ENVIRONMENTAL PRODUCT DECLARATION

IN ACCORDANCE WITH ISO 14025 AND ISO 21930:2017

SmartEPD-2024-032-0159-01

Electrochromic Insulating Glass Unit (IGU)- DGU

SageGlass® SAINT-GOBAIN

SMART EPD CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

Date of Issue: Aug 19, 2024

Expiration: Aug 19, 2029

Last updated: Aug 21, 2024

General Information

SAGE Electrochromics, Inc. Saint-Gobain

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Product Name:	Electrochromic Insulating Glass Unit (IGU)- DGU
Declared Unit:	1 m2
Declaration Number:	SmartEPD-2024-032-0159-01
Date of Issue:	August 19, 2024
Expiration:	August 19, 2029
Last updated:	August 21, 2024
EPD Scope:	Cradle to gate A1 - A3
Market(s) of Applicability:	North America

Reference Standards

Standard(s):	ISO 14025 and ISO 21930:2017
Core PCR:	UL PCR for Building-Related Products and Services Part A v.3.2 Date of issue: December 12, 2018
Sub-category PCR:	UL Part B: Processed Glass v.1 Date of issue: August 17, 2016 Valid until: June 30, 2024
Sub-category PCR review panel:	Contact Smart EPD for more information.
General Program Instructions:	Smart EPD General Program Instructions v.1.0, November 2022

Verification Information

LCA Author/Creator:	Saint-Gobain North American ESG Sustainability Group | sustainability@saint-gobain.com
EPD Program Operator:	Smart EPD | info@smartepd.com | www.smartepd.com 585 Grove St., Ste. 145 PMB 966, Herndon, VA 20170, USA

Verification:

Independent critical review of the LCA and data, according to ISO 14044 and ISO 14071 : External

Jack Geibig | Ecoform, LLC | jgeibig@ecoform.com

Independent external verification of EPD, according to ISO 14025 and reference PCR(s) : External

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Limitations, Liability, and Ownership

Environmental declarations from different programs (ISO 14025) may not be comparable. Comparison of the environmental performance of products 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 whole building life cycle. EPD comparability is only possible when all stages of a life cycle have been considered. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared. The EPD owner has sole ownership, liability, and responsibility for the EPD.

Organization Information

SageGlass is the only smart window company wholly owned by a global building materials leader with over 350 years of building science and glass experience. SageGlass is backed by one of the largest building materials company in the world.

Founded in 1665, Saint-Gobain is the world leader in light and sustainable construction. Saint-Gobain operates in 76 countries, providing materials and services for the construction and industrial markets.

Further information can be found at: https://www.sageglass.com/

Product Description

The SageGlass electrochromic insulating glass unit (IGU) is a type of dynamic glazing for use in buildings which tints automatically or on demand to control sunlight admission, controlling heat and glare, while maintaining a view to the outdoors and reducing energy consumption. The dynamic functionality is provided by the SageGlass electrochromic coating which is located on the cavity facing surface of the exterior laminate of the insulating glass unit. The SageGlass coating comprises multiple layers of ceramic materials of less than a micron thick that together, and upon application of a low voltage direct current, provides the ability to reversibly tint the glass to dynamically control the admission of the sun's heat and light. SageGlass electrochromic insulating glass units are available in a range of product configurations according to customer specifications. A typical IGU configuration comprises (i) a support lite of heat treated, float glass, the thickness of which depends on the application that is laminated to the 2.2mm device lite, (ii) a 2.2mm thick, annealed float glass lite on which the electrochromic coating is deposited (called the device lite), (iii) a third lite of heat treated float glass which is called the middle lite in the case of a triple glazed unit, or called the cover lite in case of a double glazed unit (DGU), (iv) a fourth lite of heat treated float glass which is the inboard lite of Triple glazed units (called a cover lite), the thickness and type of which depends on the application, and (v) associated insulating glass materials which comprise metallic spacer, desiccant, sealants, laminating interlayer materials, and wiring.

This EPD is for the double glazed unit (DGU). A separate EPD is available for the triple glazed unit (TGU).

Further information can be found at: https://www.sageglass.com/

Product Information

Declared Unit:	1 m2
Mass:	31.4 kg

Product Specificity:

- ✗ Product Average
- ✓ Product Specific

Averaging:

Averaging was not conducted for this EPD

Plants

SageGlass
2 Sage Way, Faribault, MN 55021, USA

Product Specifications

Product Classification Codes:

Masterformat - 08 88 36.16
EC3 - Openings -> Glazing -> InsulatingGlazingUnits

Material Composition

Material/Component Category	Origin	% Mass
Float Glass	Unknown	97.1
SentryGlass Interlayer	Unknown	0 - 3
Argon	Unknown	0 - 1
Silicone	Unknown	0 - 1
Stainless Steel	Unknown	0 - 3
Desiccant	Unknown	0 - 1
Polyisobutylene	Unknown	0 - 1
Spacer Key	Unknown	0 - 1
Wire Pigtail	Unknown	0 - 1
Obscuration Ink	Unknown	0 - 1
Frit	Unknown	0 - 1
Vario U profile	Unknown	0 - 1
Gen 2 Connector	Unknown	0 - 1
Tungsten	Unknown	0 - 1
Tungsten Nickel	Unknown	0 - 1
Indium tin oxide	Unknown	0 - 1
Lithium	Unknown	0 - 1
Niobium	Unknown	0 - 1
Aluminum Silicate	Unknown	0 - 1

Packaging Material	Origin	kg Mass
HDPE Film	Unknown	0.0869
Cardboard	Unknown	0.375
LDPE Stretch Film	Unknown	0.0107
Wooden Pallet	Unknown	6.04

Biogenic Carbon Content	kg C per m2
Biogenic carbon content in product	None
Biogenic carbon content in accompanying packaging	0.285

Hazardous Materials
No regulated hazardous or dangerous substances are included in this product.

EPD Data Specificity

Primary Data Year:	2022
Manufacturing Specificity:	✗ Industry Average ✗ Manufacturer Average ✓ Facility Specific

Software and LCI Data Sources

LCA Software:	LCA for Experts v. 10.7
LCI Foreground Database(s):	GaBi Professional Database v. 2022
LCI Background Database(s):	US LCI v. | Ecoinvent v. 3.9 | GaBi Professional Database v. 2022

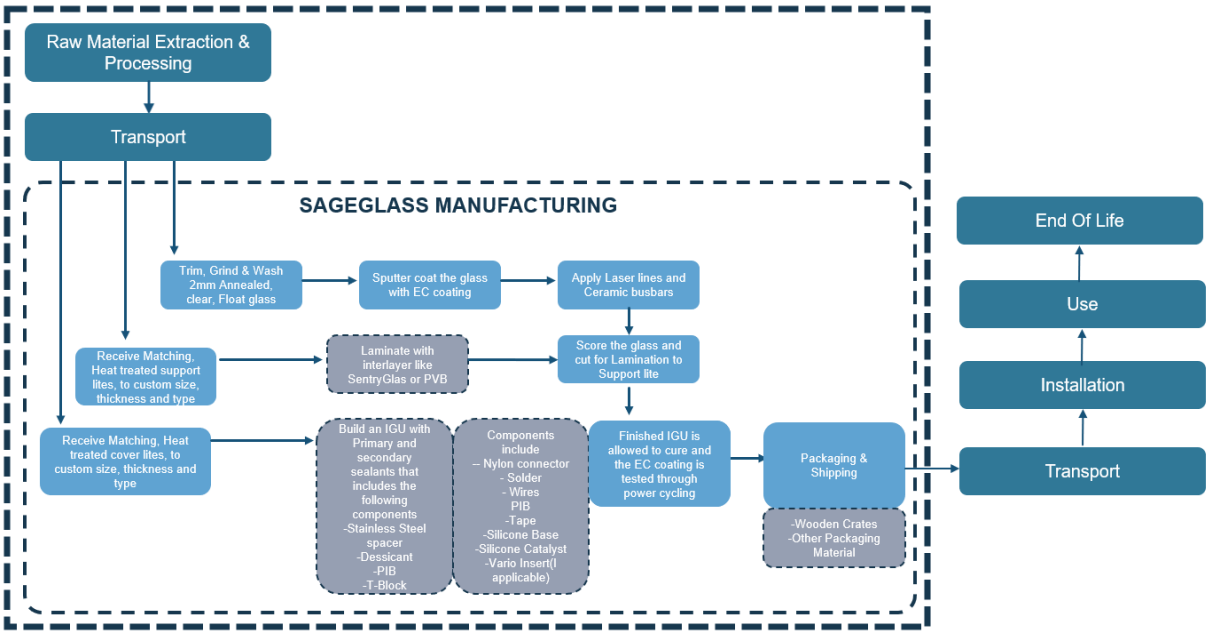
Renewable Electricity

Renewable electricity is used:	No

System Boundary

Production	A1	Raw material supply	✓
	A2	Transport	✓
	A3	Manufacturing	✓
Construction	A4	Transport to site	ND
	A5	Assembly / Install	ND
Use	B1	Use	ND
	B2	Maintenance	ND
	B3	Repair	ND
	B4	Replacement	ND
	B5	Refurbishment	ND
	B6	Operational Energy Use	ND
	B7	Operational Water Use	ND
End of Life	C1	Deconstruction	ND
	C2	Transport	ND
	C3	Waste Processing	ND
	C4	Disposal	ND
Benefits & Loads Beyond System Boundary	D	Recycling, Reuse Recovery Potential	ND

Product Flow Diagram



Life Cycle Module Descriptions

(A1-A2) Raw Material and Raw Material Transportation Stages

A thorough analysis of the material inputs was completed for the inventory of this study. SageGlass IGU is available in several various configurations depending on customer needs. Each configuration includes a 2.2mm layer of float glass and 2-3 layers of varying thicknesses of support lite and cover lite glass. Depending on the application for the product, the cover lite glass may also be laminated. The electrochromic coating process of the glass for any IGU configuration is on the 2.2mm device lite; therefore, the impacts of the 2.2mm device lite will be similar throughout the various IGU configurations. The support lite and cover lite glass, is the only glass portion of the product with varying thickness. Raw materials are transported to the manufacturing sites by standard freight truck, train, or ocean freighters. Unless otherwise noted, transport vehicles are fueled with diesel fuel.

(A3) Manufacturing

A detailed analysis of the Electrochromic Insulating Glass Unit (IGU) manufacturing process was completed by the Saint-Gobain North American ESG Department, including a site visit at the SageGlass facility to observe and understand the manufacturing and finishing processes.
SageGlass Electrochromic IGUs are manufactured in Faribault, MN. The production process begins with the trimming and washing of the 2.2mm glass lite. The coatings are then applied by vacuum sputtering, and undergo various heat treatments, frit application, and laser processing. The processed glass lite is then cut to the specified dimensions, becoming the device lite. The device lite is then laminated to the support lite, combined with the middle lite, cover lite and spacers, and sealed to form the insulating glass unit. Wiring components are added to the unit during the IGU fabrication process. The unit is then tested before packaging and shipping.

Packaging of the final product after production is included in the life cycle assessment. The SageGlass Electrochromic IGUs are packaged prior to shipping from Faribault, MN. The finished IGUs are placed on an A-frame made of wood with foam padding on the support areas. The A-frame with product is then wrapped with stretch wrap and a plastic banding.

Energy, water, and materials go into the Electrochromic Insulating Glass Unit (IGU) process and waste is an output from the manufacturing process.

The reference service life assumed is 30 years for the SageGlass DGU and TGU products.

LCA Discussion

Allocation Procedure

The Faribault, MN facility is the only location that produces the Electrochromic Insulating Glass Unit (IGU) product line in North America for SageGlass. The Faribault facility is the only facility that produces the SageGlass IGU product line for Saint-Gobain SageGlass, and the SageGlass IGU is the only product produced at this location. However, the SageGlass IGU is produced in a number of double and triple pane configurations with varying thicknesses. Allocation was conducted based on the production, energy, and mass data provided by the facilities as a percentage of the overall production mass at each facility.
Life cycle analysis requires that assumptions are made to constrain the project boundary or model processes when little to no data is available.

Cut-off Procedure

Processes whose total contribution to the final result, with respect to their mass and energy 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 – as defined by the U.S. Occupational Health and Safety Act 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 known flows were deliberately excluded. Capital items for the production processes (machines, buildings, etc.) were not taken into consideration.

Data Quality Discussion

Wherever secondary data is used, the study adopts critically reviewed data for consistency, precision, and reproducibility to limit uncertainty. The data sources used are complete and representative of North America in terms of the geographic and technological coverage and are less than ten years old. Any deviations from these initial data quality requirements for secondary data are documented in the report. The results of an LCA are only as good as the quality of input data used. Important data quality factors include precision (measured, calculated, or estimated), completeness, consistency, and reproducibility. The data used for primary data are based on direct information sources from the CertainTeed facilities. The energy and water usage data were collected directly from the utility meters, and the allocation was based on

the analysis of experts at the plant. Therefore, the precision for primary data is considered high; however, the uncertainty of the primary data has not been quantified. Secondary data sets were used for raw materials extraction and processing, transportation, and energy production flows.

Primary data was collected from the CertainTeed experts as tracked by automated systems and records. Since most of the data is annually reported, the consistency is considered high. Secondary data was consistently modeled using primarily the Sphera LCA FE database with inputs from the USLCI and Ecoinvent v3.9 when data was not available in the Sphera LCA FE database. Proxies were only identified and used if secondary data was not available. This methodology provides consistency throughout the model. The representativeness of the datasets is chosen to be representative of North America, average technologies of the major producers and distributors of recent and modern timeframes. Most of the secondary data sets have some uncertainty information documented and varies per model. Uncertainty for primary data was not quantified. However, the collected data and allocation methodologies were judged by the operations personnel to be accurate, so the uncertainty is considered low. Overall, the primary data from the manufacturing location is of very high quality, being directly tracked and measured by facility personnel. Therefore, the secondary data is likely to have a higher degree of uncertainty than the primary production data. This is considered when interpreting the results of this life cycle assessment.

Results

Environmental Impact Assessment Results

IPCC AR5 GWP 100, TRACI 2.1
per 1 m2 of product.
LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

DGU

Impact Category	Method	Unit	A1	A2	A3	A1A2A3
GWP-total	IPCC AR5 GWP 100	kg CO2 eq	6.30e+1	2.00e+1	1.79e+2	2.62e+2
ODP	TRACI 2.1	kg CFC 11 eq	4.77e-6	4.17e-6	8.61e-8	9.03e-6
AP	TRACI 2.1	kg SO2 eq	4.60e-1	1.11e-1	2.31e-1	8.02e-1
EP	TRACI 2.1	kg N eq	1.24e-1	1.92e-2	2.57e-2	1.69e-1
POCP	TRACI 2.1	kg O3 eq	4.79e+0	1.94e+0	4.74e+0	1.15e+1
ADP-fossil	TRACI 2.1	MJ	6.55e+1	3.82e+1	1.69e+2	2.73e+2
GWP-fossil	TRACI 2.1	kg CO2 eq	4.89e+1	1.98e+1	1.86e+2	2.55e+2

Abbreviations:

GWP = Global Warming Potential, 100 years (may also be denoted as GWP-total, GWP-fossil (fossil fuels), GWP-biogenic (biogenic sources), GWP-luluc (land use and land use change)), ODP = Ozone Depletion Potential, AP = Acidification Potential, EP = Eutrophication Potential, SFP = Smog Formation Potential, POCP = Photochemical oxidant creation potential, ADP-Fossil = Abiotic depletion potential for fossil resources, ADP-Minerals&Metals = Abiotic depletion potential for non-fossil resources, WDP = Water deprivation potential, PM = Particular Matter Emissions, IRP = Ionizing radiation, human health, ETP-fw = Eco-toxicity (freshwater), HTP-c = Human toxicity (cancer), HTP-nc = Human toxicity (non-cancer), SQP = Soil quality index.

Comparisons cannot be made between product-specific or industry average EPDs at the design stage of a project, before a building has been specified. Comparisons may be made between product-specific or industry average EPDs at the time of product purchase when product performance and specifications have been established and serve as a functional unit for comparison. Environmental impact results shall be converted to a functional unit basis before any comparison is attempted. Any comparison of EPDs shall be subject to the requirements of ISO 21930 or EN 15804. EPDs are not comparative assertions and are either not comparable or have limited comparability when they have different system boundaries. EPDs are not comparative assertions and are either not comparable or have limited comparability when they have different system boundaries, are based on different product category rules or are missing relevant environmental impacts. Such comparison can be inaccurate, and could lead to erroneous selection of materials or products which are higher-impact, at least in some impact categories.

Resource Use Indicators

per 1 m2 of product.

DGU

Indicator	Unit	A1	A2	A3	A1A2A3
PERE	MJ, net calorific value	1.56e+2	5.01e+0	1.15e+3	1.31e+3
PERM	MJ, net calorific value	9.20e+0	0	1.04e+1	1.96e+1
PERT	MJ, net calorific value	1.11e+2	5.01e+0	1.16e+3	1.28e+3
PENRE	MJ, net calorific value	1.15e+3	2.93e+2	2.52e+3	3.96e+3
PENRM	MJ, net calorific value	1.83e+2	0	3.70e+0	1.87e+2
PENRT	MJ, net calorific value	1.06e+3	2.94e+2	2.53e+3	3.88e+3
SM	kg	0	0	0	0
RSF	MJ, net calorific value	3.37e-20	0	0	3.37e-20
NRSF	MJ, net calorific value	3.96e-19	0	0	3.96e-19
RE	MJ	0	0	0	0
FW	m3	3.47e-1	3.09e-2	2.52e+0	2.90e+0

Abbreviations:

RPRE or PERE = Renewable primary resources used as energy carrier (fuel), RPRM or PERM = Renewable primary resources with energy content used as material, RPRT or PERT = Total use of renewable primary resources with energy content, NRPRE or PENRE = Non-renewable primary resources used as an energy carrier (fuel), NRPRM or PENRM = Non-renewable primary resources with energy content used as material, NRPRT or PENRT = Total non-renewable primary resources with energy content, SM: Secondary materials, RSF = Renewable secondary fuels, NRSF = Non-renewable secondary fuels, RE = Recovered energy, ADPF = Abiotic depletion potential, FW = Use of net freshwater resources, VOCs = Volatile Organic Compounds.

Waste and Output Flow Indicators

per 1 m2 of product.

DGU

Indicator	Unit	A1	A2	A3	A1A2A3
HWD	kg	7.78e-8	7.67e-11	-5.46e-3	-5.46e-3
NHWD	kg	2.57e+0	1.03e+0	1.73e+0	5.33e+0
RWD	kg	0	0	0	0
CRU	kg	0	0	0	0
MFR	kg	0	0	4.12e-2	4.12e-2
MER	kg	0	0	0	0
EEE	MJ	0	0	0	0
EET	MJ	0	0	0	0
HLRW	kg	2.38e-6	2.38e-8	1.43e-4	1.45e-4
ILLRW	kg	2.42e-3	2.69e-5	1.33e-1	1.35e-1

Abbreviations:

HWD = Hazardous waste disposed, NHWD = Non-hazardous waste disposed, RWD = Radioactive waste disposed, HLRW = High-level radioactive waste, ILLRW = Intermediate- and low-level radioactive waste, CRU = Components for re-use, MFR or MR = Materials for recycling, MER = Materials for energy recovery, MNER = Materials for incineration, no energy recovery, EE or EEE = Recovered energy exported from the product system, EET = Exported thermal energy.

Interpretation

Interpretation

This study was conducted following appropriate ISO standards and best practices and is intended for internal use to assist SageGlass with understanding the life cycle impacts of their products, as well as having the results published in an EPD. All data for the operation of the manufacturing facility, as well as transportation distances and modes, was collected directly from SageGlass. Efforts were made to check the data for internal consistency and to verify data with plant personnel. Sub-metering of energy use for each critical stage in the manufacturing process would allow for more detailed analysis and is recommended.

Based on the results from the life cycle assessment, the life cycle impacts are strongly driven by the manufacturing process and the raw materials, contributing as much as 72% and 20%, respectively, of the cradle-to-gate impacts of SageGlass IGU's GWP-total. The electricity and natural gas consumption are largely driving the impacts. The float glass, heat strengthened coated, and heat strengthened uncoated glass were the highest impact raw materials. Identifying alternate uses or recycling options for the product at the end of its useful life will reduce the end-of-life and potential raw materials burdens of recycled product. If possible, incorporating more recycled content into the product will help reduce the environmental impacts of the raw materials stage in the life cycle of the product.

Limitations

The findings in this research are limited by the inherent uncertainty of creating a representative model through LCA. Many assumptions were made in the modeling of the product system with representative processes and datasets. While quality control was undertaken at each step in building the LCI and conducting the LCIA, uncertainty is present in the results since the data represents only one year of manufacturing information from manufacturing location. Some level of uncertainty is inherent in conducting LCA and decision making must reflect this fact.

Additional Environmental Information

This information can prepare SageGlass for future sustainable supply chain requirements and can form the basis of marketing literature focused on environmental benefits. This LCA will also assist SageGlass with evaluating any environmental claims made by competitors. SageGlass should use the LCA study for evaluating alternate raw materials, source locations, and recycled content as part of a sustainable product development process, in order to take a leadership position in sustainable product development. SageGlass should also use this LCA as a basis to meet future requirements for customer sustainable purchasing programs and government requirements. SageGlass should investigate opportunities to reduce energy consumption in the areas of raw material transportation, final product transportation, and especially manufacturing, as these are areas of the process directly under SageGlass's control. Reduction in these areas will also provide cost savings and potential competitive advantage to SageGlass. Additionally, sub-metering of energy and water use in the manufacturing stage would be helpful for better allocation of the energy and water used within the facility, as well as to measure and benchmark for efficiency opportunity analysis. Recycling options for the DGU and TGU products at the end of the useful life should be investigated to reduce the impacts at the end-of-life and to potentially increase the recycled content of the product which will then decrease the life impacts of the raw materials stage of the product.

Further Information

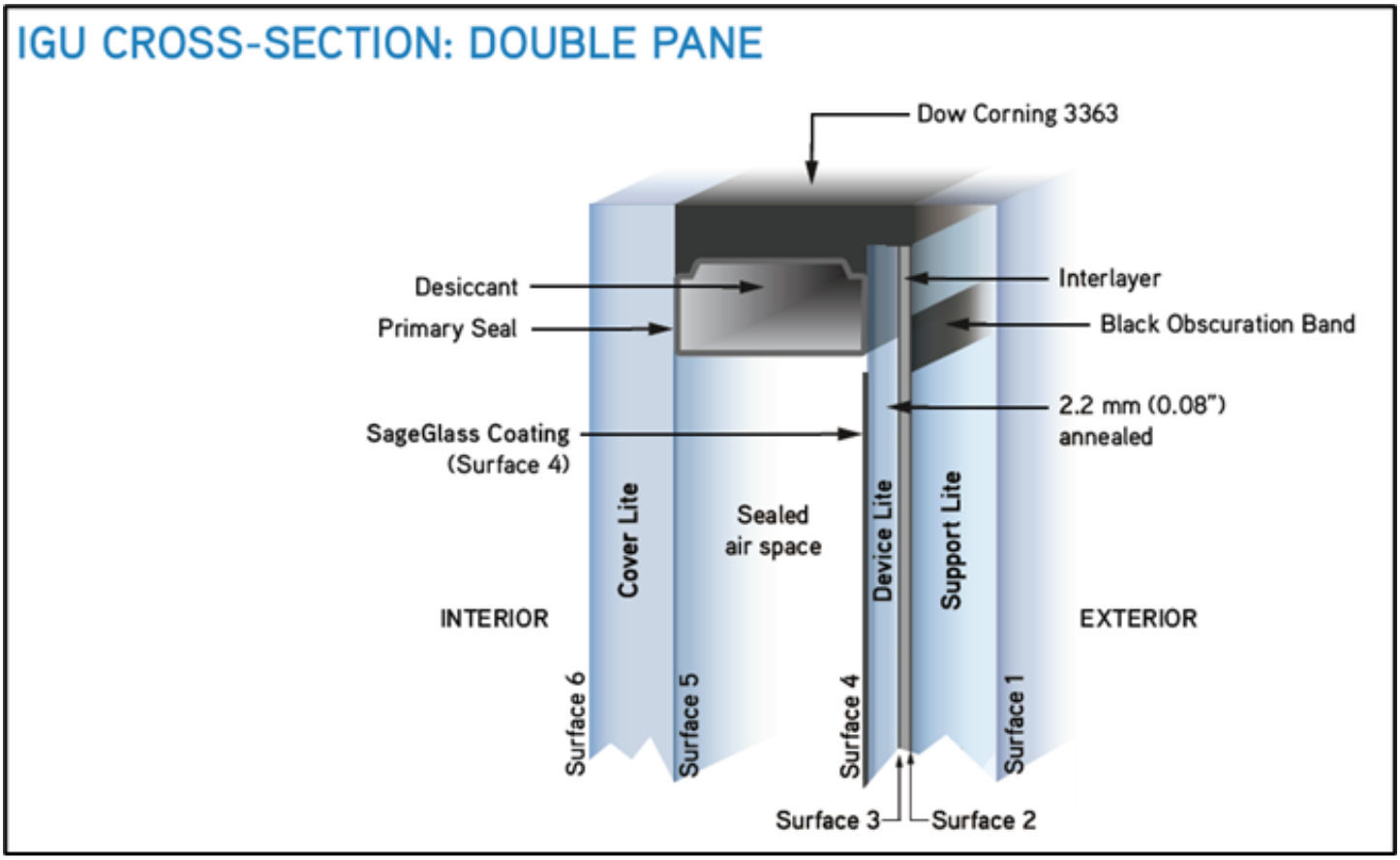
Renewable Energy

Saint-Gobain is committed to achieving Carbon Neutrality by 2050. In 2022, SageGlass invested in Renewable Energy Certificates (RECs) from the High Prairie Wind Farm II LLC via the Prairie Star Wind Farm. The RECs were retired by M-RETS Renewable Electricity for SageGlass to assist in lowering their carbon footprint. SageGlass intends to use the RECs in their existing EPDs as “Additional Information” to show lower environmental impact potentials.

Overall Environmental Impact Potentials (including RECs)

LCIA Method	Impact Category	Unit	A1A2A3	A1	A2	A3
IPCC AR5 GWP 100	GWP-total	kg CO2 eq	1.31E+02	6.30e+1	2.00e+1	4.84E+01
TRACI 2.1	ODP	kg CFC 11 eq	8.97e-6	4.77e-6	4.17e-6	4.31E-08
TRACI 2.1	AP	kg SO2 eq	5.97E-01	4.60e-1	1.11e-1	2.70E-02
TRACI 2.1	EP	kg N eq	1.48E-01	1.24e-1	1.92e-2	4.70E-03
TRACI 2.1	POCP	kg O3 eq	7.51E+00	4.79e+0	1.94e+0	7.80E-01
TRACI 2.1	ADP-fossil	MJ	2.14E+02	6.55e+1	3.82e+1	1.10E+02
TRACI 2.1	GWP-fossil	kg CO2 eq	1.13E+02	4.89E+01	1.98e+1	4.40E+01

Product Cross Section



EPD Optimization

There was a 52% reduction in Global Warming Potential, Fossil TRACI 2.1 (GWP) when comparing the DGU in this EPD to the SageGlass DGU in the most recent EPD published in 2020 for the Double Pane and Double Pane VARIO Electrochromic IGU products.

In 2020, SageGlass performed an LCA and published two EPDs using the 2018 data from the Faribault, MN manufacturing site for the SageGlass products. The EPDs were third party verified and published by UL Solutions in 2020. Two EPDs were published at that time, one for the Double Pane and Double Pane VARIO Electrochromic IGU products and one for the Triple Pane and Triple Pane VARIO Electrochromic IGU products.

The 2020 DGU product will be compared to this study's DGU product for the purpose of the EPD optimization.

TRACI Global warming potential (GWP)- kg CO2e/m²

Year	Product	A1-A3	% difference
2024	DGU	2.55E+02	-52%
2020	DGU	5.31E+02	

References

- Product Category Rules for Building-Related Product and Services: Part A – Life Cycle Assessment Calculation Rules and Report Requirements, Version 4. March 2022. UL Environment.
- Product Category Rule Guidance for Building-Related Products and Services: Part B – Processed Glass EPD Requirements. Version 1.0 2016. UL Environment
- EN 15804 EN 15804 + A2:2019, Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products.
- ISO 21930:2017– Sustainability in building construction – Environmental declaration of building products
- ISO 14025:2006, Environmental labels and declarations – Type III environmental declarations – Principles and procedures
- ISO 14040:2006, Environmental management – Life cycle assessment – Principles and framework
- ISO 14044:2006, Environmental management – Life cycle assessment – Requirements and guidelines
- ISO 14026:2006, Environmental labels and declarations — Type III environmental declarations — Principles and procedures.
- Sphera LCA FE Databases. https://sphera.com/product-sustainability-software/
- US LCI Database. https://www.nrel.gov/lci/
- Ecoinvent v3.9 Database. http://ecoinvent.org/
- SageGlass Website. https://www.sageglass.com/en