

ENVIRONMENTAL PRODUCT DECLARATION

HALIO® INSULATED GLASS UNIT (IGU)

KINESTRAL TECHNOLOGIES, INC

Electrochromic Insulated Glass Unit



Halio is smart-tinting glass that features a variable light transmission rate and solar heat gain coefficient. Based on electrochromic technologies, Halio looks like ordinary clear glass until it tints uniformly to block excessive solar heat and reduce glare, achieving its darkest shade within several minutes.



Kinestral Technologies, Inc. was founded with the belief that the energy we don't use is just as important as the energy we use. At Kinestral, we've challenged ourselves to embrace science and new technologies to create a new kind of glass that reduces the impact of buildings on the environment. Halio® smart-tinting glass makes it possible for architects and contractors to design and build with the beauty of glass without sacrificing energy efficiency or making aesthetic compromises.



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Halio Insulated Glass Unit
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According to ISO 14025, EN 15804 & ISO 21930:2007

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025, EN15804, and ISO 21930. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. 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, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment	
DECLARATION HOLDER	Kinestral Technologies, Inc.	
DECLARATION NUMBER	4789631513.101.1	
DECLARED PRODUCT	Halio Insulated Glass Unit	
REFERENCE PCR	PCR for EPDs: Building-Related Products and Services – Part B: Processed Glass EPD Requirements (v1.0 2016)	
DATE OF ISSUE	January 1, 2021	
PERIOD OF VALIDITY	5 years	
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications	
The PCR review was conducted by:	UL Environment	
	Thomas P. Gloria, Ph.D, Chair	
	epd@ulenvironment.com	
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL		
	Grant R. Martin, UL Environment	
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:		
	Thomas P. Gloria, Industrial Ecology Consultants	

This EPD conforms with EN 15804 and ISO 21920:2007

Environment





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Product Definition and Information

Description of Company/Organization and ISO Certifications

Kinestral Technologies, Inc. (Kinestral) develops technology that transforms glass into responsive, intelligent, appealing, and architectural elements. The company’s research and development efforts have resulted in a growing global patent portfolio in manufacturing, device processing, and smart window control systems. Halio products are available through Halio North America, LLC or Halio International, S.A., Kinestral and AGC, Inc. joint venture companies.

The Kinestral factory in Miaoli County, Taiwan is ISO 9001 certified as of October 2020.

Product Description

Halio is smart-tinting glass that features a variable light transmission rate and solar heat gain coefficient. Based on electrochromic technologies, Halio looks like ordinary clear glass until it tints uniformly to block excessive solar heat and reduce glare, achieving its darkest shade within several minutes. Managing daylight with Halio improves occupant comfort while achieving the highest levels of energy efficiency. Additional product features include:

- High color rendering index in clear and tinted states providing accurate natural colors.
- Fast response time for immediate glare relief; combined with fast tinting speed and unlimited tint levels, this allows for maximal access to daylight.
- The Halio Cloud allows for manual or automated control as well as secure interaction with third-party devices and building automation systems.

The materials named in this document are applicable to all Halio and Halio Black insulated glass unit configurations; the ranges provided are to accommodate the available dimensions.

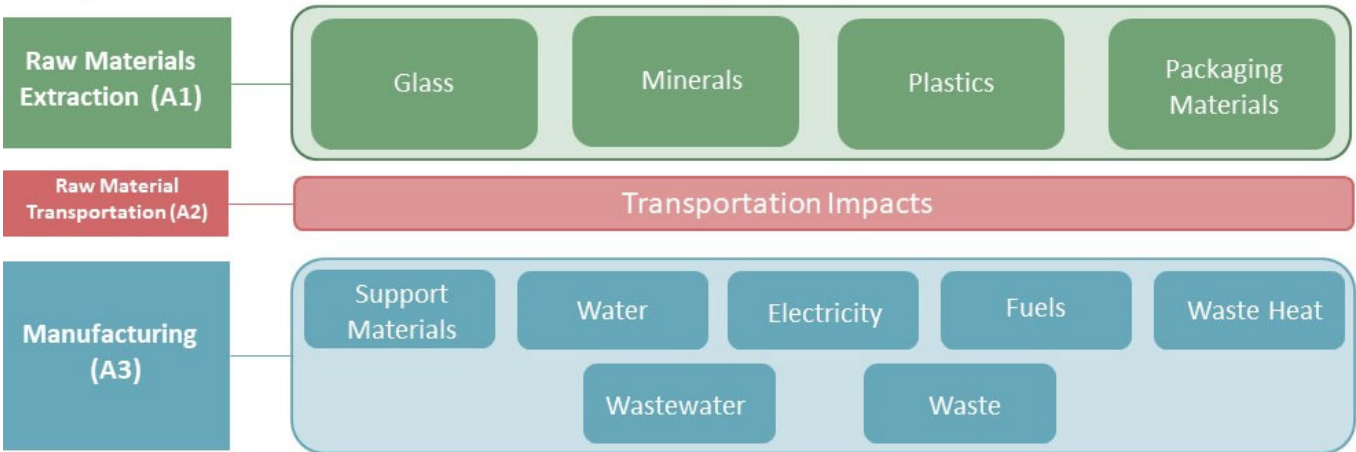


Figure 1 – System Boundary Diagram



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Application

The products covered in this declaration are for window, skylight, interior partitions, and curtain wall systems used in commercial buildings, institutional buildings, or residential buildings.

Technical Requirements

Table 1 - Halio Technical Data

Technical Data				
	Halio		Halio Black	
	Clear	Tinted	Clear	Tinted
Visible Light Transmission (VLT)	64%	2%	50%	0.1%
Solar Heat Gain Coefficient (SHGC)	0.45	0.10	0.35	0.08
U-Factor	0.26		0.26	
UV Transmission	<0.1%		<0.1%	
Reflectance Outside	14%	6%	16%	6%
Reflectance Inside	16%	11%	18%	11%
Sound Transmission Class (STC)	42		42	
Number of Tint Levels	Unlimited		Unlimited	
Width	up to 5ft (1.524m)			
Length	up to 10ft (3.048m)			
Standard Thickness	Standard configuration IGU thickness is 30.23 mm. Flexibility in configuration allows for thicknesses of 50 mm and more to be possible			
Interlayer Percent Mass	3.24%			

Note: Properties shown only for clear and fully-tinted states. Unlimited tint levels allow to achieve any value between the values reported for the fully-tinted and clear state. Other configurations available based on project requirements; to be confirmed by Halio North America. Data based on a 1.125-inch thick IGU with 10mm spacer, 90% Argon filled gap, and AGC Energy Select 63 on Purevision (low-iron) for the interior pane.



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Placing on the Market / Application Rules

The following standards are applicable for the range of products in this declaration:

- ASTM E2953-14 - Standard Specification for Evaluating Accelerated Aging Performance of Electrochromic Devices in Sealed Insulating Glass Units
- ASTM E2141 - Standard Test Methods for Assessing the Durability of Absorptive Electrochromic Coatings on Sealed Insulating Glass Units
- ASTM E2190 - Standard Specification for Insulating Glass Unit Performance and Evaluation
- EN 1279 Part 2 - High Humidity Cycling Weathering Testing
- EN 1279 Part 3 - Gas Loss Rate Per Year Through Shortened Weathering Test and Gas Leakage Test
- American National Institute (ANSI) Z97.1-2009 Standard - Safety Glazing Materials Used in Buildings
- Consumer Product Safety Commission (CPSC) 16 CFR 1201 - Safety Standard for Architectural Glazing Materials
- CAN/CBSB-12.1-M90 - Tempered or Layered Safety Glass
- ASTM F3007 - Standard Test Method for Ball Drop Impact Resistance of Laminated Architectural Flat Glass
- ASTM E1886 - Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
- ASTM E330 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference
- ASTM E822 - Standard Practice for Determining Resistance of Solar Collector Covers to Hail by Impact with Propelled Ice Balls
- ASTM E1425 - Standard Practice for Determining the Acoustical Performance of Windows, Doors, Skylight, and Glazed Wall Systems
- ASTM E1332 - Standard Classification for Rating Outdoor-Indoor Sound Attenuation

Properties of Declared Product as Delivered

Halio IGUs are available in sizes up to 1.524m x 3.048m (5ft x 10ft) with a variety of overall unit thicknesses. The Halio IGUs are delivered in a wooden shipping crate. For additional information see the "Packaging" section on page 7.



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Material Composition

Table 2 - Halio Material Composition

Material	%
Glass	95.75%
PVB	2.70%
Spacer	0.59%
Proprietary Ingredients	0.54%
Sealant	0.19%
Dessicant	0.11%
Support Materials	0.07%
Gas Fill	0.05%
Total	100.00%

Manufacturing

The Kinestral factory in Miaoli, Taiwan is the only location that manufactures Halio smart-tinting glass. This plant produces no other products besides Halio. The manufacturing process of the Halio product in this facility begins with the automated loading of the mothersheet onto a conveyor belt to enter a controlled environment. Laser equipment creates the patented gradient pattern in the transparent conductive oxide (TCO) coated glass. The substrate is then washed to remove all debris generated from previous steps. Next, in a tightly controlled environment, the glass is coated with proprietary chemicals to form the cathode or anode of the electrochromic (EC) device. After drying, the films are thermally treated. After polymer adhesive is added to the glass surface, the anode and cathode are sandwiched and sealed together into one device. Following a final heat treatment, the device is reinforced with carrier glass. The Halio device is then ready to be shipped to an LGU/IGU manufacturing facility close to the installation site and incorporated into an LGU/IGU according to the specifications of the project. At the LGU/IGU manufacturing facility, wiring is attached to the product.



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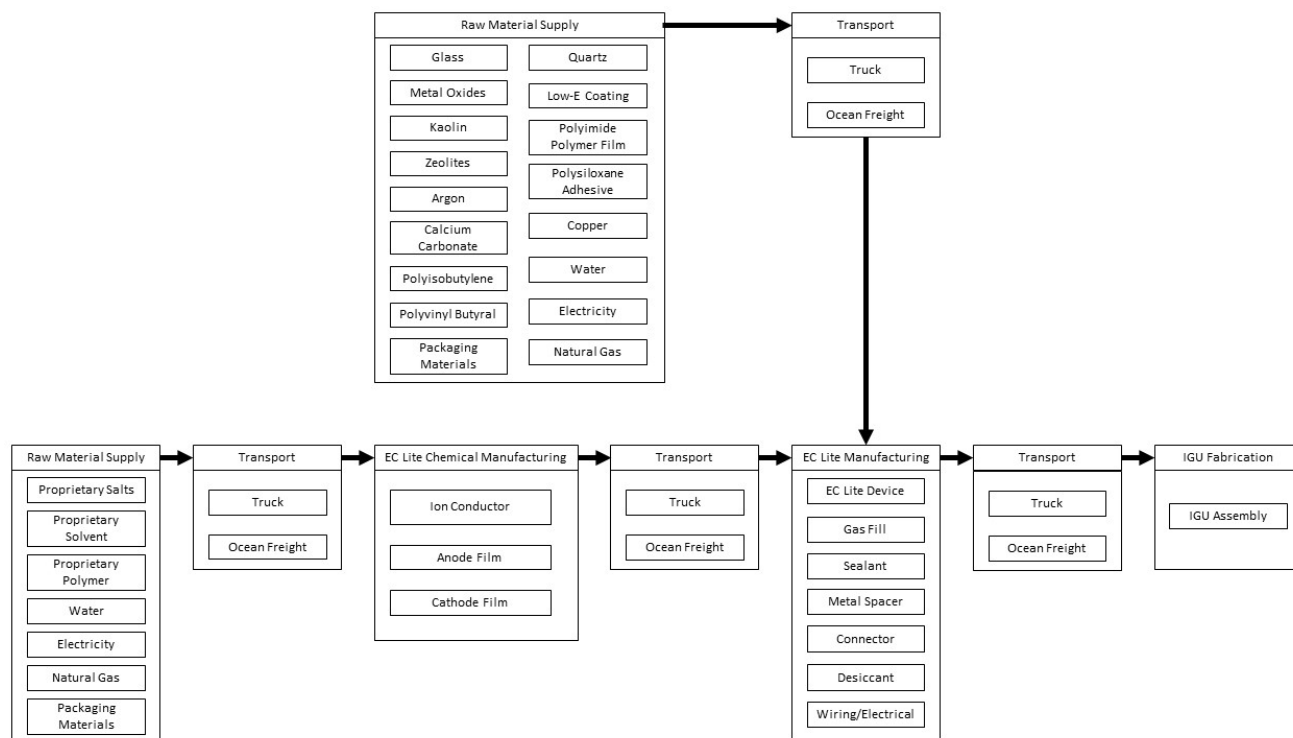


Figure 2 – Process Flow Diagram

Environment and Health During Manufacturing

Kinestral is committed to providing a healthy and safe work environment for all employees, contractors, and visitors by fostering a high-performance culture where Environmental, Health, and Safety (EHS) awareness, involvement, and accountability are intrinsic to all business activities. Processes at Kinestral manufacturing facilities comply with all local and national health and safety laws and regulations, as well as current best practices.

Product Processing/Installation

Halio insulating glass units (IGUs) need to be installed by a professional glazer using procedures that are similar to conventional IGU installation. The only additional operation is connecting the pre-terminated pigtail exiting the glass unit to the driver cable which connects it to the Halio Tint Driver for control. This cable must be accounted for in the glazing pocket or framing. A complete installation guide for electricians and glaziers is available online (<https://www.kinestral.com/resources/manual-for-glaziers-and-electricians/>). Personal protective equipment that is standard for glazing contractors (i.e. gloves, protective footwear, and eye protection) applies, but no additional industrial or environmental protection is needed as there is no exposure to or emission of chemicals or dust expected during installation.



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Packaging

Halio IGUs are packaged in wooden shipping crates. The panels are securely tightened with nylon strapping to hold them in place while shipping; small pieces of adhesive foam are placed on the side and thin paper is placed between panels for added protection.

Conditions of Use

Halio smart-tinting glass looks like normal clear glass until it tints uniformly to cool shades of gray. On-demand or automatically responding to changes in the environment, Halio tints to unlimited tint levels to maximize daylight and views, while keeping out excessive heat and glare.

Environment and Health During Use

There are no harmful substances or emissions released during use that affect the environment or human health. Halio IGUs do not require additional maintenance after installation; cleaning procedures are identical to cleaning of conventional glazing.

Reference Service Life

This declaration does not cover the product use stage (B1-B7) in accordance with the Part B: Processed Glass PCR.

Extraordinary Effects

Fire

No danger to the environment can be anticipated during fire.

Water

The product contains no substances that have any impact on water in case of flood. Electric operation of the device will be influenced negatively.

Mechanical Destruction

No danger to the environment can be anticipated during mechanical destruction.

Re-Use Phase

There are no re-use procedures for the glazing units.

Disposal

Like conventional glazing units at end of life, Halio smart-tinting glass is typically removed from the window opening and framing system and transported to a landfill for disposal. Recycling is possible for 80% of electronic components through a certified third-party electronics recycler. There are currently no re-use, recycling, and/or energy recovery procedures for the glazing units.

Further Information

<https://www.kinestral.com/company/contact/>



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Life Cycle Assessment Background Information

Functional or Declared Unit

This declaration refers to the functional unit of a Halio Insulated Glass Unit, as specified in the Processed Glass PCR.

Table 3 - Halio Declared Functional Unit

NAME	VALUE	UNIT
Declared unit	1	m²
Mass	38.50	kg
Conversion factor to 1 kg	0.03	-
Standard Thickness*	30.23	mm
Interlayer Percent Mass	3.24	%

*Standard configuration IGU thickness is 30.23 mm, but flexibility in configuration allows for thicknesses of 50 mm and more to be possible.

System Boundary

This is a cradle-to-gate Environmental Product Declaration. The following life cycle phases were considered.

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 gate to the site	Construction/ installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction /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
Description of the System Boundary Stages Corresponding to the PCR (X = Included; MND = Module Not Declared)																





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Estimates and Assumptions

Life cycle analysis requires assumptions to be made to constrain the project boundary or model processes when little to no data is available. In this study of Halio, the following assumptions were made:

- It is assumed that the raw materials are sourced from an average distance of 200 km using a truck, except the components from the Hayward, CA facility, which are transported to Taiwan by ship and truck.
- It is assumed that the packaging associated with internal transport of electronic components from Hayward, CA facility to the Taiwan facility is reused at the latter facility. This packaging is thus assumed to be incorporated into packaging of the Halio device. This is modeled as a packaging crate at the Taiwan facility.
- A distance of 50 km is assumed for the transport of waste generated during manufacturing.
- Coated glass scrap is assumed to be sent to landfill, while non-coated glass scrap is assumed to be sent to recycling.
- When a material is not available in the LCI databases, another chemical which has similar manufacturing and environmental impacts may be used as a proxy, representing the actual chemical.

Background Data

SimaPro v9 software was utilized for modeling the complete cradle-to-gate LCI for Halio. All process data including inputs (raw materials, energy, and water) and outputs (emissions, wastewater, solid waste, and final products) are evaluated and modeled to represent each process that contributes to the life cycle of the Halio product. The study's geographical and technological coverage included North America and Taiwan, focusing on the region around Hayward, CA in North America and Tongluo Township, Miaoli County in Taiwan. SimaPro v9 was used to generate life cycle impact assessment (LCIA) results utilizing the TRACI impact assessment methodology as well as single flow environmental scores (Global Warming Potential and Cumulative Energy Demand). CML methodology was also used for the life cycle impact assessment results published in this document.

Cut-off Criteria

Processes whose total contribution to the final result, with respect to their mass and in relation to all considered impact categories, is less than 1% can be neglected. The sum of the neglected processes may not exceed 5% by mass of the considered impact categories; for that a documented assumption is admissible.

For Hazardous Substances the following requirements apply:

- The Life Cycle Inventory (LCI) of hazardous substances will be included, if the inventory is available.
- If the LCI for a hazardous substance is not available, the substance will appear as an input in the LCI of the product, if its mass represents more than 0.1% of the product composition.
- If the LCI of a hazardous substance is approximated by modeling another substance, documentation will be provided.

This EPD is in compliance with the cut-off criteria. No processes were neglected or excluded. Capital items for the production processes (machine, buildings, etc.) were not taken into consideration.



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Data Sources

Primary data were collected for every process in the product system under the control of Kinestral. Secondary data from the US LCI and ecoinvent databases were utilized. These data were evaluated and have temporal, geographic, and technical coverage appropriate to the scope of the Product Category Rules for Building-Related Products and Services Part A and Part B.

Data Quality

The data sources used are complete and representative of North America in terms of the geographic and technological coverage and are a recent vintage (i.e. less than ten years old). The data used for primary data are based on direct information sources of the manufacturer. Secondary data sets were used for raw materials extraction and processing, end of life, transportation, and energy production flows. Wherever secondary data are used, the study adopts critically reviewed data for consistency, precision, and reproducibility to limit uncertainty.

Period under Review

The period under review is from July 2019 to December 2019.

Allocation

Allocation for manufacturing energy, water, and waste items was conducted per mass of production based on sub-metered processing zones in the Hayward facility. For recycled content, the “recycled content methodology,” also known as the “cut-off methodology” was applied to the raw materials. No credits from recycling or energy recovery of materials or waste were used in the modeling of this study.

Comparability (Optional)

As instructed by the PCR, comparison of the environmental performance of processed glass using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase. Full conformance with the PCR for North American Process Glass allows EPD comparability only when all stages of the processed glass life cycle have been considered, which is not permitted under this PCR. However, variations and deviations are possible.

Life Cycle Assessment Scenarios

No additional scenario or module technical information is required for cradle-to-gate EPDs using this PCR.



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Life Cycle Assessment Results

Life Cycle Impact Assessment Results

Table 4 - North American Impact Assessment Results (TRACI)

Impact Category	Unit	A1: Raw Materials	A2: Raw Material Transport	A3: Manufacturing
Global Warming	kg CO ₂ eq	4.93E+01	1.09E+00	5.71E+02
Stratospheric Ozone Layer Depletion	kg CFC ₋₁₁ eq	6.94E-04	2.74E-07	1.73E-05
Acidification	kg SO ₂ eq	4.05E-01	2.82E-03	3.10E+00
Eutrophication	kg N eq	7.98E-02	1.15E-03	9.20E-01
Photochemical Ozone Creation	kg O ₃ eq	4.68E+00	4.16E-02	4.16E+01
Abiotic Resource Depletion - Minerals	kg Fe eq	5.65E+00	3.86E-02	5.61E+00
Abiotic Resource Depletion - Fossil Fuels	MJ, surplus	7.95E+01	2.46E+00	1.81E+02

Table 5 - EU Impact Assessment Results (CML)

Impact Category	Unit	A1: Raw Materials	A2: Raw Material Transport	A3: Manufacturing
Global Warming	kg CO ₂ eq	4.98E+01	1.09E+00	5.85E+02
Ozone Layer Depletion	kg CFC ₋₁₁ eq	7.35E-05	2.06E-07	1.14E-05
Acidification	kg SO ₂ eq	4.06E-01	2.77E-03	2.98E+00
Eutrophication	kg PO ₄ eq	5.57E-02	6.19E-04	5.77E-01
Photochemical Oxidation	kg C ₂ H ₄ eq	1.54E-02	1.71E-04	1.37E-01
Abiotic Depletion (non-fossil fuel)	kg Sb eq	2.09E-04	3.22E-06	1.79E-04
Abiotic Depletion (fossil fuels)	MJ	5.83E+02	1.70E+01	5.37E+03



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Life Cycle Inventory Results

Table 6 - Resource Use

Resource Use Category	Abbreviation and Unit	A1: Raw Material	A2: Raw Material Transport	A3: Manufacturing
Renewable Primary Energy as Energy Carrier	PERE (MJ)	2.31E+01	1.28E-01	1.26E+03
Renewable Primary Energy Resources as Material Utilization	PERM (MJ)	1.27E+01	5.16E-02	6.79E+01
Total Use of Renewable Primary Energy Resources	PERT (MJ)	3.57E+01	1.79E-01	1.32E+03
Non-Renewable Primary Energy as Energy Carrier	PENRE (MJ)	6.47E+02	1.83E+01	6.32E+03
Non-Renewable Primary Energy as Material Utilization	PENRM (MJ)	0.00E+00	0.00E+00	0.00E+00
Total Use of Non-Renewable Primary Energy Resources	PENRT (MJ)	6.47E+02	1.83E+01	6.32E+03
Secondary Material Use	SM (kg)	0.00E+00	0.00E+00	0.00E+00
Renewable Secondary Fuels	RSF (MJ)	0.00E+00	0.00E+00	0.00E+00
Non-Renewable Secondary Fuels	NRSF (MJ)	0.00E+00	0.00E+00	0.00E+00
Net Water Use	FW (m ³)	2.89E+01	-4.80E-04	4.71E-01

Table 7 - Output Flows and Waste Categories

Waste and Output Category	Abbreviation and Unit	A1: Raw Material	A2: Raw Material Transport	A3: Manufacturing
Hazardous waste disposed	HWD (kg)	N/A	N/A	1.98E+00
Non-hazardous waste disposed	NHWD (kg)	N/A	N/A	1.78E+00
Radioactive waste disposed	RWD (kg)	N/A*	N/A*	N/A*
Components for reuse	CRU (kg)	N/A	N/A	N/A
Materials for recycling	MFR (kg)	N/A	N/A	2.98E+01
Materials for energy recovery	MER (kg)	N/A	N/A	0.00E+00
Exported energy	EEE (MJ)	N/A	N/A	0.00E+00

**Per sections 10.3.1 to 10.4.3 in ISO 21930:2017, some radioactive waste is expected as derived from electricity generation. However, there is a large uncertainty in how much could accurately be attributed to the production of Halio, thus the radioactive waste data has been deemed unavailable.*





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LCA Interpretation

The impacts of the Halio IGUs are driven primarily by the manufacturing (A3) stage and secondarily through the raw material (A1) stage. The manufacturing impacts are due to the electricity consumption at the Taiwan facility, while the raw material impacts are mainly attributed to the carrier and low-E glass materials. The ozone depletion category is the only one dominated by the raw material (A1) stage, and this impact is specifically due to the sealant used in the IGU.

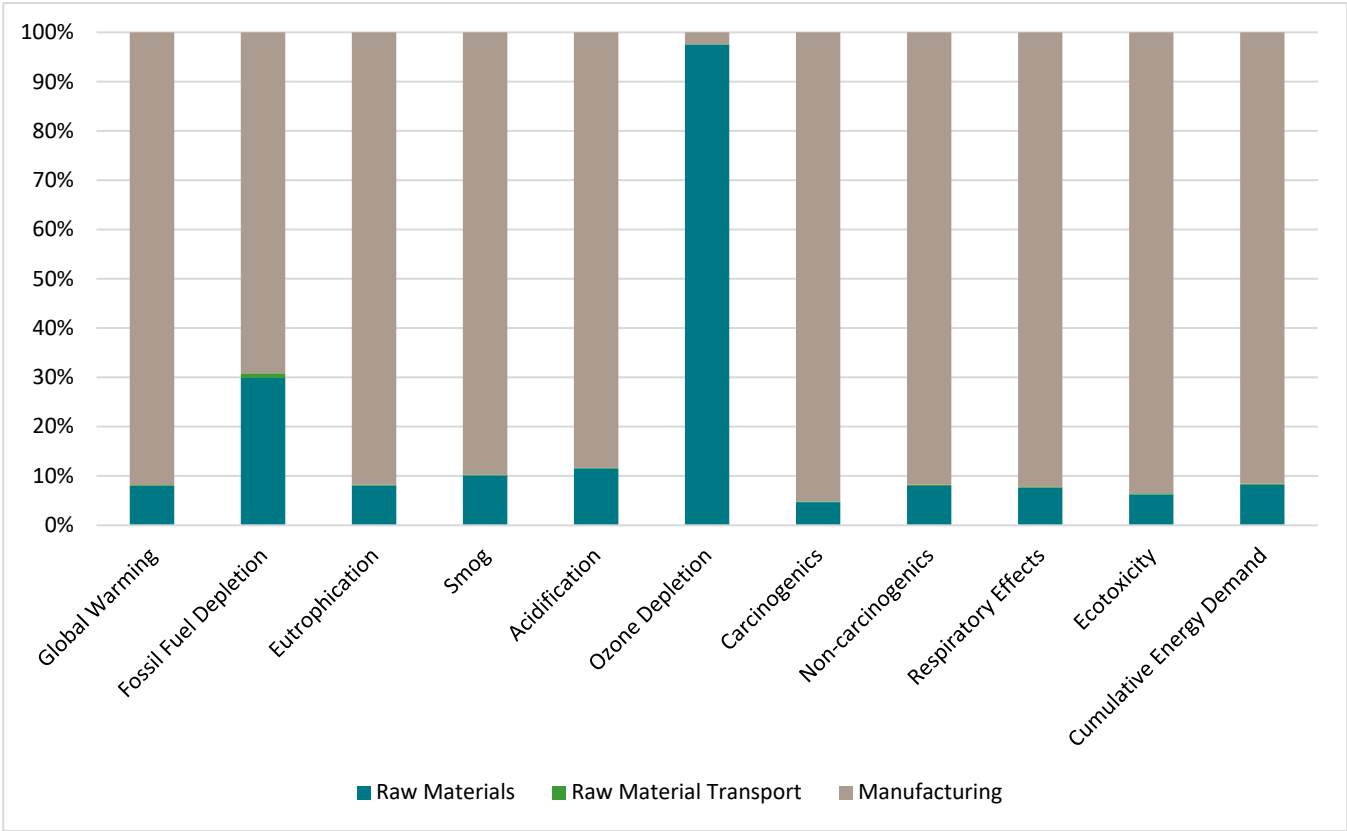


Figure 3 - Halio TRACI Impact Results



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References

STANDARD	
PCR Part A	UL Environment: Product Category Rules for Building-Related Products and Services in North America, Part A: Life Cycle Assessment Calculation Rules and Report Requirements, v.1.3, December 2018.
PCR Part B	UL Environment: Product Category Rules Part B: Processed Glass EPD Requirements, v.1.0, August 2016.
SimaPro 9.0	PRe Sustainability. (2020). <i>SimaPro LCA Software version 9.0</i> .
ISO 14025	ISO 14025:2011-10, Environmental labels and declarations — Type III environmental declarations — Principles and procedures.
ISO 14040	ISO 14040:2009-11, Environmental management — Life cycle assessment — Principles and framework.
ISO 14044	ISO 14044:2006-10, Environmental management — Life cycle assessment — Requirements and guidelines.
EN 15804	EN 15804:2012-04: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction product,
ULE 2013	UL Environment, General Program Instructions, 2013.
ASTM E90	Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements,
ASTM E283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen,
UL 2818	GREENGUARD Certification Program for Chemical Emissions for Building Materials, Finishes, and Furnishings,
ISO 21930: 2017	ISO 21930:2017, Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services.
Characterization Method	IPPC. 2014. Climate Change 2013. The Physical Science Basis. Cambridge University Press. (http://www.ipcc.ch/report/ar5/wg1/).
Characterization Method	Hauschild M.Z., & Wenzel H. Environmental Assessment of Products. Springer, US, Vol. 2, 1998.
Characterization Method	Heijungs R., Guinée J.B., Huppes G., Lankreijer R.M., Udo de Haes H.A., Wegener Sleeswijk A. Environmental Life Cycle Assessment of Products: Guide and Backgrounds. CML. Leiden University, Leiden, 1992.



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STANDARD	
Characterization Method	Jenkin M.E., & Hayman G.D. Photochemical ozone creation potentials for oxygenated volatile organic compounds: sensitivity to variations in kinetic and mechanistic parameters. Atmospheric Environment. 1999, 33 (8) pp. 1275-1293.
Characterization Method	WMO. 1999. Scientific Assessment of Ozone Depletion: 1998, World Meteorological Organization Global Ozone Research and Monitoring Project - Report No. 44, WMO, Geneva.
Characterization Method	Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers- version 1.2, January 2017.

Contact Information

Study Commissioner



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