



ICC  
EVALUATION  
SERVICE®



ENVIRONMENTAL PRODUCT DECLARATION

## Custom Painted Unitized Curtain Wall



According to ISO 14025 and ISO 21930

### Custom Painted Unitized Curtain Wall



Enclos is a facade contractor in the United States, providing design, engineering, fabrication, and assembly services for custom curtain wall systems. This EPD aims to communicate environmental impacts with Enclos' customers.

The EPD is based on a comprehensive review of past projects, materials specified by clients, schedule focused procurement, and represents a point of entry for conversations. As a custom manufacturer we build to specifications and this EPD is not inclusive of all supply chain strategies and materials Enclos can offer.

Please contact [sustainability@enclos.com](mailto:sustainability@enclos.com) to discuss project-specific EPD offerings.

Custom Painted Unitized Curtain Wall (results for 5' x 15' below)	
Amount Per Serving – 1 m <sup>2</sup> Curtain Wall	
LCA IMPACT MEASURES	TOTAL
Global Warming Potential (kgCO <sub>2</sub> equivalent)	226
Acidification Potential (kg SO <sub>2</sub> equivalent)	8.75E-01
Eutrophication Potential (kg N equivalent)	4.23E-02
Ozone Depletion (kg CFC-11 equivalent)	1.24E-07
Smog Formation Potential (kg O <sub>3</sub> equivalent)	1.30E+01
Abiotic Depletion Potential of Fossil Resources (MJ)	2.66E+03
PERFORMANCE ATTRIBUTES	
See section 3.0	
<b>Product Ingredients:</b> Glass, Aluminum, Steel, Mineral Wool Insulation, Silicone	
Visit <a href="https://enclos.com/projects/">https://enclos.com/projects/</a> for more information	





This document is a Type III declaration certified by ICC-ES as conforming to the requirements of ISO 14025. ICC-ES has assessed that the Life Cycle Assessment (LCA) information fulfills the requirements of ISO 14040 in accordance with the instructions listed in the product category rules cited below. This document intends to further the development of environmentally compatible and sustainable construction methods by providing comprehensive environmental information related to potential impacts in accordance with international standards.



<b>Declaration Number</b>	<b>EPD-1044</b>
<b>Program Operator</b>	<b>ICC-ES Evaluation Services, LLC</b> 900 Montclair Road, Suite A Birmingham, AL 35213 <a href="http://www.icc-es.org">www.icc-es.org</a>
<b>Declaration Holder</b>	<b>Enclos</b> 2770 Blue Water Road Eagan, MN 55121
<b>Program Instructions</b>	<b>ICC-ES EPD Program Instructions, v2, 2021</b>
<b>Declared Product</b>	Custom Painted Unitized Curtain Wall
<b>Declared Unit</b>	1 m <sup>2</sup> of curtain wall
<b>Declaration Type</b>	Manufacturer Specific
<b>Declaration Scope</b>	Cradle-to-Gate
<b>Applicable Region/Market</b>	North America
<b>Product Application</b>	Façade in commercial applications
<b>Content of the Declaration</b>	This declaration is complete and contains in its full form: <ul style="list-style-type: none"> <li>• Product Definition</li> <li>• Product Application</li> <li>• Performance Attributes</li> <li>• Material Content</li> <li>• Production</li> <li>• Extraordinary Effects</li> <li>• Life Cycle Assessment</li> <li>• Additional Information</li> <li>• References</li> </ul>
<b>PCR Development</b>	<input checked="" type="checkbox"/> New or Revised <input type="checkbox"/> Existing
<b>PCR Reference</b>	Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL Environment, V4.0, 2022) Part B: PCR Guidance-Texts for Building-Related Products and Services Part B: Requirements on the EPD for Curtain Walling (Institut Bauen und Umwelt e.V., v1, 2022)
<b>The sub-category PCR review was conducted by:</b>	Institut Bauen und Umwelt e.V. (IBU) PCR Review Panel <a href="mailto:info@ibu-epd.com">info@ibu-epd.com</a>
<b>EPD Date of Issue:</b>	<b>December 2023</b>
<b>EPD Period of Validity:</b>	<b>5 years</b>





**Verification and Authorization of the Declaration**

This Declaration and the rules on which the EPD is based have been examined by an independent verifier in accordance with ISO 14025.

<b>X</b> 	<b>X</b> 
Eric J Polzin, P.E., Manager of Environmental Programs, ICC-ES Date: 12/12/2023	Cara Vought, LCACP, Sustainable Solutions Corporation Date: 12/12/2023

ICC-ES certification of an Environmental Product Declaration (EPD) is not the equivalent of an ICC-ES Evaluation Report (ESR), Verification of Attributes Report (VAR), or ICC-ES Listing (ESL) for code compliance. ICC-ES certification of an EPD is limited to the requirements for Type III environmental declarations in accordance with ISO 14025 and does not apply to product performance attributes which demonstrate compliance to codes. ICC-ES certification of this EPD is not to be construed as representing aesthetics or any other attributes not specifically addressed, nor should it be construed as an ICC-ES endorsement of the subject of the EPD or a recommendation for its use. There is no warranty by ICC-ES, express or implied, as to any finding or other matter in the EPD, or as to any product covered by the EPD. The EPD holder is liable for the information and evidence on which the EPD is based. Environmental Product Declarations from different programs may not be comparable.

**Limitations**

Environmental declarations from different programs based upon differing PCRs may not be comparable.

Comparison of the environmental performance of construction works and construction products using EPD information shall be based on the product's use and impacts at the construction works level. In general, EPDs may not be used for comparability purposes when not considered in a construction works context. Given this PCR ensures products meet the same functional requirements, comparability is permissible provided the information given for such comparison is transparent and the limitations of comparability explained.

When comparing EPDs created using this PCR, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.





## Summary LCA Results

### Product Components Related to Life Cycle Assessment

This EPD covers Enclos' custom painted unitized curtain wall. Results for three sizes of curtain walls are presented separately: 5' x 15', 7.5' x 15', and 10' x 15'. The products are manufactured at three facilities and the results in this EPD are a weighted average based on relative contribution of production square footage in 2022.

### Scope and Boundaries of Life Cycle Assessment

The Life Cycle Assessment (LCA) was performed according to ISO 14040/44 and the relevant PCRs. The cradle-to-gate LCA encompasses raw material production, transport of raw materials to production facility, manufacturing of custom unitized painted curtain wall, and packaging. Detailed information regarding the LCA is found in Section 7.

### Life Cycle Assessment Summary

**Declared Unit:** 1 m<sup>2</sup> of curtain wall.

**Results and Interpretation:** Cradle-to-gate (A1-A3) impacts for painted aluminum curtain wall are dominated by raw materials (A1), mainly glass and aluminum. Transportation of raw materials (A2) and manufacturing of the product (A3) do not contribute significantly to most impact categories. Cradle-to-gate impacts per m<sup>2</sup> of painted aluminum curtain wall are shown below for each product size.

Impact Category	5' x 15'	7.5' x 15'	10' x 15'
<b>IPCC AR5 LCIA Impacts</b>			
Global Warming Potential [kg CO <sub>2</sub> eq]	2.26E+02	2.25E+02	2.40E+02
<b>TRACI LCIA Impacts</b>			
Acidification Potential [kg SO <sub>2</sub> eq]	8.75E-01	8.69E-01	9.21E-01
Eutrophication Potential [kg N eq]	4.23E-02	4.32E-02	4.48E-02
Ozone Depletion Potential [kg CFC 11 eq]	1.24E-07	1.09E-07	1.22E-07
Smog Formation Potential [kg O <sub>3</sub> eq]	1.30E+01	1.38E+01	1.43E+01
<b>CML LCIA Impacts</b>			
Abiotic Depletion of Fossil Resources [MJ]	2.66E+03	2.60E+03	2.76E+03

Global warming impacts per m<sup>2</sup> are roughly equal for the 5' x 15' and 7.5' x 15' curtain wall modules, and significantly higher for the 10' x 15' curtain wall module. This is explained by a high mass of aluminum and glass per m<sup>2</sup> in the 10' x 15' module relative to the other sizes. Trends for acidification potential and abiotic depletion of fossil resources closely follow global warming potential. Impact categories of eutrophication potential and smog formation potential show an increase in impacts per declared unit with increasing curtain wall size.





## Detailed LCA Results

### 1.0 Product Definition

#### 1.1 Product Definition and Performance

Enclos' custom painted unitized curtain walls are modular assemblies of a painted aluminum frame with glass panels and other components used as façades on the exterior of buildings. In lieu of specific production codes, these products fall under CSI code 08 44 13. Enclos' curtain walls are custom-designed for every project. Therefore, a representative aluminum curtain wall design in three sizes was chosen for this EPD, with results and data presented separately for each size:

- Custom painted unitized curtain wall, 5' x 15' (1.52 m x 4.57 m)
- Custom painted unitized curtain wall, 7.5' x 15' (2.29 m x 4.57 m)
- Custom painted unitized curtain wall, 10' x 15' (3.02 m x 4.57 m)

The product represented in this EPD is based on hypothetical design criteria derived from a survey of similar structures to drive curtain wall design logic and subsequent system sizing and requirements.

The product construction is shown in the images below.



Curtain wall construction



Curtain wall in 3 Sizes from left to right: 5' x 15', 7.5' x 15', and 10' x 15'



Enclos custom painted unitized curtain walls are assembled at three manufacturing facilities: Chester, VA; Phoenix, AZ; and Bang Kao Fe, Thailand. The results in this EPD are a weighted average based on the relative contribution of production square footage in 2022.

## 2.0 Product Application

Enclos' curtain walls are used as façades on the exterior of commercial and residential buildings.

## 3.0 Performance Attributes

The following technical data / performance attributes apply to all three sizes of custom painted unitized curtain wall. Compliance with the requirements is outside of the scope of this report.

Attribute*	Requirement	Standard
<b>Air Permeability</b>	Air pressure difference 6.24 psf Maximum allowable rate of air leakage 0.06 cfm/ft <sup>2</sup>	ASTM E283
<b>Uniform Load Deflection at Design Pressure</b>	Design wind pressures to be ASCE 7 Zone 4 or per wind tunnel study. Deflection not to exceed span / 175 or 3/4" per lite of glass.	ASTM E330
<b>Water Penetration by Uniform Static Air Pressure Difference</b>	Min air pressure difference equal to 20% of positive wind pressure or 6.24 psf Max air pressure difference 15psf No water leakage per AAMA 501.1 Section 6.7	ASTM E331
<b>Water Penetration Under Dynamic Pressure</b>	Min wind velocity equivalent to a static air pressure difference equal to 20% of positive wind pressure or 6.24 psf Max wind velocity equivalent to a static pressure difference 15psf No water leakage per AAMA 501.1 Section 6.7	AAMA 501.1
<b>Seismic and Wind Induced Inter-Story Drifts</b>	Unless otherwise specified the horizontal lateral design displacement shall be 0.010 x the story height. Deformation or damage of framing members, and/or breakage of glass may occur defined only as cracking or spalling. System anchorage may deform, but catastrophic failure or breakage of surrounding material cannot occur; glass to remain in framed openings with no glass fallout. No wall components fall off, including trim. No permanent deformation in excess of L/500	AAMA 501.4
<b>Thermal Cycling of Exterior Walls</b>	Test temperatures selected to meet job conditions, if unknown standard test condition utilized. System must remain watertight without repair, passing the subsequent water tests and structural tests. No structural damage, failure or disengagement of trim, snap on members, glazing gaskets, sealants, nor breakage of glass (defined as cracking or spalling of any kind) shall occur.	AAMA 501.5
<b>Thermal Performance Characteristics</b>	Movement to be defined in specification. Distance to be at minimum the sum of slab live load deflection, thermal expansion/contraction, a nominal allowance for install and fabrication tolerance, and column creep. System must remain watertight without repair, passing the subsequent water tests and structural tests. No structural damage, failure or disengagement of trim, snap on members, glazing gaskets, sealants, nor breakage of glass (defined as cracking or spalling of any kind) shall occur.	AAMA 501.7

\* Other performance attributes listed in the Part B PCR are not applicable to North America; additional performance attributes may be required by the applicable codes adopted by the local jurisdiction.





## 4.0 Material Content

The materials that make up the declared product systems are indicated in the table below. Product composition is per declared unit.

Material	5' x 15'		7.5' x 15'		10' x 15'	
Insulated Glass Units (IGU) [kg]	34.0	65.1%	42.9	72.0%	43.1	70.7%
Steel [kg]	2.53	4.85%	2.52	4.23%	2.49	4.08%
Aluminum Extrusion [kg]	10.1	19.3%	8.69	14.6%	9.85	16.1%
Mineral Wool Insulation [kg]	2.00	3.83%	2.04	3.42%	2.03	3.33%
Aluminum Sheet [kg]	2.79	5.34%	2.83	4.75%	2.85	4.67%
Silicone Compound [kg]	0.662	1.27%	0.682	1.14%	0.694	1.14%
<b>Total Product Weight [kg]</b>	<b>52.2</b>	<b>100%</b>	<b>59.6</b>	<b>100%</b>	<b>61.0</b>	<b>100%</b>

## 5.0 Production

Enclos receives sub-components from their suppliers, then cuts and assembles the curtain wall according to customer specifications at three facilities in the United States and Thailand: Chester, VA; Phoenix, AZ; and Bang Kaeo Fe, Thailand. The materials are delivered to the manufacturing facility via truck and ship, which is accounted for in the model. For glass and aluminum, transportation distances were modeled by material and were calculated using the supplier location and the location of manufacturing. For materials where the supplier was unknown, a transportation distance of 500 miles was assumed for transport to Enclos facilities in the United States, and a transport distance of 100 miles was assumed for transporting raw materials to the Thailand facility.

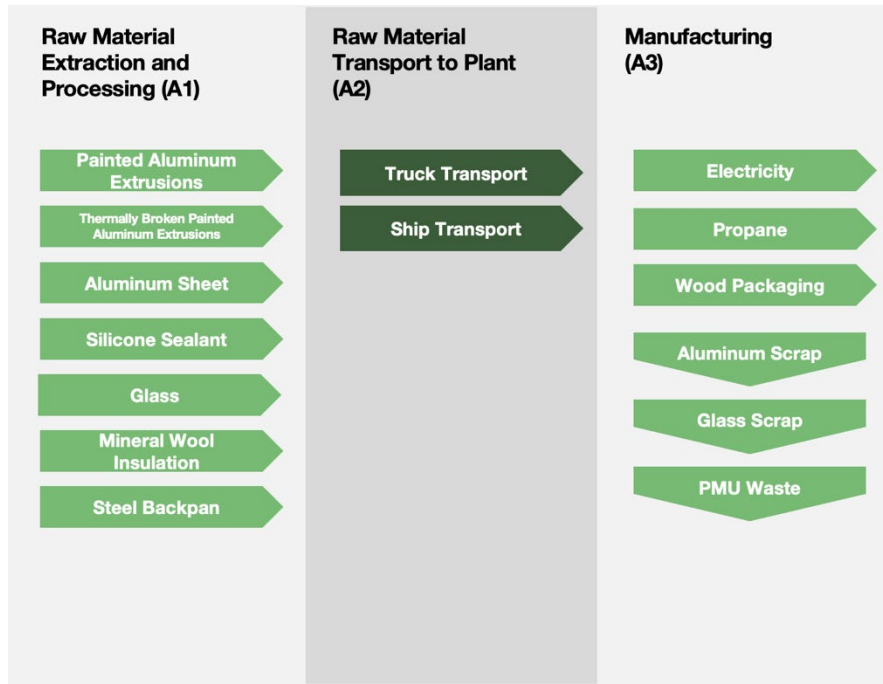
Energy resources used in the manufacturing process include electricity and propane. Manufacturing waste is also generated during production as the products are assembled. Waste is either landfilled, incinerated, or recycled.

Once curtain walls are assembled, they are packaged in wooden bunks prior to shipping. Packaging inputs are noted below per declared unit.

Packaging Material	5' x 15'	7.5' x 15'	10' x 15'
Wood [kg]	6.51	4.34	4.34



Enclos' manufacturing process is represented by the flow diagram below.



### 5.1 Health, Safety and Environmental Aspects During Production

Enclos meets all federal and state standards related to environment and health during manufacturing. No substances required to be reported as hazardous per the EPA's Resource Conservation and Recovery Act (US EPA, 2023) were identified during the LCA associated with the production or disposal of this product.

### 6.0 Extraordinary Effects

Since Enclos's unitized curtain wall systems are custom-designed to each project, extraordinary effects for custom designs shall be reviewed by a qualified third-party design professional.

### 7.0 Life Cycle Assessment

The methods for conducting the life cycle assessments used for this project were consistent with ISO 14040 and 14044. This report is intended to fulfill the reporting requirements in Section 5 of ISO 14044, UL Part A v4.0, and IBU Part B for Curtain Walling (Institut Bauen und Umwelt e.V.) v1.







7.1 Information on the Product System Definition and Modeling of the Life Cycle

Declaration of LCA Methodological Framework

This LCA follows an attributional approach.

Declared Unit

The declared unit is 1 m<sup>2</sup> of curtain wall. Details related to the declared unit are shown below.

	5' x 15'	7.5' x 15'	10' x 15'
<b>Declared Unit</b>	One square meter		
<b>Reference Size</b>	1.52 m x 4.57 m	2.29 m x 4.57 m	3.05 m x 4.57 m
<b>Mass per declared unit, including fasteners [kg]</b>	52.2	59.6	61.0

The fasteners needed for installation are supplied by the manufacturer with the product and therefore are accounted for together with the product.

Period Under Review

The period under review is calendar year 2022.

Cut-Off Criteria

All material inputs for which data were available are included. Material inputs greater than 1% (based on total mass of the final product) were included within the scope of analysis. Material inputs less than 1% were included if sufficient data were available to warrant inclusion and/or the material input was thought to have significant environmental impact. Cumulative excluded material inputs and environmental impacts are less than 5% based on the total weight of the functional unit.

- Excluded material inputs include gaskets, small plastic components in the curtain wall, and desiccants. All of these excluded materials are each below 1% by mass of the total product weight per declared unit and sum to less than 5% of total weight per declared unit.
- Some material inputs may have been excluded within the secondary Sphera MLC datasets used for this project. All Sphera MLC datasets have been critically reviewed and conform to the exclusion requirements of the PCR.

Allocation

General principles of allocation were based on ISO 14040/44. Allocation based on total production in square meters was adopted to derive a per-unit value for manufacturing inputs such as electricity and thermal energy. There are no other products manufactured at these facilities, so no allocation of co-products is needed. Regarding secondary datasets, as a default, MLC datasets use a physical mass basis for allocation. Additional details can be found at <https://gabi.sphera.com/america/databases/gabi-data-search/>. Supplier EPDs for aluminum used mass allocation while supplier EPDs for glass used area for allocation.

Of relevance to the defined system boundary is the method in which recycled materials were handled. Throughout the study recycled materials were accounted for via the cut-off method, including the impacts associated with upstream reprocessing and preparation of recycled materials (aluminum sheet and extrusions) that are part of the bill of materials of the products under study.

Software and Data Sources Used

This LCA was modeled in Sphera LCA for Experts (formerly GaBi) version 10.7.0.183 using background datasets from the Sphera Managed LCA Content (formerly GaBi) database 2023.1. Additionally, supplier EPDs were used to represent the impacts of the following purchased components: aluminum extrusions, and insulated glass units.





Life Cycle Assessment Indicators and Acronyms

Acronym	Text	Acronym	Text
<b>LCA Indicators</b>			
<b>GWP</b>	Global warming potential	AP	Acidification potential of soil and water
<b>EP</b>	Eutrophication potential	ODP	Depletion of stratospheric ozone layer
<b>SFP</b>	Smog Formation Potential	ADP-fossil	Abiotic depletion potential for fossil resources
<b>LCI Indicators</b>			
<b>RPR<sub>E</sub></b>	Use of renewable primary energy excluding renewable primary energy resources used as raw materials	RPR <sub>M</sub>	Use of renewable primary energy resources used as raw materials
<b>NRPR<sub>E</sub></b>	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	NRPR <sub>M</sub>	Use of non-renewable primary energy resources used as raw materials
<b>SM</b>	Use of secondary materials	FW	Net use of fresh water
<b>RSF</b>	Use of renewable secondary fuels	NRSF	Use of non-renewable secondary fuels
<b>HWD</b>	Disposed-of-hazardous waste	MR	Materials for recycling
<b>NHWD</b>	Disposed-of non-hazardous waste	MER	Materials for energy recovery
<b>HLRW</b>	High-level radioactive waste, conditioned, to final repository	ILLRW	Intermediate- and low-level radioactive waste, conditioned, to final repository
<b>CRU</b>	Components for reuse	EE	Exported energy
<b>RE</b>	Recovered Energy		
<b>Biogenic Carbon Indicators</b>			
<b>BCRP</b>	Biogenic Carbon Removal from Product	BCEW	Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes
<b>BCEP</b>	Biogenic Carbon Emission from Product	CCE	Calcination Carbon Emissions
<b>BCRK</b>	Biogenic Carbon Removal from Packaging	CCR	Carbonation Carbon Removals
<b>BCEK</b>	Biogenic Carbon Emission from Packaging	CWNR	Carbon Emissions from Combustion of Waste from Non- Renewable Sources used in Production Processes





7.1.1 System Boundaries

This EPD is cradle-to-gate, as represented by the table below. In the table, X=module included, ND=module not declared.

EPD Type	PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				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 supply	Transport	Manufacturing	Transport from gate to site	Assembly/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Building Operational Energy Use During Product Use	Building Operational Water Use During Product Use	Deconstruction	Transport	Waste processing	Disposal	Reuse, Recovery, Recycling Potential	
	X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

7.1.2 Assumptions and Limitations

Some limitations of the study include:

- Enclos produces custom curtain walls, so results in this LCA may not represent actual products produced by Enclos and are a weighted average of curtain wall of the same configuration from three different manufacturing facilities.
- EPDs for aluminum extrusions at Thailand and glass at all facilities are written to EN 15804 standards and use different methodologies than TRACI for characterizing environmental impacts. Because the GWP indicators used at these facilities are calculated using the same methodology (IPCC AR5), the GWP values were used directly from the EPDs. Indicators for other LCIA impact categories (acidification, eutrophication, ozone depletion, smog formation) are not easily and were pulled from other supplier EPDs as a proxy.
- Propane input and scrap rate for aluminum and glass at Enclos' Chester facility were used as a proxy for propane and scrap rate at Phoenix and Thailand. These facilities perform the same activities to produce the same products, so it is expected that this is a reasonable proxy.
- Use phase is not included in the study. Unfortunately, the PCR part B does not provide any guidance on how B phase should be modeled to reflect the potential energy saving from using this product.

7.1.3 Data Quality Assessment

**Geographical Coverage**

The geographical scope of the manufacturing portion of the life cycle is various parts of the US and Thailand for the products considered in this study. However, there are accommodations in the model to allow for additional region-specific electricity and transport to be added. All primary data were collected from the manufacturer. The geographic coverage of primary data is considered excellent.

The geographical scope of the raw material acquisition is the US, Germany, Thailand, and China. The geographical coverage of supplier EPDs and secondary datasets is specific to supplier regions in US, Germany, and Thailand. Overall geographic data quality is considered good.





**Time Coverage**

Primary data were provided by the manufacturer and represent all information for calendar year 2022. Using these data meets the PCR requirements. Time coverage of these data is considered very good.

Data necessary to model cradle-to-gate unit processes were sourced from Sphera’s MLC LCI datasets and supplier EPDs. Time coverage of the MLC datasets varies from approximately 2016 to present. Time coverage of supplier EPDs varies from 2019 to 2023. All datasets rely on at least one 1-year average data. Overall time coverage of the datasets is considered good and meets the requirement of the PCR that all data be updated within a 10-year period.

**Technological Coverage**

Primary data provided by the manufacturer are specific to the technology that the company uses in manufacturing their product. It is site-specific and considered of good quality.

Data necessary to model cradle-to-gate unit processes were sourced from MLC LCI datasets and supplier EPDs. Technological coverage of the supplier EPDs is very good as they represent actual technology from the supplier production processes. Technological coverage of the MLC datasets is considered good relative to the actual supply chain of the manufacturer. While improved life cycle data from suppliers would improve technological coverage, the use of generic secondary datasets does meet the goal of this LCA.

**Completeness**

The data included is considered complete. The LCA model included all known material and energy flows, except for what is listed in section 7.1.2. As pointed out in that section, no known flows above 1% were excluded and the sum of all excluded flows totals less than 5%.

**7.2 LCA Results**

The LCA results are documented separately for the stages and 3 curtain wall sizes:

The results presented below are per 1 m<sup>2</sup> of custom painted unitized curtain wall in a 5' x 15' size.

Impact Category	A1-A3	A1	A2	A3
<b>IPCC AR5 LCIA Impacts</b>				
<b>GWP [kg CO<sub>2</sub> eq]</b>	<b>2.26E+02</b>	2.10E+02	4.32E+00	1.19E+01
<b>TRACI LCIA Impacts</b>				
<b>AP [kg SO<sub>2</sub> eq]</b>	<b>8.75E-01</b>	7.60E-01	3.31E-02	8.16E-02
<b>EP [kg N eq]</b>	<b>4.23E-02</b>	3.26E-02	2.05E-03	7.60E-03
<b>ODP [kg CFC 11 eq]</b>	<b>1.24E-07</b>	1.24E-07	1.07E-14	3.02E-12
<b>SFP [kg O<sub>3</sub> eq]</b>	<b>1.30E+01</b>	1.11E+01	6.93E-01	1.15E+00
<b>CML LCIA Impacts</b>				
<b>ADPf [MJ]</b>	<b>2.66E+03</b>	2.29E+03	5.88E+01	3.10E+02
<b>Carbon Emissions and Uptake</b>				
<b>BCRP [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00
<b>BCEP [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00
<b>BCRK [kg CO<sub>2</sub>]</b>	<b>2.60E+00</b>	0.00E+00	0.00E+00	2.60E+00
<b>BCEK [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00
<b>BCEW [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00
<b>CCE [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00
<b>CCR [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00
<b>CWNR [kg CO<sub>2</sub>]</b>	<b>0.00E+00</b>	0.00E+00	0.00E+00	0.00E+00





Impact Category	A1-A3	A1	A2	A3
<b>Resource Use Indicators</b>				
RPRE [MJ]	9.52E+02	7.20E+02	2.11E+00	2.30E+02
RPRM [MJ]	1.04E+02	1.37E+00	0.00E+00	1.02E+02
NRPRE [MJ]	1.73E+03	1.25E+03	5.93E+01	4.14E+02
NRPRM [MJ]	1.75E+03	1.75E+03	0.00E+00	0.00E+00
SM [kg]	1.26E+01	1.26E+01	0.00E+00	0.00E+00
RSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m <sup>3</sup> ]	1.25E+02	1.25E+02	7.15E-03	1.41E-01
<b>Output Flows and Waste Categories</b>				
HWD [kg]	5.23E-04	5.23E-04	1.68E-10	1.01E-08
NHWD [kg]	4.01E+01	3.83E+01	4.86E-03	1.77E+00
HLRW [kg]	1.03E-04	5.88E-05	1.99E-07	4.44E-05
ILLRW [kg]	6.20E-02	2.46E-02	1.67E-04	3.71E-02
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR [kg]	5.16E+00	4.71E+00	0.00E+00	4.50E-01
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00

The results presented below are per 1 m<sup>2</sup> of custom painted unitized curtain wall in a 7.5' x 15' size.

Impact Category	A1-A3	A1	A2	A3
<b>IPCC AR5 LCIA Impacts</b>				
GWP [kg CO <sub>2</sub> eq]	2.25E+02	2.08E+02	5.05E+00	1.21E+01
<b>TRACI LCIA Impacts</b>				
AP [kg SO <sub>2</sub> eq]	8.69E-01	7.64E-01	3.98E-02	6.53E-02
EP [kg N eq]	4.32E-02	3.50E-02	2.42E-03	5.73E-03
ODP [kg CFC 11 eq]	1.09E-07	1.09E-07	1.25E-14	2.77E-12
SFP [kg O <sub>3</sub> eq]	1.38E+01	1.21E+01	8.31E-01	8.89E-01
<b>CML LCIA Impacts</b>				
ADP <sub>f</sub> [MJ]	2.60E+03	2.27E+03	6.87E+01	2.61E+02
<b>Carbon Emissions and Uptake</b>				
BCRP [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEP [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRK [kg CO <sub>2</sub> ]	1.74E+00	0.00E+00	0.00E+00	1.74E+00
BCEK [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEW [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00





Impact Category	A1-A3	A1	A2	A3
<b>Resource Use Indicators</b>				
RPRE [MJ]	8.31E+02	6.55E+02	2.44E+00	1.74E+02
RPRM [MJ]	6.99E+01	1.73E+00	0.00E+00	6.81E+01
NRPRE [MJ]	1.69E+03	1.27E+03	6.93E+01	3.54E+02
NRPRM [MJ]	1.64E+03	1.64E+03	0.00E+00	0.00E+00
SM [kg]	1.11E+01	1.11E+01	0.00E+00	0.00E+00
RSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m³]	1.56E+02	1.56E+02	8.27E-03	1.17E-01
<b>Output Flows and Waste Categories</b>				
HWD [kg]	4.49E-04	4.49E-04	1.96E-10	1.02E-08
NHWD [kg]	3.65E+01	3.46E+01	5.65E-03	1.90E+00
HLRW [kg]	9.35E-05	5.37E-05	2.32E-07	3.95E-05
ILLRW [kg]	6.18E-02	2.86E-02	1.95E-04	3.30E-02
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR [kg]	4.77E+00	4.24E+00	0.00E+00	5.27E-01
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00

The results presented below are per 1 m<sup>2</sup> of custom painted unitized curtain wall in a 10' x 15' size.

Impact Category	A1-A3	A1	A2	A3
<b>IPCC AR5 LCIA Impacts</b>				
GWP [kg CO <sub>2</sub> eq]	2.40E+02	2.23E+02	5.15E+00	1.21E+01
<b>TRACI LCIA Impacts</b>				
AP [kg SO <sub>2</sub> eq]	9.21E-01	8.15E-01	4.04E-02	6.53E-02
EP [kg N eq]	4.48E-02	3.66E-02	2.46E-03	5.73E-03
ODP [kg CFC 11 eq]	1.22E-07	1.22E-07	1.27E-14	2.77E-12
SFP [kg O <sub>3</sub> eq]	1.43E+01	1.26E+01	8.43E-01	8.89E-01
<b>CML LCIA Impacts</b>				
ADP <sub>f</sub> [MJ]	2.76E+03	2.43E+03	7.00E+01	2.61E+02
<b>Carbon Emissions and Uptake</b>				
BCRP [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEP [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRK [kg CO <sub>2</sub> ]	1.74E+00	0.00E+00	0.00E+00	1.74E+00
BCEK [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEW [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR [kg CO <sub>2</sub> ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00





Impact Category	A1-A3	A1	A2	A3
<b>Resource Use Indicators</b>				
RPRE [MJ]	8.98E+02	7.22E+02	2.49E+00	1.74E+02
RPRM [MJ]	6.99E+01	1.74E+00	0.00E+00	6.81E+01
NRPRE [MJ]	1.76E+03	1.34E+03	7.06E+01	3.54E+02
NRPRM [MJ]	1.80E+03	1.80E+03	0.00E+00	0.00E+00
SM [kg]	1.23E+01	1.23E+01	0.00E+00	0.00E+00
RSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m3]	1.57E+02	1.57E+02	8.45E-03	1.18E-01
<b>Output Flows and Waste Categories</b>				
HWD [kg]	5.09E-04	5.09E-04	2.00E-10	1.02E-08
NHWD [kg]	4.01E+01	3.82E+01	5.76E-03	1.94E+00
HLRW [kg]	9.88E-05	5.90E-05	2.36E-07	3.95E-05
ILLRW [kg]	6.22E-02	2.89E-02	1.99E-04	3.30E-02
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR [kg]	5.27E+00	4.73E+00	0.00E+00	5.39E-01
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00

### 7.3 LCA Interpretation

Cradle-to-gate global warming potential (GWP) for Enclos curtain wall ranges from 225-240 kg CO<sub>2</sub>e per m<sup>2</sup> of custom painted unitized curtain wall. Raw materials (A1) dominate GWP, contributing 92-93% of GWP. Other stages, such as raw materials transportation (A2) and manufacturing (A3) are insignificant. The 5' x 15' and 7.5' x 15' curtain wall modules have roughly equal global warming impacts, while the 10' x 15' module has significantly higher impacts than the smaller-sized curtain wall modules. This is explained by a combination of glass and aluminum extrusion impacts.

Trends for acidification potential (AP) and abiotic depletion of fossil resources (ADP<sub>f</sub>) closely follow global warming potential. Impact categories of eutrophication potential (EP) and smog formation potential (SFP) show an increase in impacts per declared unit with increasing curtain wall size.

### 8.0 Additional Information

No additional environmental information is reported in this EPD. Please visit <https://enclos.com/insights/feature-articles/> or contact [sustainability@enclos.com](mailto:sustainability@enclos.com) for additional information.



## 9.0 References

- WAP Sustainability. (2023). *LCA Background Report or Custom Unitized Curtain Wall*.
- ICC-ES. (2021). *ICC-ES EPD Program Instructions*. Retrieved from ICC-ES.com: <https://cdn-v2.icc-es.org/wp-content/uploads/2018/09/epd-prog.pdf>
- Institut Bauen und Umwelt e.V. (2022). *Part B: PCR Guidance-Texts for Building-Related Products and Services Part B: Requirements on the EPD for Curtain Walling v1*.
- IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- ISO. (2006). *ISO 14025: Environmental labels and declarations - Type III environmental declarations - Principles and procedures*. Geneva: International Organization for Standardization.
- ISO. (2006). *ISO 14040/Amd 1:2020: Environmental management - Life cycle assessment - Principles and framework*. Geneva: International Organization for Standardization.
- ISO. (2006). *ISO 14044/Amd 1:2017/Amd 2:2020: Environmental Management - Life cycle assessment - Requirements and Guidelines*. Geneva: International Organization for Standardization.
- ISO. (2017). *ISO 21930: Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services*. Geneva: International Organization for Standardization.
- UL Environment. (2022). *Part A: Life Cycle Assessment Calculation Rules and Report Requirements, UL 10010, V4.0*.
- Universiteit Leiden. (2016). *CML-IA Characterisation Factors*. Retrieved from <https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors>
- US EPA. (2012). *TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. Version 2.1 - User Guide*. Retrieved from <https://nepis.epa.gov/Adobe/PDF/P100HN53.pdf>
- US EPA. (2020, November 2020). *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Background Chapters*. Retrieved from EPA.gov: [https://www.epa.gov/sites/default/files/2020-12/documents/warm\\_background\\_v15\\_10-29-2020.pdf](https://www.epa.gov/sites/default/files/2020-12/documents/warm_background_v15_10-29-2020.pdf)
- US EPA. (2023). *Resource Conservation and Recovery Act (RCRA) Laws and Regulations*. Retrieved from <https://www.epa.gov/rcra>