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

Products
Vitro Flat Glass

Declared Unit
1 metric ton of flat glass with a service life of 30 years

EPD Number and Period of Validity
SCS-EPD-08776
EPD Valid March 17, 2023 through March 16, 2028
Version: March 12, 2024

Product Category Rule

Product Category Rule for Environmental Product Declarations: NGA PCR for Flat Glass: UN CPC 3711. Version 2.0. September 2020. NSF International.

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

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Address:	400 Guys Run Road
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Version Date:	March 12, 2024
Product:	Flat 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 Lindita Bushi, Ph.D., Athena Sustainable Materials Institute
Product Category Rule:	Product Category Rule for Environmental Product Declarations: NGA PCR for Flat Glass: UN CPC 3711. Version 2.0. September 2020. NSF International.
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 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.

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; Fresno, California; and Garcia, Mexico. Flat glass is produced exclusively at the Carlisle, Wichita Falls, Fresno, and Garcia facilities.

2. Product

2.1 Product Description

Vitro flat glass is a clear, sheet glass produced from soda-lime silicates, along with metal-oxide materials that are used in the creation of tinted glass. The products are commonly used for windows, glass doors and walls, as well as a base raw material for processed glass. The declared glass products are available in a range of thicknesses and treatment options. Colored or tinted glasses are primarily the same composition as clear glass with minor adjustments to account for the addition of colorants. 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. However, the resulted are reported based on mass (1 metric tonne) per the Product Category Rule (PCR).

The UNSPSC code for flat glass is 30171700. The various Vitro flat glass products included in this EPD are listed below:

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

2.2 Application

The Vitro flat 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.

Resource use at the production facility is allocated to the product based on expert opinion and mass. All processes contributing to greater than 1% of the total environmental impact indicator for each impact is included in the inventory. All known materials and processes were included in the life cycle inventory.

2.4 Material Composition

The primary materials include a blend of sand, soda ash, dolomite, limestone and color/tint additives sourced from various suppliers.

Table 1. *Material component summary for the Vitro flat glass products per metric ton.*

Material	kg/ton	Percent
Sand	599	59.9%
Soda ash	196	19.6%
Dolomite	153	15.3%
Limestone	45.0	4.5%
Tin oxide	0.048	0.005%
Sodium Sulfate	4.88	0.5%
Rouge	0.75	0.1%
Coal	0.278	0.03%
Sodium nitrate	0.103	0.01%
Graphite	0.060	0.01%
Cobalt oxide	0.008	0.001%
Selenium	0.010	0.001%
Total:	**1000**	**100%**

2.5 Manufacture

The flat glass manufacturing process begins when raw materials 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 1,100° F, the glass is lifted out of the liquid tin and on to conveyor rolls, then fed into an annealing lehr. The lehr cools the glass at a controlled rate to achieve proper stresses for easy and accurate cutting. As the glass exits the lehr, it is cooled to room temperature by open air fans and inspected for flaws prior to cutting. The non-contaminated waste glass is collected from manufacture scrap and stored on-site for use as input to the processes. The flat glass products are then sorted and either stored for further processing or packaged for distribution.

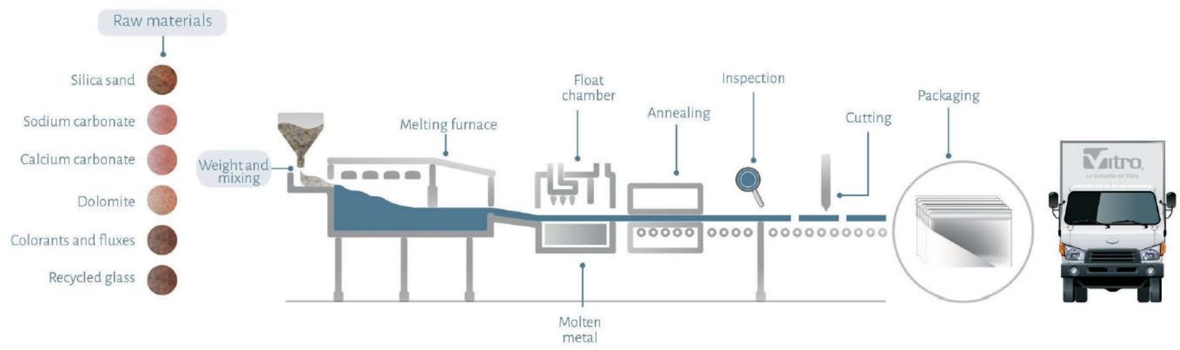

Figure 1: *Vitro flat glass manufacturing process.*

2.6 Packaging

Some flat glass product is stored on-site for further processing, while the remaining product is packaged and shipped for distribution.

Table 2. *Packaging material input summary for Vitro flat glass products per metric ton.*

Packaging Material	kg/ton	Percent
Cellulose board	1.18	7.5%
EPS foam	0.543	3.5%
Cardboard	0.564	3.6%
Wood	2.45	15.6%
Rubber	0.046	0.3%
Plastic	9.08	57.8%
Foam	0.495	3.2%
Steel	0.2.66	1.7%
LX powder	0.022	0.1%
Desiccant	0.096	0.6%
Tape	0.026	0.2%
Paper	0.930	5.9%
Total Packaging:	**15.7**	**100%**

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 for flat glass products, is 1 metric ton for a service life of 30 years.

Table 3: *Vitro flat glass declared unit summary.*

Product Name	Declared Unit	Reference Service Life	Mass	Conversion Factor to 1kg
Vitro Flat Glass	1 metric ton	30 years	1000 kg	0.001

3.2 System Boundary

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

Table 4: *Vitro flat 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

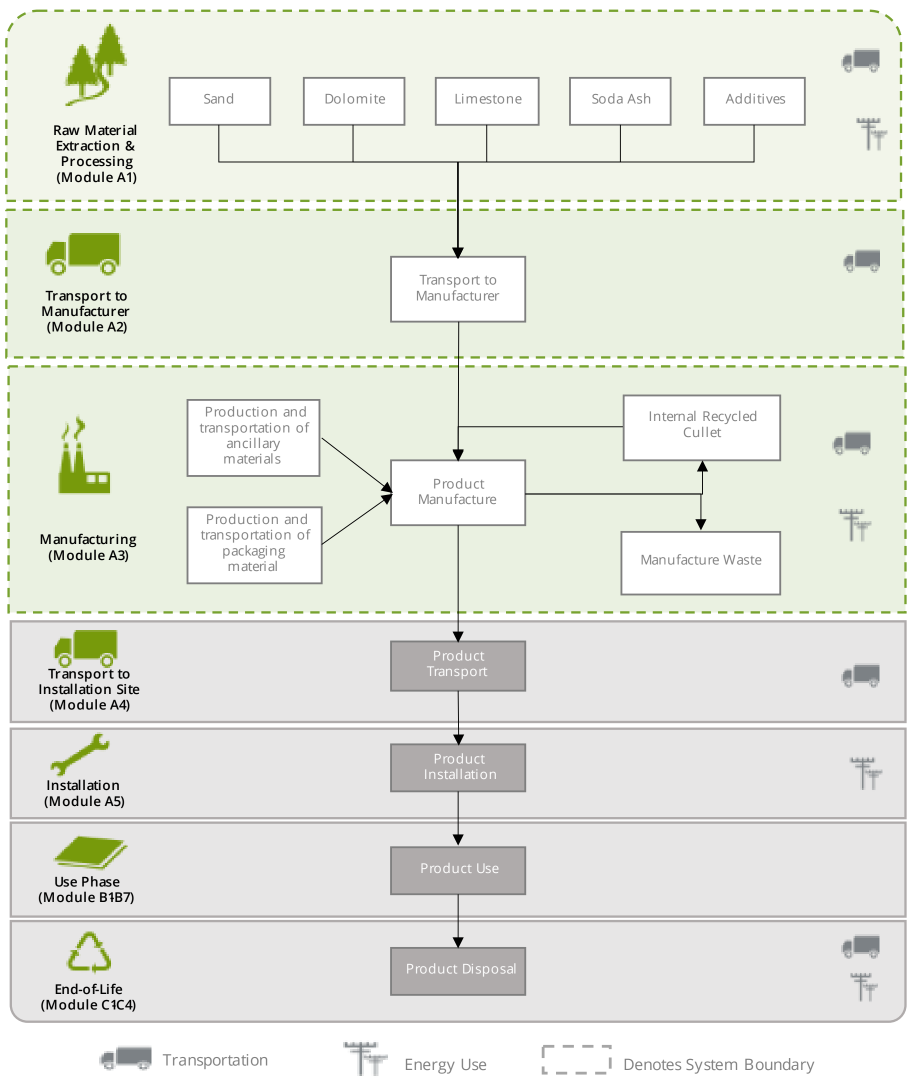

Figure 2. *Flow diagram and system boundaries for the life cycle of the Vitro flat glass products.*

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 rouge in the product recipe. A secondary dataset for iron ore concentrate was used from the Ecoinvent database.
- Specific data were not available on the tin oxide in the product recipe. A secondary dataset for tin concentrate was used from the Ecoinvent database.
- Specific data were not available on the LX powder used as an ancillary material and packaging material. A secondary dataset for acrylic filler was used from the Ecoinvent database.
- Specific data were not available on the desiccant used as a packaging material. A secondary dataset for activated silica was used from the Ecoinvent database.
- Specific data were not available on the some of the ancillary materials. Appropriate secondary datasets were 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.
- As required by the PCR, transportation to waste/scrap facilities is not included.
- Municipal water input for the Fresno facility for 2018 was only available for 7 months. An average of the 7 months was used to calculate an annual amount.
- Wastewater data from the Fresno facility for 2018 was incomplete. An average of the wastewater output of the Carlisle and Wichita Falls facilities was used to estimate the Fresno output.
- Propane and diesel input for the Fresno facility for 2019 was incomplete. An average of the propane and diesel inputs of the Carlisle and Wichita Falls facilities was used for the Fresno inputs.
- Data for the waste to landfill and waste to external recycle for the Fresno facility in 2019 was not available. The 2018 data for the Fresno waste to landfill and waste to external recycle was used as the best alternative.

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, Fresno, Wichita Falls, and Garcia manufacturing facilities. The sources of secondary LCI data are the Ecoinvent database.

Table 5. *LCI datasets and associated databases used to model the Vitro flat glass products.*

Component	Dataset	Geographic Coverage	Data Source	Publication Date
Product Materials				
Adipic Acid	market for adipic acid | adipic acid | Cutoff, U	Global	Ecoinvent 3.8	2021
Aluminum Oxide	aluminium oxide production | aluminium oxide, metallurgical | Cutoff, U	RNA	Ecoinvent 3.8	2021
Argon	market for argon, liquid | argon, liquid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Biocide	market for chlorine dioxide | chlorine dioxide | Cutoff, U	Row	Ecoinvent 3.8	2021
Coal	market for hard coal | hard coal | Cutoff, U	RNA†	Ecoinvent 3.8	2021
Cobalt Oxide	market for cobalt oxide | cobalt oxide | Cutoff, U	Global	Ecoinvent 3.8	2021
Dolomite	market for dolomite | dolomite | Cutoff, U	RoW‡	Ecoinvent 3.8	2021

Component	Dataset	Geographic Coverage	Data Source	Publication Date
Flocculent	market for polyacrylamide | polyacrylamide | Cutoff, U	Global	Ecoinvent 3.8	2021
Graphite	market for graphite | graphite | Cutoff, U	Global	Ecoinvent 3.8	2021
Helium	market for helium | helium | Cutoff, U	Global	Ecoinvent 3.8	2021
Hydrochloric Acid	market for hydrochloric acid, without water, in 30% solution state | hydrochloric acid, without water, in 30% solution state | Cutoff, U	RoW	Ecoinvent 3.8	2021
Limestone	market for limestone, crushed, for mill | limestone, crushed, for mill | Cutoff, U	RoW	Ecoinvent 3.8	2021
Lubricant/Grease	market for lubricating oil | lubricating oil | Cutoff, U	RoW	Ecoinvent 3.8	2021
Other Additives	market for chemical, inorganic | chemical, inorganic | Cutoff, U	Global	Ecoinvent 3.8	2021
Rouge	market for iron ore concentrate | iron ore concentrate | Cutoff, U	Global	Ecoinvent 3.8	2021
Sand	market for silica sand | silica sand | Cutoff, U	Global	Ecoinvent 3.8	2021
Selenium	market for selenium | selenium | Cutoff, U	Global	Ecoinvent 3.8	2021
Soda Ash	market for soda ash, light, crystalline, heptahydrate | soda ash, light, crystalline, heptahydrate | Cutoff, U	Global	Ecoinvent 3.8	2021
Sodium Nitrate	market for sodium nitrate | sodium nitrate | Cutoff, U	Global	Ecoinvent 3.8	2021
Sodium Silicate	market for sodium silicate, solid | sodium silicate, solid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Sodium Sulfate	market for sodium sulfate, anhydrite | sodium sulfate, anhydrite | Cutoff, U	RoW	Ecoinvent 3.8	2021
Tin Oxide	market for tin concentrate | tin concentrate | Cutoff, U	Global	Ecoinvent 3.8	2021
Ancillary Materials				
Aqueous Ammonia	market for ammonia, anhydrous, liquid | ammonia, anhydrous, liquid | Cutoff, U	RNA	Ecoinvent 3.8	2021
Hydrogen	market for hydrogen, gaseous | hydrogen, gaseous | Cutoff, U	Global	Ecoinvent 3.8	2021
LX	market for acrylic filler | acrylic filler | Cutoff, U - RoW	RoW	Ecoinvent 3.8	2021
Nitrogen	market for nitrogen, liquid | nitrogen, liquid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Oxygen	market for oxygen, liquid | oxygen, liquid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Sulfur dioxide	market for sulfur dioxide, liquid | sulfur dioxide, liquid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Sulfuric acid	market for sulfuric acid | sulfuric acid | Cutoff, U	RoW	Ecoinvent 3.8	2021
Tin	market for tin concentrate | tin concentrate | 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
Paper/Label	market for kraft paper | kraft paper | 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				

Component	Dataset	Geographic Coverage	Data Source	Publication Date
Carlisle Electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U	RFCE sub-region	EPA	2018-2019
Fresno Electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U	CAMX sub-region	EPA	2018-2019
Garcia Electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U	Mexico	Ecoinvent 3.8	2021
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	RoW	Ecoinvent 3.8	2021
Landfill waste	market for inert waste, for final disposal | inert waste, for final disposal | Cutoff, U - RoW	RoW	Ecoinvent 3.8	2021
Wastewater	market for wastewater from glass production | wastewater from glass production | Cutoff, U - GLO	Global	Ecoinvent 3.8	2021

†Rest of North America, ‡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 6. *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, Fresno, CA, Wichita Falls, TX, and Garcia, Mexico facilities on annual production for 2018 and 2019. Representative datasets (secondary data) for upstream and background processes are generally less than 5 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 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.

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 7. *Allocation details for resources at Carlisle and Witchita manufacturing facilities..*

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 four of the flat glass manufacturing sites share the same basic raw materials and manufacturing process but not all products are made at all manufacturing facilities. An average flat glass product was calculated using a weighted average of production at the four manufacturing facilities, based on the total mass of flat glass produced at each facility.

3.10 Comparability

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.

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 flat glass product. The following impact indicators, specified by the PCR, are reported below:

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.

Table 8: *Environmental impact categories and characterization methods.*

CML Impact Category	Unit	TRACI Characterization Method	Unit
Global Warming Potential (GWP 100)	kg CO_2 eq	Global Warming Potential (GWP 100)	kg CO2 eq
Ozone Depletion Potential (ODP)	kg CFC 11 eq	Ozone Depletion Potential (ODP)	kg CFC 11 eq
Eutrophication Potential (EP)	kg PO_4^{3-} eq	Eutrophication Potential (EP)	kg N eq
Acidification Potential (AP)	kg SO_2 eq	Acidification Potential (AP)	kg SO2 eq
Photochemical Oxidant Creation Potential (POCP)	kg C_2H_4 eq	Smog Formation Potential (SFP)	kg O3 eq
Abiotic Depletion Potential for Fossil Resources (ADPF)	MJ	Mineral Resource Depletion Potential (MRD) (ReCiPe method)	kg Fe eq

ISO 21930 and the PCR require that several other parameters be reported, including resource use, waste categories and output flows, and other environmental information. 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 flat glass products do not contain bio-based materials, biogenic carbon emissions and removals are not declared.

Table 9: *Resource use, Waste and Output flow, and Emission indicators.*

Resources	Unit	Waste and Outflows	Unit
RPR_E: Renewable primary resources used as energy carrier (fuel)	MJ, LHV	HWD: Hazardous waste disposed	kg
RPR_M: Renewable primary resources with energy content used as material	MJ, LHV	NHWD: Non-hazardous waste disposed	kg
$NRPR_E$: Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	HRWD: High-level radioactive waste, conditioned, to final repository	kg
$NRPR_M$: Non-renewable primary resources with energy content used as material	MJ, LHV	ILRWD: Intermediate, and low-level radioactive waste, conditioned, to final repository	kg
SM: Secondary materials	MJ, LHV	IRE: Incineration with energy recovery	kg
RSF: Renewable secondary fuels	MJ, LHV	INC: Incineration without energy recovery	kg
NRSF: Non-renewable secondary fuels	MJ, LHV	CRU: Components for re-use	kg
RE: Recovered energy	MJ, LHV	MR: Materials for recycling	kg
FW: Use of net freshwater resources	m^3	MER: Materials for energy recovery	kg
		EE: Recovered energy exported from the product system	MJ, LHV
Air Emissions	**Unit**	**Water Emissions**	**Unit**
SOx: Sulfur oxides	kg	Phosphates	kg
NOx: Nitrogen oxides	kg	Nitrates	kg
CO2e: Carbon dioxide	kg	Dioxin	kg
CO: Carbon monoxide	kg	Heavy Metals	kg
VOCs: Volatile Organic Compounds	kg		
Fe: Iron	kg		
PM: Particulate Matter	kg		

Table 10. *CML Impact Assessment Method Life Cycle Impact Assessment (LCIA) results for the Vitro Flat Glass products, per ton.*

Indicator	Unit	A1	A2	A3	Total A1-A3
GWP 100	kg CO_2 eq	150	64.2	1040	**1250**
ODP	kg CFC-11 eq	7.00×10^{-6}	1.03×10^{-5}	7.60×10^{-5}	**9.33×10^{-5}**
AP	kg SO_2 eq	1.30	0.377	6.27	**7.94**
EP	kg PO_4^{3-} eq	0.345	0.090	1.57	**2.01**
POCP	kg C_2H_4 eq	0.047	0.012	0.211	**0.269**
ADPF	MJ	1520	892	15,300	**17,700**

Table 11. *TRACI Impact Assessment Method Life Cycle Impact Assessment (LCIA) results for the Vitro Flat Glass products, per ton.*

Indicator	Unit	A1	A2	A3	Total A1-A3
GWP 100	kg CO_2 eq	149	64.0	1030	**1240**
ODP	kg CFC-11 eq	9.29×10^{-6}	1.37×10^{-5}	9.98×10^{-5}	**1.23×10^{-4}**
AP	kg SO_2 eq	1.36	0.460	7.40	**9.22**
EP	kg N eq	0.566	0.088	1.74	**2.40**
SFP	kg O_3 eq	13.3	12.4	186	**212**
MRD	kg Fe eq	75.7	4.65	50.0	**130**

Table 12. *Additional resource use results for the Vitro Flat Glass products, per ton.*

Indicator	Unit	A1	A2	A3	Total A1-A3
RPRE	MJ	237	16.1	599	**852**
RPRM	MJ	0.00	0.00	0.00	**0.00**
NRPRE	MJ	1630	909	16,300	**18,800**
NRPRM	MJ	8.97	0.00	0.00	**8.97**
SM	kg	5.44	0.00	0.00	**5.44**
RSF	MJ	0.00	0.00	0.00	**0.00**
NRSF	MJ	0.00	0.00	0.00	**0.00**
RE	MJ	0.00	0.00	0.00	**0.00**
FW	m^3	4.09	0.131	5.82	**10.0**

Table 13. *Additional waste and output results for the Vitro Flat Glass products, per ton.*

Indicator	Unit	A1	A2	A3	Total A1-A3
HWD	kg	0.00	0.00	1.06	**1.06**
NHWD	kg	0.00	0.00	2.64	**2.64**
HRWD	kg	0.00	0.00	0.00	**0.00**
ILRWD	kg	0.00	0.00	0.00	**0.00**
IRE	kg	0.00	0.00	0.530	**0.530**
INC	kg	0.00	0.00	0.530	**0.530**
CRU	kg	0.00	0.00	0.00	**0.00**
MR	kg	0.00	0.00	20.3	**20.3**
MER	kg	0.00	0.00	0.00	**0.00**
EE	MJ, LHV	0.00	0.00	0.00	**0.00**

Table 14. *Air and Water Emission results for the Vitro Flat Glass products, per ton.*

Indicator	Unit	A1	A2	A3	Total A1-A3
Air – SOx	kg	2.30×10^{-4}	1.13×10^{-4}	2.04×10^{-4}	**5.47×10^{-4}**
Air – NOx	kg	0.536	0.501	7.50	**8.54**
Air – CO2e	kg	158	62.7	1760	**1980**
Air – CO	kg	0.291	0.196	2.02	**2.51**
Air – VOCs	kg	1.79×10^{-4}	3.23×10^{-4}	0.034	**0.035**
Air – Fe	kg	0.004	0.002	3.90×10^{-4}	**0.006**
Air – PM total	kg	0.366	0.114	1.22	**1.70**
Water – Phosphates	kg	0.018	0.002	0.059	**0.079**
Water – Nitrates	kg	0.021	0.002	0.028	**0.050**
Water – Dioxin	kg	6.53×10^{-16}	6.76×10^{-17}	1.74×10^{-16}	**8.94×10^{-16}**
Water – Heavy Metals	kg	0.006	0.001	0.153	**0.159**

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 contributions to total indicator impacts for the Vitro Flat Glass products are dominated by the product manufacture phase. Within the manufacture phase, the natural gas and ancillary materials account for the majority of the impacts.

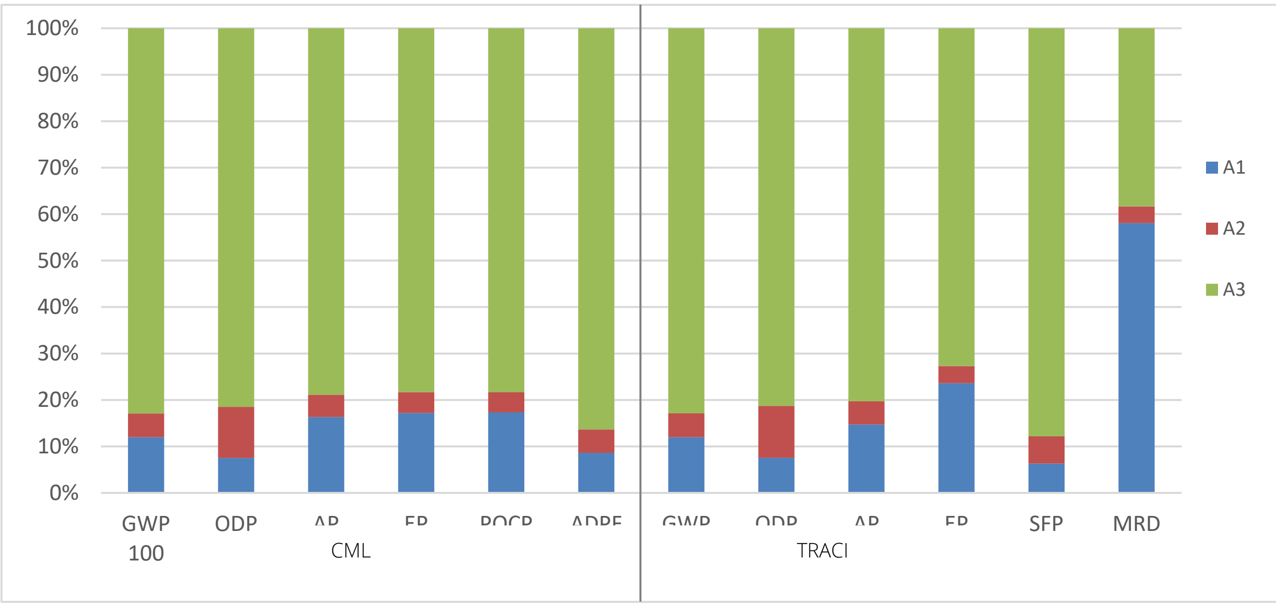

Figure 3. *Cradle-to-Gate contribution analysis for the Vitro flat glass products.*

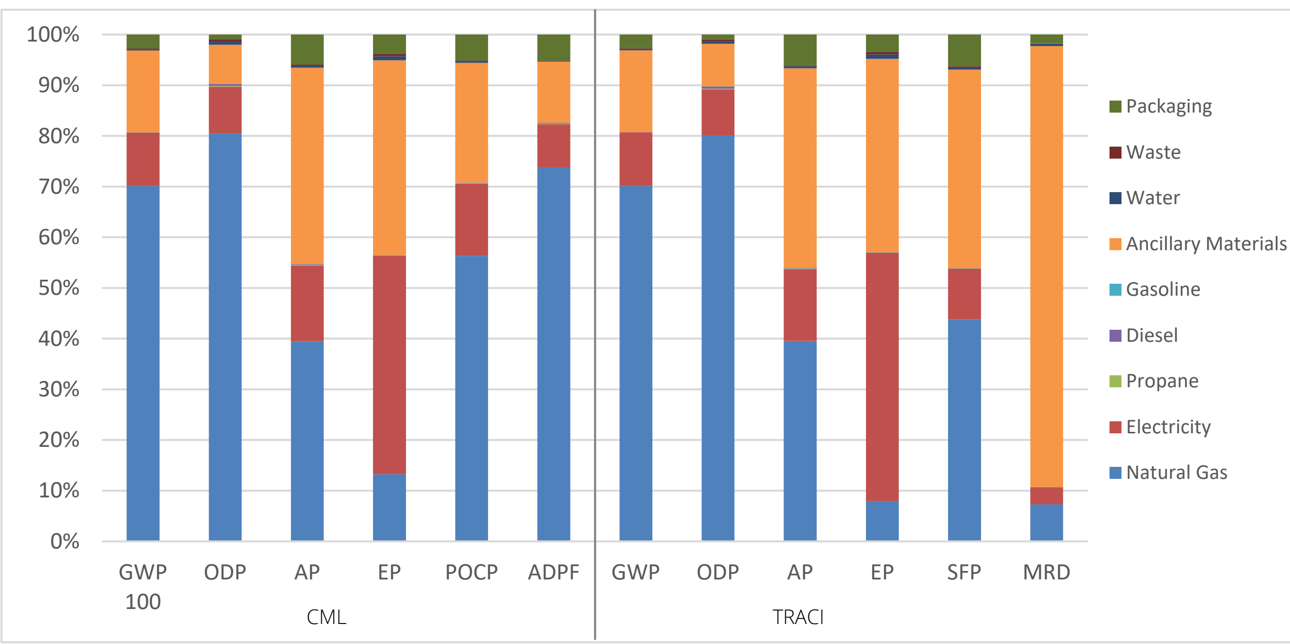

Figure 4. *Manufacturing phase contribution analysis for the Vitro flat glass products.*

7. Additional Environmental Information

7.1 Environment and Health during Manufacture

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

7.2 Environment and Health during Installation

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

7.3 Extraordinary Effects

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

7.4 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.

7.5 Further Information

Further information on the product can be found on the manufacturers' website at https://www.vitroglazings.com/.

8. References

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