BENDHEIM

Laminated Glass and Mirrors

727 West Madison, Chicago, IL

Bendheim LLC

ENVIRONMENTAL PRODUCT DECLARATION

ISO 14025:2006 and ISO 21930:2017

ASTM INTERNATIONAL

Bendheim LLC is pleased to present this Environmental Product Declaration (EPD) for their Laminated products. This EPD was developed in compliance with ISO 14025 and ISO 21930 and has been verified by Lindita Bushi, Ph.D., Athena Sustainable Materials Institute.

The LCA and EPD were prepared by Vertima Inc. The EPD includes cradle-to-gate life cycle assessment (LCA) results.

For more information about Bendheim LLC, visit www.bendheim.com.

For any explanatory material regarding this EPD, please contact the program operator.

1. GENERAL INFORMATION

PCR GENERAL INFORMATION	
Reference PCR	ISO 21930:2017 Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services
The PCR review was conducted by:	*Technical Committee ISO/TC 59, Buildings and civil engineering works, Subcommittee SC 17, Sustainability in buildings and civil engineering works*

EPD GENERAL INFORMATION		
Program Operator	ASTM International 100 Barr Harbor Drive West Conshohocken, PA 19428 USA www.astm.org	
Declared Products	Laminated Glass to Glass Laminated Glass to Mirror	
EPD Registration Number EPD# 849	**EPD Date of Issue** December 20, 2024	**EPD Period of Validity** December 20, 2024 to December 19, 2029
EPD Recipient Organization	Bendheim LLC 82 Totowa Road Wayne, NJ 07470 USA	BENDHEIM

EPD Type/Scope and Declared Unit	**Year of Reported Manufacturer Primary Data**
Product-specific cradle-to-gate EPD with declared unit of 1 m^2 of processed glass.	2023

Geographical Scope	**LCA Software**	**LCI Databases**	**LCIA Methodology**
North America	OpenLCA v.2.0.3	Ecoinvent 3.9.1 and US LCI	TRACI 2.1 CML 4.8 (ADP_{fossil}) and CED, LHV, v1.0

This LCA and EPD were prepared by:	Chantal Lavigne, M.A.Sc. Vertima Inc. www.vertima.ca
This EPD and LCA were independently verified in accordance with ISO 14025:2006, ISO 14040:2006 and ISO 14044:2006, as well as ISO 21930:2017. ☐ Internal ☒ External	Lindita Bushi Lindita Bushi, Ph.D. Athena Sustainable Materials Institute

LIMITATIONS

Environmental declarations within the same product category but from different programs may not be comparable. [1]

EPDs are comparable only if they comply with the ISO 21930:2017 standard, 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.[2]

King Street Condo Tower, Toronto, ON. Textured glass laminated to mirror [Picture courtesy of Bendheim LLC].

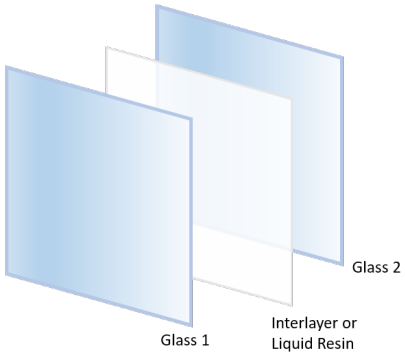
2. PRODUCT SYSTEM DESCRIPTION

Bendheim LLC is one of the world's foremost resources for specialty architectural glass. Founded in New York City in 1927, the third-generation, family-owned company offers a virtually unlimited range of in-stock and custom architectural glass varieties. Bendheim develops, fabricates, and distributes its products worldwide. The company maintains production facilities in New Jersey and offices in New York City.

2.1. PRODUCT DESCRIPTION

Laminated glass to glass[1] is a safety glass that contains two or more glass panes permanently bonded together with a clear or colored interlayer (PVB or EVA) or with liquid resin. A safety glass, if broken, remains in place, held together by the interlayer at its core. The glass is either annealed, heat-strengthened or tempered and it may be back painted or digitally printed. Annealed glass is glass in its basic form that breaks into jagged pieces, while tempered glass is approximately four times stronger and breaks into small, dice-sized pieces. Furthermore, the glass may be regular, low iron, or tinted float glass and may be etched or textured.

Laminated glass to mirror[1] are also safety glasses with a glass pane bonded to a mirror pane utilizing a clear or colored interlayer (PVB or EVA).

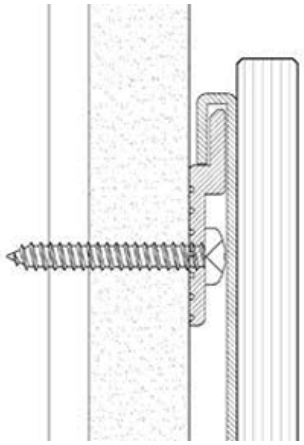


Laminated glass to glass

Options

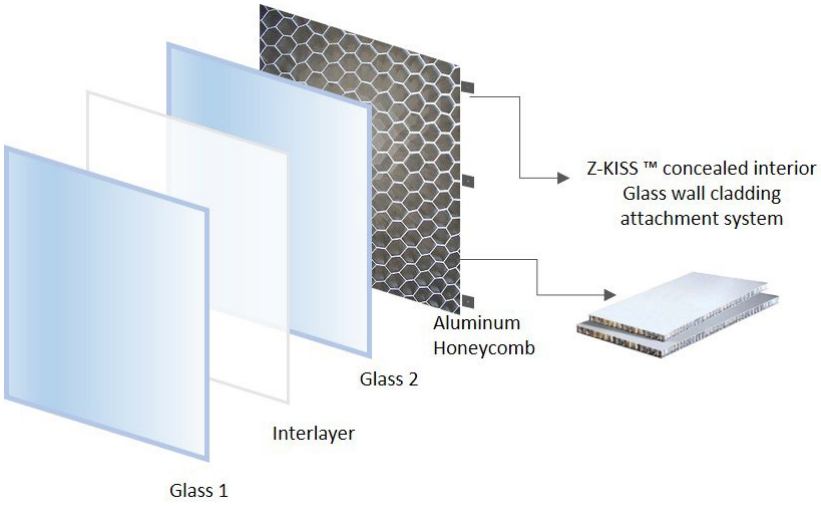
Bendheim's opaque processed glass products can be supplied with the patented Z-KISS™ factory-applied attachment system, for the installation of a concealed and frameless glass wall cladding system. The Z-KISS™ system is attached to the back of the processed glass product as shown in the figure below. To learn more about the Z-KISS™ attachment system, please visit www.bendheim.com/introducing-z-kiss-concealed-attachment-system/

[1] Laminated glass to glass and laminated glass to mirror products are classified under the United Nations Standard Products and Services Code (UNSPSC) 3711 and the Construction Specification Institute (CSA) MasterFormat code 08 81 00.



Z-KISS™ concealed interior glass cladding attachment system.

Bendheim's processed glass products may also be reinforced with an aluminum honeycomb backing as shown in the figure below. This line of products is found under the brand name Hexalite™ Honeycomb for glass cladding.



Laminated Glass to Glass HexaLite™ product with Z-KISS™ concealed interior glass wall cladding attachment system.

2.2. PRODUCT APPLICATION

Bendheim products may be used in interior or exterior applications for residential or commercial projects.

Back-painted glass may be used as cladding for interior walls, including lobbies, elevator interiors, backsplashes, counter tops and glass marker boards. Digitally printed glass can transform spaces with its graphic design capabilities.

2.3. PLACING ON THE MARKET

Bendheim products meet or exceed the following standards per product type:

a) Glass
   - ASTM C1036-21 - Standard Specification for Flat Glass [5]

b) Tempered glass
   - ASTM-C1048-18 - Standard Specification for Heat-Strengthened and Fully Tempered Glass [6]

c) Laminated glass
   - ASTM C1172-19 - Laminated Architectural Flat Glass [7]

2.4. PROPERTIES OF DECLARED PRODUCT AS DELIVERED

Laminated glass to glass and laminated glass to mirror products are available in regular, low-iron, and tinted glass. Low-iron glass is produced with a minimal amount of iron, reducing the greenish tint and improving light transmission. Tinted glass, also called colored glass, is made by adding mineral oxides during the float glass process to create different colors. Glass is available as standard annealed, heat-strengthened or tempered. Furthermore, the glass may be float glass, rolled, textured or etched. Laminated glass to glass products range from 6 mm to 24 mm in total glass thickness. Laminated glass to mirror products combine 3 mm to 12 mm glass types with 3 mm to 6 mm mirror. Total glass and mirror thickness for laminated glass to mirror products is 9 mm to 18 mm.

2.5. MATERIAL COMPOSITION

The raw materials input for laminated products are detailed in the tables below. As for details on material content, refer to the health product declaration (HPD) that can be found at http://www.hpd-collaborative.org/hpd-public-repository/ [8].

Laminated products material composition

Materials	Laminated Glass to Glass	Laminated Glass to Mirror
Glass	92.4%	45.4%
Mirror	0.0%	47.0%
Paint (back-paint colorant)	0.1%	0.0%
Ceramic inks (digital printing)	0.0%	0.0%
Interlayer or liquid resin	7.5%	7.5%
Total Mass (kg/m^2)	1.68E+01	1.71E+01

2.6. MANUFACTURING

Processed glass manufacturing is a multi-step process. First, the glass or mirror is cut, seamed or polished, and washed. The product is then digitally printed (optional) before being heat-strengthened or tempered. The glass may then be back-painted. Laminated products are laminated with liquid resin, EVA or PVB. The product is heated and then cooled to allow the lamination layer to adhere to the glass. Lastly, the products are packaged and ready for shipment.

2.7. PACKAGING

Bendheim products are either shipped on rack trucks, which do not require packaging, or packed in crates. The crates are made of wood lined with polystyrene foam. Cardboard is used to fill any gaps and protect glass panels from touching each other.

Amount of packaging materials per kg of glass and/or mirrors.

Packaging materials	kg/kg glass
Wood	1.55E-1
Cardboard	2.27E-02
Polystyrene foam	9.74E-2

2.8. PRODUCT INSTALLATION

Products should be processed and installed according to industry standards and according to applicable building codes.

2.9. USE CONDITIONS

As specified by the architect, contractor, or owner.

2.10. RE-USE PHASE

Products can be reused if still in good condition.

2.11. DISPOSAL

According to the Glass Association of North America (GANA), a wide variety of architectural glass products can be recycled.[7] Annealed, tempered and low-e glass can be recycled with virtually no restrictions, with the exception of the need to separate contaminants. Recycled glass can enter the composition of numerous products such as fiberglass, glass containers, roadways, highway paint, terrazzo flooring and polishing materials, as well as in landscaping.

In sum, glass can be recycled where facilities exist. Otherwise, it is landfilled as an inert and non-hazardous waste.

3. LCA CALCULATION RULES

3.1. DECLARED UNIT

The selected declared unit (DU) for the processed glass EPDs is **1 m^2 of processed glass products**.

Laminated products declared unit and reference flow

Materials	Laminated Glass to Glass	Laminated Glass to Mirror
Declared unit (m^2)	1	1
Mass per piece (kg/m^2)	1.68E+01	1.71E+01
Conversion factor to 1 kg	5.94E-02	5.84E-02

3.2. PRODUCTION AVERAGE

Bendheim has one facility located in Wayne, New Jersey, and the production data is from their 2023 production year.

Laminated glass to glass products represent a production average of laminated glass to glass, back-painted laminated glass to glass, digitally printed laminated glass to glass and back-painted and digitally printed laminated glass to glass. It should be noted that the impact of colorants is less than 10%; hence, the weighted average includes all colors.

Laminated glass to mirror products are not averaged.

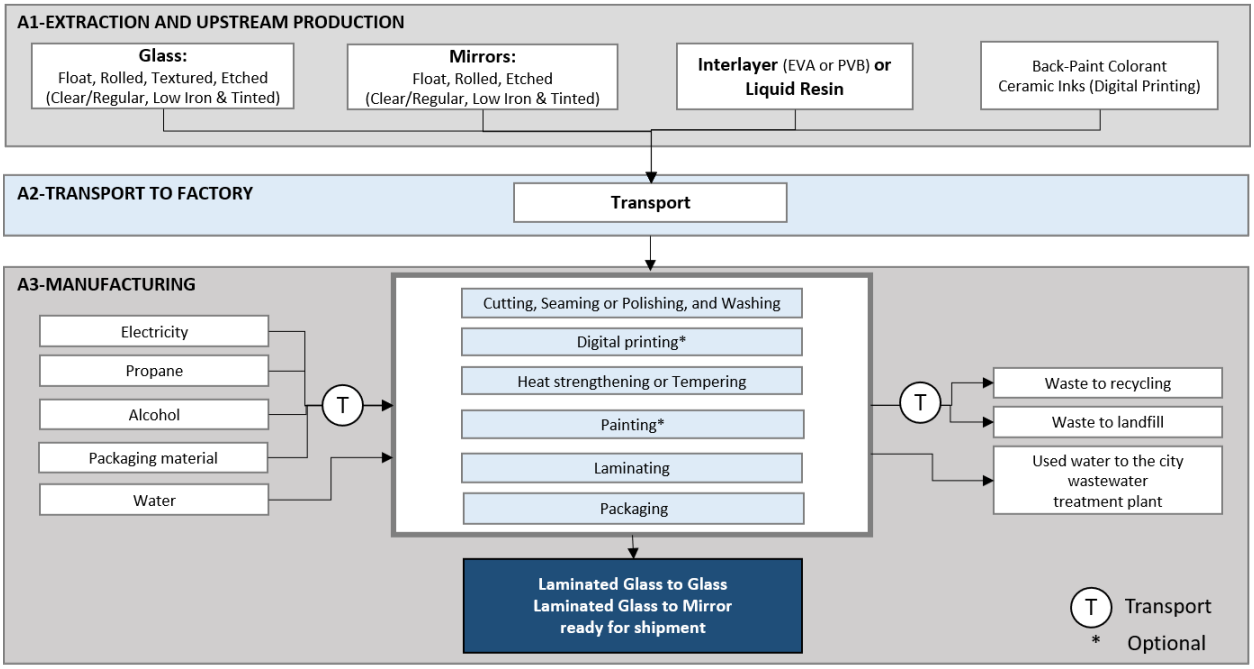
3.3. SYSTEM BOUNDARIES

The system boundaries are **cradle-to-gate**, i.e., only cover the production life cycle stage as illustrated in the table below. Within this life cycle stage, three (3) modules are considered, namely A-1) Extraction and Upstream Production, A-2) Transport to Factory and A-3) Manufacturing. Construction (A-4; A-5), Use (B-1 to B-7) and End-of-life (C-1 to C-4) stages are not included in this study. The figure below presents the process flow diagram. No CO2 credits are used in the framework of this project. An attributional LCA approach is used.

Description of the system boundary life cycle stages and related information modules

PRODUCTION STAGE			CONSTRUC-TION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Extraction and Upstream Production	Transport to Factory	Manufacturing	Transport to Site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction / Demolition	Transport to Waste Processing or Disposal	Waste Processing	Disposal of Waste
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Key: X = included; MND = module not declared (excluded)



Cradle-to-gate LCA system boundaries of Bendheim's Laminated Products.

Extraction and upstream production (A1): This module includes the extraction and transformation of raw materials needed to produce Bendheim's products, such as glass, mirrors, paint, ceramic ink and interlayer (EVA or PVB) or liquid resin.

Transport to factory (A2): This module includes the transportation of raw materials from Bendheim's suppliers to the Wayne, New Jersey facility.

Manufacturing (A3): This module includes water and energy (electricity, propane) consumption during the manufacturing process. Alcohol used to clean the glass has been considered here, as well as its transport to the plant.

Production losses have been determined by weight and are considered as waste sent either to a recycling center or landfill depending on the component.

Finally, packaging materials to make products ready for shipment, as well as their transport to Bendheim's manufacturing plant, are covered in this stage.

3.4. CUT-OFF CRITERIA

Cut-off rules shall not be applied in order to hide data.[2]

In this study, no known mass nor energy flows were excluded from the system boundaries.

For this study, no data on the construction, maintenance or dismantling of the capital assets, daily transport of the employees, office work, business trips and other activities from Bendheim were included in the model. The model only takes into account the processes associated with infrastructure that are already included in the ecoinvent unit processes.

3.5. ALLOCATION

The ISO 14040 allocation procedure states that whenever possible, allocation should be avoided by collecting data related to the process under study or by expanding the product system.

According to ISO 14040, step 2 consists of partitioning the inputs and outputs between the different products in a way that reflects the physical relationship between them.

When allocation was unavoidable, **mass allocation** was used.

Waste processing of the material flows undergoing **recycling** processes are included up to the system boundary of the end-of-waste state.[2] In other words, a **cut-off** approach was used as further processing of the recycled material is part of raw material preparation of another product system (open-loop recycling). No burdens are allocated across the system boundary with secondary material, secondary fuel or recovered energy flows arising from waste.

3.6. DATA SOURCES AND QUALITY REQUIREMENTS

Data Quality Parameter	Data Quality Discussion
Source of manufacturing data	Manufacturing data was collected from the Bendheim LLC manufacturing plant located in Wayne, New Jersey, for the 2023 production year. This data included: total annual mass of products produced at the manufacturing plant; specific product composition; raw materials and fuels entering the product production process; transport distance of materials; electricity consumption; water consumption; and packaging.
Source of secondary data	Background data was taken from the ecoinvent 3.9.1 "cut-off" database, the US LCI database of product EPDs.[9], [10] Datasets were selected based on their representativeness of the products' composing materials. When appropriate, the dataset's grid mix was changed for the grid mix of the country where production takes places. Otherwise, ecoinvent data representative of the global market or "rest-of-the-world" were selected as proxies.
Geographical representativeness	Bendheim's manufacturing facility is located in the state of New Jersey; hence electricity consumption is based on the RFC grid mix. Geographical correlation of the material supply and the selected datasets are largely representative of the same area. When this was not possible, datasets representing a larger geographical area were used.
Temporal representativeness	Primary data was collected so as to be representative of the full 2023 production year. Datasets selected were not always published within the last ten years, although this is not always the case for ecoinvent and US LCI datasets. Nevertheless, ecoinvent and US LCI remain the reference LCI databases.
Technological representativeness	Primary data, obtained from the manufacturer, is representative of the current technologies and materials used by this company.
Completeness	All relevant process steps were considered and modelled to satisfy the goal and scope. No known flows were cut off.

4. LIFE CYCLE ASSESSMENT RESULTS

4.1. RESULTS TABLES

It should be noted that Life Cycle Impact Assessment (LCIA) results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

The table below presents the LCIA results using TRACI methodologies, as well as primary energy consumption, consumption of renewable and non-renewable materials, water consumption, and waste generation.

Environmental Indicator	Unit	Laminated Glass to Glass products (6 mm total glass thickness)			
		A1	A2	A3	A1 - A3
		(per m^2)	(per m^2)	(per m^2)	(per m^2)
TRACI 2.1					
GWP_{100}-AR5[1]	kg CO_2 eq.	4.07E+01	1.11E+01	8.25E+00	6.00E+01
GWP_{100}-AR4[2]	kg CO_2 eq.	4.06E+01	1.08E+01	8.15E+00	5.96E+01
AP	kg SO2 eq.	1.94E-01	1.07E-01	3.01E-02	3.31E-01
EP	kg N eq.	3.65E-02	6.97E-03	4.15E-02	8.51E-02
ODP	kg CFC-11 eq.	4.13E-07	4.02E-08	2.13E-07	6.66E-07
SFP	kg O_3 eq.	3.89E+00	2.70E+00	3.56E-01	6.94E+00
FFD	MJ Surplus	1.04E+02	1.34E+01	2.04E+00	1.19E+02
ADP_{fossil}[3]	MJ	7.07E+02	9.70E+01	5.25E+01	8.57E+02
Resource use					
RPR_E[4]	MJ, LHV	6.67E+01	2.62E-01	6.49E+01	1.32E+02
RPR_M[5]	MJ, LHV	4.45E+00	0.00E+00	0.00E+00	4.45E+00
RPR_T	MJ, LHV	7.11E+01	2.62E-01	6.49E+01	1.36E+02
$NRPR_E$[6]	MJ, LHV	6.08E+02	9.67E+01	1.08E+02	8.13E+02
$NRPR_M$[7]	MJ, LHV	7.59E+01	0.00E+00	0.00E+00	7.59E+01
$NRPR_T$	MJ, LHV	6.84E+02	9.67E+01	1.08E+02	8.89E+02
SM	kg	3.08E+00	0.00E+00	0.00E+00	3.08E+00
RSF	MJ, LHV	4.17E-21	0.00E+00	0.00E+00	4.17E-21
NRSF	MJ, LHV	4.91E-20	0.00E+00	0.00E+00	4.91E-20
RE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW[8]	m^3	3.84E+01	1.92E-03	1.56E-01	3.86E+01
Output flows and waste categories					
HWD[9]	kg	3.61E+00	2.50E-01	1.78E+01	2.17E+01
NHWD[10]	kg	6.38E+00	1.06E-01	1.03E+01	1.68E+01
HLRW[11]	m^3	1.32E-05	9.16E-11	2.97E-08	1.32E-05
ILLRW[12]	m^3	1.28E-05	4.81E-10	2.59E-07	1.31E-05
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	5.94E-01	0.00E+00	6.19E+00	6.78E+00
MER	kg	1.54E-05	0.00E+00	0.00E+00	1.54E-05
EE	MJ, LHV	4.22E-02	0.00E+00	0.00E+00	4.22E-02

Environmental Indicator	Unit	Laminated Glass to Mirror products (6 mm total glass&mirror thickness)			
		A1	A2	A3	A1 - A3
		(per m^2)	(per m^2)	(per m^2)	(per m^2)
TRACI 2.1					
GWP_{100}-AR5[1]	kg CO_2 eq.	4.84E+01	9.13E+00	8.43E+00	6.60E+01
GWP_{100}-AR4[2]	kg CO_2 eq.	4.83E+01	8.90E+00	8.33E+00	6.55E+01
AP	kg SO2 eq.	2.34E-01	9.03E-02	3.09E-02	3.55E-01
EP	kg N eq.	4.60E-02	5.82E-03	4.25E-02	9.43E-02
ODP	kg CFC-11 eq.	6.10E-07	3.49E-08	2.18E-07	8.63E-07
SFP	kg O_3 eq.	4.04E+00	2.25E+00	3.69E-01	6.66E+00
FFD	MJ Surplus	1.13E+02	1.11E+01	2.17E+00	1.26E+02
ADP_{fossil}[3]	MJ	7.75E+02	8.02E+01	5.42E+01	9.10E+02
Resource use					
RPR_E[4]	MJ, LHV	6.66E+01	2.24E-01	6.61E+01	1.33E+02
RPR_M[5]	MJ, LHV	5.79E+00	0.00E+00	0.00E+00	5.79E+00
RPR_T	MJ, LHV	7.24E+01	2.24E-01	6.61E+01	1.39E+02
$NRPR_E$[6]	MJ, LHV	6.95E+02	8.00E+01	1.11E+02	8.86E+02
$NRPR_M$[7]	MJ, LHV	7.95E+01	0.00E+00	0.00E+00	7.95E+01
$NRPR_T$	MJ, LHV	7.75E+02	8.00E+01	1.11E+02	9.66E+02
SM	kg	2.22E+00	0.00E+00	0.00E+00	2.22E+00
RSF	MJ, LHV	2.09E-21	0.00E+00	0.00E+00	2.09E-21
NRSF	MJ, LHV	2.45E-20	0.00E+00	0.00E+00	2.45E-20
RE	MJ, LHV	0.00E+00	1.00E+00	2.00E+00	3.00E+00
FW[8]	m^3	4.35E+01	1.66E-03	1.60E-01	4.37E+01
Output flows and waste categories					
HWD[9]	kg	3.24E+00	2.26E-01	1.81E+01	2.16E+01
NHWD[10]	kg	7.99E+00	8.92E-02	1.37E+01	2.18E+01
HLRW[11]	m^3	3.57E-05	8.46E-11	3.02E-08	3.58E-05
ILLRW[12]	m^3	3.48E-05	4.44E-10	2.64E-07	3.50E-05
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.41E+00	0.00E+00	3.10E+00	4.51E+00
MER	kg	9.87E-06	0.00E+00	0.00E+00	9.87E-06
EE	MJ, LHV	2.75E-02	0.00E+00	0.00E+00	2.75E-02

(1) GWP 100, excludes biogenic CO_2 removals and emissions associated with biobased products and packaging; 100-year time horizon. GWP factors are provided by the IPCC 2013 Fifth Assessment Report (AR5).

(2): GWP 100, excludes biogenic CO_2 removals and emissions associated with biobased products and packaging; 100-year time horizon. GWP factors are provided by the IPCC 2007 Fourth Assessment Report (AR4).

(3): Calculated according to CML-baseline, v.4.8, August 2016.[11]

(4): $RPR_E = RPR_T - RPR_M$, where RPR_T is equal to the value for renewable energy obtained using the CED methodology (LHV).

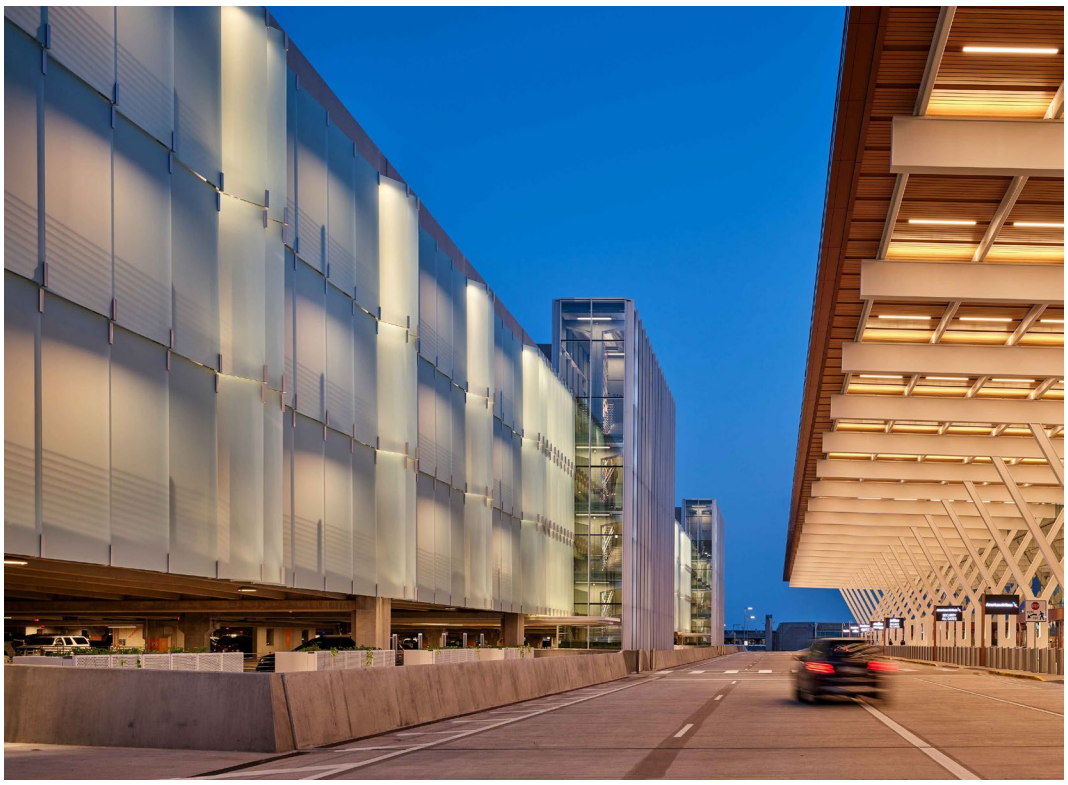
(5) Calculated as per ACLCA ISO 21930 Guidance, 6.2 Renewable primary resources with energy content used as a material, RPR_M.

(6): $NRPR_E = NRPR_T - NRPR_M$, where $NRPR_T$ is equal to the value for non-renewable energy obtained using the CED methodology (LHV).

(7): Calculated as per ACLCA ISO 21930 Guidance, 6.4 Non-renewable primary resources with energy content used as a material, $NRPR_M$.
(8): Represents the use of net fresh water calculated from life cycle inventory results, i.e., water consumption.
(9): Calculated from life cycle inventory results, based on datasets classified under "treatment and disposal of hazardous waste." The manufacturer does not generate hazardous waste.
(10): Calculated from life cycle inventory results, based on waste that is neither "hazardous" nor "radioactive" and EPD values.
(11): Calculated from life cycle inventory results, based on ecoinvent waste flow "high-level radioactive waste for final repository." The manufacturer does not generate radioactive waste.
(12): Calculated from life cycle inventory results, based on ecoinvent waste flow "low-level radioactive waste for final repository." The manufacturer does not generate radioactive waste.

Environmental indicator acronym

GWP: Global Warming Potential; **AP**: Acidification Potential; **EP**: Eutrophication Potential; **ODP**: Ozone Layer Depletion Potential; **SFP**: Smog Formation Potential; **ADP_{fossil}**: Abiotic Resource Depletion Potential of Non-Renewable (Fossil) Energy Resources; **RPR_E**: Renewable Primary Resources Used as Energy Carrier (Fuel); **RPR_M**: Renewable Primary Resources with Energy Content Used as Material; **RPR_T**: Renewable Primary Resources Total; **$NRPR_E$**: Non-Renewable Primary Resources Used as Energy Carrier (Fuel); **$NRPR_M$**: Non-Renewable Primary Resources with Energy Content Used as Material; **$NRPR_T$**: Non-Renewable Primary Resources Total; **SM**: Secondary Materials; **RSF**: Renewable Secondary Fuels; **NRSF**: Non-Renewable Secondary Fuels; **RE**: Recovered Energy; **FW**: Use of Net Fresh Water Resources; **HWD**: Hazardous Waste Disposed; **NHWD**: Non-Hazardous Waste Disposed; **RWD**: Radioactive Waste Disposed; **HLRW**: High-Level Radioactive Waste, Conditioned, to Final Repository; **ILLRW**: Intermediate and Low-Level Radioactive Waste, Conditioned, to Final Repository; **CRU**: Components for Re-Use; **MFR**: Materials for Recycling; **MER**: Materials for Energy Recovery; **E**E: Exported Energy.



Kansas City International Airport parking structure, Kansas City, MO. Laminated etched glass
[Picture courtesy of Bendheim LLC].

4.2. HEXALITE™ HONEYCOMB FOR GLASS CLADDING AND Z-KISS™ CONCEALED INTERIOR GLASS WALL CLADDING SYSTEM

Processed glass products may come with an aluminum honeycomb reinforcing backing and then become products branded under HexaLite™ honeycomb for glass cladding. Products may also have a Z-KISS™ concealed interior glass wall cladding attachment system. Use the results presented in the table below to include the impacts of these systems.

Results for 1 m² of Bendheim aluminum honeycomb reinforcing backing.

Environmental Indicator	Unit	Aluminum Honeycomb			
		A1	A2	A3	A1 - A3
		(per m²)	(per m²)	(per m²)	(per m²)
TRACI 2.1					
GWP_{100}-AR5[1]	kg CO_2 eq.	4.66E+01	1.88E+00	1.55E-02	4.85E+01
GWP_{100}-AR4[2]	kg CO_2 eq.	4.58E+01	1.83E+00	1.54E-02	4.77E+01
AP	kg SO2 eq.	1.77E-01	1.47E-02	1.31E-04	1.92E-01
EP	kg N eq.	6.67E-03	1.05E-03	1.40E-05	7.74E-03
ODP	kg CFC-11 eq.	1.99E-09	4.01E-09	2.36E-10	6.24E-09
SFP	kg O_3 eq.	1.96E+00	4.07E-01	3.55E-03	2.37E+00
FFD	MJ Surplus	8.88E+01	2.19E+00	3.76E-02	9.11E+01
ADP_{fossil}[3]	MJ	6.95E+01	1.58E+01	2.72E-01	8.56E+01
Resource use					
RPR_E[4]	MJ, LHV	2.20E+02	3.04E-02	1.62E-03	2.20E+02
RPR_M[5]	MJ, LHV	1.02E+02	0.00E+00	0.00E+00	1.02E+02
RPR_T	MJ, LHV	3.22E+02	3.04E-02	1.62E-03	3.22E+02
$NRPR_E$[6]	MJ, LHV	5.88E+02	1.57E+01	2.72E-01	6.04E+02
$NRPR_M$[7]	MJ, LHV	4.25E+00	0.00E+00	0.00E+00	4.25E+00
$NRPR_T$	MJ, LHV	5.92E+02	1.57E+01	2.72E-01	6.08E+02
SM	kg	4.98E+00	0.00E+00	0.00E+00	4.98E+00
RSF	MJ, LHV	1.16E-10	0.00E+00	0.00E+00	1.16E-10
NRSF	MJ, LHV	3.91E-10	0.00E+00	0.00E+00	3.91E-10
RE	MJ, LHV	0.00E+00	1.00E+00	2.00E+00	3.00E+00
FW[8]	m³	4.25E+00	1.94E-04	1.75E-04	4.25E+00
Output flows and waste categories					
HWD[9]	kg	2.94E-07	1.02E-02	2.83E-03	1.30E-02
NHWD[10]	kg	1.22E+01	1.52E-02	1.08E+00	1.33E+01
HLRW[11]	m^3	2.04E-05	1.17E-12	1.29E-12	2.04E-05
ILLRW[12]	m^3	1.59E-02	6.97E-12	6.97E-12	1.59E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.47E+00	0.00E+00	4.09E-01	1.88E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Results for 1 m² of Bendheim Z-KISS™ concealed interior glass wall cladding attachment system.

Environmental Indicator	Unit	Z-KISS™			
		A1 (per m²)	A2 (per m²)	A3 (per m²)	A1 - A3 (per m²)
TRACI 2.1					
GWP_{100}-AR5[1]	kg CO_2 eq.	4.71E+00	1.39E-01	1.18E-03	4.85E+00
GWP_{100}-AR4[2]	kg CO_2 eq.	4.71E+00	1.36E-01	1.17E-03	4.85E+00
AP	kg SO2 eq.	1.36E-02	1.10E-03	9.92E-06	1.47E-02
EP	kg N eq.	7.59E-04	8.02E-05	1.07E-06	8.40E-04
ODP	kg CFC-11 eq.	4.41E-10	3.47E-10	1.82E-11	8.06E-10
SFP	kg O_3 eq.	1.87E-01	3.03E-02	2.69E-04	2.18E-01
FFD	MJ Surplus	6.98E+00	1.89E-01	2.86E-03	7.17E+00
ADP_{fossil}[3]	MJ	5.79E+01	1.37E+00	2.07E-02	5.93E+01
Resource use					
RPR_E[4]	MJ, LHV	1.32E+01	2.62E-03	1.25E-04	1.32E+01
RPR_M[5]	MJ, LHV	1.95E-02	0.00E+00	0.00E+00	1.95E-02
RPR_T	MJ, LHV	1.33E+01	2.62E-03	1.25E-04	1.33E+01
$NRPR_E$[6]	MJ, LHV	5.94E+01	1.36E+00	2.08E-02	6.08E+01
$NRPR_M$[7]	MJ, LHV	1.48E-01	0.00E+00	0.00E+00	1.48E-01
$NRPR_T$	MJ, LHV	5.95E+01	1.36E+00	2.08E-02	6.09E+01
SM	kg	1.92E+00	0.00E+00	0.00E+00	1.92E+00
RSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE	MJ, LHV	0.00E+00	1.00E+00	2.00E+00	3.00E+00
FW[8]	m^3	7.89E-02	1.68E-05	1.35E-05	7.90E-02
Output flows and waste categories					
HWD[9]	kg	3.77E-04	8.82E-04	2.19E-04	1.48E-03
NHWD[10]	kg	5.99E-01	1.32E-03	8.38E-02	6.85E-01
HLRW[11]	m^3	4.00E-07	1.02E-13	1.00E-13	4.00E-07
ILLRW[12]	m^3	4.87E-06	6.02E-13	5.39E-13	4.87E-06
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	2.36E-01	0.00E+00	2.79E-02	2.64E-01
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00

4.3. CALCULATING IMPACT CATEGORY RESULTS FOR PRODUCTS WITH OTHER GLASS & MIRROR THICKNESSES

The results were presented for products with total glass, mirror, or glass and mirror thickness of 6 mm.

To obtain the results for other glass, mirror, or glass and mirror thicknesses, use the equation below. Note that, for laminated glass to mirror products, the results are for an equivalent glass and mirror thickness. For example, the 6 mm total glass and mirror thickness represents a 3 mm glass laminated to a 3 mm mirror.

$$Impact\ result_t = sf * (t - 6) + Impact\ result_{6mm}$$

Where

Impact result$_t$: Impact results for the desired glass and/or mirror thickness

t: Desired glass and/or mirror thickness (mm)

sf: Scaling factor

Impact result6mm: Impact results for products with a total glass and/or mirror thickness of 6 mm

For example, to calculate the global warming potential (GWP-AR5) of a Laminated Glass to Mirror product with a total glass and mirror thickness of 12 mm, the calculation is as follows:

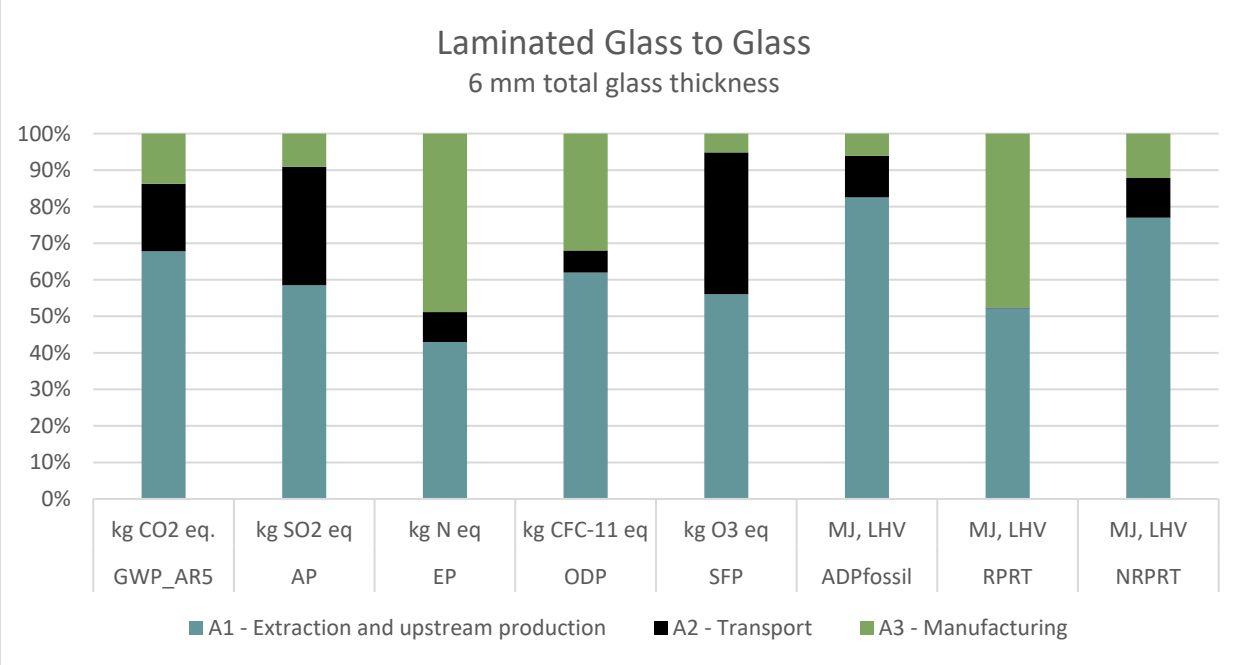
Impact result$_{12}$ = 9.59 * (12-6) + 65.8 = 123 kg CO_2 eq./m2

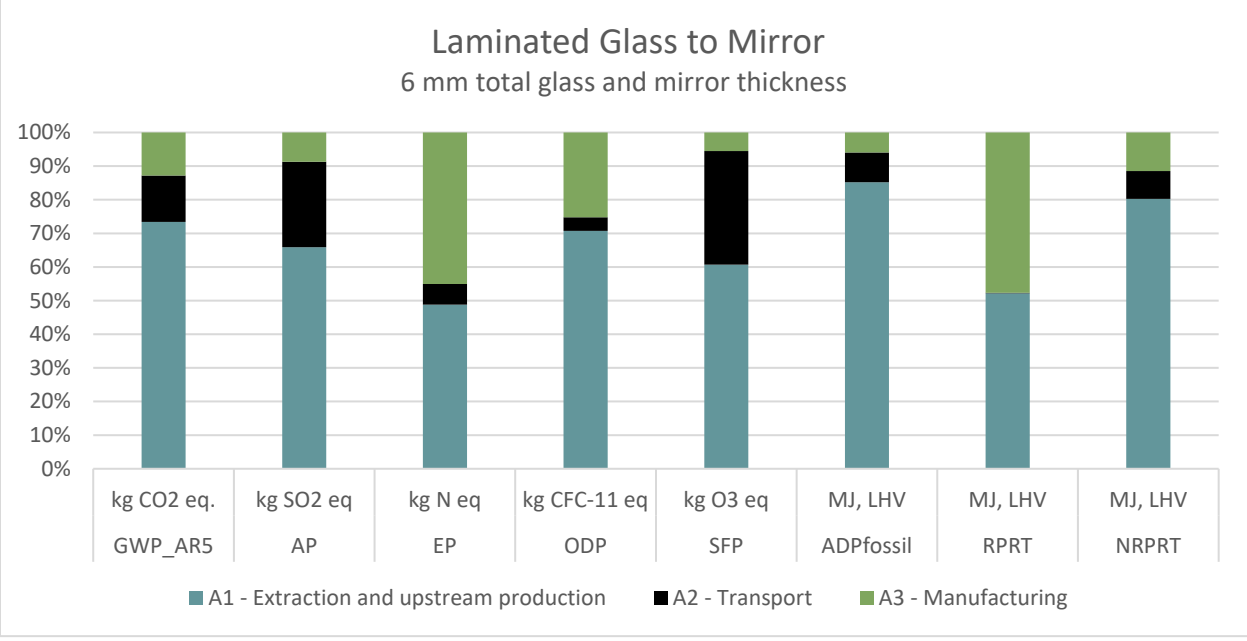
Laminated products scaling factor (A1-A3)

Environmental Indicator	Laminated Glass to Glass	Laminated Glass to Mirror
	sf	sf
TRACI 2.1		
GWP_{100}-AR5	8.60E+00	9.59E+00
AP	5.01E-02	5.42E-02
EP	1.11E-02	1.26E-02
ODP	1.05E-07	1.38E-07
SFP	1.05E+00	1.00E+00
FFD	1.60E+01	1.72E+01
ADP_{fossil}	1.15E+02	1.23E+02
RPRT	1.94E+01	4.21E+01
NRPRT	1.21E+02	1.11E+02

4.4. CONTRIBUTION ANALYSIS

As can be seen from the three figures below, extraction and upstream production (A1) is the main contributor to all potential impact categories, as well as renewable and non-renewable primary resource consumption.





GWP: Global Warming Potential; **AP**: Acidification Potential; **EP**: Eutrophication Potential; **ODP**: Ozone Layer Depletion Potential; **SFP**: Smog Formation Potential; **ADP_{fossil}**: Abiotic Resource Depletion Potential of Non-Renewable (Fossil) Energy Resources; **RPRT**: Renewable Primary Resources – Total; **NRPRT**: Non-Renewable Primary Resources – Total.

5. ADDITIONAL ENVIRONMENTAL INFORMATION

5.1. REGULATED HAZARDOUS SUBSTANCES

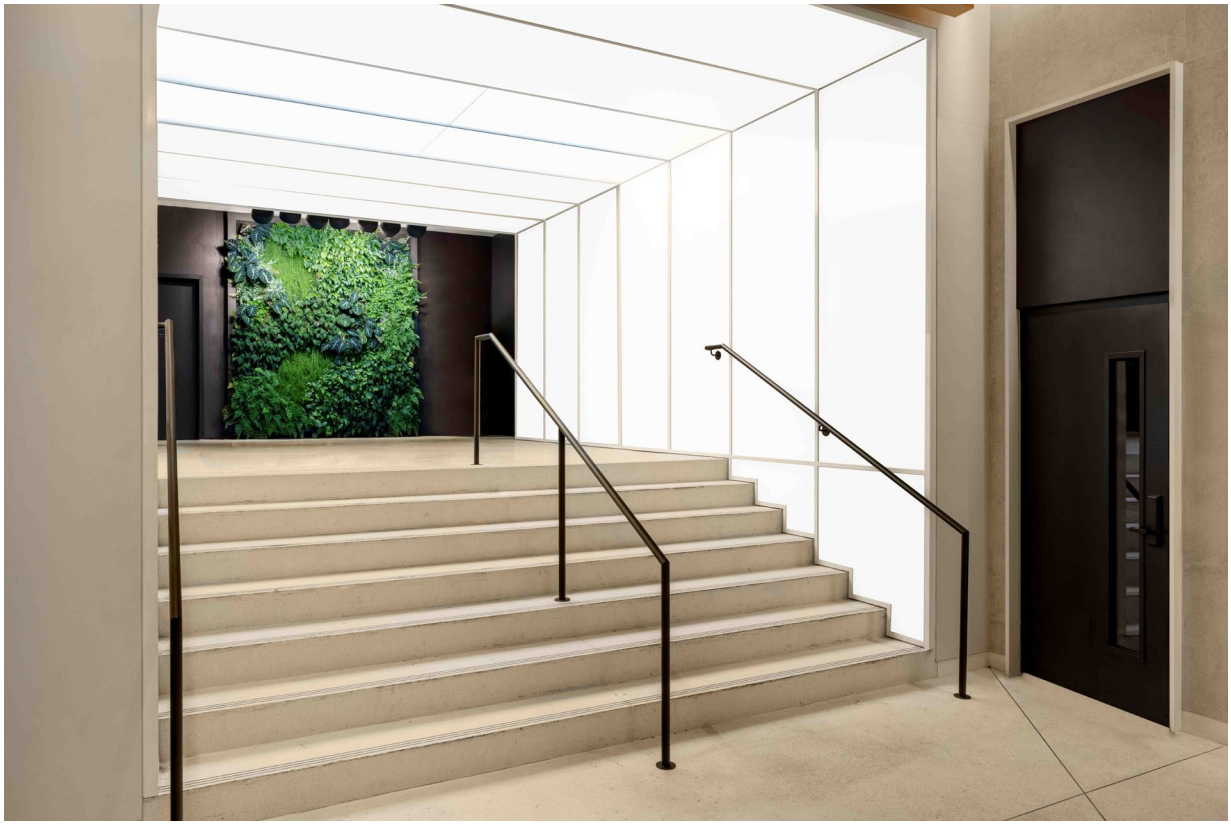
No substances required to be reported as hazardous are associated with the products.

5.2. DANGEROUS SUBSTANCES

The products are not known to release dangerous substances.

5.3. FURTHER INFORMATION

Bendheim has also published a Health Product Declaration® for all their products. More details are available on the HPDC public repository: https://www.hpd-collaborative.org/hpd-public-repository/.



200 Varick St., New York, NY. Laminated glass with white EVA [Picture courtesy of Bendheim LLC].

6. REFERENCES

[1] International Organization for Standardization (ISO), "ISO 14025 Environmental labels and declarations - Type III environmental declarations - Principles and procedures," 2006.

[2] International Organization for Standardization (ISO), "ISO 21930:2017(E) Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services," 2017.

[3] International Organization for Standardization (ISO), "ISO 14040:2006/AMD 1:2020 Environmental management - Life cycle assessment - Principles and framework," 2020.

[4] International Organization for Standardization (ISO), "ISO 14044:2006/AMD1:2017/AMD 2:2020 Environmental management - Life cycle assessment - Requirements and guidelines," 2006.

[5] ASTM International, "ASTM C1036-21, Standard Specification for Flat Glass," 2021. [Online]. Available: www.astm.org.

[6] ASTM International, "ASTM C1048-18, Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass," West Conshohocken, PA, 2018[Online]. Available: www.astm.org.

[7] ASTM International, "ASTM C1172 - 19 Standard Specification for Laminated Architectural Flat Glass," West Conshohocken, PA, 2019[Online]. Available: www.astm.org.

[8] HPDC, "HPD Public Repository," 2022. [Online]. Available: https://www.hpd-collaborative.org/hpd-public-repository/.

[9] F. R. *et al.*, "Overview and Methodology. ecoinvent report No. 1," Dübendorf, 2007.

[10] National Renewable Energy Laboratory, "U.S. Life Cycle Inventory Database," 2012. [Online]. Available: https://www.lcacommons.gov/nrel/search. [Accessed: 03-Feb-2020].

[11] University of Leiden, "CML-IA Characterisation Factors." [Online]. Available: https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors. [Accessed: 22-Jun-2021].

[12] ASTM International, "ASTM Program Operator Rules. Version: 8.0, Revised 04/29/20," 2020[Online]. Available: www.astm.org.

[13] Vertima, "Bendheim Life Cycle Assessment of Processed Glass and Glass Marker Boards," 2024.

82 Totowa Road

Wayne, New Jersey 07470

USA

www.bendheim.com

EPD

This LCA and EPD were prepared by Vertima Inc.

604 Saint Viateur Street
Quebec, QC
(418) 990-2800
G2L 2K8 CANADA

vertima
Environmental certification experts
vertima.ca