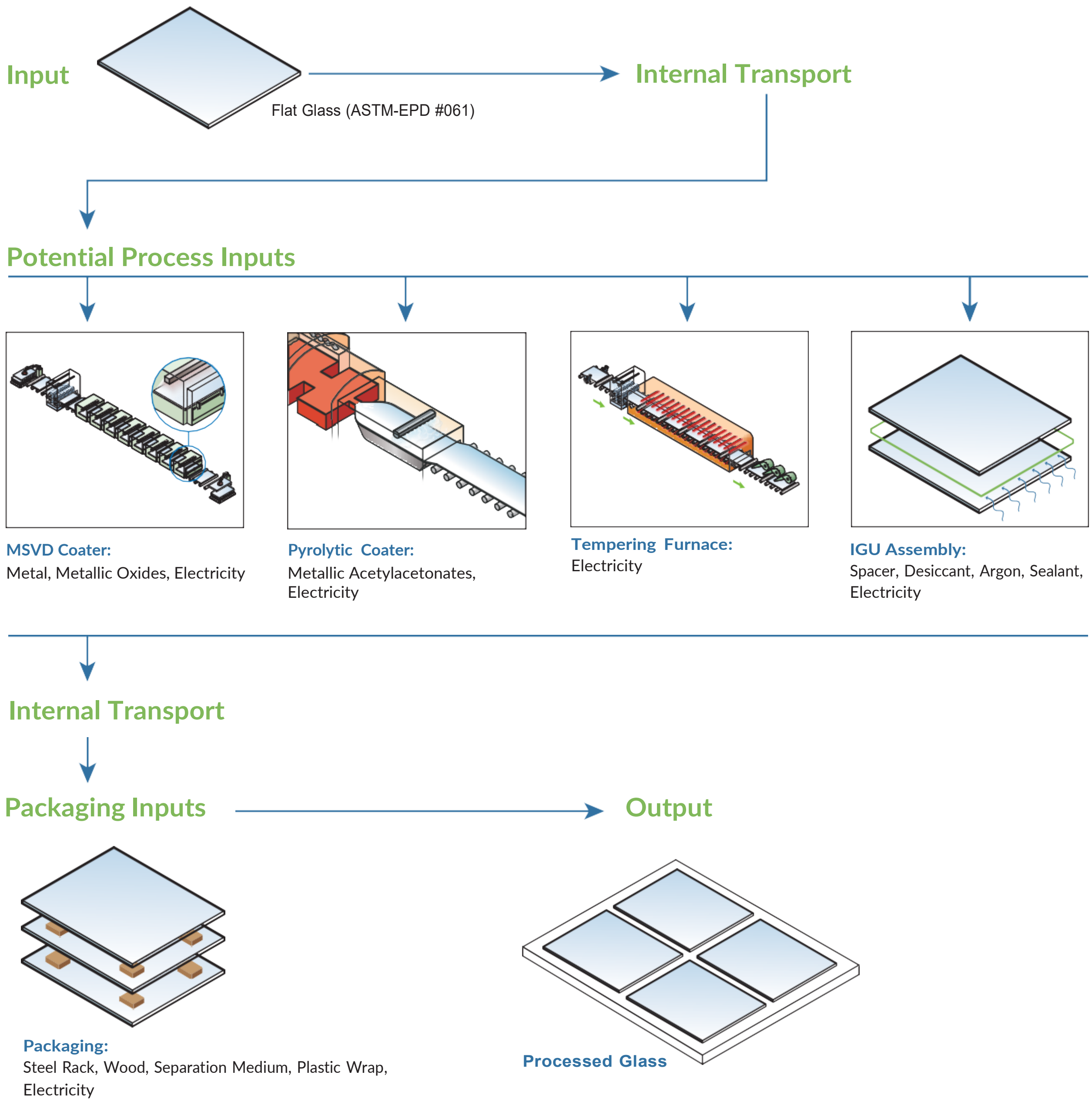
1.7 Base and Ancillary Materials

Processed glass is primarily comprised of uncoated glass (see ASTM EPD #061), yet, in the case of IGUs, spacer materials and insulation-gas make up a significant portion of the product mass. Table 2 shows the glass-to-spacer massratios for double- and triple-pane IGUs. In non-low-e coated and reflective glass products, coating materials represent an insignificant mass percentage. The ratio of materials used to model an average spacer also is presented in Table 2.

Table 2: Material composition of IGU products

MATERIAL	MASS [%]
Double-Pane IGU	
Uncoated glass	95.3
Spacer material	4.7
Triple-Pane IGU	
Uncoated glass	93.8
Spacer material	6.2
Spacer	
Sealant	29
Stainless steel	27
Desiccant	23
Steel coil	20
Aluminum	2

1.8 Processed Glass Manufacturing

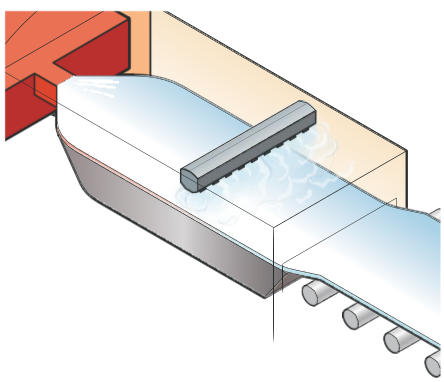


The glass manufacturing process begins when raw materials, including sand, soda ash, limestone, dolomite and other minor ingredients, arrive at a Vitro Glass manufacturing facility. As materials are batched and fed into the furnace, they react to form a ribbon of liquid glass. The glass ribbon flows 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 towards 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. During this time, coatings may be applied to the molten glass via the chemical vapor deposition (CVD)process. The conveyor rolls feed the glass into an annealing lehr, where it cools at a controlled rate to achieve proper stresses for easy and accurate cutting. As the glass exits the lehr, it is cooled to room temperature by open air fans andinspected for flaws prior to cutting.

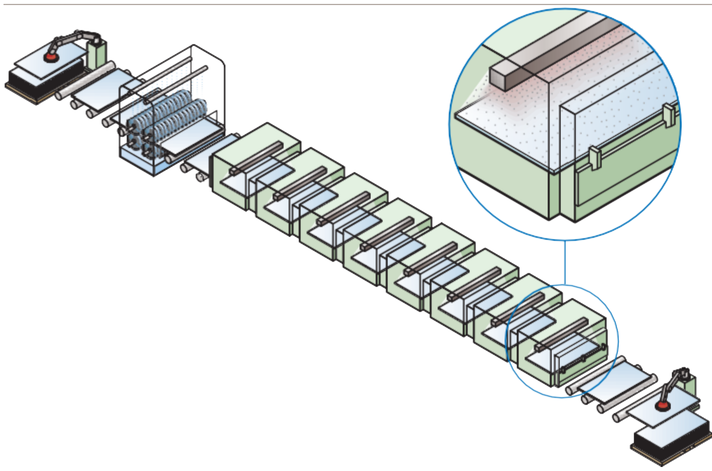
Once flat glass is cut, it may undergo additional conditioning before it is installed in a finished building. This may includethe application of low-e and/or reflective coatings via the magnetron-sputtered vacuum deposition (MSVD) coatings process. Other options include heat-treatment (heat-strengthening or tempering), and/or assembly into finished IGUs.

Pyrolytic Process



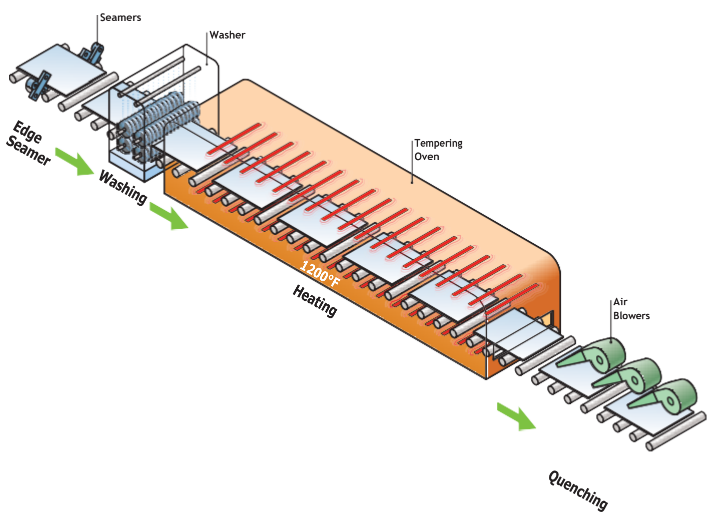
Passive Low-E:
Pyrolytic Coating Process
During the CVD process, high-performance coatings are pyrolytically fused or baked on to the glass before it leaves the float glass line. The CVD process is generally associated with the application of passive low-e coatings, tintsthat give glass a hue, or reflective coatings thatmake architectural glass more mirror-like (and more heat-reflective).

MSVD Process



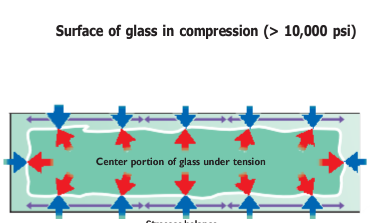
During the MSVD coating process, annealed or heat-treated glass is rolled into the vacuum chamber where microscopic materials, mainly silver, are bonded on to the glass surface. The silver is combined with other materials in a layered coating stack that promotes the transmission of sunlight into the building while reflecting solar heat. The purpose of these low-e coatings is to reduce demand for artificial lighting, heating and cooling so that buildings consume less energy and emit fewer greenhouse gases.

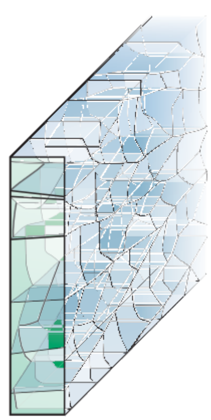
Heat-Strengthening and Tempering Processes



Heat-treated glass refers to glass that has undergone one of two heat-treatment processes: heat-strengthening or tempering.

During both processes, glass is heated to approximately 923 K (1,200 degrees F), then force-cooled to create surface and edgecompression. When the surface compressionis between 3,500 and 7,500 psi, the glass isconsidered heat-strengthened. When greaterthan or equal to 10,000 psi, it is considered tempered. Both processes produce a product that is more resistant to certain typesof breakage. For more information on heat-treated glasses, please visit VitroGlazings.com to download Technical Document (TD)-138 or call 855-VTRO-GLS (887-6457).





1.9 Environment and Health during Manufacturing

In 2008, Vitro Glass (formerly PPG Glass) became the first U.S. glass manufacturer to earn *Cradle to Cradle™ Certification* for its products and they have been recognized by the *Cradle to Cradle Certified™* Products Program 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 manufacturesis 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 yearsince 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 buildingprojects. 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.

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 *UL Environment PCR Guidance for Building-Related Products and Services: Part B: Processed Glass EPD Requirements*

1.14 Extraordinary Effects

To meet the *Cradle to Cradle Certified™* Product Standard, Vitro Glass has undergone a thorough audit of the materialsused 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*.

1.15 Re-use Phase

Vitro Glass products offer multiple options for reuse and repurposing after deconstruction, including as an aggregate inconcrete 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 lowers the melting temperature for batch materials, which reduces 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 hasseveral 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 repurposing of all glass products due to their ease of reuse and reuse versatility. When processed glass is not suitable for reuse, recycling options are typically available and should be investigated rather than introducing the product into the waste stream.

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 processed glass, as specified by the *UL Environment PCR Guidance for Building-Related Products and Services: Part B: Processed Glass EPD Requirements*, is 1 m^2 of processed glass. Though glass products are sold at varying thicknesses, for the purpose of this study it is assumed that the processedglass products are 6mm thick, which is the most common thickness sold; therefore, each pane weighs 15 kg, assuming a glass density of 2,500 kg/m^3. Double-pane IGUs are comprised of two panes of "average" glass and one
spacer, while triple-pane IGUs are comprised of three panes of "average" glass and two spacers. The reference weightsfor the double-pane and triple-pane IGUs (including spacers) are 30.7 kg and 46.1 kg per m^2, respectively. Information regarding the declared unit of the study can be found in Table 3.

Table 3: Declared unit and reference flow information

NAME	VALUE	UNIT
Declared unit	1	m^2
Mass per piece		
Vacuum-coated	15	kg
Reflective	15	kg
Double-pane IGU	30.7	kg
Triple-pane IGU	46.1	kg
Conversion factor to 1 kg		
Vacuum-coated	0.067	m^2/kg
Reflective	0.067	m^2/kg
Double-pane IGU	0.033	m^2/kg
Triple-pane IGU	0.022	m^2/kg
Pane thickness	6	mm

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), including modules A1-A3. 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.

Table 4: System Boundary

PRODUCTION			INSTALLATION		USE STAGE							END-OF-LIFE				NEXT PRODUCT SYSTEM
Raw material supply	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to EoL	Waste processing for reuse, recovery or recycling	Disposal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = declared module; MND = module not declared

2.3 Assumptions

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

Additionally, the “average” glass pane used in IGU modeling is a calculated production weighted average pane and does not represent a specific product manufactured by Vitro Glass. However, since the majority of environmental impactin IGU products can be attributed to uncoated glass production and IGU manufacturing, this assumption is not likely to affect the results significantly.

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 LCI are available to represent a flow, proxy data have been appliedbased 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 foundat 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 fromthe GaBi 2017 databases.

2.7 Period Under Review

The data are representative of Vitro Glass's processed 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 judgement.

2.9 Comparability

Full conformance with the PCR for North American Processed Glass allows EPD comparability only when all stagesof the processed glass life cycle have been considered, which is not permitted under this PCR. However, variation and deviations are possible, as different LCA software and background LCI datasets may lead to differences in results upstream or downstream of the life cycle stages declared.

Comparison of the environmental performance of processed glass using EPD information shall be based on the product's use and impacts at the building level; therefore, EPDs may not be used for comparability purposes when notconsidering the building energy phase as instructed under this PCR.

3. LCA: Results

3.1 Results

LCA results are presented per the declared unit (1 m^2 of processed glass). Note that, at this point, the reported impactcategories 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 predictactual impacts, the exceeding of thresholds, safety margins, or risks.

Table 5: Emissions LCI results for reflective and non-low-e processed glass, per declared unit (1 m^2)

TYPE	FLOW	UNIT	REFLECTIVE FLOAT GLASS ONLY (A1)	REFLECTIVE PROCESSING (A1-A3)	REFLECTIVE (TOTAL, A1-A3)	NON-LOW-E FLOAT GLASS ONLY (A1)	NON-LOW-E PROCESSING (A1-A3)	NON-LOW-E (TOTAL, A1-A3)
	SOx	kg	2.12E-02	4.50E-06	**2.12E-02**	1.94E-02	1.19E-06	**1.94E-02**
	NOx	kg	1.62E-01	7.23E-04	**1.62E-01**	1.48E-01	4.17E-03	**1.53E-01**
	CO_2	kg	2.45E+01	3.77E-01	**2.49E+01**	2.25E+01	3.50E+00	**2.60E+01**
	Methane	kg	5.76E-02	8.90E-04	**5.85E-02**	5.28E-02	5.83E-03	**5.86E-02**
	Nitrous oxide	kg	3.47E-04	3.45E-05	**3.82E-04**	3.18E-04	7.30E-05	**3.92E-04**
	CO	kg	1.50E-02	9.98E-04	**1.60E-02**	1.37E-02	1.50E-03	**1.52E-02**
	NMVOCs	kg	5.26E-03	2.57E-04	**5.52E-03**	4.83E-03	3.37E-04	**5.16E-03**
	Fe	kg	8.89E-06	1.36E-07	**9.03E-06**	8.15E-06	2.38E-07	**8.39E-06**
	PM (total)	kg	1.40E-01	2.03E-04	**1.41E-01**	1.29E-01	8.62E-04	**1.30E-01**
Water usage and emissions to water	Water consumption	m^3	5.95E+01	2.06E+00	**6.15E+01**	5.45E+01	1.34E+01	**6.79E+01**
	PO_4^{3-}	kg	1.92E-05	2.81E-06	**2.20E-05**	1.76E-05	4.70E-06	**2.23E-05**
	NO^{3-}	kg	5.40E-04	2.72E-05	**5.67E-04**	4.95E-04	2.39E-04	**7.34E-04**
	Dioxin	kg	2.85E-19	2.95E-20	**3.15E-19**	2.61E-19	1.32E-20	**2.75E-19**
	Arsenic	kg	2.06E-07	1.73E-09	**2.08E-07**	1.89E-07	1.08E-10	**1.89E-07**
	Lead	kg	9.65E-06	2.22E-07	**9.87E-06**	8.85E-06	7.29E-07	**9.58E-06**
	Mercury	kg	5.35E-08	4.32E-09	**5.79E-08**	4.91E-08	1.06E-08	**5.97E-08**
	Cadmium	kg	3.12E-06	1.43E-07	**3.27E-06**	2.86E-06	1.48E-07	**3.01E-06**
	Chromium	kg	7.25E-04	7.60E-06	**7.33E-04**	6.65E-04	1.81E-05	**6.83E-04**

Table 6: Emissions LCI results for double-pane and triple-pane IGU processed glass, per declared unit (1 m^2)

TYPE	FLOW	UNIT	DOUBLE-PANE IGU FLOAT GLASS ONLY (A1)	DOUBLE-PANE IGU PROCESSING (A1-A3)	DOUBLE-PANE IGU (TOTAL, A1-A3)	TRIPLE-PANE IGU FLOAT GLASS ONLY (A1)	TRIPLE-PANE IGU PROCESSING (A1-A3)	TRIPLE-PANE IGU (TOTAL, A1-A3)
Emissions to air	SOx	kg	3.55E-02	5.20E-06	**3.56E-02**	5.33E-02	8.41E-06	**5.33E-02**
	NOx	kg	2.71E-01	1.66E-02	**2.88E-01**	4.07E-01	2.90E-02	**4.36E-01**
	CO_2	kg	4.11E+01	1.42E+01	**5.53E+01**	6.17E+01	2.40E+01	**8.56E+01**
	Methane	kg	9.66E-02	2.70E-02	**1.24E-01**	1.45E-01	4.59E-02	**1.91E-01**
	Nitrous oxide	kg	5.83E-04	2.72E-04	**8.55E-04**	8.74E-04	4.61E-04	**1.33E-03**
	CO	kg	2.51E-02	9.66E-03	**3.48E-02**	3.77E-02	1.75E-02	**5.52E-02**
	NMVOCs	kg	8.83E-03	2.63E-03	**1.15E-02**	1.32E-02	4.71E-03	**1.80E-02**
	Fe	kg	1.49E-05	3.28E-06	**1.82E-05**	2.24E-05	6.12E-06	**2.85E-05**
	PM (total)	kg	2.35E-01	4.73E-03	**2.40E-01**	3.53E-01	8.59E-03	**3.62E-01**
Water usage and emissions to water	Water consumption	m^3	9.98E+01	5.67E+01	**1.56E+02**	1.50E+02	9.66E+01	**2.46E+02**
	PO_4^{3-}	kg	3.22E-05	1.83E-05	**5.05E-05**	4.83E-05	3.17E-05	**8.01E-05**
	NO^{3-}	kg	9.06E-04	7.47E-04	**1.65E-03**	1.36E-03	1.26E-03	**2.62E-03**
	Dioxin	kg	4.78E-19	1.30E-18	**1.77E-18**	7.18E-19	2.57E-18	**3.29E-18**
	Arsenic	kg	3.46E-07	1.43E-09	**3.47E-07**	5.18E-07	2.21E-09	**5.21E-07**
	Lead	kg	1.62E-05	3.36E-06	**1.96E-05**	2.43E-05	5.63E-06	**2.99E-05**
	Mercury	kg	8.99E-08	4.06E-08	**1.30E-07**	1.35E-07	6.81E-08	**2.03E-07**
	Cadmium	kg	5.24E-06	1.21E-06	**6.45E-06**	7.86E-06	2.15E-06	**1.00E-05**
	Chromium	kg	1.22E-03	1.32E-04	**1.35E-03**	1.82E-03	2.10E-04	**2.03E-03**

Table 7: Energy usage LCI results for reflective and non-low-e processed glass, per declared unit (1 m^2)

FLOW	UNIT	REFLECTIVE FLOAT GLASS ONLY (A1)	REFLECTIVE PROCESSING (A1-A3)	REFLECTIVE (TOTAL, A1-A3)	NON-LOW-E FLOAT GLASS ONLY (A1)	NON-LOW-E PROCESSING (A1-A3)	NON-LOW-E (TOTAL, A1-A3)
PERE	MJ	1.22E+01	1.07E+00	**1.33E+01**	1.12E+01	2.08E+00	**1.33E+01**
Hydro	MJ	2.69E+00	1.60E-01	**2.84E+00**	2.46E+00	5.29E-01	**2.99E+00**
Solar	MJ	3.76E+00	8.17E-01	**4.58E+00**	3.45E+00	6.95E-01	**4.14E+00**
Wind	MJ	4.58E+00	5.09E-02	**4.63E+00**	4.20E+00	7.89E-01	**4.99E+00**
Biomass	MJ	2.98E-02	4.00E-02	**6.97E-02**	2.73E-02	1.05E-02	**3.78E-02**
PERM	MJ	1.04E+00	1.45E+00	**2.49E+00**	9.49E-01	3.11E-01	**1.26E+00**
PERT	MJ	1.33E+01	2.53E+00	**1.58E+01**	1.22E+01	2.39E+00	**1.46E+01**
PENRE	MJ	3.74E+02	6.26E+00	**3.80E+02**	3.43E+02	5.67E+01	**4.00E+02**
Fossil fuel	MJ	3.55E+02	6.00E+00	**3.61E+02**	3.26E+02	4.09E+01	**3.67E+02**
Nuclear	MJ	1.88E+01	2.64E-01	**1.91E+01**	1.72E+01	1.58E+01	**3.31E+01**
PENRM	MJ	9.33E-01	1.51E+00	**2.45E+00**	8.56E-01	1.56E-01	**1.01E+00**
PENRT	MJ	3.75E+02	7.77E+00	**3.83E+02**	3.44E+02	5.69E+01	**4.01E+02**
SM	MJ	-	-	-	-	-	-
RSF	MJ	-	-	-	-	-	-
NRSF	MJ	-	-	-	-	-	-

Table 8: Energy usage LCI results for double-pane and triple-pane IGU processed glass, per declared unit (1 m^2)

FLOW	UNIT	DOUBLE-PANE IGU FLOAT GLASS ONLY (A1)	DOUBLE-PANE IGU PROCESSING (A1-A3)	DOUBLE-PANE IGU (TOTAL, A1-A3)	TRIPLE-PANE IGU FLOAT GLASS ONLY (A1)	TRIPLE-PANE IGU PROCESSING (A1-A3)	TRIPLE-PANE IGU (TOTAL, A1-A3)
PERE	MJ	2.05E+01	1.47E+01	**3.53E+01**	3.08E+01	2.43E+01	**5.51E+01**
Hydro	MJ	4.51E+00	3.22E+00	**7.73E+00**	6.76E+00	5.54E+00	**1.23E+01**
Solar	MJ	6.31E+00	3.56E+00	**9.87E+00**	9.46E+00	6.24E+00	**1.57E+01**
Wind	MJ	7.68E+00	7.74E+00	**1.54E+01**	1.15E+01	1.21E+01	**2.36E+01**
Biomass	MJ	5.00E-02	4.61E-02	**9.61E-02**	7.49E-02	7.46E-02	**1.50E-01**
PERM	MJ	1.74E+00	1.80E+00	**3.54E+00**	2.61E+00	2.94E+00	**5.54E+00**
PERT	MJ	2.23E+01	1.65E+01	**3.88E+01**	3.34E+01	2.72E+01	**6.06E+01**
PENRE	MJ	6.28E+02	2.29E+02	**8.57E+02**	9.41E+02	3.90E+02	**1.33E+03**
Fossil fuel	MJ	5.96E+02	1.89E+02	**7.85E+02**	8.94E+02	3.22E+02	**1.22E+03**
Nuclear	MJ	3.16E+01	4.07E+01	**7.22E+01**	4.73E+01	6.75E+01	**1.15E+02**
PENRM	MJ	1.57E+00	1.67E+00	**3.23E+00**	2.35E+00	2.58E+00	**4.93E+00**
PENRT	MJ	6.29E+02	2.31E+02	**8.60E+02**	9.44E+02	3.92E+02	**1.34E+03**
SM	MJ	-	-	-	-	-	-
RSF	MJ	-	-	-	-	-	-
NRSF	MJ	-	-	-	-	-	-

Table 9: Wastes and outputs LCI results for reflective and non-low-e processed glass products,per declared unit (1 m^2)

FLOW	UNIT	REFLECTIVE FLOAT GLASS ONLY (A1)	REFLECTIVE PROCESSING (A1-A3)	REFLECTIVE (TOTAL, A1-A3)	NON-LOW-E FLOAT GLASS ONLY (A1)	NON-LOW-E PROCESSING (A1-A3)	NON-LOW-E (TOTAL, A1-A3)
Hazardous waste disposed	kg	1.77E-07	4.04E-08	**2.18E-07**	1.62E-07	3.29E-08	**1.95E-07**
Non-hazardous waste disposed	kg	6.05E-01	2.40E-02	**6.29E-01**	5.54E-01	1.89E-02	**5.73E-01**
Radioactive waste disposed	kg	7.38E-03	1.00E-04	**7.48E-03**	6.77E-03	6.20E-03	**1.30E-02**
Components for re-use	kg	-	-	-	-	-	-
Materials for recycling	kg	2.25E-01	4.09E+00	**4.32E+00**	2.06E-01	2.50E+00	**2.71E+00**
Materials for energy recovery	kg	-	-	-	-	-	-
Exported energy	MJ	-	-	-	-	-	-

Table 10: Wastes and outputs LCI results for double-pane and triple-pane IGU processed glass products,per declared unit (1 m^2)

FLOW	UNIT	DOUBLE-PANE IGU FLOAT GLASS ONLY (A1)	DOUBLE-PANE IGU PROCESSING (A1-A3)	DOUBLE-PANE IGU (TOTAL, A1-A3)	TRIPLE-PANE IGU FLOAT GLASS ONLY (A1)	TRIPLE-PANE IGU PROCESSING (A1-A3)	TRIPLE-PANE IGU (TOTAL, A1-A3)
Hazardous waste disposed	kg	2.97E-07	1.39E-07	**4.36E-07**	4.46E-07	2.38E-07	**6.84E-07**
Non-hazardous waste disposed	kg	1.01E+00	3.54E-01	**1.37E+00**	1.52E+00	6.88E-01	**2.21E+00**
Radioactive waste disposed	kg	1.24E-02	1.59E-02	**2.83E-02**	1.86E-02	2.65E-02	**4.50E-02**
Components for re-use	kg	-	-	-	-	-	-
Materials for recycling	kg	3.77E-01	9.16E-01	**1.29E+00**	5.66E-01	1.39E+00	**1.96E+00**
Materials for energy recovery	kg	-	-	-	-	-	-
Exported energy	MJ	-	-	-	-	-	-

Table 11: LCIA results for reflective and non-low-e processed glass products per declared unit (1 m^2)

IMPACT CATEGORY	UNIT	REFLECTIVE FLOAT GLASS ONLY (A1)	REFLECTIVE PROCESSING (A1-A3)	REFLECTIVE (TOTAL, A1-A3)	NON-LOW-E FLOAT GLASS ONLY (A1)	NON-LOW-E PROCESSING (A1-A3)	NON-LOW-E (TOTAL, A1-A3)
CML 2001 (January 2016)							
GWP	[kg CO_2 eq.]	2.62E+01	4.11E-01	**2.66E+01**	2.41E+01	3.68E+00	**2.77E+01**
ODP	[kg CFC-11 eq.]	1.98E-09	1.05E-10	**2.08E-09**	1.81E-09	1.78E-09	**3.60E-09**
AP	[kg SO_2 eq.]	1.27E-01	2.73E-03	**1.30E-01**	1.16E-01	1.41E-02	**1.31E-01**
EP	[kg $(PO_4)^{3-}$ eq.]	2.25E-02	2.03E-04	**2.27E-02**	2.06E-02	7.46E-04	**2.14E-02**
POCP	[kg ethene eq.]	7.84E-03	1.22E-04	**7.97E-03**	7.19E-03	7.79E-04	**7.97E-03**
ADPe	[kg Sb eq.]	6.52E-05	9.65E-07	**6.62E-05**	5.98E-05	3.94E-07	**6.02E-05**
ADPf	[MJ]	3.56E+02	7.51E+00	**3.64E+02**	3.27E+02	4.11E+01	**3.68E+02**
TRACI 2.1							
GWP	[kg CO_2 eq.]	2.61E+01	4.10E-01	**2.65E+01**	2.39E+01	3.67E+00	**2.76E+01**
ODP	[kg CFC-11 eq.]	2.10E-09	1.14E-10	**2.22E-09**	1.93E-09	1.90E-09	**3.83E-09**
AP	[kg SO_2 eq.]	1.53E-01	2.70E-03	**1.56E-01**	1.40E-01	1.31E-02	**1.53E-01**
EP	[kg N eq.]	8.80E-03	1.13E-04	**8.91E-03**	8.07E-03	5.30E-04	**8.60E-03**
POCP	[kg O_3 eq.]	4.04E+00	2.51E-02	**4.07E+00**	3.71E+00	1.07E-01	**3.81E+00**
ADPe	[kg Fe eq., per ReCiPe 1.08]	2.35E-01	7.27E-02	**3.08E-01**	2.16E-01	1.16E-02	**2.27E-01**
ADPf	[MJ, surplus]	4.76E+01	9.73E-01	**4.86E+01**	4.37E+01	1.81E+00	**4.55E+01**

Table 12: LCIA results for double-pane and triple-pane IGU processed glass products per declared unit (1 m^2)

IMPACT CATEGORY	UNIT	DOUBLE-PANE IGU FLOAT GLASS ONLY (A1)	DOUBLE-PANE IGU PROCESSING (A1-A3)	DOUBLE-PANE IGU (TOTAL, A1-A3)	TRIPLE-PANE IGU FLOAT GLASS ONLY (A1)	TRIPLE-PANE IGU PROCESSING (A1-A3)	TRIPLE-PANE IGU (TOTAL, A1-A3)
CML 2001 (January 2016)							
GWP	[kg CO_2 eq.]	4.40E+01	1.50E+01	**5.90E+01**	6.60E+01	2.54E+01	**9.14E+01**
ODP	[kg CFC-11 eq.]	3.31E-09	8.31E-09	**1.16E-08**	4.97E-09	1.50E-08	**2.00E-08**
AP	[kg SO_2 eq.]	2.13E-01	4.96E-02	**2.63E-01**	3.20E-01	8.59E-02	**4.06E-01**
EP	[kg $(PO_4)^{3-}$ eq.]	3.78E-02	2.93E-03	**4.07E-02**	5.67E-02	5.10E-03	**6.18E-02**
POCP	[kg ethene eq.]	1.32E-02	3.13E-03	**1.63E-02**	1.97E-02	5.44E-03	**2.52E-02**
ADPe	[kg Sb eq.]	1.09E-04	1.61E-04	**2.71E-04**	1.64E-04	3.15E-04	**4.79E-04**
ADPf	[MJ]	5.98E+02	1.90E+02	**7.88E+02**	8.96E+02	3.25E+02	**1.22E+03**
TRACI 2.1							
GWP	[kg CO_2 eq.]	4.38E+01	1.49E+01	**5.87E+01**	6.56E+01	2.53E+01	**9.09E+01**
ODP	[kg CFC-11 eq.]	3.53E-09	8.94E-09	**1.25E-08**	5.29E-09	1.62E-08	**2.15E-08**
AP	[kg SO_2 eq.]	2.57E-01	4.67E-02	**3.04E-01**	3.85E-01	8.10E-02	**4.66E-01**
EP	[kg N eq.]	1.48E-02	1.93E-03	**1.67E-02**	2.21E-02	3.32E-03	**2.55E-02**
POCP	[kg O_3 eq.]	6.78E+00	4.25E-01	**7.21E+00**	1.02E+01	7.43E-01	**1.09E+01**
ADPe	[kg Fe eq., per ReCiPe 1.08]	3.95E-01	4.81E+00	**5.21E+00**	5.92E-01	9.56E+00	**1.01E+01**
ADPf	[MJ, surplus]	7.99E+01	1.50E+01	**9.49E+01**	1.20E+02	2.61E+01	**1.46E+02**

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 as follows:

- **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

Relative contributions of uncoated glass manufacturing versus glass processing are broken down in Figure 1 and Figure 2. In most cases, the impacts of uncoated glass significantly outweigh those of glass processing. However, in non-low-e coating and IGU manufacturing, glass processing significantly contributes to ozone depletion potential.In the case of non-low-e coating, it is due to nuclear energy consumption at the Carlisle facility. On the other hand, inIGU manufacturing, ODP is primarily driven by the raw materials production and specifically the R-11 (CFC-11) andR-114 (CFC-114) emissions resulting from stainless steel production in the IGU spacer (as seen in Figure 3, Figure 4 and Figure 5).

Figure 1: Relative contributions of uncoated glass production and the application of reflective coating (TRACI 2.1)

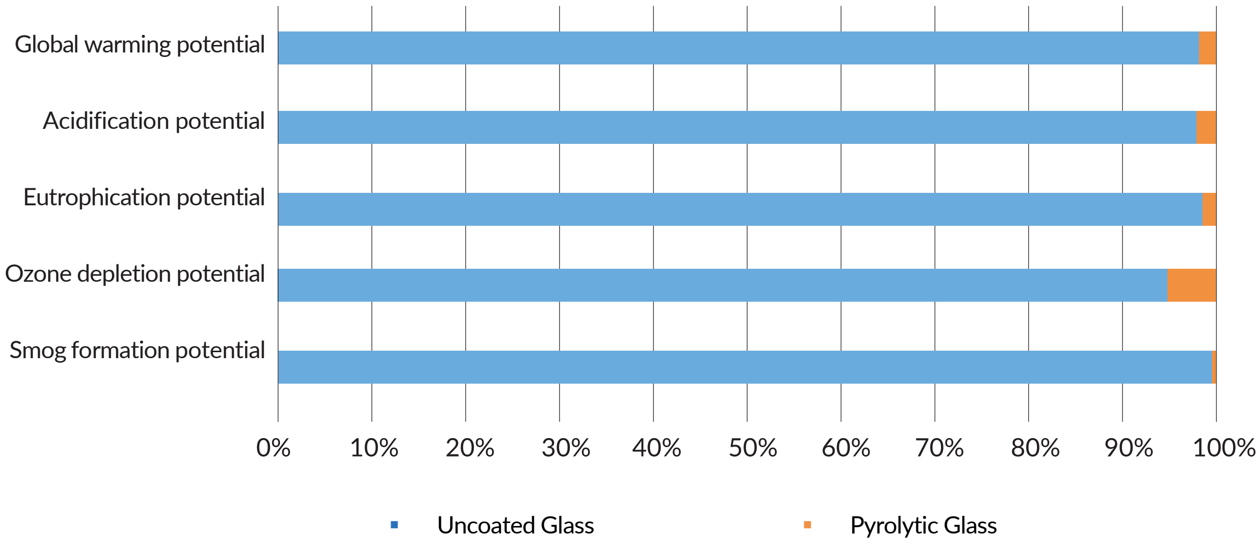


Figure 2: Relative contributions of uncoated glass production and the application of non-low-e coating (TRACI 2.1)

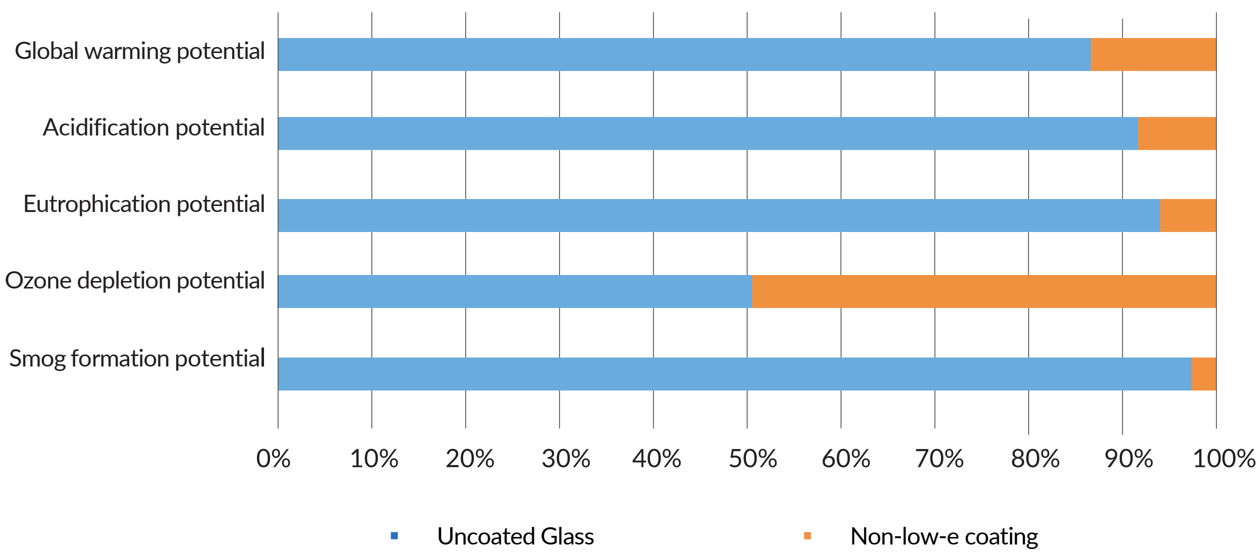


Figure 3: Relative contributions of uncoated glass production, low-e coating, heat-treatment,and IGU assembly for “average” double-pane IGUs (TRACI 2.1)

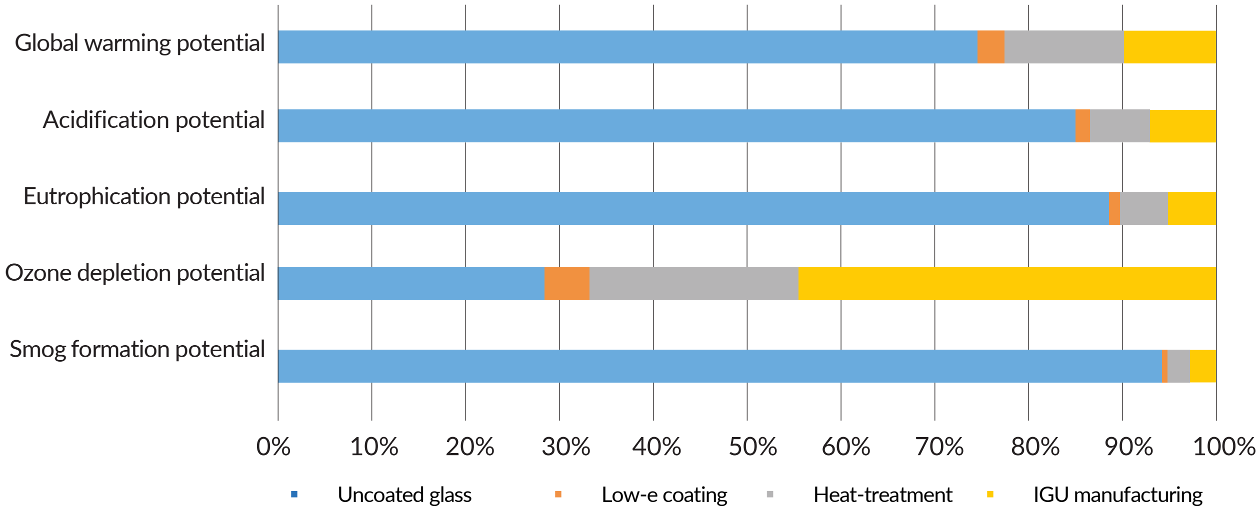
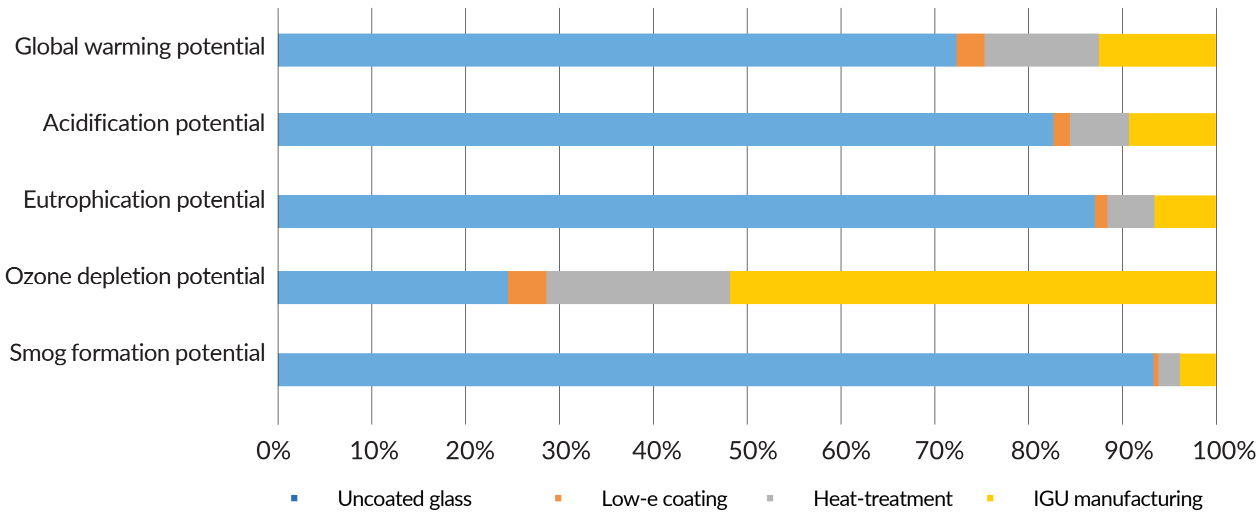
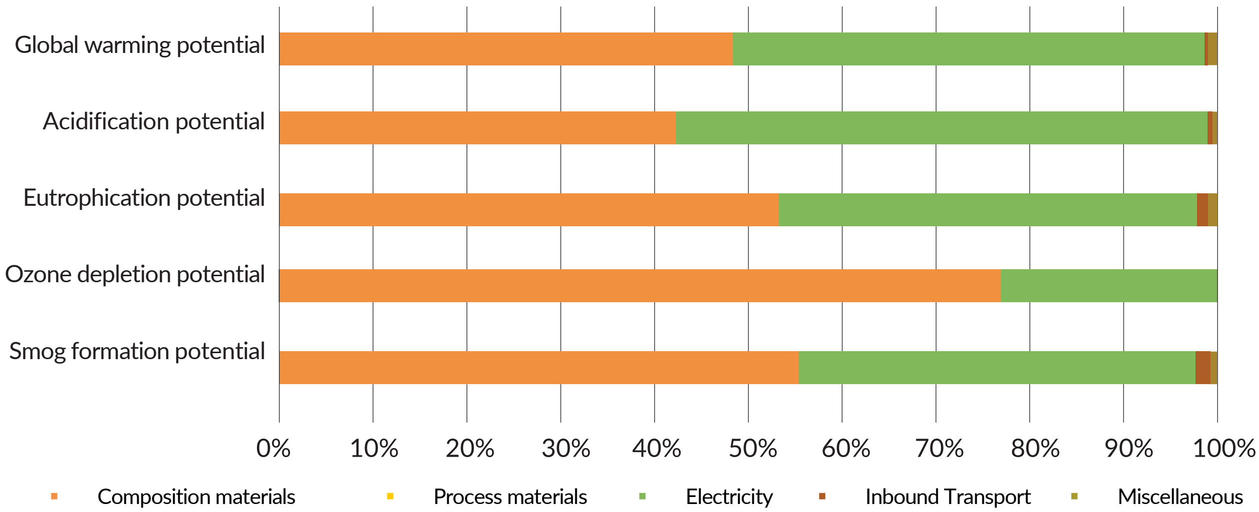


Figure 4: Relative contributions of uncoated glass production, low-e coating, heat-treatment,and IGU assembly for “average” triple-pane IGUs (TRACI 2.1)



Because IGU manufacturing contributes so significantly to many impact categories, this processing step (representedby the yellow bars in Figure 3 and Figure 4) is further broken down in Figure 5 into composition materials, process materials (negligible), electricity, inbound transport of raw materials and other miscellaneous inputs and outputs. Both electricity consumption and composition materials drive the IGU manufacturing process in all impact categories.

Figure 5: Relative contributions of materials, energy, transport and miscellaneous functions forIGU manufacturing (TRACI 2.1)



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 that 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 impactsof 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).

6. References

ANSI Z97.1-2015: Safety Glazing Materials Used in Building – Safety Performance Specifications and Methods of Test

ASTM C 1036: Standard Specification for Flat Glass

ASTM C 1376: Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass

CEN. (2013). *EN 15804:2013-05 Sustainability of construction works – Environmental Product Declarations – Core rules for the product category of construction products.*

CEN. (n.d.). *EN 15804:2013-05 Sustainability of construction works - Environmental Product Declarations - Core rulesfor the product category of construction products.*

CPSC 16CFR 1201: Safety Standard for Architectural Glazing Materials

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*

EN 572: Glass in Building. Basic soda lime silicate glass products. Float glass.EN

12898: Glass in building. Determination of the emissivity

EPA. (2012). *Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) - User'sManual. Washington, D.C.: US EPA.*

GANA. (2014) *DD 04-0114 – Recyclability of Architectural Glass Products Glass* Information Bulletin

GANA. (2014). *Product Category Rule for Environmental Product Declarations: GANA PCR for Flat Glass. US: NSF.*

Global Code of Ethics: *http://corporate.ppg.com/getmedia/0d11c0ab-8126-4832-850a-975e9eaa4fff/Code-of-Ethics-Bi-Fold_v9-LINKS-12-12-16-HiRes-Single-Pages.pdf.aspx*

Goedkoop, M., Heijungs, R., Huijbregts, M., De Schryver, A., Struijs, J., & Van Zelm, R. (2009). *ReCiPe 2008, A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level; First edition Report I: Characterisation. Retrieved from http://www.lcia-recipe.net.*

ISO. (2006). *ISO 14040: Environmental management - Life cycle assessment - Principles and framework. Geneva:International Organization for Standardization*.

ISO. (2006). *ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines*. Geneva: International Organization for Standardization.

ISO. (2007). *ISO 21930: Sustainability in building construction – Environmental declaration of building products.* Geneva: International Organization for Standardization.

ISO 9001: Quality Management System

Malaysia – MS 1135: Specification for Float Glass and Polished Plate

MS 2397: Coated Glass in Building - Specification

PPG Corporate Sustainability Report: *http://sustainability.ppg.com/Reporting/Reporting-Overview.aspx*

thinkstep. (2016). GaBi LCA Database Documentation. Retrieved from thinkstep AG: *http://www.gabi-software.com/international/databases/gabi-databases/*.

thinkstep. (2017). Float and Process Glass Products: Background Report in Support of Environmental Product Declarations. On behalf of Vitro Architectural Glass.

UL Environment. (2016). *PCR Guidance for Building-Related Products and Services Part B: Processed Glass EPDRequirements*. *ULE*.

Vitro Architectural Glass: Technical Document 138 (TD-138) Heat-Treated Glass for Architectural Glazing, *https://www.vitroglazings.com/media/acmdf3a5/vitro-td-138.pdf*

Vitro Architectural Glass: Technical Document 143 (TD-143) Vitro Flat Glass Glazing Products Information on: Ingredient Disclosure; Compliance with EU RoHS Directive; REACH Regulations; Conflict Minerals Reporting;and Safety Data Sheets, (Material Safety Data Sheets).: *https://www.vitroglazings.com/media/1n4j3pnh/vitro-td-143.pdf*

Vitro Architectural Glass: *VitroGlazings.com*

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

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

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