ENVIRONMENTAL PRODUCT DECLARATION

FLAT GLASS

CARDINAL GLASS INDUSTRIES

Cardinal Glass Flat Glass

Cardinal Glass Industries is considered one of the world's leading providers of superior quality glass products. From the melting of sand to produce clear flat glass to the vacuum sputtering of silver to produce low-emissivity coatings.

With this EPD Cardinal intends to support architects and designers with the information they need about the life-cycle environmental impact of Cardinal glass products.

For additional information, visit www.cardinalcorp.com

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

ENVIRONMENTAL PRODUCT DECLARATION

CARDINAL Glass Industries

Cardinal Glass Industries
Flat Glass EPD

According to ISO 14025, ISO21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Solutions www.ul.com 333 Pfingsten Rd, Northbrook IL, 60062 www.spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	Program Operator Rules v 2.7 2022
MANUFACTURER NAME AND ADDRESS	Cardinal Glass Industries | 775 Prairie Center Dr #200 Eden Prairie, MN 55344
DECLARATION NUMBER	4791939895.102.1
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	Flat Glass product; 1 metric ton
REFERENCE PCR AND VERSION NUMBER	ISO 21930:2017, UL PCR Part A published in 2022
DESCRIPTION OF PRODUCT APPLICATION/USE	Flat glass are used within the building envelope or interior, or further processed into tempered, laminated, and/or multi-pane insulating glass units.
PRODUCT RSL DESCRIPTION (IF APPL.)	N/A
MARKETS OF APPLICABILITY	North America
DATE OF ISSUE	January 15th, 2026
PERIOD OF VALIDITY	5 Years
EPD TYPE	Product-specific Type III
RANGE OF DATASET VARIABILITY	N/A
EPD SCOPE	Cradle-to-gate
YEAR(S) OF REPORTED PRIMARY DATA	2023
LCA SOFTWARE & VERSION NUMBER	LCA for Experts v10.9.0.31
LCI DATABASE(S) & VERSION NUMBER	Sphera's MLC databases v 2025.1
LCIA METHODOLOGY & VERSION NUMBER	IPCC AR6, TRACI 2.2, CML 2016

The PCR review was conducted by:	International Standards Organization – ISO UL Solutions epd@ul.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum, UL Solutions
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Sphera Inc.
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Omar Mayorga, UL Solutions

LIMITATIONS

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc.

Accuracy of Results: EPDs regularly rely on estimations of impacts; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible". Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

1. Product Definition and Information

1.1. Description of Company/Organization

Cardinal Glass Industries is a management-owned S-Corporation leading the industry in the development of residential glass for windows and doors. We have grown to approximately 9,000 employees located at 43 manufacturing locations around the United States. Cardinal operates (5) divisions:

- Cardinal FG (float glass)
- Cardinal CT (custom tempered glass)
- Cardinal LG (laminated glass)
- Cardinal CG (coated glass)
- Cardinal IG (insulating glass).

1.2. Product Description

Product Identification

This Environmental Product Declaration (EPD) covers Flat Glass manufactured by Cardinal. Float glass is the process used to make flat glass. From there the glass can be tempered or laminated for safety glazing requirements, low-E coated for energy efficiency, and then fabricated into multi-pane insulating glass units for installation into a window.

1.3. Application

Flat glass may be used within the building envelope or interior, or further processed into tempered, laminated, and/or multi-pane insulating glass units.

1.4. Declaration of Methodological Framework

The EPD has been created strictly in accordance with the standards and norms below:

- ISO 14025:2011 Type III environmental declarations – Principles and procedures
- ISO 21930:2017 Sustainability in building and construction – Environmental declaration of building products, International Organisation for Standardization, Geneva, Switzerland.

1.5. Technical Requirements

Primary use is governed by building codes. These codes layout safety glazing requirements, structural sufficiency needs, and building energy compliance.

1.6. Material Composition

The composition of the final uncoated flat glass produced by Cardinal is 100% glass oxide (CAS number: 65997-17-3). No substances required to be reported as hazardous are associated with the production of this product.

1.7. Manufacturing

To manufacture flat glass, raw materials (sand, soda ash, limestone, dolomite, cullet, etc.) are stored, weighed, and mixed in a batch process inside of the batch house. This batch material is conveyed to the furnace where it is melted to form molten glass. After melting and refining in the furnace, the glass pours onto molten tin inside of the tin bath. Glass has a lower density than that of tin, allowing the glass to float and achieve a smooth, flat surface. It is in the tin bath that the glass is stretched both laterally and longitudinally to create a continuous ribbon of the desired thickness and width. Upon leaving the tin bath, the ribbon passes through the annealing lehr where it is cooled slowly, at a rate that prevents excessive permanent stress formation in the glass. Once through the permanent stress zones of the lehr, the continuous glass ribbon is cooled to a temperature at which it can be scored by automatic cutters, separated, and have the edge trim removed. Finished glass is then packed and shipped to customers for further processing.

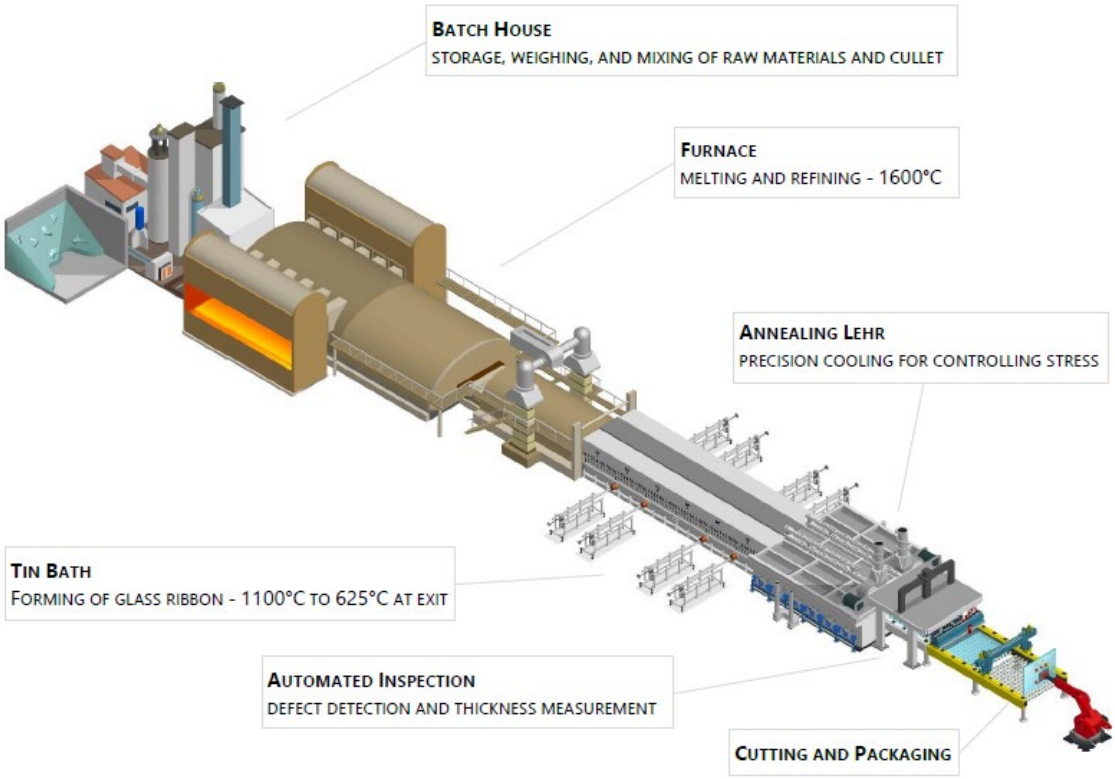

Figure 1: Flow diagram for Flat Glass manufacturing steps

1.8. Packaging

The flat glass product is packaged in cardboard and secured using plastic and steel banding as well as plastic wrap. The flat glass is also supported using wood.

1.9. Transportation

Transportation to customer after production is not declared in this EPD.

1.10. Product Installation

Product installation is not declared in this EPD.

1.11. Use

Use of product is not declared in this EPD.

1.12. Reference Service Life and Estimated Building Service Life

As the declared system boundary is A1-A3, a reference service life is not declared.

1.13. Reuse, Recycling, and Energy Recovery

Reuse, Recycling, and Energy Recovery of the product is not declared in this EPD.

1.14. Disposal

Disposal of product is not declared in this EPD.

2. Life Cycle Assessment Background Information

A cradle-to-gate analysis using life cycle assessment (LCA) techniques was conducted for this EPD. The analysis was done according to ISO 21930:2017 Sustainability in building and construction, PCR UL PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements and followed LCA principles, requirements and guidelines laid out in the ISO 14040/14044 standards. As such, EPDs of construction products may not be comparable if they do not comply with the same PCR. While the intent of the PCR is to increase comparability, there may still be differences among EPDs that comply with the same PCR.

2.1. Functional or Declared Unit

The declared unit evaluated for the study is:

1 metric ton of Flat Glass product

A declared unit is used in place of a functional unit. Declared units are defined under ISO 21930 and permitted for information modules, for which only a subset of life cycle stages is included in the analysis. The reference flow includes packaging associated with one metric ton of product. Environmental performance results therefore represent the production average of flat glass production, normalized to 1 metric ton. The reference service life is not specified. Because the use stage is not included in system scope, no reference service life is necessary for the analysis.

2.2. System Boundary

The declared system boundary is cradle-to-gate. Cradle-to-gate includes the PCR life cycle modules A1, A2, and A3. Capital goods and infrastructure flows are excluded from the product system boundary.The declared system boundaries is shown in Table 1 below:

Table 1. Description of the system boundary modules

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse- Recovery- 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

The system boundary and life cycle stages assessed in this EPD are shown in Figure 2.

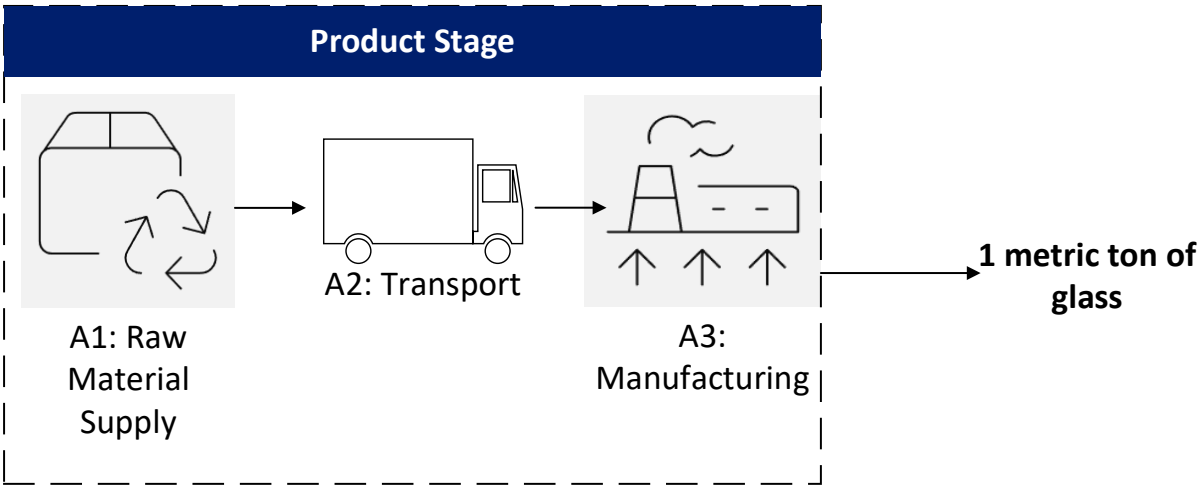

Figure 2: Life cycle stages included in system boundary.

2.3. Estimates and Assumptions

All raw materials and energy inputs have been modeled using processes and flows that closely follow actual production data on raw materials and processes. All reported materials and energy flows have been accounted for. No significant assumptions have been made beyond the aforementioned.

Proxy data were applied to some materials where no matching life cycle inventories were available, as documented in the background report. The following limitations to the study have been identified:

- Proxy datasets were used where no exact dataset match was found using a conservative selection approach. These datasets have minimal impact on overall results.
- This study used 100 miles according to ISO21930 as the inbound transport distance for some of the raw materials of the flat glass and laminated glass .
- The study excludes the use stage. Weighted averages for the total results from several manufacturing facilities for each glass product were used for this EPD.

2.4. Cut-off Criteria

No cut-off criteria are defined for this study. The system boundary was defined based on relevance to the goal of the study. For the processes within the system boundary, all available energy and material flow data have been included in the model. In cases where no matching life cycle inventories are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts. No known flows are deliberately excluded from this EPD.

2.5. Data Sources

All upstream background data have been taken from the MLC 2025.1 database, using Sphera's LCAFE software. All

manufacturing data were collected from Cardinal for the calendar year 2023.

To ensure the highest quality data, primary data were collected by Cardinal. Where primary data could not be obtained, background LCI data were sourced from the MLC database.To maintain confidentiality, specific sources are not disclosed in this report but are available upon request.

2.6. Data Quality

Precision and Completeness

Precision: As the majority of the relevant foreground data are measured data or calculated based on primary information sources of the owner of the technology, precision is considered to be high. Seasonal variations were balanced out by using yearly averages. All background data are sourced from MLC databases with documented precision; documentation can be found at https://sphera.com/product-sustainability-gabi-data-search/.

Completeness: Each foreground process was checked for mass balance and completeness of the emission inventory. No data were knowingly omitted. Completeness of foreground unit process data is considered to be high. All background data are sourced from MLC databases with the documented completeness.

Consistency and Reproducibility

Consistency: To ensure data consistency, all primary data were collected with the same level of detail, while all background data were sourced from the MLC databases.

Reproducibility: Reproducibility is supported as much as possible through the disclosure of input-output data, dataset choices, and modeling approaches in this report. Based on this information, any third party should be able to approximate the results of this study using the same data and modeling approaches.

Representativeness

Temporal: All primary data were collected for the year 2023. All secondary data come from the MLC 2025.1 databases and are representative of the years 2020-2023. As the study intended to compare the product systems for the reference year 2023, temporal representativeness is considered to be high.

Geographical: All primary and secondary data were collected specific to the countries or regions under study. Where country-specific or region-specific data were unavailable, proxy data were used. Geographical representativeness is considered to be high.

Technological: All primary and secondary data were modeled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used. Technological representativeness is considered to be high.

2.7. Period under Review

Primary data collected represent production during the 2024 calendar year. This analysis is intended to represent production in 2024.

2.8. Allocation

Allocation of background data

Allocation of background data (energy and material) taken from the MLC 2025.1 databases is documented online at https://lcadatabase.sphera.com/dataset-documentation-download/.

Allocation in the foreground data

For this study, no co-product was present at any facility; therefore, no allocation was conducted. The weighted average data for flat glass was provided from Cardinal.

2.9. Comparability

EPDs are not comparative assertions and are either not comparable or have limited comparability when they have different system boundaries. According to UL PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements, only EPDs prepared from cradle-to-grave life-cycle results, and based on the same function, quantified by the same functional unit, and taking account of replacement based on the product reference service life (RSL) relative to an assumed building service life, can be used to assist purchasers and users in making informed comparisons between products.— EPDs based on cradle-to-gate and cradle-to-gate with options information modules shall not be used for comparisons. Also, EPDs based on a declared unit shall not be used for comparisons..

2.10. Audience

Audience The intended audience of this EPD is business-to-business (BTB) stakeholders.

3. Life Cycle Assessment Scenarios

In accordance with ISO 21930:2017 PCR, this EPD covers only modules A1-A3.

Since these later modules are outside the declared system boundary, BCEK values are reported as zero in A1-A3. It should be noted that the biogenic carbon sequestration within the packaging material is only temporary. All stored biogenic carbon will eventually be released back to the atmosphere upon incineration of packaging material, or its degradation in a landfill, or will be carried over to the next product system if the packaging material is recycled. This approach ensures transparent and standardized reporting, providing a clear understanding of biogenic carbon flows beyond the scope of this EPD.

4. Life Cycle Assessment Results

4.1. Life Cycle Impact Assessment Results

Life cycle impact assessment and inventory results are mentioned in this section. Results are calculated using TRACI 2.2 and IPCC AR6. Tabulated results are followed by contribution analyses of flat glass products, to provide a sense of which modules are driving environmental burden. Module A3 (manufacturing) contributes the most to GWP, ODP, and ADPf (70% to 94%). Module A1 (raw materials) contributes the most to AP, EPm, EPf, and POFP (45% to 76%). Within A1 module, soda ash contributes the most (16%) to overall results, followed by lubricants (3%). Within Module A3, natural gas contributes the most (60%) to overall results, followed by manufacturing energy (10%). The figure below shows the total A1-A3 results.

LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Table 2. North American Impact Assessment Results

IPCC AR6	Total (A1-A3)	A1*	A2	A3
GWP100 [kg CO_2 eq]	1.07E+03	2.66E+02	5.56E+01	7.51E+02
TRACI V2.2	**TOTAL (A1-A3)**	**A1***	**A2**	**A3**
ODP [kg CFC-11 eq]	5.91E-09	3.18E-10	1.57E-11	5.58E-09
AP [kg SO_2 eq]	1.65E+00	1.17E+00	1.40E-01	3.41E-01
EPf [kg P eq]	1.30E-03	9.84E-04	4.53E-05	2.67E-04
EPm [kg N eq]	9.25E-01	5.51E-01	1.25E-01	2.49E-01
POFP [kg O_3 eq]	2.24E+01	1.01E+01	3.16E+00	9.14E+00
ADPfossil [MJ, LHV]	1.41E+04	3.03E+03	7.08E+02	1.03E+04

*A1 is the sum of flat glass cradle-to-gate impacts plus the raw materials processing of additional processing materials.

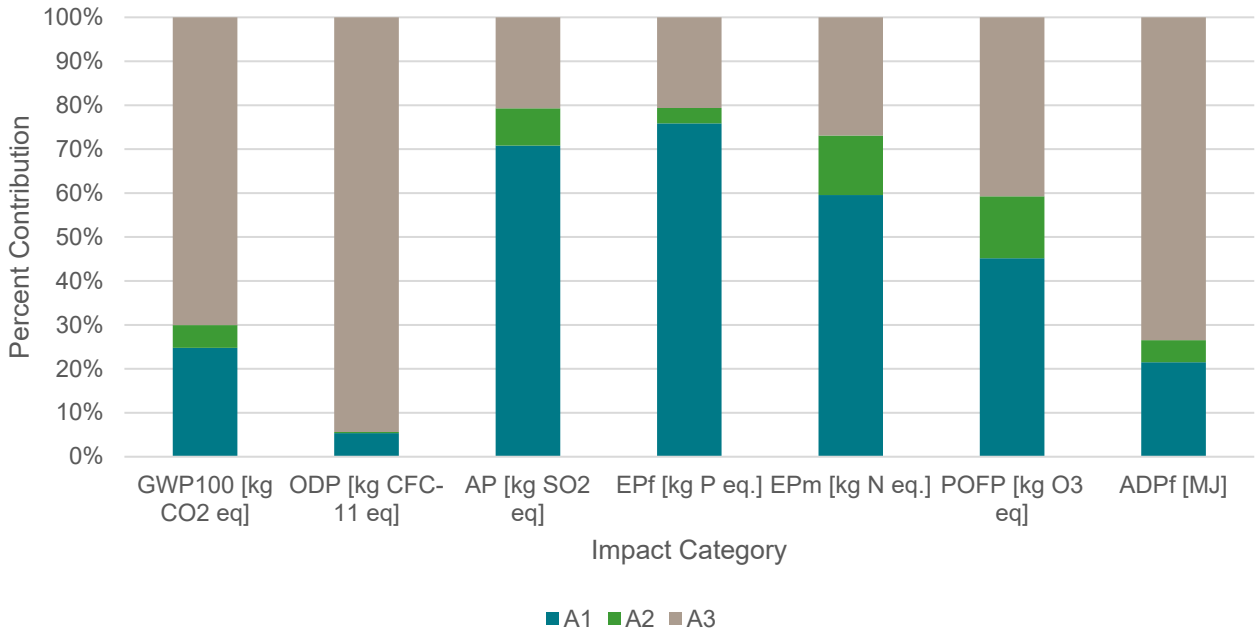

Figure 3: Cradle-to-gate life cycle impact results

These seven 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. Global warming potential (GWP) excludes biogenic carbon.

4.2. Life Cycle Inventory Results

Table 3. Resource Use

PARAMETER	TOTAL (A1-A3)	A1*	A2	A3
RPR_E [MJ, LHV]	1.85E+03	1.23E+03	2.97E+01	5.94E+02
RPR_M [MJ, LHV]	3.35E+01	0.00E+00	0.00E+00	3.35E+01
RPR_T [MJ, LHV]	1.88E+03	1.23E+03	2.97E+01	6.28E+02
$NRPR_E$ [MJ, LHV]	1.44E+04	3.08E+03	7.15E+02	1.06E+04
$NRPR_M$ [MJ, LHV]	9.77E+01	8.65E+01	0.00E+00	1.11E+01
$NRPR_T$ [MJ, LHV]	1.45E+04	3.16E+03	7.15E+02	1.06E+04

SM [kg]	6.22E-01	0.00E+00	0.00E+00	6.22E-01
RSF [MJ, LHV]	-	-	-	-
NRSF [MJ, LHV]	-	-	-	-
RE [MJ, LHV]	-	-	-	-
FW [m^3]	2.37E+00	1.02E+00	3.21E-02	1.32E+00

*A1 is the sum of flat glass cradle-to-gate impacts plus the raw materials processing of additional processing materials.

Table 4. Output Flows and Waste Categories

PARAMETER	TOTAL (A1-A3)	A1*	A2	A3
HWD [kg]	2.65E-01	0.00E+00	0.00E+00	2.65E-01
NHWD [kg]	7.46E+00	0.00E+00	0.00E+00	7.46E+00
HLRW [kg] or [m^3]	1.90E-04	5.66E-05	2.92E-06	1.30E-04
ILLRW [kg] or [m^3]	1.60E-01	4.81E-02	2.45E-03	1.09E-01
CRU [kg]	-	-	-	-
MFR [kg]	3.89E+00	0.00E+00	0.00E+00	3.89E+00
MER [kg]	-	-	-	-
EE [MJ, LHV]	-	-	-	-

*A1 is the sum of flat glass cradle-to-gate impacts plus the raw materials processing of additional processing materials.

Table 5. Carbon Emissions and Removals

PARAMETER	UNIT	TOTAL (A1-A3)	A1*	A2	A3
BCRK	kg CO_2 eq.	4.06E+00	0.00E+00	0.00E+00	4.06E+00
BCEK	kg CO_2 eq.	-	-	-	-
BCRP	kg CO_2 eq.	-	-	-	-
BCEP	kg CO_2 eq.	-	-	-	-
BCEW	kg CO_2 eq.	-	-	-	-
CCE	kg CO_2 eq.	-	-	-	-
CCR	kg CO_2 eq.	-	-	-	-
CWNR	kg CO_2 eq.	-	-	-	-

*A1 is the sum of flat glass cradle-to-gate impacts plus the raw materials processing of additional processing materials.

5. LCA Interpretation

The results represent the cradle-to-gate environmental performance of 1 metric ton of flat glass product and the packaging associated with it.

Module A1 (raw materials) contributes the most to AP, EPm, EPf, and POFP (45% to 76%). Module A2 contributes up to 14% of all impacts. Module A3 (manufacturing) contributes the most to GWP, ODP, and ADPf (70% to 94%).

Waste management, which includes transport of waste material to recovery or disposal, and relevant waste processing makes negligible contributions to overall production phase impacts.

6. Additional Environmental Information

6.1. Environment and Health During Manufacturing

Based on available information, no known hazardous materials are included in the product and no substances of very high concern have been identified in this product. Hence, no further declaration is required.

Please refer to the Article Data Sheet for flat glass products, which can be found at www.cardinalcorp.com.

6.2. Environment and Health during Use

Please refer to the Article Data Sheet for flat glass products, which can be found at www.cardinalcorp.com

6.3. Extraordinary Effects

Please refer to the Article Data Sheet for flat glass products, which can be found at www.cardinalcorp.com

6.4. Environmental Activities and Certifications

Please refer to the Article Data Sheet for flat glass products, which can be found at www.cardinalcorp.com

7. References

1. ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations – Principles and Procedures.
2. ISO 14040: 2006 Environmental Management – Life cycle assessment – Principles and Framework
3. ISO 14044: 2006/AMD 1:2017/ AMD 2:2020 Environmental Management – Life cycle assessment – Requirements and Guidelines.
4. ISO 21930: 2017 Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services.
5. Sphera Managed LCA Content Database. October 2024.
6. UL Environment. (2020). UL Environmental General Program Instructions, Version 2.5.
7. UL Environment (2022). UL PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements.