Environmental Product Declaration

Guardian Glass Coated Flat Glass

Coated EU Flat Glass

Guardian Glass is dedicated to continually improving the science and process of its core competency, flat glass manufacturing.

Guardian Glass is committed to the efficient use of natural resources while operating in a way that protects the safety, health, and well-being of its employees, customers, the environment, and society.

As a manufacturing leader of high performance, energy-efficient glass products for commercial, residential, interior, transportation, solar, and specialty applications, Guardian Glass makes products that help improve people's lives. By allowing abundant natural light into homes, offices, and vehicles, glass products can help contribute to occupants' well-being and low-emissivity glass helps reduce energy consumption for heating and cooling.

By publishing this EPD, Guardian Glass intends to support architects and designers who strive to enhance the environmental profiles of the buildings they design through the products they specify. The goal is to provide them with the information needed to achieve credits in global building rating systems.

UL CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

The values stated in this environmental product declaration (EPD) are reported in accordance with ISO 14025 and EN15804+A2/AC. EPDs rely on a Life Cycle Assessment (LCA) and associated Product Category Rules (PCR) to estimate various environmental impacts of products over their life cycle. Environmental impact data and other metrics reported in this EPD may differ from values reported elsewhere as there may be differences in reporting expectations, methodology, assumptions, and allocation methods. 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 other 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, thus the level of accuracy for any estimated effect may differ between product lines and reported impacts. 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.

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Solutions 2211 Newmarket Pkwy, Marietta, GA 30067 USA
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	UL Solutions: General Program Instructions v2.7. 2022.
MANUFACTURER NAME AND HEADQUARTERS ADDRESS	Guardian Glass European Headquarters 19 rue du Puits Romain, L-8070 Bertrange, Luxembourg
DECLARATION NUMBER	4791438322.101.1
DECLARED PRODUCT & FUNCTIONAL UNIT OF DECLARED UNIT	Guardian Coated Flat Glass (EU Products) Functional Unit = 1 m^2 of 4mm Glass
REFERENCE PCR AND VERSION NUMBER	EN15804 +A2/AC:2021 and EN17074:2019
DESCRIPTION OF PRODUCT(S) APPLICATION/USE	Building/Construction and Automotive Sector in the EU Market
PRODUCT RSL DESCRIPTION	30 Years
MARKETS OF APPLICABILITY	Europe
DATE OF ISSUE	August 29, 2024
PERIOD OF VALIDITY	5 years
EPD TYPE	Product Specific
DATASET VARIABILITY	N/A
EPD SCOPE	Cradle-to-Grave
YEAR(S) OF REPORTED PRIMARY DATA	Calendar Year 2021
LCA SOFTWARE & VERSION NUMBER	LCA for Experts (formerly GaBi) 10.6
LCI DATABASE(S) & VERSION NUMBER	Sphera Managed LCA Content (formerly GaBi) databases
LCIA METHODOLOGY & VERSION NUMBER	EN15804+A2
The sub-category PCR review was conducted by:	European Standards - info@en-standard.eu
This declaration was independently verified in accordance with ISO 14025: 2006. EN17074, based on the EN15804+A2 standard, serves as the core PCR. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum Cooper McCollum, UL Solutions
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

Environmental declarations from different programs (ISO 14025) may not be comparable. Comparison of the environmental performance using EPD information shall consider all relevant information modules over the full life cycle of the products within the building. This PCR allows EPD comparability only when the same functional requirements between products are ensured and the requirements of EN 15804 §5.3 are met. It should be noted that different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

Summary of Declaration and Global Warming Potential Results

This Environmental Product Declaration covers coated flat glass produced in the European Union. The following manufacturing facilities are included within this declaration.

Manufacturing Facilities Covered:

- Bascharage, Luxembourg
- Czestochowa, Poland
- Goole, UK
- Oroshaza, Hungary
- Thalheim, Germany
- Tudela, Spain

Product Description

This EPD is valid for the following coated products:

- ClimaGuard® Residential Glass
- Guardian Sun® range
- SunGuard® Architectural Glass
  - Covers all SunGuard® products and includes product series: HD, HP, SN, SNX, Solar, ViewBoost and RD
- Guardian Technical Glass
  - Covers all products in the following Technical Glass product series: Anti-reflective glass, , Guardian Clarity™ Neutral, Guardian PureSight, ThermaGuard®, and Dielectric Mirror
- Guardian Automotive Glass: IRR & SilverGuard® Range, NRG

Global Warming Potential Cradle-to-Gate Impact Assessment Results:

The following table details the A1-A3 Global Warming Potential (GWP) results as found in Table 11 but scaled to each thickness available. The results are presented below per square meter of coated flat glass. The calculation by given thickness is from scaling factors found in Table 14 which are based on the weight per square meter of glass at each thickness. EN15804+A2 global warming potential impact assessment values are provided.

Table 1 - Global Warming Potential per Thickness of Coated Glass

Thickness	Cradle to Gate (A1- A3) GWP, Total (kg CO_2 eq/m^2)
2.0 mm	5.97
2.1 mm	6.23
2.85 mm	8.14
3 mm	8.52
3.15 mm	8.91
3.85 mm	10.69
4 mm	11.1
4.85 mm	13.2

Thickness	Cradle to Gate (A1- A3) GWP, Total (kg CO_2 eq/m^2)
5 mm	13.6
5.85 mm	15.8
6 mm	16.2
8 mm	21.4
10 mm	26.5
12 mm	31.5
15 mm	39.1

General Information

Description of Company / Organization

Guardian Glass is one of the largest flat glass producers and innovators in the world. We've been working with glass since 1932 and manufacturing float glass since 1970, and yet the limitless potential of this amazing material still fascinates and inspires us every day. We are committed to advancing glass technology and exploring every application possible. Not only to enhance our customers' well-being with light and space, but to help conserve energy, regulate temperatures, protect privacy, preserve history and help us See What's Possible™.

Through pioneering research, the dedication of our people and a firm belief in close collaboration with our partners and customers, we find new ways to build, design and inspire with glass. We continue to build our expertise on each and every project, whether that's an iconic, energy-efficient building or a new glass coating that will solve the challenges of today and beyond.

Every day, we work to create more value, using fewer resources. We constantly challenge ourselves to identify opportunities to build upon the benefits of glass. We expertly combine glass types to maximize energy savings and bring light and an unrivalled aesthetic to people's lives. We're committed to the efficient use of natural resources while operating in a way that protects the safety, health and well-being of our employees, customers, the environment and society.

For more information visit our website at www.guardianglass.com

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- Guardian Automotive Glass: IRR & SilverGuard® Range, NRG

Figure 1 – Coated Glass

Manufacturer-Specific EPD

This product-specific EPD was developed based on the Guardian Glass EU Cradle-to-Grave Flat Glass Life Cycle Assessment. The EPD accounts for raw material extraction and processing, transport, and product manufacturing, use, and disposal. Manufacturing data were gathered directly from company personnel. When updated company-specific data were not available the ratio of production units, within the calendar year 2021, was used as a proxy. For any product group EPDs, an impact assessment was completed for each product and the highest impacts were reported as conservative representations of the product group. Product grouping was considered appropriate if the individual product impacts differed by no more than ±10% in any impact category.

Application

Coated glass products are used in a variety of applications including commercial, residential, interior, transportation, solar, and specialty applications. Guardian Glass typically supplies float glass and coated glass products to either its fabricator customers or its own fabrication facilities who further process that glass into the final product by cutting, heat-treating, laminating, insulating, or otherwise fabricating the glass into the desired size and makeup for use in the intended application. The glass makeup is typically specified by architects, glazing contractors, window manufacturers, and other design professionals.

Material Composition

Flat glass is typically manufactured from virgin, non-renewable raw materials such as silica sand, soda ash, dolomite, limestone, and cullet (internal cullet is comprised of the afore-mentioned raw materials). It can also contain recycled cullet. The crystalline raw materials chemically and structurally transform into amorphous glass through a fusion (melting) process, thereby producing a product which is >99.9% glass oxide.

The flat glass product is then processed by sputter coating, wet coating, laminating and / or heat treating, depending on application needs. These processed glass products are similar in composition to uncoated / unprocessed flat but include slight additions of trace elements to achieve required optical properties.

Technical Data

Technical data on Guardian Glass products is available on at www.guardianglass.com and http://cemarking.eu.guardian.com/cemarking/ . The following technical data can be presumed for coated flat glass.

Table 2 – Technical Data (example: SunGuard® SNX70)

Name	Value	Unit
Thickness	4	mm
Light Transmittance (LT)	74	%
External Light Reflectance (ELR)	5	%
Solar Energy transmittance (ET)	35	%
Solar Energy Reflection (coated side)	45	%
Solar factor (coated side)	40	%

Placing on the Market / Application Rules

Coated flat glass is produced according to European harmonized standard EN 1096-4: Glass in Building – Coated glass – Part 4 – Product Standard. The standard that can be applied for Guardian coated flat glass products:

- EN 14449: Glass in Building – Laminated glass and Laminated Safety Glass – Evaluation of conformity/Product Standard
- EN 1279-5: Glass in Building – Insulated glass unit – part 5: evaluation of conformity

Properties of Declared Product as Shipped

Product Sizes: While products are primarily produced in jumbo size (3.21m x 6m), they can also be cut to customers' specified dimensions.

While thickness of glass also varies based on customer needs, some standard thicknesses for flat glass include:

- 2 mm
- 2.1 mm
- 2.85 mm
- 3 mm
- 3.15 mm
- 3.85 mm
- 4 mm
- 4.85 mm
- 5 mm
- 5.85 mm
- 6 mm
- 8 mm
- 10 mm
- 12 mm
- 15 mm

Please contact a local sales representative for available sizes in your area.

Declaration Type: Business-to-Business

Geographic Scope: This declaration is valid for products produced in the European Union and United Kingdom from Guardian Glass.

Additional Notes: This analysis represents the performance of a production-weighted average of Guardian glass products, based on 2021 calendar year production volumes.

Methodological Framework

Functional Unit

The declaration refers to the functional unit of 1 square meter of coated flat glass.

Table 3 – Declared Unit Description

Name	Value	Unit
Declared Unit	1	m^2
Mass Covered by Declared Unit	10	kg
Thickness	4	mm
Reference Service Life	30	years

System Boundary

This a cradle-to-grave environmental product declaration. The following life cycle phases were considered:

Table 4 - Description of the System Boundary

Product			Construction Installation		Use							End-of-Life*				Benefits of loads beyond the system boundary		
Raw Material Extraction and Processing	Transport	Manufacturing	Transport	Construction/ Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste Processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Description of the System Boundary Stages Corresponding to the PCR
(X = Included; MND = Module Not Declared)
*This includes provision of all materials, products and energy, packaging processing and its transport, as well as waste processing up to the end-of waste state or disposal of final residues.

Allocation

Where manufacturing inputs, such as electricity use, were not sub-metered, allocation was determined on a per metric tonne basis for primary data for float glass production. For the processing of the glass (that is, the coating process), allocation per area was conducted as coating is contingent on the surface area being treated. For secondary data, cut-off methodology was used.

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.

Data Sources

Primary data were collected for every process in the product system under the control of Guardian Glass. Secondary data from the LCA for Experts (formerly GaBi) LCA Managed Content database were utilized. These data were evaluated and have temporal, geographic, and technical coverage appropriate to the scope of the product.

Data Quality

The data sources used are complete and representative of Europe 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 is used, the study adopts critically reviewed data for consistency, precision, and reproducibility to limit uncertainty.

Comparability and Benchmarking

A comparison or an evaluation of EPD data is only possible if all data sets to be compared were created according to EN15804+A2 and the building context, respectively the product-specific characteristics of performance, are taken into account. Environmental declarations from different programs may not be comparable. Full conformance with the EN15804+A2 allows EPD comparability only when all stages of the product's life cycle have been considered. However, variations and deviations are possible.

Estimates and Assumptions

Due to limitations in data availability, assumptions were made in allocating important manufacturing inputs and outputs including process materials, natural gas, and facility emissions. The allocation approaches taken may therefore overestimate the environmental burden for glass production.

Additionally, the “average” glass pane used in modeling is a calculated average and does not represent a specific product manufactured by Guardian Glass.

Units

The LCA results within this EPD are reported in the International System (SI) units.

Additional Environmental Information

Background data

For life cycle modeling of the considered products, the LCA for Experts for Life Cycle Engineering, developed by Sphera, is used. The LCA Managed Content database, as developed by Sphera, contains consistent and documented datasets which are documented in the online LCA for Experts- documentation. To ensure comparability of results in the LCA, the basic data of the LCA for Experts database were used for energy, transportation and auxiliary materials.

Manufacturing

Flat glass production involves heating the raw materials to a liquid state and then floating the subsequent ribbon of glass atop a bath of molten tin. Once the ribbon has sufficiently cooled, it is transferred onto rollers and annealed to limit residual stresses, its edges are trimmed and the ribbon is cut to the desired sizes. The finished flat glass products are stored for additional processing (e.g., lamination, acid-etched or coating) or directly packaged and shipped to customers or Guardian's other sites for further processing.

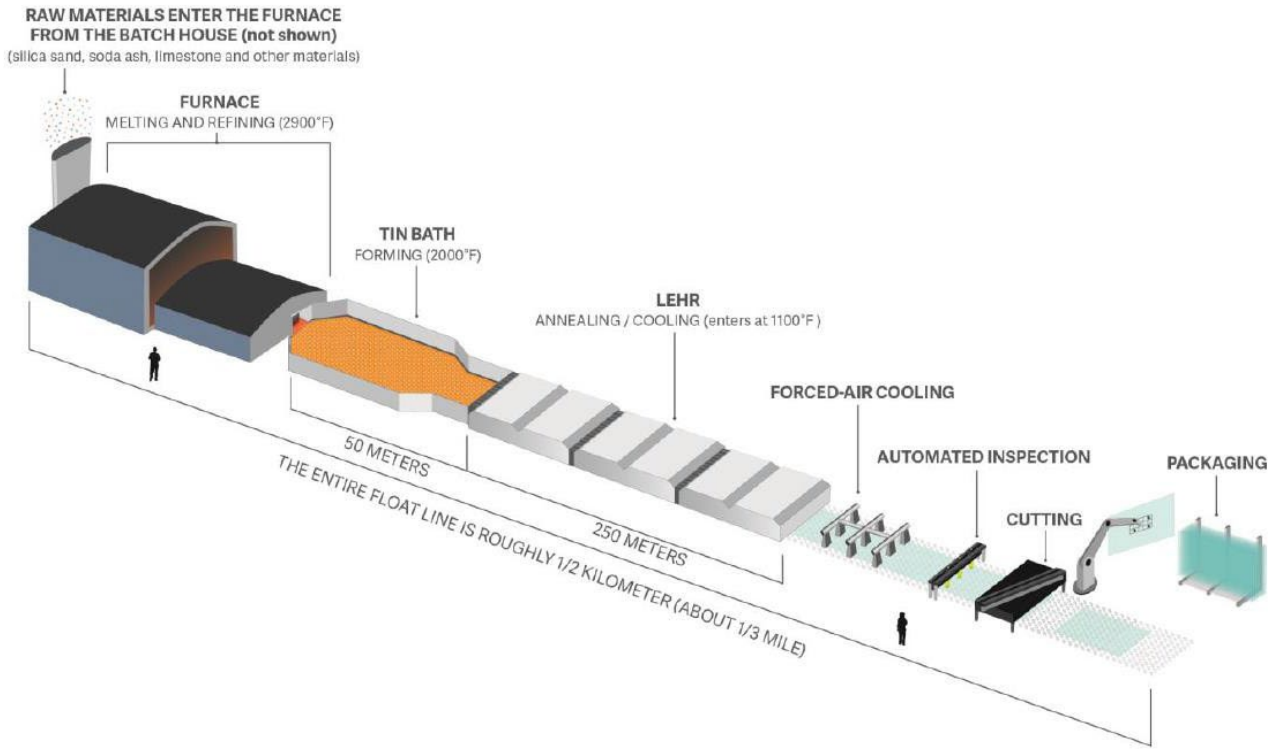

Figure 2 - Flat Glass Production

For the vacuum sputtering process, glass is loaded onto the coating line, washed and cleaned, and then enter vacuum chambers where the sputter coating process occurs. The product is inspected, packaged, and then shipped to customers or Guardian's other sites for further processing.

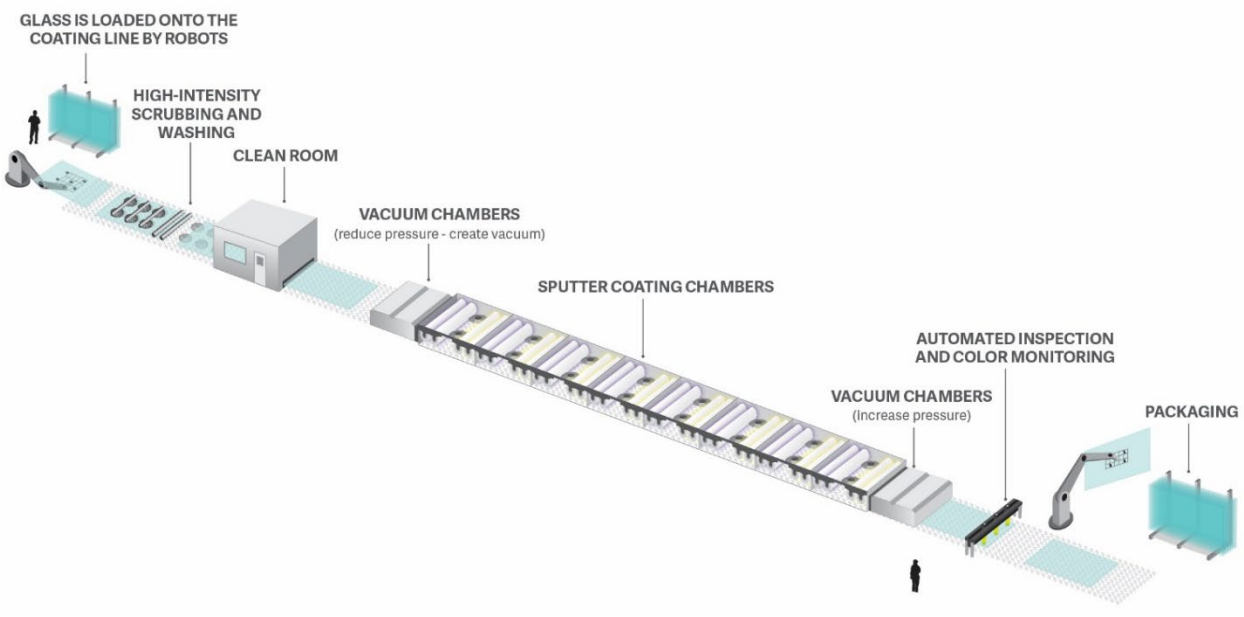

Figure 3 - Vacuum Sputter Coating Process

Product Distribution

Upon leaving Guardian Glass facilities, coated flat glass can be further processed through a nationwide network of independent fabricators or Guardian's own fabrication facilities. Racks used for distribution of glass are reused many times both in the manufacturing plant and shipped to the customer and returned to Guardian Glass plants. It is assumed that the transportation between the plant and the customer is 800 kilometers and that mode of transport is freight truck. This information can vary.

Table 5 - Product Distribution Details

Name	Value	Unit
Fuel type	Diesel	-
Type of Transport	Freight Truck	-
Liters of fuel	36	l/100km
Capacity utilization	100	% by volume
Capacity utilization (empty runs)	30	%
Transport distance	800	km
Weight of products transported	10	kg
Volume of products transported	0.004	m^3

Product Installation

Guardian Glass products should be processed and installed according to best industry standards and according to all applicable building codes in the given jurisdiction. Per the EN17074 standard on glass, no installation scrap is assumed due to the variable nature of applications.

Table 6 - Installation Details

Name	Value	Unit
Auxiliary materials	0.0	kg
Water consumption	0.0	m^3
Other resources	0.0	kg
Electricity consumption	0.0	kWh
Other energy carriers	0.0	MJ

Name	Value	Unit
Product loss per functional unit	0.0	kg
Waste materials at construction site	0.0	kg
Output substance (recycle)	0.0	kg
Output substance (landfill)	0.0	kg
Output substance (incineration)	0.0	kg
Packaging waste (recycle)*	0.0	kg
Packaging waste (landfill)	0.0	kg
Packaging waste (incineration)	0.0	kg
Direct emissions to ambient air*, soil, and water	0.0	kg CO_2
VOC emissions	0.0	kg

**Guardian uses steel racks that are reusable and returned by the customer. These racks are reused by Guardian.*

Product Use

Glass should be installed according to industry standards and according to all applicable building codes in the given jurisdiction. Installed glass should be washed frequently to remove surface dirt and to protect the glass from staining. Glass staining occurs when the sodium within the glass reacts with moisture in the air. Sodium, when combined with small amounts of water, can create sodium hydroxide which is corrosive to glass.

Once installed, Guardian Glass products do not consume energy or require maintenance beyond general cleaning to fulfill their estimated service life. This study assumes a 30-year lifetime for the product. See Table 7 and Table 8 in regard to the use phase and service life assumptions per EN17074:2019.

Table 7 - Use Phase Details (Module B)

Maintenance (B2)		
Name	**Value**	**Unit**
Maintenance	Regular cleaning using a cleaning agent and water.	
Maintenance Cycle	See guardianglass.com for more details	
Ancillary Materials		
Cleaning Agent	0.01	kg/m2 per yr
Water	0.2	kg/m2 per yr
Energy Input	None required	kWh
Replacements (B4)		
Replacement Cycle	Every 30 years	
Replacements (B4)	0	#
Energy Use	0	kWh

Table 8 - Reference Service Life

Name	Value	Unit
Reference Service Life	30	years
Estimated Service Life	30	years
Number of Replacements	0.0	#

Product Disposal

At the end of life, coated flat glass is typically landfilled or reclaimed and recycled. This study assumed landfill as the end-of-life disposition, where the final waste site is 100 kilometers from the de-construction site. The end-of-life scenario was modeled based on the 2024 Glass for Europe study's conclusion[1] that almost all building glass is landfilled. Even though the chosen scenario is not favorable from a recycling point of view, Guardian is actively working to increase the amount of recovered glass that can be recycled and put back in the batch.

Table 9 - End of Life (C1-C4)

Name	Quantity	Unit
Collected separately	0	kg/m²
Collected as mixed construction waste	10	kg/m²
Reuse	0	kg/m²
Recycling	0	kg/m²
Landfilling	10	kg/m²
Incineration with energy recovery	0	kg/m²
Energy conversion	n/a	%
Material for final deposition	10	kg/m²
Removals of biogenic carbon	0	kg/m²

Table 10 - Re-Use, recovery, and/or Recycling Potential (D)

Name	Value	Unit
Net energy benefit from energy recovery from waste treatment declared as exported energy in C3 (R>0.6)	0	MJ/m²
Net energy benefit from thermal energy due to treatment of waste declared as exported energy in C4 (R<0.6)	0	MJ/m²
Net energy benefit from material flow declared in C3 for energy recovery	0	MJ/m²
Process and conversion efficiencies	n/a	%
Further Assumptions	n/a	

Coated Flat Glass Results per Square Meter

Results below show the life cycle impact assessment results throughout the product per EN15804+A2.

Table 11 - EN15804+A2 Life Cycle Impact Assessment Results per Square Meter of Coated Flat Glass

Impact Category		Unit	A1-A3	A4	B2	C2	C4
Global Warming Potential	Total	kg CO_2 eq	1.11E+01	6.89E-01	1.35E+00	9.49E-02	4.33E-01
	Fossil	kg CO_2 eq	1.11E+01	6.91E-01	1.35E+00	9.49E-02	4.29E-01
	Biogenic	kg CO_2 eq	1.66E-02	-6.83E-03	5.21E-04	0.00E+00	4.41E-03
	Land Use and Land Use Change	kg CO_2 eq	1.93E-03	4.71E-03	3.96E-05	0.00E+00	1.53E-04
Ozone depletion		kg CFC-11 eq	1.07E-09	1.26E-09	6.98E-13	2.41E-12	6.67E-13
Acidification		Mole of H+ eq	2.01E-02	2.38E-02	5.17E-03	6.17E-04	2.12E-03
Eutrophication	Freshwater	kg P eq	7.27E-06	2.50E-06	2.02E-06	2.65E-08	1.33E-06
	Marine	kg N eq	6.38E-03	2.04E-03	8.78E-04	2.37E-04	5.73E-04
	Terrestrial	Mole of N eq	7.65E-02	2.27E-02	9.59E-03	2.59E-03	6.30E-03
Photochemical ozone formation		kg NMVOC eq	1.48E-02	1.68E-02	3.15E-03	6.99E-04	1.57E-03
Resource Use	Minerals and Metals	kg SB eq	7.37E-07	7.04E-08	1.69E-07	0.00E+00	1.14E-07
	Fossils	MJ	1.42E+02	9.17E+00	4.42E+01	1.19E+00	6.22E+00
Water use		m³ world equiv.	7.65E-01	1.05E+00	2.79E-01	0.00E+00	2.60E-02
Particulate matter		Disease incidences	1.87E-07	2.24E-07	3.81E-08	2.43E-09	2.21E-08
Ionising radiation, human health[1]		kBq U235 eq.	1.36E-01	6.17E-01	3.05E-01	2.10E-20	5.17E-03
Ecotoxicity, freshwater[2]		CTUe	1.26E+02	1.55E+02	4.85E+00	5.03E+00	3.47E+00
Human toxicity	Cancer[2]	CTUh	1.33E-09	1.34E-10	1.49E-10	2.51E-11	3.35E-10
	Non-cancer[2]	CTUh	7.86E-08	7.76E-09	5.52E-09	2.37E-09	3.51E-08
Land Use		Pt	6.23E+00	1.16E+01	3.34E-01	0.00E+00	7.32E-01

**Modules and life cycle stages not displayed above are assumed to have an impact of 0.*

† According to EN15804+A2 and EN17074, this impact category is also known as "climate change"

[1] Disclaimer: This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

[2] Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

[1] https://glassforeurope.com/policy-manifesto-2024-2029-2/

Results below contain the resource use throughout the life cycle of the product.

Table 12 - Resource Use per Square Meter of Coated Flat Glass

Resource Use							
Parameter		**Unit**	**A1-A3**	**A4**	**B2**	**C2**	**C4**
PERE	Renewable primary energy as energy carrier	MJ	1.43E+01	6.36E-01	1.11E+00	0.00E+00	6.01E-01
PERM	Renewable primary energy resources as material utilization	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	Total renewable primary energy resources	MJ	1.43E+01	6.36E-01	1.11E+00	0.00E+00	6.01E-01
PENRE	Nonrenewable primary energy as energy carrier	MJ	1.42E+02	9.21E+00	4.42E+01	1.19E+00	6.41E+00
PENRM	Nonrenewable primary energy as material utilization	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	Total nonrenewable primary energy resources		1.42E+02	9.21E+00	4.42E+01	1.19E+00	6.41E+00
SM	Use of secondary material	kg	4.40E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	Use of renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	Use of nonrenewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE	Energy recovered from disposed waste	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	Use of net fresh water	m^3	2.99E-02	7.34E-04	7.03E-03	0.00E+00	9.20E-04

**Modules and life cycle stages not displayed above are assumed to have an impact of 0.*

Results below contain the output flows and wastes throughout the life cycle of the product.

Table 13 - Waste and Outflows per Square Meter of Coated Flat Glass

Parameter	Unit	A1-A3	A4	B2	C2	C4
Hazardous waste	kg	2.05E-08	5.10E-11	5.68E-04	0.00E+00	2.40E-10
Non-hazardous solid waste	kg	1.13E-01	1.57E-03	8.24E-03	0.00E+00	1.00E+01
Radioactive waste	kg	2.45E-03	1.79E-05	4.35E-04	0.00E+00	5.63E-05
Components for re-use	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported Energy	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Biogenic carbon content in product	kg C	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Biogenic carbon content in packaging	kg C	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Modules and life cycle stages not displayed above are assumed to have an impact of 0.*

LCA Interpretation

The production of glass dominates the impacts across all impact categories. This is due to the electricity and natural gas used to make the products. Raw materials drives the impacts in the ozone depletion category.

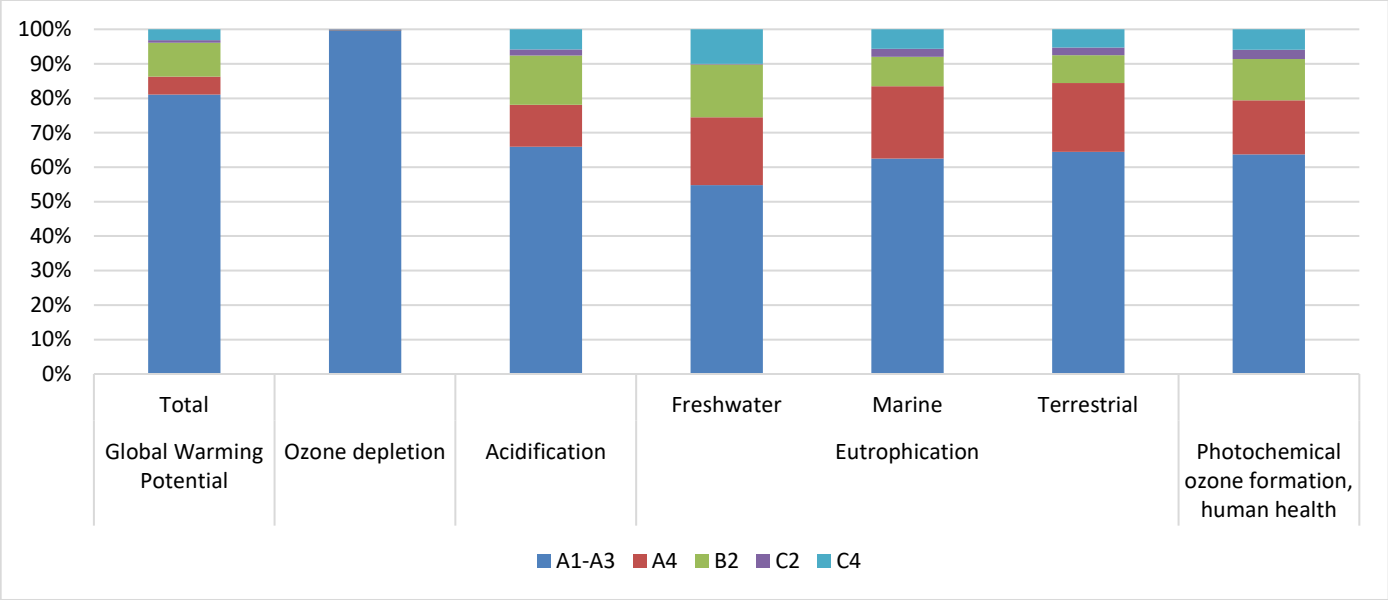

Figure 4 - Relative Contributions of Cradle-to-Gate Life Cycle Stages for Coated Flat Glass

Glass can come in a variety of different sizes, but its impacts can be scaled to different glass thicknesses. For this EPD, results are reported per square meter of 4mm glass. To convert to other given thickness, please see the scaling factor below for different sizes. Multiply the A1-A3 results by the scaling factors below using Equation 1. For all other life cycle stages, multiply by the scaling factor in Table 14.

Equation 1. A1-A3 Scaling Results to an Area at an Assumed Thickness

$$Impact\ Assessment\ Result\ per\ m^2 = Scaling\ Factor\ at\ Desired\ Thickness\ (Table\ 14)\ x\ Flat\ Glass\ Impacts\ (Table\ 15) + Coating\ Impacts\ (Table\ 15)$$

Table 14 - Scaling Factors Used to Multiply the Results to Various Thicknesses

Thickness	Scaling Factor
2.0 mm	0.500
2.1 mm	0.525
2.85 mm	0.713
3 mm	0.750
3.15 mm	0.788
3.85 mm	0.963
4 mm	1.00
4.85 mm	1.21

Thickness	Scaling Factor
5 mm	1.25
5.85 mm	1.46
6 mm	1.50
8 mm	2.00
10 mm	2.50
12 mm	3.00
15 mm	3.75

Table 15 - Impacts by Process

Impact category		Unit	Flat Glass Production			Coating Process
Global Warming Potential*	Total	kg CO_2 eq	1.02E+01	X Scaling Factor (Table 14)	+	8.70E-01
	Fossil	kg CO_2 eq	1.02E+01			8.59E-01
	Biogenic	kg CO_2 eq	5.85E-03			1.08E-02
	Land Use and Land Use Change	kg CO_2 eq	1.79E-03			1.45E-04
Ozone depletion		kg CFC-11 eq	1.17E-09			8.70E-11
Acidification		Mole of H+ eq	2.16E-02			2.18E-03
Eutrophication	Freshwater	kg P eq	4.91E-06			2.35E-06
	Marine	kg N eq	5.95E-03			4.24E-04
	Terrestrial	Mole of N eq	7.20E-02			4.46E-03
Photochemical ozone formation		kg NMVOC eq	1.56E-02			1.18E-03
Resource Use	Minerals and Metals	kg SB eq	5.55E-07			1.82E-07
	Fossils	MJ	1.31E+02			1.10E+01
Water use		m^3 world equiv.	7.03E-01			3.49E-01
Particulate matter		Disease incidences	2.05E-07			1.91E-08
Ionising radiation, human health		kBq U235 eq.	1.59E-01			4.58E-01
Ecotoxicity, freshwater		CTUe	1.51E+02			4.42E+00
Human toxicity	Cancer	CTUh	1.12E-09			2.18E-10
	Non-cancer	CTUh	7.25E-08			6.12E-09
Land Use		Pt	7.19E+00			4.40E+00

** According to EN15804+A2 and EN17074, this impact category is also known as "climate change"*

Additional Environmental Information

Environmental and Health During Manufacturing

At Guardian Glass, our vision is to help people improve their lives by providing the products and services they value more highly than their alternatives. We do this responsibly, while consuming fewer resources; seeking mutually beneficial outcomes with customers, employees, suppliers, communities, and other key constituencies.

Our Stewardship Framework flows directly from this vision, describing our commitment and priorities around Environmental, Social and Governance (ESG) topics. Stewardship broadly encompasses the responsible management of our actions and the resources entrusted to our care in a manner that respects the rights of others.

Guardian has invested in socially responsible policies and practices to help our businesses embed stewardship into the company culture and business decisions. Through responsible practices in the areas of environmental management and health and safety, Guardian's goal is to reduce potential environmental impacts to the communities in which it operates and create an exceptional workplace for its employees.

The safety and well-being of our employees and communities is our first priority. We build capability through our employees and resilience in our systems to prevent serious outcomes when the unexpected happens. We promote a principle-based, bottom-up approach to safety, involving front-line employees and supervisors in the identification of hazards and implementation of solutions all around the world. Each person is expected to raise concerns and share ideas about opportunities for improvement. Each manufacturing site has completed a risk evaluation that identified priorities with a focus on critical hazards. Action plans are developed, and knowledge networks are leveraged across the organization to better manage risk in those areas.

We pride ourselves on being solution providers, especially in the context of environmental stewardship, which involves considering each stage of the life cycle – from the sourcing of raw materials for each product, through to its production, application and end-of-life. Our approach to environmental stewardship is twofold – we strive to discover new and innovative technologies that improve both the environmental performance and effectiveness of our manufacturing processes and of our products.

We're committed to improving the energy efficiency of our manufacturing processes and reducing our use of resources. One way to achieve these is to maximize the amount of glass cullet (broken or old glass) used. Wider use of cullet in the glass manufacturing process helps to reduce consumption of virgin raw materials, save energy and reduce emissions. In line with our environmental stewardship priorities, Guardian Glass has started various initiatives aiming to use more cullet in glass manufacturing instead of virgin raw materials. The ratio of cullet in batch and glass can vary from site to site and over time, depending on cullet availability.

Extraordinary Effects

There are no known negative effects from the use of this product during fire, water, or mechanical destruction.

Delayed Emissions

Global warming potential is calculated using the EN15804+A2 and EN15804+A2 impact assessment methodologies. Delayed emissions are not considered.

Environmental Activities and Certifications

In an effort to provide greater support to the architects and designers who strive to meet increasingly stringent regulations, codes and standards and achieve ratings within various sustainable building rating systems such as LEED and BREEAM, Guardian Glass provides product and regionally specific documents and certifications to communicate transparent information about the life-cycle environmental impact of many of our products. More information on Guardian Glass's product certifications and declarations is available at www.guardianglass.com.

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