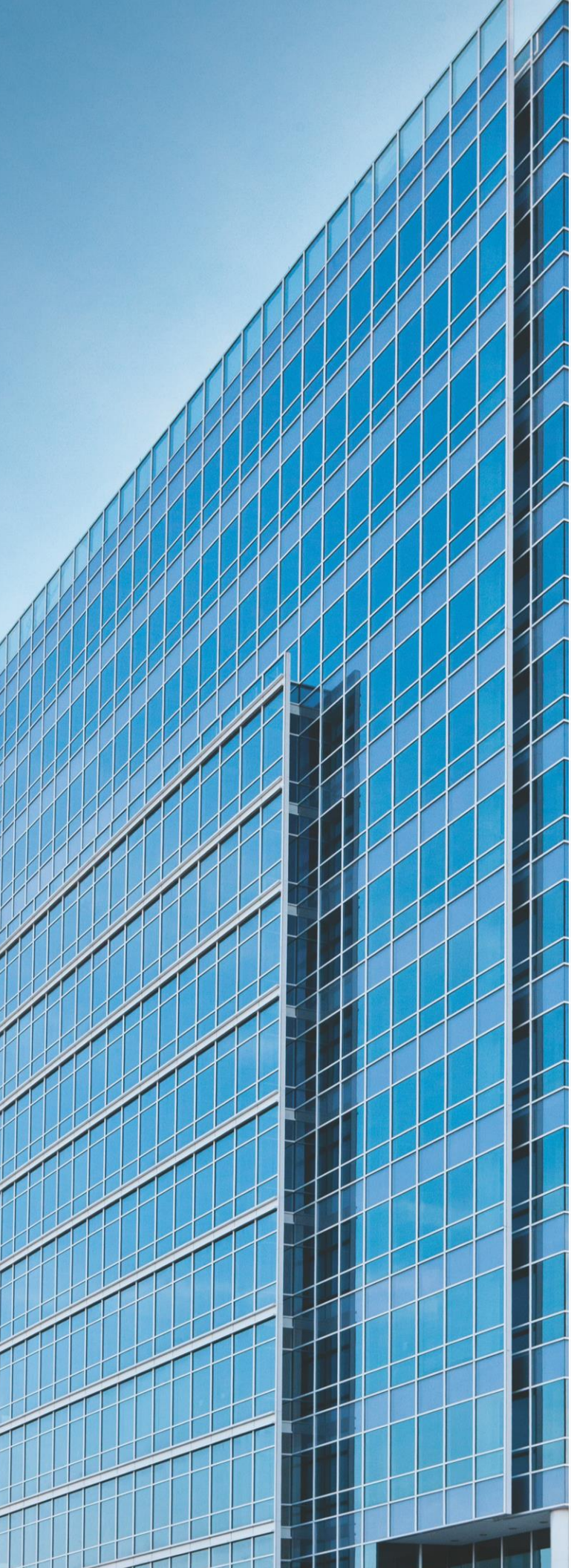

Vitro Architectural Glass

VERIFIED by SCS GLOBAL SERVICES ENVIRONMENTAL PRODUCT DECLARATION BASED ON LCA

Declaration Owner
Vitro Architectural Glass
400 Guys Run Road
Cheswick, PA 15024 USA
1-855-887-6457 | www.vitroglazings.com

Products
Vitro Processed Glass

Functional Unit
1 square meter (1 m^2)

EPD Number and Period of Validity
SCS-EPD-08787
EPD Valid March 23, 2023 through March 22, 2028
Version: June 14, 2023

Product Category Rule
UL PCR Guidelines for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2. 2018 UL Environment.
UL PCR Guidelines for Building-Related Products and Services Part B: Processed Glass EPD Requirements. Version 1.0. August 2016. (Extended to December 2023) UL Environment.

Program Operator
SCS Global Services
2000 Powell Street, Ste. 600, Emeryville, CA 94608
+1.510.452.8000 | www.SCSglobalServices.com

SCSglobal SERVICES

Declaration Owner:	Vitro Architectural Glass
Address:	400 Guys Run Road, Cheswick, PA 15024 USA
Declaration Number:	SCS-EPD-08787
Declaration Validity Period:	EPD Valid March 23, 2023 through March 22, 2028
Version:	June 14, 2023
Product:	Processed Glass
Program Operator:	SCS Global Services
Declaration URL Link:	https://www.scsglobalservices.com/certified-green-products-guide
LCA Practitioner:	Beth Cassese, LCACP, SCS Global Services
LCA Software:	OpenLCA 1.11, ecoinvent v3.8
Independent critical review of the LCA and data, according to ISO 14044, ISO 21930 and ISO 14071	☐ internal ☒ external
LCA Reviewer:	Lindita Bushi, Ph.D., Athena Sustainable Materials Institute
Product Category Rule:	UL PCR Guidelines for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2. 2018 UL PCR Guidelines for Building-Related Products and Services Part B: Processed Glass EPD Requirements. Version 1.0. August 2016, extended to December 2023.
Part B PCR Review conducted by:	Jack Geibig, Ecoform; Thomas P. Gloria, Ph.D., Industrial Ecology Consultants; Bill Stough, Sustainable Resource Group
Independent verification of the declaration and data, according to ISO 14025, ISO 21930 and the PCR	☐ internal ☒ external
EPD Verifier:	Lindita Bushi, Ph.D., Athena Sustainable Materials Institute
Declaration Contents:	

Disclaimers: *This EPD conforms to ISO 14025, 14040, 14044, and 21930.*

Scope of Results Reported: *The PCR requirements limit the scope of the LCA metrics such that the results exclude environmental and social performance benchmarks and thresholds, and exclude impacts from the depletion of natural resources, land use ecological impacts, ocean impacts related to greenhouse gas emissions, risks from hazardous wastes and impacts linked to hazardous chemical emissions.*

Accuracy of Results: *Due to PCR constraints, this EPD provides estimations of potential impacts that are inherently limited in terms of accuracy.*

Comparability: *The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.*

In accordance with ISO 21930:2017, EPDs are comparable only if they comply with the core PCR, use the same sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

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1. About Vitro

Vitro Architectural Glass (Vitro) 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. Processed glass is produced exclusively at the Carlisle, Wichita Falls, and Salem facilities, and the Insulating Glass Unit (IGU) products are manufactured only at the Carlisle, PA location.

2. Product

2.1 Product Description

Vitro processed glass is glass that has been coated, heat-treated, or combined to form multi-pane insulating glass unit products. 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. IGU products are available in double or triple pane options that include 2-3 panes of glass, either flat or processed, with steel spacers between the panes. 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. The various processed glass products included in this EPD are listed and described below.

- Solarban® 60 solar control low-e glass
- Solarban® 67 solar control low-e glass
- Solarban® 70 solar control low-e glass
- Solarban® 72 solar control low-e glass
- Solarban® R77 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
- Herculite® tempered glass
- Clarvista® shower glass
- Double-Pane IGU
- Triple-Pane IG

Table 1. *Processed Glass Product Descriptions.*

Product Type	Description	Vitro Product
Reflective Glass	Flat glass coated with reflective coating	Vistacool® glass Solarcool ®glass
Low-E Coated Glass	Flat glass vacuum-coated with low-emissivity coating	Solarban® glass Sungate® glass
Non-Low-E Coated Glass	Flat glass vacuum-coated with non-low-emissivity coating	Clarvista® glass
Heat-Treated Glass	Flat, coated, or reflective glass that is heat treated for increased durability	Herculite® glass
Double-Pane IGU	An Insulating Glass Unit (IGU) assembly comprised of two "average" glass panes and one spacer. An "average" pane is comprised of a production-weighted average of flat glass and various processed glass.	
Triple-Pane IGU	An Insulating Glass Unit (IGU) assembly comprised of three "average" glass panes and two spacers. An "average" pane is comprised of a production-weighted average of flat glass and various processed glass.	

The UNSPSC codes for processed glass products are 30171705 (laminated glass), 30171706 (tempered glass), and 30171710 (insulating glass). The CSI code for processed glass products in 08 81 00 (glass glazing).

2.2 Application

The Vitro processed glass products are intended primarily for interior and exterior applications for commercial and residential building projects.

2.3 Methodological Framework

This EPD is a cradle-to-gate, including the life cycle stages for raw material extraction and processing, raw material transport, and manufacture including packaging. This EPD follows the attributional LCA approach.

2.3 Technical Data

Vitro Architectural Glass products can be combined in a vast array of configurations, including 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.

2.4 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
- EN 572: Glass in Building. Basic soda lime silicate glass products. Float glass.
- Malaysia – MS 1135: Specification for Float Glass and Polished Plate
- ASTM C 1376: Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass
- CPSC 16CFR 1201: Safety Standard for Architectural Glazing Materials
- ANSI Z97.1: Standard for Safety Glazing Materials Used in Buildings
- EN 12898: Glass in building. Determination of the emissivity
- MS 2397: Coated Glass in Building - Specification

Safety Glazing Certification Council (SGCC) certifications are available upon request.

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2.5 Properties of Declared Product as Delivered

Vitro processed 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″)

2.6 Base Materials

The primary materials include flat glass and metal coatings. IGU products also include spacer materials.

Table 2. *Material composition summary for Vitro processed glass and IGU products per square meter.*

Materials	Processed Glass (Coated)	
	kg/m²	Percent
Flat glass	14.99	99.97%
Proprietary mixed metals	0.005	0.03%
Total:	**15.0**	**100%**

Materials	Double-Pane IGU		Triple-Pane IGU	
	kg/m²	Percent	kg/m²	Percent
Flat glass	17.1	55.7%	25.7	55.7%
Coated/Treated glass	12.1	39.3%	18.1	39.3%
Sealant	0.451	1.5%	0.678	1.5%
Stainless steel	0.412	1.3%	0.618	1.3%
Desiccant	0.346	1.1%	0.519	1.1%
Steel coil	0.302	0.98%	0.453	0.98%
Aluminum	0.024	0.08%	0.037	0.08%
Argon	0.0008	0.002%	0.002	0.002%
Total:	**30.7**	**100%**	**46.1**	**100%**

2.7 Manufacture

The processed glass manufacturing process begins with a completed pane of clear or tinted flat glass. The flat glass is coated with various metals and/or heated for additional energy efficiency and durability. Coated or heat-treated products are then either packaged and shipped for distribution or used for further processing into IGUs (Carlisle facility, only). The IGU products use 2 or 3 panes of flat or processed glass, separated by a steel and aluminum spacer with an air or argon fill. A description of the available coating or heat-treatment processes is included below along with a diagram of the manufacturing process.

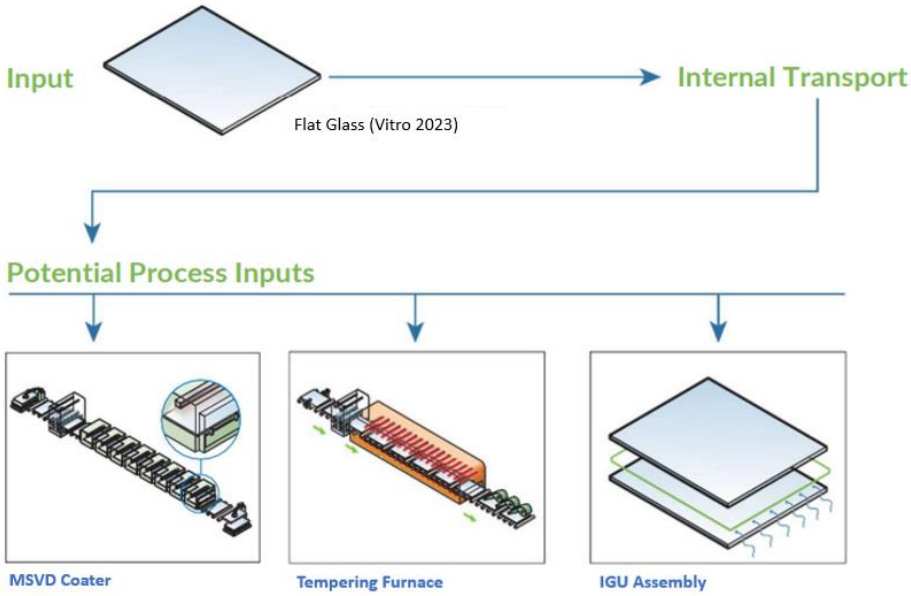
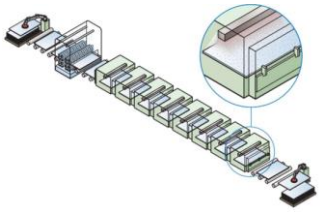
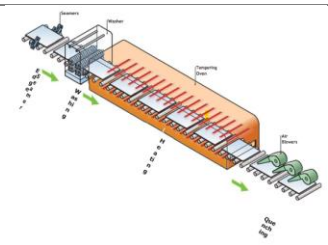


Figure 1. *Vitro processed glass manufacturing process.*

Table 3. *Vitro coating and heat treatment process descriptions.*

	**MSVD Coater (magnetron-sputtered vacuum deposition):** 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.
	**Tempering Furnace (Heat-Strengthening or Tempering):** Glass is heated to approximately 1,200°F, then force-cooled to create surface and edge compression. When the surface compression is between 3,500 and 7,500 psi, the glass is considered heat-strengthened. When greater than or equal to 10,000 psi, it is considered tempered. Both processes produce a product that is more resistant to certain types of breakage.

2.8 Environment and Health During Manufacture

No environmental or health impacts are expected during the manufacture of the product.

2.9 Product Processing/Installation

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

2.10 Packaging

The processed glass packaging materials are listed below in kg/m^2 of final product.

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Table 4. *Vitro processed glass packaging summary (kg per square meter).*

Packaging Material	Processed (Coated/Heat Treated)	Double-Pane IGU	Triple-Pane IGU
Cellulose Board	0.057	0.095	0.142
EPS Foam	0.023	0.063	0.095
Cardboard	0.012	0.043	0.064
Wood	0.045	0.028	0.042
Rubber	0.002	0.007	0.010
Plastic	0.007	0.007	0.010
Foam	0.016	0.005	0.007
Steel	0.001	0.005	0.007
LX Powder	0.001	0.003	0.004
Desiccant	0.002	0.0004	0.0005
Tape	0.001	0.0003	0.0004
Aluminized Bag	0.0001	0.0001	0.0002
Total Packaging:	**0.167**	**0.255**	**0.384**

2.11 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.

2.12 Environment and Health During Use

No environmental or health impacts are expected due to normal use of the products.

2.13 Extraordinary Effects

No environmental or health impacts are expected due to extraordinary effects including fire and/or water damage and unforeseeable mechanical destruction.

2.14 Re-Use Phase

Vitro glass products offer multiple options for reuse and repurposing after deconstruction, including 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) is a valuable feedstock in the production of glass, as it greatly reduces the demand for virgin materials. The use of cullet also lowers the melting temperature for batch materials, which reduces energy consumption.

2.15 Disposal

Glass is not regarded as a hazardous material, so it may be disposed via typical, non-hazardous waste stream classifications and disposable routes; however, Vitro Architectural 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 then introducing the product into the waste stream.

2.16 Further Information

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

3. LCA: Calculation Rules

3.1 Declared Unit

According to ISO 14044, the functional/declared unit is "the quantified performance of a product system, for use as a reference unit." According to the PCR, the declared unit applicable to processed glass products, is 1 square meter.

Table 5. *Vitro processed glass declared unit summary.*

	Unit	Processed (Coated/Heat Treated)	Double-Pane IGU	Triple-Pane IGU
Declared Unit	m^2	1	1	1
Mass	kg	15.0	30.7	46.1
Conversion factor to 1kg		0.067	0.033	0.022
Thickness	mm	6.0	12.0	18.0
Interlayer percent mass	%	n/a	4.7	6.2

3.2 System Boundary

The scope of the EPD is cradle-to-gate, including raw material extraction and processing, transportation, and product manufacture.

Table 6. *Vitro processed glass system boundary summary.*

Product			Construction Process		Use							End-of-life				Benefits and loads beyond the system boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material extraction and processing	Transport to manufacturer	Manufacturing	Transport	Construction - installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction demolition	Transport	Waste processing	Disposal	Reuse, recovery and/or recycling potential
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = Included in system boundary | MND = Module not declared

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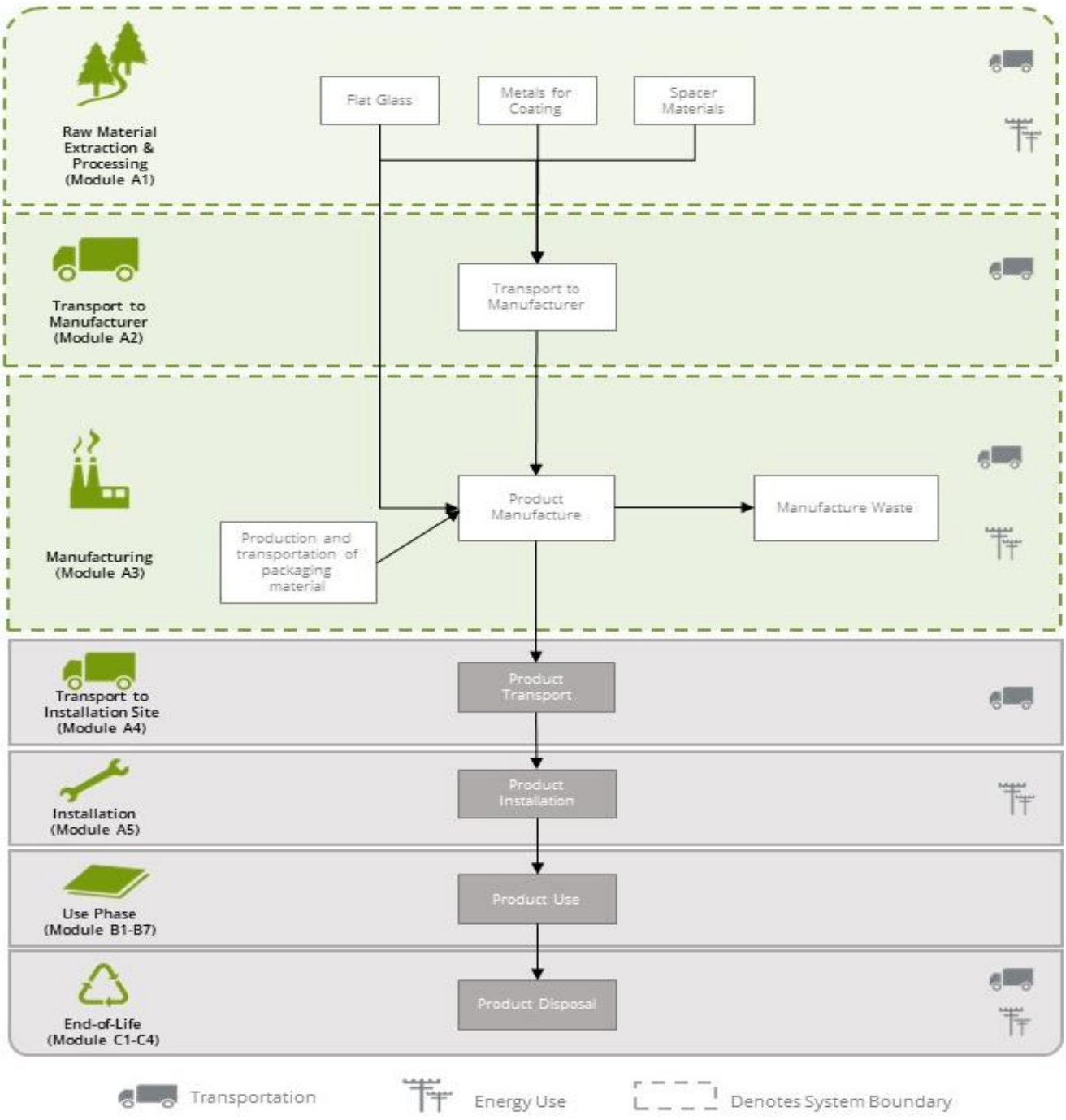

Figure 2. *Vitro processed glass system boundary.*

3.3 Estimates and Assumptions

Vitro supplied data for its supply chain including material supplier, consumption (usage), and supplier locations; however, several suppliers do not have supplier specific data.

- Specific data were not available on the desiccant used in the product recipe and packaging material. A secondary dataset for activated silica was used from the Ecoinvent database.
- Specific data were not available on the LX powder used as packaging material. A secondary dataset for acrylic filler was used from the Ecoinvent database.
- Specific data were not available on the aluminized bag used as packaging material. A secondary dataset for packaging film was used from the Ecoinvent database.
- Manufacture waste to waste/scrap facilities is assumed to be 50km by truck.
- Packaging data from the Salem facility was not available. An average of the packaging inputs of the Carlisle and Wichita Falls facilities was used for the Salem inputs.
- Spacer material for the IGU products manufactured at Carlisle was not available. The per functional unit spacer data from the 2017 Vitro Float and Processed Glass LCA was used for the current study.

3.4 Cut-off criteria

According to the PCR, processes contributing greater than 1% of the total environmental impact indicator for each impact are included in the inventory. No data gaps were allowed which were expected to significantly affect the outcome of the indicator results. No known flows are deliberately excluded from this EPD.

3.5 Background Data

Primary data were provided by Vitro for the Carlisle, Salem, and Wichita Falls manufacturing facilities. The sources of secondary LCI data are the Ecoinvent database.

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Table 7. *Vitro processed glass model datasets.*

Component	Dataset	Geographic Coverage	Data Source	Publication Date
Product Materials				
Aluminum	sheet rolling, aluminium | sheet rolling, aluminium | Cutoff, U	RoW‡	Ecoinvent 3.8	2021
	aluminium production, primary, ingot | aluminium, primary, ingot | Cutoff, U	RoW	Ecoinvent 3.8	2021
Argon	market for argon, liquid | argon, liquid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Desiccant	market for activated silica | activated silica | Cutoff, U	Global	Ecoinvent 3.8	2021
Flat glass	Vitro flat glass LCA	North America	SCS	2023
Sealant	market for polyurethane adhesive | polyurethane adhesive | Cutoff, U	Global	Ecoinvent 3.8	2021
Silver	market for silver | silver | Cutoff, U	Global	Ecoinvent 3.8	2021
Stainless steel	market for steel, chromium steel 18/8 | steel, chromium steel 18/8 | Cutoff, U	Global	Ecoinvent 3.8	2021
Steel coil	market for wire drawing, steel | wire drawing, steel | Cutoff, U - GLO	Global	Ecoinvent 3.8	2021
	steel production, low-alloyed, hot rolled | steel, low-alloyed, hot rolled | Cutoff	RoW	Ecoinvent 3.8	2021
Tin	market for tin concentrate | tin concentrate | Cutoff, U	Global	Ecoinvent 3.8	2021
Titanium	market for titanium | titanium | Cutoff, U	Global	Ecoinvent 3.8	2021
Zinc	market for zinc | zinc | Cutoff, U	Global	Ecoinvent 3.8	2021
Package Materials				
Aluminized bag	market for packaging film, low density polyethylene | packaging film, low density polyethylene | Cutoff, U	Global	Ecoinvent 3.8	2021
Cardboard	market for corrugated board box | corrugated board box | Cutoff, U	RoW	Ecoinvent 3.8	2021
cellulose fiber board	market for cellulose fibre | cellulose fibre | Cutoff, U	RoW	Ecoinvent 3.8	2021
Desicant	market for activated silica | activated silica | Cutoff, U	Global	Ecoinvent 3.8	2021
EPS Foam	market for polystyrene, expandable | polystyrene, expandable | Cutoff, U	Global	Ecoinvent 3.8	2021
Foam	market for polyurethane, flexible foam | polyurethane, flexible foam | Cutoff, U	RoW	Ecoinvent 3.8	2021
LX	market for acrylic filler | acrylic filler | Cutoff, U	RoW	Ecoinvent 3.8	2021
Plastic	market for polypropylene, granulate | polypropylene, granulate | Cutoff, U	Global	Ecoinvent 3.8	2021
Rubber	market for synthetic rubber | synthetic rubber | Cutoff, U	Global	Ecoinvent 3.8	2021
Steel	market for hot rolling, steel | hot rolling, steel | Cutoff, U	Global	Ecoinvent 3.8	2021
Tape	market for polyurethane adhesive | polyurethane adhesive | Cutoff, U	Global	Ecoinvent 3.8	2021
Wood	market for sawnwood, beam, softwood, dried (u=20%), planed | sawnwood, beam, softwood, dried (u=20%), planed | Cutoff, U	RoW	Ecoinvent 3.8	2021
Transportation				
Train	market for transport, freight train | transport, freight train | Cutoff, U	United States	Ecoinvent 3.8	2021
Truck	market for transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U	RoW	Ecoinvent 3.8	2021
Ship	market for transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, U	Global	Ecoinvent 3.8	2021
Manufacture				
Carlisle Electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U	RFCE sub-region	EPA	2018-2019
Salem Electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U	NWPP sub-region	EPA	2018-2019
Wichita Falls Electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U	ERCT sub-region	EPA	2018-2019
Diesel	market for diesel | diesel | Cutoff, U	RoW	Ecoinvent 3.8	2021
Gasoline	market for petrol, unleaded | petrol, unleaded | Cutoff, U	RoW	Ecoinvent 3.8	2021
Natural Gas	heat production, natural gas, at industrial furnace >100kW | heat, district or industrial, natural gas | Cutoff, U	RoW	Ecoinvent 3.8	2021
Propane	market for propane | propane | Cutoff, U	Global	Ecoinvent 3.8	2021
Water	market for tap water | tap water | Cutoff, U	RoW	Ecoinvent 3.8	2021
Hazardous waste	market for hazardous waste, for incineration | hazardous waste, for incineration | Cutoff, U	RoW	Ecoinvent 3.8	2021
Landfill waste	market for inert waste, for final disposal | inert waste, for final disposal | Cutoff, U	RoW	Ecoinvent 3.8	2021
Wastewater	market for wastewater from glass production | wastewater from glass production | Cutoff, U	Global	Ecoinvent 3.8	2021

‡Rest of World

3.6 Data Quality

The data quality assessment addressed the following parameters: time-related coverage, geographical coverage, technological coverage, precision, completeness, representativeness, consistency, reproducibility, sources of data, and uncertainty.

Table 8. *Data quality assessment.*

Data Quality Parameter	Data Quality Discussion
Time-related Coverage: Age of data and the minimum length of time over which data is collected	The manufacturer provided primary data on product manufacturing for the Carlisle, PA, Salem, OR, and Wichita Falls, TX facilities on annual production for 2018 and 2019. Representative datasets (secondary data) for upstream and background processes are generally less than 5 years old. Data for the spacer materials at the Carlisle facility are used from the previous 2017 study and is less than 10 years old.
Geographical Coverage: Geographical area from which data for unit processes is collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Electricity use for product manufacture is modeled using representative data modelled for the specific EPA eGRID subregion of each facility represented in this study. Surrogate data used in the assessment are representative of global or European operations and are considered sufficiently similar to actual processes.
Technology Coverage: Specific technology or technology mix	For the most part, data are representative of the actual technologies used for processing, transportation, and manufacturing operations. Representative component datasets, specific to the type of material, are used to represent the actual processes, as appropriate.
Precision: Measure of the variability of the data values for each data expressed	Precision of results are not quantified due to a lack of data. Data collected for operations were typically averaged for one more years and over multiple operations, which is expected to reduce the variability of results.
Completeness: Percentage of flow that is measured or estimated	The LCA model included all known mass and energy flows for production of the products. In some instances, surrogate data used to represent upstream and downstream operations may be missing some data which is propagated in the model. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded.
Representativeness: Qualitative assessment of the degree to which the data set reflects the true population of interest	Data used in the assessment represent typical or average processes as currently reported from multiple data sources and are therefore generally representative of the range of actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis; however, such a determination would require detailed data collection throughout the supply chain back to resource extraction.
Consistency: Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent v3.8 data where available. Different portions of the product life cycle are equally considered.
Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of the data and assumptions used, this assessment would be reproducible by other practitioners. All assumptions, models, and data sources are documented.
Sources of the Data: Description of all primary and secondary data sources	Data representing energy use at the manufacturing facility represents a 24-month average and is considered of high quality due to the length of time over which these data are collected, as compared to a snapshot that may not accurately reflect fluctuations in production. For secondary LCI data, Ecoinvent v3.8 data are used.
Uncertainty of the Information: Uncertainty related to data, models, and assumptions	Uncertainty related to materials in the products and packaging is low. Actual supplier data for upstream operations was not available for all suppliers and the study relied upon the use of existing representative datasets. These datasets contained relatively recent data (<10 years) but lacked geographical representativeness. Uncertainty related to the impact assessment methods used in the study are high. The impact assessment methodology includes impact potentials, which lack characterization of providing and receiving environments or tipping points.

3.7 Period under review

The period of review is calendar year 2018 and 2019.

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3.8 Allocation

This study follows the allocation guidelines of ISO 14044 and sought to minimize the use of allocation wherever possible. In general, manufacturing facilities may produce multiple products, and in such cases, it is necessary to divide the environmental impacts between the different products. Product and manufacture experts from Vitro recommended specific allocation between flat glass and processed glass for a number of the manufacture resources and the remaining resources were allocated based on mass of total production at the facilities. Impacts from transportation were allocated based on the mass of material and distance transported.

Table 9. *Vitro manufacturing allocation summary.*

Resource to be Allocated	Allocation Method
Electricity	Mass-based allocation across all glass product types.
Natural gas	Only applicable to flat glass manufacture.
Propane	Mass-based allocation across all glass product types.
Diesel	Mass-based allocation across all glass product types.
Gasoline	Mass-based allocation across all glass product types.
Water	Only applicable to flat glass manufacture.
LX Powder	Only applicable to flat glass manufacture.
Tin	Only applicable to flat glass manufacture.
Sulfur Dioxide	Mass-based allocation across flat glass and heat-treated glass only.
Aqueous ammonia	Only applicable to flat glass manufacture, and only used in Carlisle.
Nitrogen	Only applicable to flat glass manufacture.
Hydrogen	Only applicable to flat glass manufacture.
Oxygen	Mass-based allocation across flat glass and vacuum-coated glass only.
Sulfuric Acid	Only applicable to flat glass manufacture.
Emissions	Only applicable to flat glass manufacture.
Manufacture waste	Mass-based allocation across all glass product types.

3.9 Average Product

All three of the processed glass manufacturing sites share the same raw materials and manufacturing process. An average processed glass product (coated/heat treated) was calculated using a weighted average of production at the three manufacturing facilities, based on the total mass of processed glass produced at each facility. The IGU products are only manufactured at the Carlisle facility and required no averaging.

3.10 Comparability

The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.

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

Full conformance with the PCR for processed glass allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category Part B PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible.

4. LCA: Results

Results of the Life Cycle Assessment are presented below. It is noted that LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. All values in the tables below are rounded to three significant digits. The results in the tables below are for the average Vitro processed glass and IGU products. The following impact indicators, specified by the PCR, are reported below:

Table 10. *Environmental impact categories and characterization methods*.

Impact Category	Unit	Characterization Method
Global Warming Potential (GWP 100 TRACI)	kg CO_2 eq	TRACI
Global Warming Potential (GWP 100 CML)	kg CO_2 eq	CML
Ozone Depletion Potential (ODP)	kg CFC 11 eq	TRACI
Eutrophication Potential (EP)	kg N eq	TRACI
Acidification Potential (AP)	kg SO2 eq	TRACI
Smog Formation Potential (SFP)	kg O_3 eq	TRACI
Abiotic Resource Depletion Potential – elements (ADP-E)	kg Fe eq	ReCiPe
Abiotic Resource Depletion Potential – fossil (ADP-F)	MJ surplus, LHV	CML

These impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development, however the EPD users shall not use additional measures for comparative purposes.

ISO 21930 and the PCR require that several other parameters be reported, including resource use, and waste categories and output flows. Many of these additional parameters seek to classify resources and materials with respect to their use as raw materials for the product. Elementary flows related to land occupation were not included. As processed glass products do not contain bio-based materials, biogenic carbon emissions and removals are not declared.

Table 11. *Resource use indicators.*

Resource Use	Unit
RPR_E: Renewable primary resources used as energy carrier (fuel)	MJ, LHV
RPR_M: Renewable primary resources with energy content used as material	MJ, LHV
RPR_T: Total use of renewable primary energy resources	MJ, LHV
$NRPR_E$: Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV
$NRPR_M$: Non-renewable primary resources with energy content used as material	MJ, LHV
$NRPR_T$: Total use of non-renewable primary energy resources	MJ, LHV
SM: Secondary materials	MJ, LHV
RSF: Renewable secondary fuels	MJ, LHV
NRSF: Non-renewable secondary fuels	MJ, LHV
RE: Recovered energy	MJ, LHV
FW: Use of net freshwater resources	m^3

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Table 12. *Waste and output flow indicators.*

Waste and Outflows	Unit
HWD: Hazardous waste disposed	kg
NHWD: Non-hazardous waste disposed	kg
RWD: High-level, intermediate, and low-level radioactive waste, conditioned, to final repository	kg
CRU: Components for re-use	kg
MR: Materials for recycling	kg
MER: Materials for energy recovery	kg
EE: Recovered energy exported from the product system	MJ, LHV

Processed Glass Results (Coated/Heat Treated)

Table 13. *Vitro processed glass environmental impact potential results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
GWP 100 TRACI	kg CO_2 eq	21.2	0.212	0.530	3.41	**25.4**
GWP 100 CML	kg CO_2 eq	21.4	0.213	0.531	3.44	**25.5**
ODP	kg CFC-11 eq	$2.05x10^{-6}$	$2.08x10^{-8}$	$1.23x10^{-7}$	$2.64x10^{-7}$	**$2.46x10^{-6}$**
AP	kg SO_2 eq	0.172	0.002	0.002	0.009	**0.186**
EP	kg N eq	0.046	0.004	$5.80x10^{-4}$	0.024	**0.074**
SFP	kg O_3 eq	4.07	0.041	0.058	0.090	**4.26**
ADP-E	kg Fe eq	2.53	1.84	0.020	0.061	**4.45**
ADP-F	MJ surplus, LHV	298	2.45	7.86	42.5	**350**

Table 14. *Vitro processed glass resource use indicator results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
RPR_E	MJ, LHV	14.0	0.273	0.092	8.23	**22.6**
RPR_M	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
RPR_T	MJ, LHV	14.0	0.273	0.092	8.23	**22.6**
$NRPR_E$	MJ, LHV	321	2.83	7.96	57.2	**389**
$NRPR_M$	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
$NRPR_T$	MJ, LHV	321	2.83	7.96	57.2	**389**
SM	kg	0.00	0.00	0.00	0.00	**0.00**
RSF	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
NRSF	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
RE	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
FW	m^3	0.182	0.002	$9.10x10^{-4}$	0.090	**0.275**

Table 15. *Vitro processed glass waste and output flow indicator results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
HWD	kg	0.00	0.00	0.00	0.011	**0.011**
NHWD	kg	0.00	0.00	0.00	0.034	**0.034**
HRWD	kg	0.00	0.00	0.00	0.00	**0.00**
ILRWD	kg	0.00	0.00	0.00	0.00	**0.00**
CRU	kg	0.00	0.00	0.00	0.00	**0.00**
MR	kg	0.00	0.00	0.00	0.806	**0.806**
MER	kg	0.00	0.00	0.00	0.00	**0.00**
EE	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**

Double-Pane IGU Results

Table 16. *Vitro double-pane IGU environmental impact potential results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
GWP 100 TRACI	kg CO_2 eq	43.5	5.58	0.091	6.49	**55.7**
GWP 100 CML	kg CO_2 eq	43.8	5.62	0.092	6.54	**56.1**
ODP	kg CFC-11 eq	$4.63x10^{-6}$	$5.01x10^{-7}$	$2.12x10^{-8}$	$5.88x10^{-7}$	**$5.74x10^{-6}$**
AP	kg SO_2 eq	0.376	0.027	$4.20x10^{-4}$	0.018	**0.422**
EP	kg N eq	0.062	0.028	$9.99x10^{-5}$	0.017	**0.107**
SFP	kg O_3 eq	9.26	0.361	0.010	0.186	**9.82**
ADP-E	kg Fe eq	3.47	4.66	0.003	0.112	**8.24**
ADP-F	MJ surplus, LHV	633	70.2	1.36	81.6	**786**

**A1 – Flat Glass includes any flat glass used in the processed glass portion of the IGU, as well as the flat glass portion of the IGU.*

Table 17. *Vitro double-pane IGU resource use indicator results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
RPR_E	MJ, LHV	14.9	9.43	0.016	7.65	**32.0**
RPR_M	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
RPR_T	MJ, LHV	14.9	9.43	0.016	7.65	**32.0**
$NRPR_E$	MJ, LHV	719	102	1.37	162	**984**
$NRPR_M$	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
$NRPR_T$	MJ, LHV	719	102	1.37	162	**984**
SM	kg	0.00	0.00	0.00	0.00	**0.00**
RSF	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
NRSF	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
RE	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
FW	m^3	0.275	0.063	$1.60x10^{-4}$	0.042	**0.380**

**A1 – Flat Glass includes any flat glass used in the processed glass portion of the IGU, as well as the flat glass portion of the IGU.*

Table 18. *Vitro double-pane IGU waste and output flow indicator results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
HWD	kg	0.00	0.00	0.00	0.077	**0.077**
NHWD	kg	0.00	0.00	0.00	0.004	**0.004**
HRWD	kg	0.00	0.00	0.00	0.00	**0.00**
ILRWD	kg	0.00	0.00	0.00	0.00	**0.00**
CRU	kg	0.00	0.00	0.00	0.00	**0.00**
MR	kg	0.00	0.00	0.00	0.409	**0.409**
MER	kg	0.00	0.00	0.00	0.00	**0.00**
EE	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**

**A1 – Flat Glass includes any flat glass used in the processed glass portion of the IGU, as well as the flat glass portion of the IGU.*

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Triple-Pane IGU Results

Table 19. *Vitro triple-pane IGU environmental impact potential results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
GWP 100 TRACI	kg CO_2 eq	65.4	9.89	0.183	10.3	**85.8**
GWP 100 CML	kg CO_2 eq	65.9	10.0	0.183	10.4	**86.4**
ODP	kg CFC-11 eq	$6.96x10^{-6}$	$8.82x10^{-7}$	$4.24x10^{-8}$	$1.76x10^{-6}$	**$9.65x10^{-6}$**
AP	kg SO_2 eq	0.566	0.050	$8.30x10^{-4}$	0.032	**0.648**
EP	kg N eq	0.093	0.047	$2.00x10^{-4}$	0.028	**0.168**
SFP	kg O_3 eq	13.9	0.641	0.020	0.330	**14.9**
ADP-E	kg Fe eq	5.21	8.03	0.007	0.188	**13.4**
ADP-F	MJ surplus, LHV	952	125	2.71	173	**1250**

**A1 – Flat Glass includes any flat glass used in the processed glass portion of the IGU, as well as the flat glass portion of the IGU.*

Table 20. *Vitro triple-pane IGU resource use indicator results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
RPR_E	MJ, LHV	25.8	13.0	0.032	11.8	**50.7**
RPR_M	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
RPR_T	MJ, LHV	25.8	13.0	0.032	11.8	**50.7**
$NRPR_E$	MJ, LHV	1080	174	2.75	295	**1550**
$NRPR_M$	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
$NRPR_T$	MJ, LHV	1080	174	2.75	295	**1550**
SM	kg	0.00	0.00	0.00	0.00	**0.00**
RSF	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
NRSF	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
RE	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**
FW	m^3	0.413	0.118	$3.10x10^{-4}$	0.064	**0.596**

**A1 – Flat Glass includes any flat glass used in the processed glass portion of the IGU, as well as the flat glass portion of the IGU.*

Table 21. *Vitro triple-pane IGU waste and output flow indicator results, per square meter.*

Indicator	Unit	A1 – Flat Glass	A1 – Other	A2	A3	Total A1-A3
HWD	kg	0.00	0.00	0.00	0.117	**0.117**
NHWD	kg	0.00	0.00	0.00	0.006	**0.006**
HRWD	kg	0.00	0.00	0.00	0.00	**0.00**
ILRWD	kg	0.00	0.00	0.00	0.00	**0.00**
CRU	kg	0.00	0.00	0.00	0.00	**0.00**
MR	kg	0.00	0.00	0.00	0.619	**0.619**
MER	kg	0.00	0.00	0.00	0.00	**0.00**
EE	MJ, LHV	0.00	0.00	0.00	0.00	**0.00**

**A1 – Flat Glass includes any flat glass used in the processed glass portion of the IGU, as well as the flat glass portion of the IGU.*

6. LCA: Interpretation

The interpretation included the use of evaluation and sensitivity checks to steer the iterative process during the assessment, and a final evaluation including completeness, sensitivity, and consistency checks, at the end of the study.

The contribution to total indicator impacts for the Vitro processed glass products are dominated by the raw material phase. Within the raw material phase, the flat glass accounts for the majority of the impacts, and the additional spacer material also significantly contributing to impacts for the IGU products.

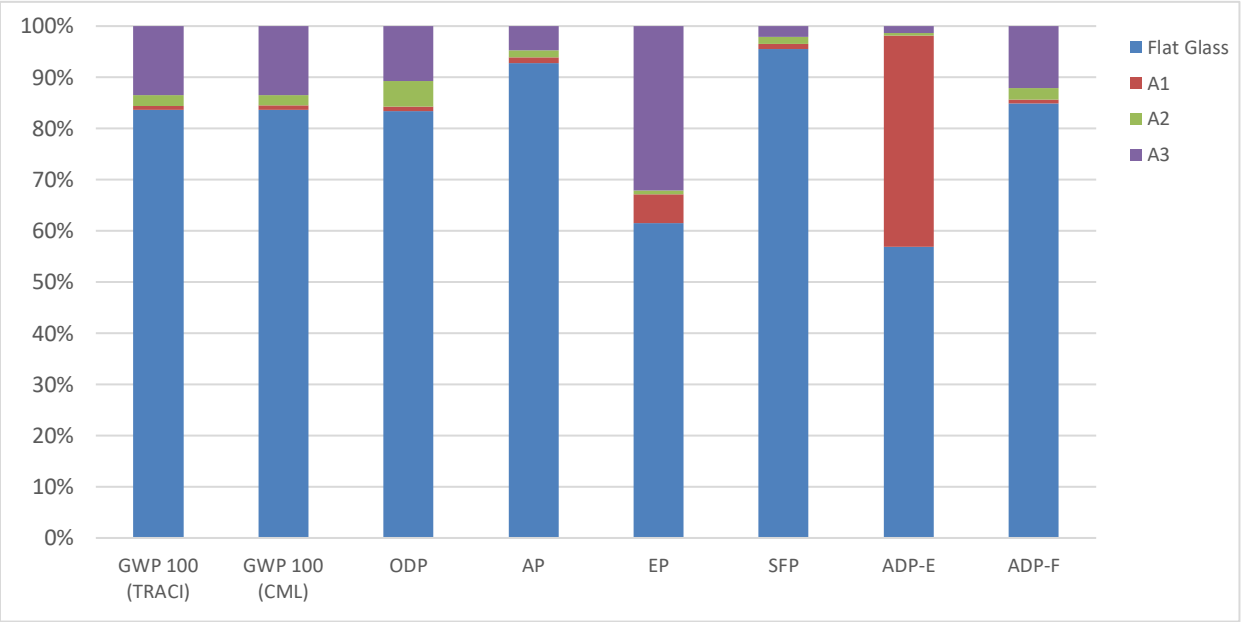

Figure 3. *Cradle-to-gate contribution analysis for Vitro processed glass products.*

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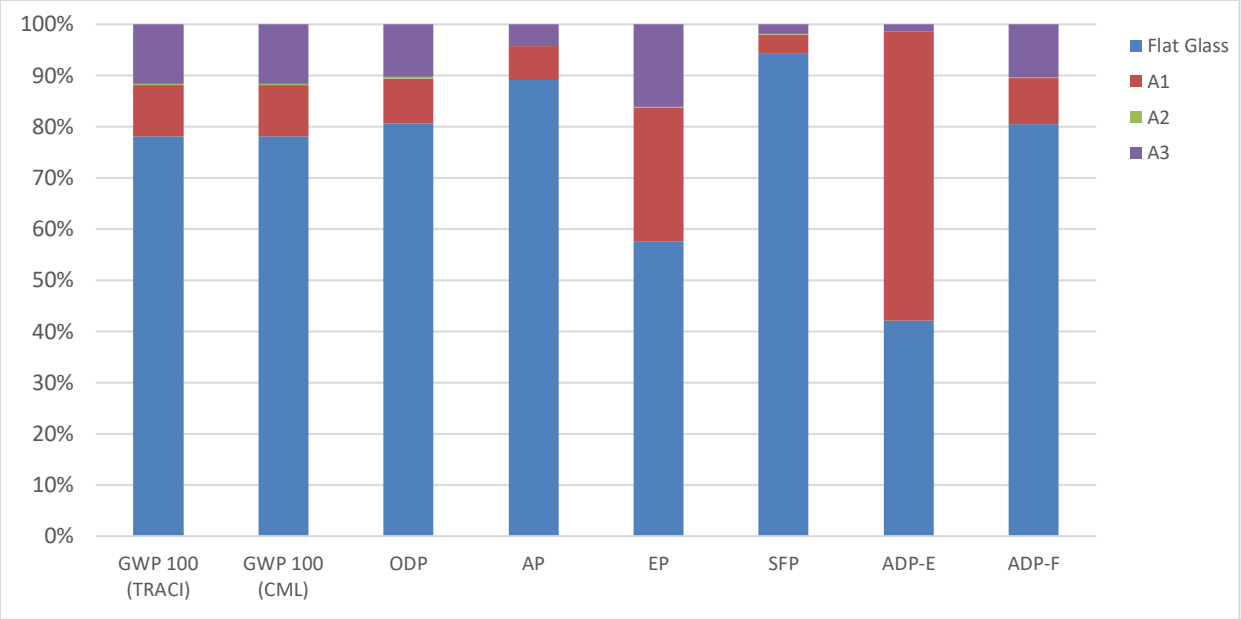

Figure 4. *Cradle-to-gate contribution analysis for Vitro double-pane IGU products.*

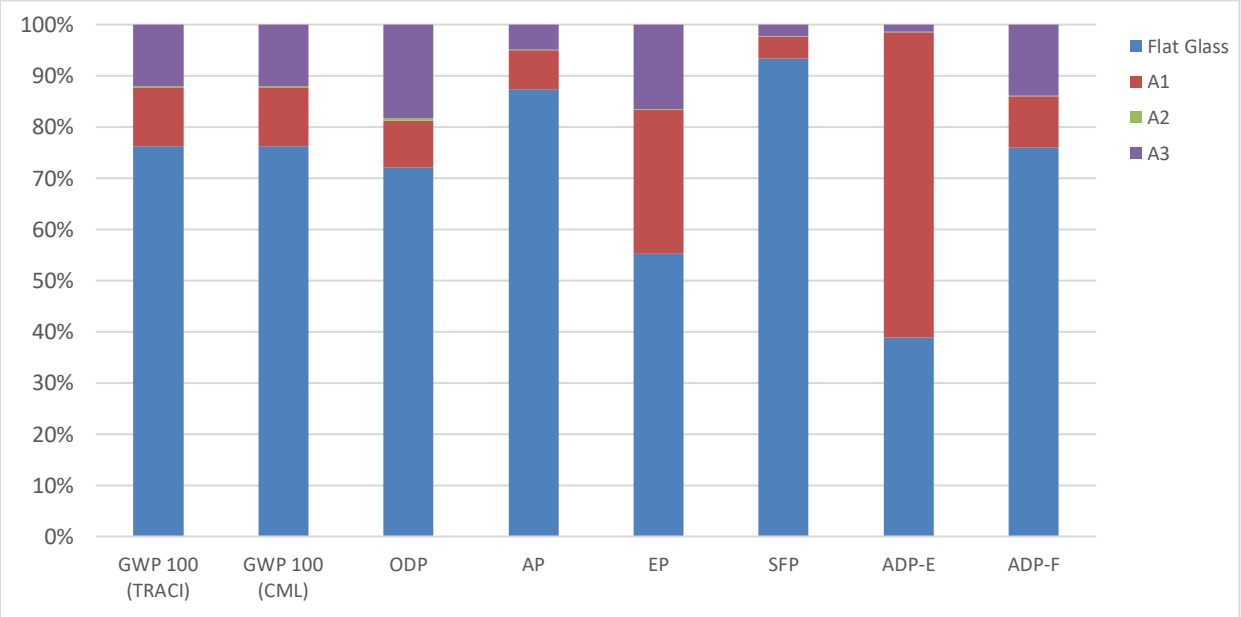

Figure 5. *Cradle-to-gate contribution analysis for Vitro triple-pane IGU products.*

7. Additional Environmental Information

7.1 Environmental Activities and Certifications

In 2008, Vitro 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 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. Vitro's Cradle to Cradle certificate can be found on the Vitro website: https://www.vitroglazings.com/design-resources/sustainability/sustainability-documentation/

Vitro 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 manufactures is reutilized in production.

Vitro products offer multiple options for reuse and repurposing after deconstruction, including use as an aggregate in concrete and asphalt applications. When finely ground, recycled flat 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 the demand for virgin materials. The use of cullet also reduces the melting temperature for batch materials, which further diminishes energy consumption.

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