LIFE CYCLE ASSESSMENT (LCA) OF UNIVERSAL SERIES™ FIXED & OPERABLE WINDOWS AND DOORS, AND UNIVERSAL SERIES™ WINDOW WALL

Status	Public
Client	Cascadia
Date	August 2024
Authors	Luyi Huang, Sustainable Minds Ray Li, Sustainable Minds Kim Hammer, Sustainable Minds

Sustainable Minds

Contents

1 INTRODUCTION 4
1.1 Opportunity 4
1.2 Life cycle assessment 5
1.3 Status 5
1.4 Team 5
1.5 Structure 5

2 GOAL AND SCOPE 6
2.1 Intended application and audience 6
2.2 Product description 6
2.3 Declared unit 9
2.4 System boundary 9
2.4.1. Production stage (A1-A3) 10

3 LIFE CYCLE INVENTORY ANALYSIS 11
3.1 Data collection procedures 11
3.2 Primary data 11
3.2.1. Raw materials acquisition and transportation (A1-A2) 13
3.2.2. Manufacturing (A3) 15
3.2.3. Installation (A5) 16
3.3 Background data 17
3.3.1. Raw materials production 17
3.3.2. Transportation 18
3.3.3. Fuels and energy 19
3.3.4. Disposal 19
3.4 Comparability 20
3.5 Limitations 20
3.6 Cut-off criteria 20
3.7 Allocation 21
3.8 Software and database 21
3.9 Critical review 22

4 IMPACT ASSESSMENT METHODS 23
4.1 Impact assessment characterization 23
4.2 Normalization and weighting 24

5 ASSESSMENT AND INTERPRETATION 25
5.1 Resource use and waste flows 25
5.1.1. Fixed Window 26
5.1.2. Casement Window 27
5.1.3. Tilt & Turn Window 29
5.1.4. Awning Window 30
5.1.5. Hopper Window 32
5.1.6. Single Swing Door 33
5.1.7. Double Swing Door 35
5.1.8. Sliding Door 36
5.1.9. Window Wall Vision Glass 38
5.1.10. Window Wall Spandrel Glass 39
5.1.11. Window Wall Bypass 41
5.2 Life cycle impact assessment (LCIA) 42
5.2.1. Fixed Window 43
5.2.1.1. Fixed Window (Frame only) 44
5.2.1.2. Fixed Window (Glazing only) 44

5.2.2.Casement Window 45
5.2.2.1. Casement Window (Frame only) 47
5.2.2.2. Casement Window (Glazing only) 47
5.2.3.Tilt & Turn Window 47
5.2.3.1. Tilt & Turn Window (Frame only) 49
5.2.3.2. Tilt & Turn Window (Glazing Only) 49
5.2.4.Awning Window 50
5.2.4.1. Awning Window (Frame only) 52
5.2.4.2. Awning Window (Glazing only) 52
5.2.5.Hopper Window 52
5.2.5.1. Hopper Window (Frame only) 54
5.2.5.2. Hopper Window (Glazing only) 54
5.2.6.Single Swing Door 55
5.2.6.1. Single Swing Door (Frame only) 57
5.2.6.2. Single Swing Door (Glazing only) 57
5.2.7.Double Swing Door 57
5.2.7.1. Double Swing Door (Frame only) 59
5.2.7.2. Double Swing Door (Glazing only) 59
5.2.8.Sliding Door 60
5.2.8.1. Sliding Door (Frame only) 62
5.2.8.2. Sliding Door (Glazing only) 62
5.2.9.Window Wall Vision Glass 62
5.2.9.1. Window Wall Vision Glass (Frame only) 64
5.2.9.2. Window Wall Vision Glass (Glazing only) 64
5.2.10.Window Wall Spandrel Glass 65
5.2.10.1. Window Wall Spandrel Glass (Frame only) 67
5.2.10.2. Window Wall Spandrel Glass (Glazing only) 67
5.2.11.Window Wall Bypass 67
5.2.11.1. Window Wall Bypass (Frame only) 69
5.2.11.2. Window Wall Bypass (Glazing only) 69
5.2.12.Contributors in raw material acquisition stage 70
5.3 Scaling factors 70
5.4 Sensitivity analyses 72
5.4.1.Switch to 100% reusable steel racks 72
5.4.2.Triple glazing option 72
5.5 Overview of relevant findings 73
5.6 Discussion of data quality 73
5.7 Conclusions and recommendations 74

6 REFERENCES 76

APPENDIX 78

1 INTRODUCTION

1.1 Opportunity

Cascadia is a window manufacturer specializing in high-performance fiberglass windows, doors, and cladding support systems. With a focus on designing solutions for energy-effective fenestration assemblies, Cascadia aims to shape the future for enhancing building energy performance while remaining committed to sustainable manufacturing practices. Going forward, Cascadia continues its dedication to providing sustainable products to the market and driving continuous energy-saving efforts within the industry.

The ongoing effort for this action is to transparently communicate the environmental impact and performance of its products. As a result, it is important to conduct life cycle assessments (LCAs) to evaluate the environmental impacts from raw materials acquisition through manufacturing. The goal of conducting an LCA is to explore the potential environmental impacts that Cascadia's fiberglass windows have and to identify ways to improve processes and reduce impacts.

To understand the true impact of its building solutions, Cascadia commissioned Sustainable Minds to develop an LCA for its two main product lines: Universal Series™ Fixed & Operable Windows and Doors, and Universal Series™ Window Wall using a cradle-to-gate approach. Cascadia is looking forward to having guidance for future product improvements that can be informed by the results of this study.

This LCA is dedicated to analyzing the environmental impact of Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall, for a total of eleven window and door types, incorporating plant-specific data from Cascadia's British Columbia, Canada facility. This comprehensive approach to LCA will enable Cascadia to make informed decisions and further their commitment to sustainable practices across their operations.

Cascadia is interested in having LCA data available for Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall to be able to obtain Sustainable Minds Transparency Reports [EPDs]™ (TRs), which are ISO 14025 Type III environmental declarations that can be used for communication with and amongst other companies, architects, and consumer communications, and that can also be utilized in whole building LCA tools in conjunction with the LCA background report and life cycle inventory (LCI). This study conforms to the requirements of ISO 14044 [1], ISO 21930:2017 [2], and the NSF PCR for fenestration assemblies [3].

1.2 Life cycle assessment

This LCA report follows an attributional approach and comprises four key phases:

- Goal and scope definition
- Life cycle inventory analysis
- Life cycle impact assessment
- Interpretation of results

A critical review of the LCA and an independent verification of the TR are required for ISO 14025 Type III environmental declarations. Both are included in this project.

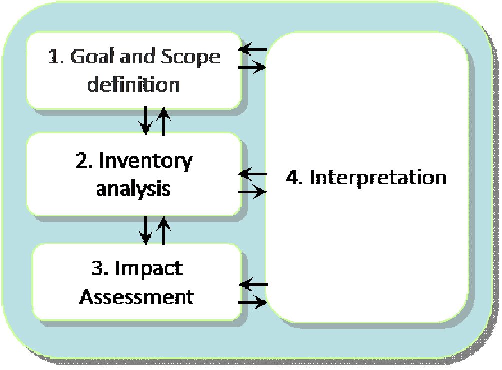

Figure 1. Phases in an LCA

1.3 Status

All information in this report reflects the best possible inventory by Cascadia at the time it was collected, and Sustainable Minds and Cascadia adhered to best practices in transforming the inventory into this report.

The data covers annual manufacturing data for May 2022 – April 2023 from Cascadia's manufacturing facility. Where data was missing, assumptions were made from manufacturing data for the facility based upon expertise from Cascadia employees.

This study includes primary data from the processes at this manufacturing facility and background data to complete the inventory and fill gaps where necessary.

The LCA review and verification of the Sustainable Minds Transparency Reports [EPDs]™ were carried out by Jack Geibig, President, Ecoform and found to be conformant to ISO 14044 and the relevant PCR.

1.4 Team

The data originating from this report is based on the work of the team led by Amber Mengede, Solveig Rey, Chris Guelpa, Michael Bousfield, Michael Zaklan, and Peter Thomson. Sustainable Minds led the development of the LCA modeling, results, report, and Transparency Reports [EPDs]™.

1.5 Structure

The subsequent sections of this LCA report are structured as follows:

Chapter 2: Goal and scope
Chapter 3: Life cycle inventory analysis
Chapter 4: Impact assessment methods
Chapter 5: Assessment and interpretation

This report incorporates LCA terminology. To assist the reader, special attention has been given to list definitions of important terms used at the end of this report.

2 GOAL AND SCOPE

This chapter explains the goal and scope of the LCA study. The goal and scope establish the boundaries of the analysis and define the level of detail and comprehensiveness of the assessment for the products in question.

2.1 Intended application and audience

This report intends to define the specific application of the LCA methodology to the life cycle of Universal Series™ Fixed & Operable Windows and Doors, and of Universal Series™ Window Wall. The report serves both internal and external purposes and is intended for a diverse audience. The intended audience includes the program operator (Sustainable Minds) and reviewers who will be assessing the LCA for conformance to the PCR, as well as Cascadia's internal stakeholders involved in marketing and communications, operations, and design.

The results presented in this document are not meant to support comparative claims. The outcomes will be made available to the public in Sustainable Minds Transparency Reports [EPDs]™ (Type III environmental declarations per ISO 14025), which are intended for communication between businesses and consumers (B2C).

2.2 Product description

This LCA study covers fiberglass windows, doors, and window wall products assembled with pultruded fiberglass lineals manufactured by Cascadia in British Columbia, Canada. The products considered in this declaration are different window and door types and sizes under the list prescribed by the NSF PCR for fenestration assemblies [3].

The Cascadia Universal Series™ Fixed & Operable Windows and Doors, and Cascadia Universal Series™ Window Wall, are fenestration assembly products. These products are made up of fiberglass profile frames, insulating glass units (IGUs), and other components including hardware, gaskets, and sealant. The fiberglass profiles are painted on an automated line to produce colored and smooth surfaces while minimizing paint waste. Components made of silicone and other plastics are installed as gaskets to ensure air and water tightness. The high-performance fiberglass frames offer thermal performance and structural integrity, with a high glass fiber-to-resin ratio that ensures durability and the ability to withstand extreme temperatures without sagging or weakening over time [4].

Cascadia Universal Series™ Fixed & Operable Windows and Doors and Cascadia Universal Series™ Window Wall products include the profile frame and IGU. Table 1 lists the product information in accordance with PCR, including the declaration name, products included in the declaration, CSI MasterFormat® classification, manufacturing location, and the type of declaration.

The primary function of these fenestration systems is to create a façade between the building's interior and exterior, while limiting thermal transfer through the building envelope, as shown in Figure 2.

Table 1. Declared product information and type of declaration

Transparency Report [EPD]™ name	Product name	CSI MasterFormat® classification	Manufacturing location(s)	Type of declaration
Cascadia Universal Series™ Fixed & Operable Windows and Doors	Fixed Window, Casement Window, Tilt & Turn Window, Awning Window, Hopper Window, Single Swing Door, Double Swing Door, Sliding Door	08 54 13 08 16 13	British Columbia, Canada	Product-specific, plant-specific declaration for one manufacturer
Cascadia Universal Series™ Window Wall	Window Wall Vision Glass, Window Wall Spandrel Glass, Window Wall Bypass	08 54 13 or 08 46 00	British Columbia, Canada	Product-specific, plant-specific declaration for one manufacturer

Universal Series™ Fixed & Operable Windows and Doors	Universal Series™ Window Wall
	

Figure 2. Visual representation of Universal Series™ Fixed & Operable Windows and Doors, and Universal Series™ Window Wall

Cascadia's fenestration systems are versatile and can be applied in various building types, including residential, multi-family, commercial, institutional, and high-rise buildings. The products come in multiple configurations to meet diverse design requirements: The configurations include fixed windows, casement windows, tilt and turn windows, awning windows, hopper windows, single swing doors, double swing doors, and sliding doors. The Cascadia Universal Series™ Window Wall includes three configurations: window wall vision glass, spandrel, and bypass. Product descriptions are listed in Tables 2-3.

During production, long fiberglass profiles are shipped to the manufacturing facility for fabrication processes, including cutting, drilling, packaging, and cleaning. The IGUs are distributed to the Cascadia facility from the USA or Canada.

While the operational energy of buildings where the products are installed is excluded from the scope of this study, it should be noted that fenestration systems contribute to building performance through enhancing thermal efficiency. By limiting thermal transfer through the building envelope, windows and doors help improve energy efficiency and comfort within buildings. The products are designed to meet or exceed building standards and requirements, and to ensure compliance with regulations.

Table 2. Cascadia Universal Series™ Fixed & Operable Windows and Doors product descriptions

Product name	NFRC size (width x height)	Product description
Universal Series™ Fixed Window	47 in * 59 in	Fixed windows consist of a singular frame around a transparent glazing unit that remains in one position and cannot be opened.
Universal Series™ Casement Window	24 in * 59 in	Casement windows swing open on vertical axis. They include an external frame, an internal sash that moves with the IGU, and a hardware kit that includes a crank, extension mechanism, stop locks, and hinges.
Universal Series™ Tilt &Turn Window	47 in * 59 in	Tilt-and-turn windows can open in two ways: tilting inward from the top for secure ventilation or swinging inwards from the side for maximum ventilation and easy cleaning. They include an external frame, an internal sash that moves with the IGU, and a handle mechanism.
Universal Series™ Awning Window	59 in * 24 in	Awning windows swing open outwards from the bottom on horizontal axis. They include an external frame, an internal sash that moves with the IGU, and a hardware kit that includes a crank, extension mechanism, stop locks, and hinges.
Universal Series™ Hopper Window	59 in * 24 in	Hopper windows are hinged at the bottom and tilt inward from the top. They include an external frame, an internal sash that tilts inwards with the IGU, and a locking mechanism.
Universal Series™ Single Swing Door	38 in * 82 in	Single swing doors operate on a set of hinges to open in one direction either inwardly or outwardly. They include an external frame, a door panel that swings on hinges, and a hardware kit.
Universal Series™ Double Swing Door	76 in * 82 in	Double swing doors open in both directions, either inwardly or outwardly. They include an external frame, two door panels that are hinged on either side, and a hardware kit that typically includes pivot hinges, handles, and sometimes a self-closing mechanism.
Universal Series™ Sliding Door	79 in * 79 in	Sliding doors operate by moving horizontally along a track. They consist of an external frame, one or more door panels that glide along a set of tracks, and a hardware kit that includes rollers, guides, handles, and locking mechanisms.

Table 3. Cascadia Universal Series™ Window Wall product descriptions

Product name	NFRC size (width x height)	Product description
Universal Series™ Window Wall Vision Glass	79 in * 79 in	Window wall with vision glazing is a floor-to-ceiling glazing system that contains multiple lites of fixed vision glass and operable sashes. The system includes framing, vision glass panels, and hardware for installation and attachment.
Universal Series™ Window Wall Spandrel Glass	79 in * 79 in	Window wall spandrel glass is contained within the window wall system features opaque panels within the window wall system in conjunction with insulation and waterproof components in board of the opaque panels. Spandrel glass contains 6mm coated glass panes and wool insulation to provide an opaque exterior appearance.
Universal Series™ Window Wall Bypass	79 in * 79 in	Window wall bypass is a portion of a window wall unit that covers the structure that the window is supported on. The system includes framing, opaque glass panes on the exterior, and a layer of insulation behind it, plus necessary hardware for installation and secure attachment.

For more information about the Cascadia Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall, including details about the materials that conform to the relevant standards, visit the links below: https://www.cascadiawindows.com/products/windows https://www.cascadiawindows.com/products/doors https://www.cascadiawindows.com/products/window-wall

2.3 Declared unit

This LCA covers the cradle-to-gate stage for Cascadia Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall products. According to the PCR, the declared unit in this study is normalized to one square meter (1 m^2) of fenestration assemblies (including frame and glazing). Glazing stops, sealants, gaskets, and other parts that retain or support the glazing are considered part of the frame assembly. Insect screens attached to the fenestration assemblies are not included. The products also meet the relevant performance standards in ANSI/NFRC 100 per the identified sub-type [3].

Table 4. Reference flows (mass per declared unit) per product

Product name	Whole unit, kg	Frame, kg	Glazing, kg	Whole unit, lbs	Frame, lbs	Glazing, lbs
Cascadia Universal Series™ Fixed & Operable Windows and Doors						
Universal Series™ Fixed Window	28.14	9.96	18.18	62.04	21.95	40.09
Universal Series™ Casement Window	39.73	26.94	12.79	87.60	59.40	28.20
Universal Series™ Tilt &Turn Window	33.02	17.46	15.56	72.80	38.50	34.30
Universal Series™ Awning Window	40.29	27.50	12.79	88.83	60.63	28.20
Universal Series™ Hopper Window	40.10	27.03	13.07	88.42	59.59	28.82
Universal Series™ Single Swing Door	41.17	25.34	15.83	90.76	55.87	34.90
Universal Series™ Double Swing Door	36.58	20.29	16.29	80.65	44.74	35.91
Universal Series™ Sliding Door	33.00	14.58	18.41	72.75	32.15	40.60
Cascadia Universal Series™ Window Wall						
Universal Series™ Window Wall Vision Glass	41.54	15.01	26.53	91.58	33.09	58.49
Universal Series™ Window Wall Spandrel Glass	35.96	22.70	13.27	79.28	50.04	29.24
Universal Series™ Window Wall Bypass	19.15	6.13	13.02	42.22	13.51	28.71

2.4 System boundary

This section describes the system boundary for the analysis. The system boundary defines which life cycle stages are included and which are excluded.

Scope	PRODUCTION STAGE			CONSTRUC-TION STAGE		USE STAGE					END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
	Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Deconstruction/Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste	Reuse, Recovery, Recycling Potential
						B6 Operational energy use									
						B7 Operational water use									
Cradle to gate	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Figure 3. Applied system boundary

Figure 3 illustrates all the life cycle phases included in this study. This LCA's system boundary is from cradle to gate. Therefore, the life cycle activities and related processes shall include modules A1, A2, and A3. This includes raw materials extraction and preprocessing, transportation, and manufacturing and final assembly for both the product and its associated packaging. Table 5 lists specific inclusions and exclusions for the system boundary. This study follows the modularity principle, where all environmental impacts and potential impacts are declared in the life cycle stage where they can be attributed.

Table 5. System boundary inclusions and exclusions

Included	Excluded
• Raw material extraction for components • Transport of raw materials • Processing of raw materials into components • Packaging of raw materials and their disposal • Energy production • Transport of components to assembly locations • Manufacturing scrap and its disposal • Packaging for the final product	• Construction of major capital equipment • Maintenance and operation of support equipment • Human labor and employee transport • Manufacture and transport of packaging materials not associated with final product • Building operational energy and water use

2.4.1. Production stage (A1-A3)

The production stage starts when raw materials are extracted from nature and ends when the product is packaged and ready to be loaded onto a transport vehicle at the Cascadia facility.

The production stage includes three product life cycle modules:

I. **Extraction and upstream preprocessing (A1)**
   - Extraction and processing of raw materials
   - Transport of raw materials from extraction/production to manufacturer
   - Energy and water consumption for raw material manufacturing

II. **Transport to factory (A2)**
   - Transportation of components to Cascadia's manufacturing facility
   - Raw material packaging inputs

III. **Manufacturing (A3)**
   - Energy and water consumption for product manufacturing
   - Product packaging inputs
   - Releases to environmental media (air, soil, ground, & surface water)
   - Manufacturing waste, scrap
   - Manufacturing waste transportation from plant to disposal sites
   - Manufacturing waste disposal/recycling/reuse/energy recovery

3 LIFE CYCLE INVENTORY ANALYSIS

This chapter includes an overview of the obtained data and data quality that has been used in this study. A complete life cycle inventory calculation workbook, which catalogs the flows crossing the system boundary and provides the starting point for life cycle impact assessment, can be found in the appendix.

3.1 Data collection procedures

Data used for this project represents a mix of primary data collected from Cascadia on the manufacturing processes for the window and door products and background data from SimaPro databases. Overall, the quality of the data used in this study is considered to be good and representative of the described systems. All appropriate means were employed to guarantee the data quality and representativeness as described below.

- **Gate-to-gate:** Data on materials and processing related to both the frame and glazing were collected in a consistent manner and level of detail to ensure high quality data. All submitted data were checked for quality multiple times on the plausibility of inputs and outputs. All questions regarding data were resolved with Cascadia. Annual data (May 2022 to April 2023) was collected at the Cascadia facility in British Columbia, Canada by Cascadia representatives with knowledge on the products and processing. Resulting inventory calculations were developed by an analyst at Sustainable Minds and subsequently checked internally.

- **Background data:** The model was constructed in SimaPro with consistency in mind. Expert judgment was used in selecting appropriate datasets to model the materials and energy for this study and has been noted in the preceding sections. Databases adopted in the model include ecoinvent v3.10 and US-EI 2.2 databases.

All primary data were provided by Cascadia. Upon receipt, data were cross-checked for completeness and plausibility using mass balance and benchmarking. If gaps, outliers, or other inconsistencies occurred, Sustainable Minds engaged with Cascadia to resolve any open issues.

3.2 Primary data

Primary data were collected for every process in the product system under the control of Cascadia. Primary data were collected using either direct measurement or the Cascadia facility representative personnel's best engineering estimates based on actual production if measurements were not available.

Cascadia Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall products are produced at Cascadia's facility in British Columbia, Canada. The fiberglass lineals are shipped from a facility in Etobicoke, Canada. Fiberglass lineals are produced by combining glass fibers and catalyzed polyester resin via a pultrusion process. After being shipped to the Cascadia facility, the long profiles of fiberglass are fabricated into the fiberglass window and door frames. The manufacturing process at Cascadia involves painting, cutting, drilling, assembling, cleaning, installing hardware, glazing, and packaging. The glazing is produced and manufactured in the USA or Canada and then shipped to Cascadia for distribution.

The flow chart in Figure 4 illustrates the cradle-to-gate fenestration system process flow diagram for Cascadia Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall products. This study has included all upstream energy and material flows related to production.

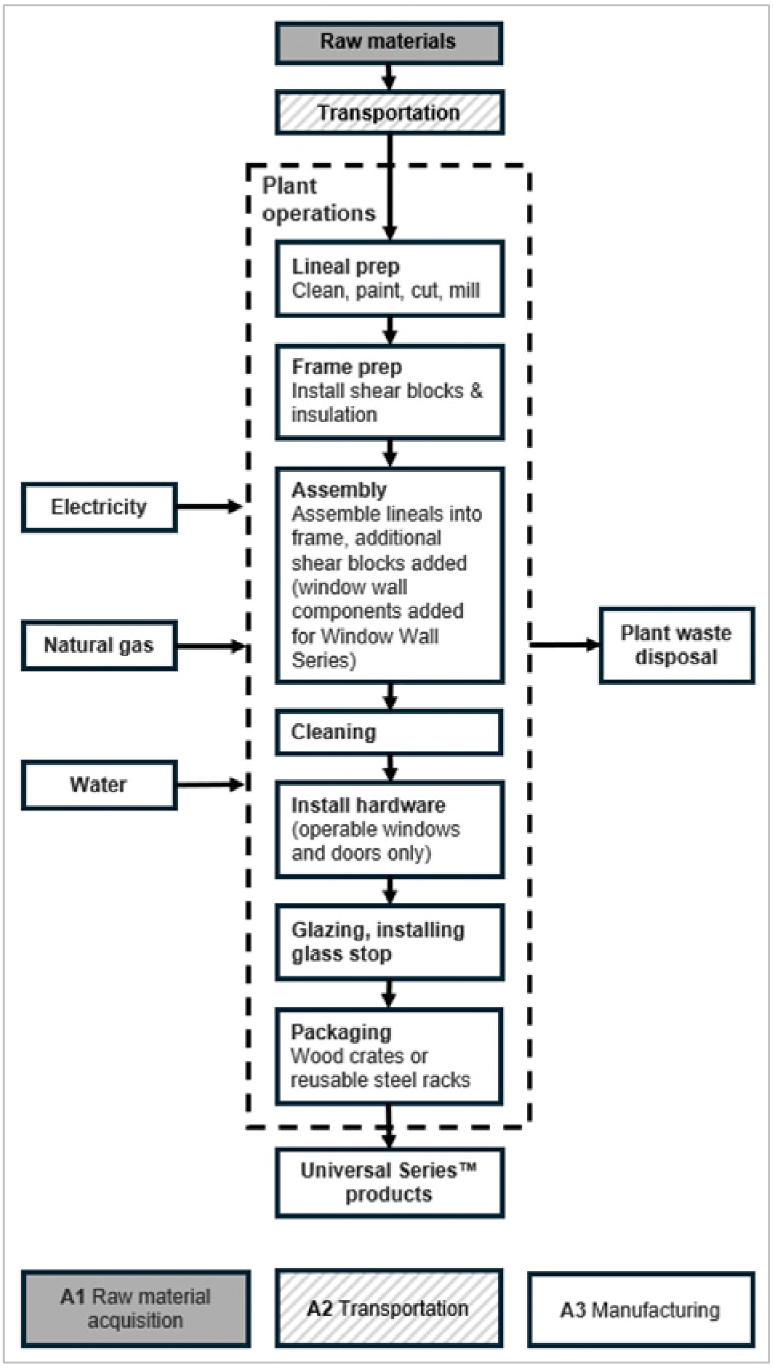

Figure 4. Life cycle flow diagram of for Cascadia Universal Series™ Fixed & Operable Windows and Doors, and Universal Series™ Window Wall products manufactured at Cascadia's facility

The facility receives fiberglass lineals and goes through cleaning and painting. An automated paint line handles the bulk painting. Individual parts are hand-painted in a spray booth. Once painted, the fiberglass lineals are cut to specific lengths according to the window profile requirements. The lineals are prepared with internal shear blocks and insulation prior to frame assembly. The lineals are then assembled into window shapes, with additional shear blocks added at this stage. After the initial assembly, the frames undergo rough cleaning to remove fiberglass dust. Gaskets and hardware are then installed on the assembled window frames. The glazing arrives on reusable metal racks from a North American supplier and is installed in the window frames, followed by the installation of glass stops. Depending on the project requirements, the final windows are packaged in reusable steel racks or custom-made reusable wood crates for outbound transportation. The steel racks are returned to Cascadia via a return program and reused many times over several years; therefore, their impact on the total results was assumed to be negligible. Steel racks are used to package outgoing products for approximately two thirds of all shipments. Custom-made wood crates are used for the remaining one third of shipments and are assumed to be made with virgin materials.

3.2.1. Raw materials acquisition and transportation (A1-A2)

Raw materials extraction, preprocessing, and transportation represent the first stage of the Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall life cycle. The full bills of material (BOMs) were provided by Cascadia with a detailed breakdown of the raw materials mass percentage for each product, as summarized in Table 6 and Table 7. The Cascadia Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall products do not contain hazardous substances according to the standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C or materials characterized as hazardous by the TRI.

Raw materials are extracted and manufactured by material suppliers. The supplier of glass fibers to the fiberglass lineal manufacturer stated that their products are comprised of 90% post-industrial recycled glass material, and since the fiberglass accounts for approximately 65% of the fiberglass lineal by mass, the pultruded fiberglass frames contain roughly 58% recycled content.

Suppliers then transport raw materials along with their associated packaging to Cascadia's manufacturing plant. Transportation by truck was modeled assuming empty returns (i.e., round trip). Most of the ingredients sourced in North America are transported by semi-truck, whereas materials sourced from overseas follow a mix of road transport by semi-truck and sea transport by ship. The materials sourced in North America were assumed to come directly from the supplier and not go through a distribution center. Transportation modes and distances for each of the raw materials supplied for Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall were provided. Waste and scrap created during raw material manufacturing, and the emissions associated with transporting waste and scrap to the point of disposal, were included in the background data sets used to model the raw materials.

Table 6. Cascadia Universal Series™ Fixed & Operable Windows and Doors raw material inputs by %wt.

Raw material	Universal Series™ Fixed Window	Universal Series™ Casement Window	Universal Series™ Tilt & Turn Window	Universal Series™ Awning Window	Universal Series™ Hopper Window	Universal Series™ Single Swing Door	Universal Series™ Double Swing Door	Universal Series™ Sliding Door
Fiberglass lineals	30.10%	50.13%	40.29%	49.43%	50.26%	45.80%	38.38%	34.20%
Glazing	64.61%	32.20%	47.12%	31.75%	32.60%	38.45%	44.53%	55.81%
Aluminum lineals	0%	0%	0%	0%	0%	1.25%	0.79%	1.82%
Polypropylene lineals	0%	0%	0%	0%	0%	0.88%	1.03%	0%
Insulation	0.74%	1.27%	1.01%	1.26%	1.27%	1.26%	1.65%	1.23%
Hardware	0%	7.12%	3.43%	5.89%	3.17%	4.85%	5.45%	0.74%
Packaging	1.64%	2.28%	3.54%	4.99%	5.71%	4.69%	5.28%	3.54%
Shear block	0.57%	2.27%	1.21%	2.53%	1.95%	0.91%	1.27%	1.27%
Paint	0.59%	1.02%	0.70%	1.00%	1.01%	0.68%	0.70%	0.41%
Gaskets	0.05%	0.43%	0.35%	0.43%	0.43%	0.27%	0.30%	0.31%
Sealant	0.07%	0.18%	0.45%	0.18%	0.18%	0.08%	0.09%	0.08%
Sill angle	0.97%	1.34%	0.83%	0.80%	1.66%	0%	0%	0%
Strap anchor	0.55%	0.76%	0.47%	0.75%	0.75%	0.44%	0.28%	0.35%
Screws	0.12%	1.00%	0.61%	0.99%	0.99%	0.44%	0.25%	0.27%

Table 7. Cascadia Universal Series™ Window Wall raw material inputs by %wt.

Raw material	Universal Series™ Window Wall Vision Glass	Universal Series™ Window Wall Spandrel Glass	Universal Series™ Window Wall Bypass
Fiberglass lineals	16.14%	18.65%	0.00%
Glazing	63.87%	36.89%	68.01%
Aluminum lineals	15.74%	23.66%	29.68%
Polypropylene lineals	0.00%	0.00%	0.00%
Insulation	0.48%	16.10%	0.00%
Outgoing packaging crate	1.95%	2.26%	2.12%
Shear block	0.68%	0.79%	0.00%
Paint	0.40%	0.19%	0.16%
Gaskets	0.16%	0.58%	0.00%
Sealant	0.04%	0.26%	0.00%
Sill angle	0.49%	0.56%	0.00%
Strap anchor	0.00%	0.00%	0.00%
Screws	0.05%	0.06%	0.04%

The Cascadia Universal Series™ offers a variety of window and door products, each capable of accommodating multiple glass/IGU thicknesses (Table 8). This study covers the range of 4mm to 6mm glass thicknesses used in Universal Series™ fixed and operable windows and window walls. The table below details the insulating glass unit thickness for each window and door type analyzed in this study.

Table 8. Insulating glass unit (IGUs) Thickness per window and door types calculated in this study

Windows types	Glass	Thickness (mm/panes)
Universal Series™ Fixed Window, Universal Series™ Casement Window, Universal Series™ Tilt & Turn Window, Universal Series™ Awning Window, Universal Series™ Hopper Window	Double Glazed	4 mm
Universal Series™ Single Swing Door Universal Series™ Double Swing Door Universal Series™ Sliding Door	Double Glazed	5 mm
Universal Series™ Window Wall Vision Glass	Double Glazed	6 mm
Universal Series™ Window Wall Spandrel Glass Universal Series™ Window Wall Bypass	Single Lite	6 mm

Table 104 provides scaling factors for converting double glazed units to triple glazed units, if any further calculations are needed.

3.2.2. Manufacturing (A3)

The fiberglass lineals and metal materials are transported to Cascadia's facility and stored before processing. After the fiberglass lineals and the glazing are transported to the Cascadia facility with associated packaging, the long profiles of fiberglass are fabricated on site. The fabrication process includes cutting the fiberglass, drilling, packaging, and cleaning.

The glazing is produced with double-coated and uncoated glass panels at a facility in the USA or Canada. After the glazing arrives at the Cascadia facility, the glazing unit is installed onto the fabricated fiberglass frame. Manufacturing inputs and outputs for Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall production are shown in Table 9.

All product scrap generated during the manufacturing stage as well as fiberglass dust, carboard boxes, and plastic wrap are assumed to be 100% landfilled. The fiberglass dust, incoming material packaging waste, and other non-hazardous wastes are assumed to be transported 32 km (19.9 mi) by truck to a landfill per the PCR. Recycled content (glass fibers) of input fiberglass lineals made from post-industrial or post-consumer scraps are reported. Wood pallets for incoming materials are reused within the plant or burned for firewood. Trucks are used for shipping landfill waste and recycling waste.

Table 9. Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall manufacturing inputs and outputs per declared unit

Product name	Electricity (kWh)	Natural gas (kWh)	Water (L)	Waste collection transport (kgkm)	Landfill disposal- fiberglass dust and packaging materials (kg)
Universal Series™ Fixed Window	12.6	18.2	0.231	7.20	0.225
Universal Series™ Casement Window	56.6	81.9	1.04	30.7	0.958
Universal Series™ Tilt &Turn Window	32.3	46.6	0.592	17.2	0.538
Universal Series™ Awning Window	56.6	81.9	1.04	31.4	0.981
Universal Series™ Hopper Window	32.3	46.6	0.592	16.9	0.527
Universal Series™ Single Swing Door	53.7	77.6	0.985	27.4	0.857
Universal Series™ Double Swing Door	53.7	77.6	0.985	26.7	0.834
Universal Series™ Sliding Door	33.9	49.1	0.623	17.1	0.534
Universal Series™ Window Wall Vision Glass	22.7	32.8	0.416	11.5	0.360
Universal Series™ Window Wall Spandrel Glass	22.7	32.8	0.416	11.3	0.353
Universal Series™ Window Wall Bypass	22.7	32.8	0.416	11.0	0.344

3.2.3. Installation (A5)

This section presents the biogenic carbon emissions from packaging associated with the final product in the installation stage (A5). While the impacts from installation are out of the scope of this cradle-to-gate study, ISO 21930:2017 requires that biogenic carbon emissions associated with packaging disposed after product installation are separately reported. The table below shows that the biogenic carbon removals from packaging in the manufacturing stage (A3) are then accounted for as biogenic carbon emissions from packaging in the installation stage (A5).

Table 10. Biogenic Carbon Emission from packaging associated with the final Installation (A5) kg CO2

Product name	Biogenic Carbon Emission from packaging associated with the final Installation (A5) kg CO_2
Universal Series™ Fixed Window	6.55E-02
Universal Series™ Casement Window	6.01E-01
Universal Series™ Tilt &Turn Window	7.76E-01
Universal Series™ Awning Window	1.34E+00
Universal Series™ Hopper Window	1.52E+00
Universal Series™ Single Swing Door	1.28E+00
Universal Series™ Double Swing Door	7.28E-01
Universal Series™ Sliding Door	2.44E+02
Universal Series™ Window Wall Vision Glass	7.88E-02
Universal Series™ Window Wall Spandrel Glass	7.88E-02
Universal Series™ Window Wall Bypass	7.88E-02

3.3 Background data

This section details background data sets used for modeling all activities associated with production. Each table lists the data set name, database, reference year, and geography.

3.3.1. Raw materials production

Data representing up- and down-stream raw materials were obtained from the ecoinvent v3.10 and US-EI 2.2 databases. Table 11 lists the most relevant LCI data sets used in modeling the raw materials.

Table 11. Key material data sets used in inventory analysis

Component name	Material name	Data set	Database	Technology	Reference year	Geography
Fiberglass lineals	Glass fibers (strands + mats)	Glass fibre {GLO}| market for glass fibre | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
	Polyester resin	Polyester resin, unsaturated {RoW}| market for polyester resin, unsaturated | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
	Clay (alumina)	Alumina, at plant NREL /US	USLCI	Appropriate technology	2021	United States
	Styrene	Styrene {RER}	ecoinvent v3.10	Appropriate technology	2024	Europe
	Vinyl acetate polymers	Ethylene vinyl acetate copolymer {RER}	ecoinvent v3.10	Appropriate technology	2024	Europe
	Calcium carbonate	Calcium carbonate, precipitate {RoW}	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
	Di-(4-tert-butylcyclohexyl Peroxydicarbonate)	Chemical, organic {GLO}	ecoinvent v3.10	Appropriate technology	2024	Global (GLO)
	Tert-bulylperoxy-2-ethylhexanoate	Chemical, organic {GLO}	ecoinvent v3.10	Appropriate technology	2024	Global (GLO)
	Stoddard solvent	Chemical, inorganic {GLO}	ecoinvent v3.10	Appropriate technology	2024	Global (GLO)
	Fatty acid esters (oil)	Chemical, organic {GLO}	ecoinvent v3.10	Appropriate technology	2024	Global (GLO)
	Cardboard box	Corrugated board box {US}| market for corrugated board box | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	United States
	Plastic wraps	Packaging film, low density polyethylene {GLO}| market for packaging film, low density polyethylene | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Glazing	Uncoated flat glass	Flat glass, uncoated, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
	Coated flat glass	Flat glass, coated, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
	Aluminum	Aluminium, production mix, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
	Sheet rolling	Sheet rolling, aluminium/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
	Argon	Argon, liquid, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
	PIB	Zeolite, powder, at plant/RER S	US-EI 2.2	Appropriate technology	2018	United States
	Spacer bar	Polybutadiene, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
	Sealant	Polysulphide, sealing compound, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
Aluminum lineals	Aluminum	Aluminium, cast alloy {GLO}| market for aluminium, cast alloy | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)

	Packaging- Steel wrap	Steel, low-alloyed, hot rolled {GLO}| market for steel, low-alloyed, hot rolled | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Polypropylene lineals	Polypropylene	Polypropylene, granulate {RoW}| polypropylene production, granulate | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Frame insulation	Expanded polystyrene	Polystyrene, expandable {RoW}| polystyrene production, expandable | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	United States
Outgoing packaging	Styrofoam	Polystyrene, expandable {RoW}| polystyrene production, expandable | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
	Screws	Steel, low-alloyed {RoW}| steel production, converter, low-alloyed | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
	Lumber	Sawn lumber, hardwood, rough, green, at sawmill, NE-NC/kg NREL/RNA U Sawn lumber, softwood, rough, green, at sawmill, INW/kg NREL/RNA U	US-EI 2.2	Appropriate technology	2018	United States
	Plastic wrap	Packaging film, low density polyethylene {RoW}| packaging film production, low density polyethylene | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Shear block	Polyamide 6	Nylon 6 {RoW}| nylon 6 production | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Acrylic liquid paint	Acrylic liquid paint Part A	Acrylic binder, with water, in 54% solution state {RoW}| acrylic binder production, with water, in 54% solution state | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
	Acrylic liquid paint Part B	Acrylic dispersion, with water, in 58% solution state {RoW}| acrylic dispersion production, with water, in 58% solution state | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Gaskets	Silicone rubber	Silicone product {RoW}| market for silicone product | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Glazing sealant	Glazing sealant	Polysulphide, sealing compound, at plant/US- US-EI U	US-EI 2.2	Appropriate technology	2018	United States
Installation sill angle	Aluminum	Aluminium, production mix, at plant/US- US-EI U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Glazing tape	Acrylic resin	Acrylic binder, with water, in 54% solution state {RoW}| market for acrylic binder, with water, in 54% solution state | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
	EAC (ethyl acetate)	Ethyl acetate {GLO}| market for ethyl acetate | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	United States

3.3.2. Transportation

Average transportation distances and modes of transport were included for the transportation of raw materials to the Cascadia manufacturing facility. The typical vehicle used for shipment is a semi-truck. Raw materials sourced from overseas are transported through container ships. Transportation distances from the production facility to the adjacent ports and from the destination port to the Cascadia facility are included and occur via semi-trucks. As the transportation data sets represent load factors as an average of empty and fully loaded (i.e., average load factor), empty backhauls are accounted for in the model. Table 12 shows the most relevant LCI data sets used in modeling transportation.

Table 12. Transportation data sets used in inventory analysis

Vehicle type	Data set	Database	Technology	Reference year	Geography
Semi-truck	Transport, freight, lorry 16-32 metric ton, EURO6 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	ecoinvent v3.10	Appropriate technology	2022	Rest of World (non-Europe)
Container ship	Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, U	ecoinvent v3.10	Appropriate technology	2022	Global (GLO)

3.3.3. Fuels and energy

Electricity at the facility was modeled using regionally specific inventory data based on the electricity market consumption mix in British Columbia, Canada. The fuel input and electricity grid mix were obtained accordingly using the databases available in SimaPro. Table 13 shows the most relevant LCI datasets used in modeling the product systems. For the manufacturing stage, the US-EI 2.2 database was adopted to represent the provincial and territorial energy production and consumption profile in British Columbia. This data set reflects that approximately 87% of electricity generation in British Columbia comes from hydroelectric sources.

Table 13. Key energy datasets used in inventory analysis

Energy source	Dataset	Facility location	Database	Technology	Reference year
Electricity	Electricity mix, British Columbia/CA U	British Columbia, Canada	US-EI 2.2	Appropriate technology	2019
Natural gas	Heat, district or industrial, natural gas {CA-QC}| market for heat, district or industrial, natural gas | Cut-off, U	British Columbia, Canada	ecoinvent v3.10	Appropriate technology	2022
Diesel	Diesel {RoW}| market for diesel | Cut-off, U	North America	ecoinvent v3.10	Appropriate technology	2024
Propane	Propane {GLO}| market for propane | Cut-off, U	North America	ecoinvent v3.10	Appropriate technology	2024

3.3.4. Disposal

Disposal processes were obtained from the ecoinvent v3.10 database. These processes were selected to correspond to the disposal of fiberglass dust and packaging waste. Table 14 lists the relevant disposal data sets used in the model.

Table 14. Key disposal data sets used in inventory analysis

Material disposed	Data set	Database	Technology	Reference year	Geography
Fiberglass dust	Disposal, inert material, 0% water, to sanitary landfill/US* US-EI U	US-EI 2.2	Appropriate technology	2018	United States
Cardboard box	Disposal, packaging cardboard, 0% water, to sanitary landfill/US* US-EI U	US-EI 2.2	Appropriate technology	2018	United States
Plastic wraps	Disposal, polyethylene, to US sanitary landfill/US US-EI U	US-EI 2.2	Appropriate technology	2018	United States
Waste transportation	Transport, municipal waste collection, lorry 21t/US* US-EI U	US-EI 2.2	Appropriate technology	2018	United States

3.4 Comparability

ISO 21930:2017 section 5.5 highlights the following limitations and clarifications in EPD comparability: EPDs are comparable only if they use the same PCR (or 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].

The PCR for Fenestration Assemblies allows EPD comparability only when the same functional requirements between products are ensured and the requirements of ISO 21930:2017 §5.5 are met [3].

However, additional variations and deviations are possible. For example, different LCA software and background LCI datasets may lead to different results for the life cycle stages declared.

3.5 Limitations

A life cycle assessment of a product system is broad and complex, and it inherently requires assumptions and simplifications. The following limitations of the study should be recognized:

- Primary data were modeled based on the information provided by Cascadia and supplemented by data contained in the technical and safety data sheets provided. Proxy materials were used when matching secondary data sets were not identified.
- Since energy inputs were not available on a per-product basis, electricity and natural gas consumption were allocated proportionately based on the percentage of labor unit per production for individual window products versus total site annual labor unit recorded.
- Generic data sets used for material inputs, transport, and waste processing are considered good quality, but actual impacts from material suppliers, transport carriers, and local waste processing may vary.
- The impact assessment methodology categories do not represent all possible environmental impact categories.
- Characterization factors used within the impact assessment methodology may contain varying levels of uncertainty.
- LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

3.6 Cut-off criteria

The cut-off criteria on a unit process level can be summarized as follows:

- All inputs and outputs to a (unit) process shall be included in the calculation of the pre-set parameters results, for which data are available. Data gaps shall be filled by conservative assumptions with average, generic or proxy data. Any assumptions for such choices shall be documented.
- Mass – If a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern. However, this study includes all components regardless of

their weight percentage to reflect the whole range of materials composition.

- Energy – If a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern.
- Environmental relevance – If a flow meets the above criteria for exclusion, yet it is thought to potentially have a significant environmental impact, it is included.
- Hazardous and toxic materials – The study shall include all hazardous and toxic materials in the inventory, including intentionally added materials characterized as hazardous by the TRI; therefore, the cutoff rules shall not apply to such substances.
- The sum of the neglected material flows does not exceed 5% of mass, energy or environmental relevance for flows indirectly related to the process (e.g., operating materials).

In this report, no known flows are deliberately excluded; therefore, these criteria have been met. The completeness of the bill of materials defined in this report satisfies the above-defined cut-off criteria.

3.7 Allocation

Whenever a system boundary is crossed, environmental inputs and outputs have to be assigned to the different products. Where multi-inputs or multi-outputs are considered, the same applies. The PCR prescribes to report where and how allocation occurs in the modeling of the LCA. In this LCA, the following assumptions and rules have been applied.

- The Cascadia facility produces various types of window products in any given year. To accurately allocate electricity and natural gas used at the facility to window, door, and window wall production, the total annual energy consumption was calculated through labor unit allocation. This proportionally assesses the percentage of manufacturing activities for each window types under the Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall versus total annual labor activities.

- Although there are no co-products produced during the manufacturing processes, the production in the Cascadia facility includes different types of window products. Therefore, the manufacturing inputs that needed allocation were electricity, water, and natural gas consumption, which were allocated based on labor units. Additionally, the manufacturing outputs of waste disposals were allocated based on labor units required through product types.

- The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring.

3.8 Software and database

The LCA model was created using SimaPro Analyst 9.5. The ecoinvent v3.10 and US-EI 2.2 databases provided the life cycle inventory data of the raw materials and processes for modeling the products.

3.9 Critical review

This is a supporting LCA report for Cascadia Transparency Reports [EPDs]™ and was evaluated for conformance to the PCR according to ISO 14025 [5] and ISO 14044 [1]. Critical review was performed by Jack Geibig, President, Ecoform, and access to a public version of this critically reviewed report can be found linked in the references section of the Transparency Reports [EPDs]™.

4 Impact Assessment Methods

4.1 Impact assessment characterization

The environmental indicators as required by the PCR are included as well as other indicators required to use the SM2013 Methodology [6] (see Table15). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [7]. Long-term emissions (>100 years) are not taken into consideration in the impact estimate. USEtox indicators[2] are used to evaluate toxicity. Emissions from waste disposal are considered part of the product system under study, according to the "polluter pays principle".

Table15. Selected impact categories and units

Impact category	Unit	Description
Acidification	kg SO_2 eq (sulphur dioxide)	Acidification processes increase the acidity of water and soil systems and causes damage to lakes, streams, rivers and various plants and animals as well as building materials, paints and other human-built structures.
Ecotoxicity	CTUe	Ecotoxicity causes negative impacts to ecological receptors and, indirectly, to human receptors through the impacts to the ecosystem.
Eutrophication	kg N eq (nitrogen)	Eutrophication is the enrichment of an aquatic ecosystem with nutrients (nitrates and phosphates) that accelerate biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass.
Global warming	kg CO_2 eq (carbon dioxide)	Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere.
Ozone depletion	kg CFC-11 eq	Ozone depletion is the reduction of ozone in the stratosphere caused by the release of ozone depleting chemicals.
Carcinogenics	CTUh	Carcinogens have the potential to form cancers in humans.
Non-carcinogenics	CTUh	Non-Carcinogens have the potential to causes non-cancerous adverse impacts to human health.
Respiratory effects	kg $PM_{2.5}$ eq (fine particulates)	Particulate matter concentrations have a strong influence on chronic and acute respiratory symptoms and mortality rates.
Smog	kg O_3 eq (ozone)	Smog formation (photochemical oxidant formation) is the formation of ozone molecules in the troposphere by complex chemical reactions.
Fossil fuel depletion	MJ surplus	Fossil fuel depletion is the surplus energy to extract minerals and fossil fuels.

With respect to global warming potential, biogenic carbon uptake and removal are included in impact category calculations. The biogenic carbon measured in this study originates from packaging materials, and no other raw materials in the fenestration assembly systems are expected to contain biogenic carbon. Greenhouse gas emissions from land-use change are

[1]The 100-year period relates to the period in which the environmental impacts are modeled. This is different from the time period of the declared unit. The two periods are related as follows: all environmental impacts that are created in the period of the declared unit are modeled through life cycle impact assessment using a 100-year time horizon to understand the impacts that take place.
[2] USEtox is available in TRACI and at http://www.usetox.org/

expected to be insignificant and were not reported. Carbon emissions during carbonation and calcination are b also considered in this study, and no carbonation or calcination are expected to occur during the production and manufacture of the products. No delayed emissions from a temporary carbon sequestration are expected to occur.

It shall be noted that the above impact categories represent impact potentials. They are approximations of environmental impacts that could occur if the emitted molecules follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen declared unit (relative approach).

The results from the impact assessment indicate potential environmental effects and do not predict actual impacts on category endpoints, the exceedance of thresholds, or safety margins or risks.

4.2 Normalization and weighting

To arrive at a single score indicator, normalization [8] and weighting [9] as shown in the table below conforming to the SM2013 Methodology were applied. The SM2013 Methodology uses TRACI 2.1 impact categories developed by the U.S. EPA, and North American normalization and weighting values developed by the EPA and NIST respectively, to calculate single figure LCA results. Sustainable Minds recognizes that weighting is socially defined based on the importance that society attaches to the different environmental impact categories. However, these single score indicators serve as an easy starting point to get to know the product under consideration across all impact categories, rather than focusing all efforts on just one impact category (like global warming potential). The interpretation of the results starts with the Sustainable Minds single score results and then allows users to further explore the underlying impact categories individually. Details including the characterization models, factors, and methods used, including all assumptions and limitations, can be found in the SM2013 Methodology Report [6].

Normalization and weighting factors

Impact category	Normalization	Weighting (%)
Acidification	90.9	3.6
Ecotoxicity	11000	8.4
Eutrophication	21.6	7.2
Global warming	24200	34.9
Ozone depletion	0.161	2.4
Carcinogenics	5.07E-05	9.6
Non-carcinogenics	1.05E-03	6.0
Respiratory effects	24.3	10.8
Smog	1390	4.8
Fossil fuel depletion	17300	12.1

5 ASSESSMENT AND INTERPRETATION

This chapter includes the results from the LCA for the products studied. It details the results per declared unit, outlines the sensitivity analysis, and concludes with recommendations.

5.1 Resource use and waste flows

Resource use indicators, output flows and waste category indicators, and carbon emissions and removals are presented in this section. These life cycle inventory (LCI) indicators reflect the flows from and to nature for the product system, prior to characterization using an impact assessment methodology to calculate life cycle impact assessment (LCIA) results (as shown in section 5.2).

LCI flows were calculated with the help of American Center for Life Cycle Assessment's (ACLCA) guidance to the ISO 21930:2017 metrics [10]. The consumption of freshwater indicator, which was calculated in accordance with this guidance, is reported in compliance with ISO 14046. Abiotic depletion potential was calculated using the CML impact assessment methodology [11]. LCI flows were reported in conformance to ISO 21930:2017 [2].

Resource use indicators represent the amount of materials consumed to produce not only the product itself but also the raw materials, electricity, natural gas, etc. that go into the product's life cycle.

Primary energy is an energy form found in nature that has not been subjected to any conversion or transformation process and is expressed in energy demand from renewable and non-renewable resources. Efficiencies in energy conversion are considered when calculating primary energy demand from process energy consumption. Water use represents the total water used over the entire life cycle. No renewable energy was used in production beyond that accounted for in the British Columbia grid mix, and no energy was recovered.

Non-hazardous wastes are calculated based on the amount of waste generated during manufacturing based on Cascadia's record. Additionally, per the PCR, quantities of high-level or intermediate/low-level radioactive waste were reported by A1-A3 modules for the frame and glazing separately, as well as by system total. All waste treatments in models were considered based on the local waste management code and the assumptions prescribed by the PCR. Waste treatments included within the system boundary are reported. Unrecyclable waste is picked up from the facility and is transported to landfills. Tables 16-48 show resource use and waste flows for all products per declared unit.

5.1.1. Fixed Window

Table 16. Resource use and waste flows for Universal Series™ Fixed Window whole system (frame and glazing) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	6.45E+01	1.60E-01	4.73E+01	**1.12E+02**
Renewable primary resources with energy content used as material	MJ, NCV	9.41E+00	0.00E+00	0.00E+00	**9.41E+00**
Total use of renewable primary resources with energy content	MJ, NCV	7.39E+01	1.60E-01	4.73E+01	**1.21E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	7.22E+02	1.04E+02	9.06E+01	**9.17E+02**
Non-renewable primary resources with energy content used as material	MJ, NCV	8.76E+01	0.00E+00	0.00E+00	**8.76E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	8.10E+02	1.04E+02	9.06E+01	**1.00E+03**
Secondary materials	kg	4.96E+00	0.00E+00	4.62E-01	**5.42E+00**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	1.64E+00	**1.64E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	9.53E+00	4.31E-01	4.44E-01	**1.04E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	6.63E+02	9.78E+01	8.14E+01	**8.42E+02**
Output flows and waste category indicators					
Hazardous waste disposed	kg	2.36E+02	2.21E+01	4.56E-01	**2.59E+02**
Non-hazardous waste disposed	kg	3.47E+00	8.94E-02	6.76E-03	**3.57E+00**
High-level radioactive waste, conditioned, to final repository	kg	1.67E-05	1.17E-06	3.84E-06	**2.17E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.00E-04	2.27E-06	2.00E-06	**6.05E-04**
Components for re-use	kg	0.00E+00	0.00E+00	4.62E-01	**4.62E-01**
Materials for recycling	kg	0.00E+00	0.00E+00	1.31E-01	**1.31E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	6.55E-02	0.00E+00	3.07E-01	**3.72E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	6.55E-02	**6.55E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 17. High and low-level radioactive waste reported by A1-A3 modules for fixed window (frame only) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
Output flows and waste category indicators					
High-level radioactive waste, conditioned, to final repository	kg	1.67E-05	9.23E-07	1.37E-06	**1.90E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.21E-04	1.79E-06	7.15E-07	**1.24E-04**

Table 18. High- and low-level radioactive waste reported by A1-A3 modules for the fixed window (glazing only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Output flows and waste category indicators					
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	2.45E-07	2.46E-06	**2.71E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.79E-04	4.75E-07	1.40E-07	**4.81E-04**

5.1.2. Casement Window

Table 19. Resource use and waste flows for Universal Series™ Casement Window whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.06E+02	3.29E-01	2.13E+02	**3.19E+02**
Renewable primary resources with energy content used as material	MJ, NCV	1.64E+01	0.00E+00	0.00E+00	**1.64E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.23E+02	3.29E-01	2.13E+02	**3.36E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	8.29E+02	2.14E+02	4.08E+02	**1.45E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.24E+02	0.00E+00	0.00E+00	**2.24E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.05E+03	2.14E+02	4.08E+02	**1.68E+03**
Secondary materials	kg	1.17E+01	0.00E+00	9.05E-01	**1.26E+01**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	1.84E+00	**1.84E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	2.12E+01	5.79E-01	1.04E+00	**2.18E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	8.83E+02	2.01E+02	3.66E+02	**1.45E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	2.81E+00	4.46E-02	2.05E-03	**2.86E+00**
Non-hazardous waste disposed	kg	1.32E+01	1.83E-01	3.04E-02	**1.34E+01**
High-level radioactive waste, conditioned, to final repository	kg	7.63E-05	2.57E-06	1.43E-05	**9.31E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.41E-04	6.81E-06	2.35E-05	**6.72E-04**
Components for re-use	kg	0.00E+00	0.00E+00	9.05E-01	**9.05E-01**
Materials for recycling	kg	0.00E+00	0.00E+00	1.47E-01	**1.47E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	7.35E-02	0.00E+00	6.01E-01	**6.74E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	7.35E-02	**7.35E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 20. High and low-level radioactive waste reported by A1-A3 modules for Casement Window (frame only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	7.63E-05	2.24E-06	1.17E-05	**9.02E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.04E-04	6.63E-06	1.76E-05	**3.28E-04**

Table 21. High- and low-level radioactive waste reported by A1-A3 modules for Casement Window (glazing only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	3.34E-07	2.58E-06	**2.91E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.37E-04	1.75E-07	5.89E-06	**3.43E-04**

5.1.3. Tilt & Turn Window

Table 22. Resource use and waste flows for Universal Series™ Tilt & Turn Window whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	8.34E+01	2.30E-01	1.21E+02	**2.05E+02**
Renewable primary resources with energy content used as material	MJ, NCV	9.41E+00	0.00E+00	0.00E+00	**9.41E+00**
Total use of renewable primary resources with energy content	MJ, NCV	9.29E+01	2.30E-01	1.21E+02	**2.14E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	7.91E+02	1.50E+02	2.32E+02	**1.17E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	8.76E+01	0.00E+00	0.00E+00	**8.76E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	8.78E+02	1.50E+02	2.32E+02	**1.26E+03**
Secondary materials	kg	4.96E+00	0.00E+00	4.62E-01	**5.42E+00**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	1.64E+00	**1.64E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	1.45E+01	4.95E-01	1.05E+00	**1.60E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	7.29E+02	1.41E+02	2.09E+02	**1.08E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	1.17E+00	3.14E-02	1.17E-03	**1.20E+00**
Non-hazardous waste disposed	kg	7.14E+00	1.28E-01	1.73E-02	**7.28E+00**
High-level radioactive waste, conditioned, to final repository	kg	3.12E-05	1.68E-06	9.83E-06	**4.28E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.71E-04	3.30E-06	5.14E-06	**5.79E-04**
Components for re-use	kg	0.00E+00	0.00E+00	4.62E-01	**4.62E-01**
Materials for recycling	kg	0.00E+00	0.00E+00	1.31E-01	**1.31E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	6.55E-02	0.00E+00	7.76E-01	**8.42E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	6.55E-02	**6.55E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 23. High and low-level radioactive waste reported by A1-A3 modules for Tilt & Turn Window (frame only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	3.12E-05	1.47E-06	5.20E-06	**3.79E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.60E-04	2.87E-06	2.70E-06	**1.65E-04**

Table 24. High and low-level radioactive waste reported by A1-A3 modules for Tilt & Turn Window (glazing only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	2.10E-07	4.63E-06	**4.84E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.10E-04	4.07E-07	2.53E-07	**4.13E-04**

5.1.4. Awning Window

Table 25. Resource use and waste flows for Universal Series™ Awning Window whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	8.78E+01	3.28E-01	2.09E+02	**2.99E+02**
Renewable primary resources with energy content used as material	MJ, NCV	3.32E+01	0.00E+00	0.00E+00	**3.32E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.21E+02	3.28E-01	2.09E+02	**3.32E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	8.32E+02	2.14E+02	4.01E+02	**1.46E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.28E+02	0.00E+00	0.00E+00	**2.28E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.06E+03	2.14E+02	4.01E+02	**1.68E+03**
Secondary materials	kg	1.17E+01	0.00E+00	2.01E+00	**1.37E+01**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	2.00E+00	**2.00E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	1.89E+01	5.77E-01	1.03E+00	**2.14E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	8.87E+02	2.01E+02	3.61E+02	**1.46E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	2.12E+00	4.46E-02	2.02E-03	**2.50E+00**
Non-hazardous waste disposed	kg	1.18E+01	1.83E-01	2.99E-02	**1.28E+01**
High-level radioactive waste, conditioned, to final repository	kg	7.18E-05	2.40E-06	1.70E-05	**9.38E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.93E-04	4.68E-06	8.83E-06	**6.07E-04**
Components for re-use	kg	0.00E+00	0.00E+00	2.01E+00	**2.01E+00**
Materials for recycling	kg	0.00E+00	0.00E+00	1.60E-01	**1.60E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	2.93E-01	0.00E+00	1.34E+00	**1.63E+00**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	2.93E-01	**2.93E-01**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 26. High and low-level radioactive waste reported by A1-A3 modules for Awning Window (frame only) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	7.44E-05	2.23E-06	1.16E-05	**8.82E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.56E-04	4.34E-06	6.03E-06	**2.66E-04**

Table 27. High and low-level radioactive waste reported by A1-A3 modules for Awning Window (glazing only) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	1.72E-07	5.40E-06	**5.57E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.37E-04	0.00E+00	3.01E-07	**3.38E-04**

5.1.5. Hopper Window

Table 28. Resource use and waste flows for Universal Series™ Hopper Window whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	9.10E+01	3.29E-01	2.39E+02	**3.30E+02**
Renewable primary resources with energy content used as material	MJ, NCV	3.72E+01	0.00E+00	0.00E+00	**3.72E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.28E+02	3.29E-01	2.39E+02	**3.67E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	8.15E+02	2.14E+02	4.57E+02	**1.49E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.23E+02	0.00E+00	0.00E+00	**2.23E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.04E+03	2.14E+02	4.57E+02	**1.71E+03**
Secondary materials	kg	1.18E+01	0.00E+00	2.29E+00	**1.41E+01**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	1.84E+00	**1.84E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	1.99E+01	6.56E-01	1.17E+00	**2.17E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	8.67E+02	2.01E+02	4.11E+02	**1.48E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	1.82E+00	4.50E-02	2.30E-03	**1.87E+00**
Non-hazardous waste disposed	kg	1.12E+01	1.84E-01	3.41E-02	**1.14E+01**
High-level radioactive waste, conditioned, to final repository	kg	5.80E-05	2.41E-06	1.94E-05	**7.97E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.73E-04	4.73E-06	1.01E-05	**6.88E-04**
Components for re-use	kg	0.00E+00	0.00E+00	2.29E+00	**2.29E+00**
Materials for recycling	kg	0.00E+00	0.00E+00	1.47E-01	**1.47E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	2.70E-01	0.00E+00	1.52E+00	**1.79E+00**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	2.70E-01	**2.70E-01**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 29. High and low-level radioactive waste reported by A1-A3 modules for Hopper Window (frame only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	5.80E-05	2.23E-06	1.30E-05	**7.33E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.27E-04	4.34E-06	6.79E-06	**3.38E-04**

Table 30. High and low-level radioactive waste reported by A1-A3 modules for Hopper Window (glazing only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	1.76E-07	6.31E-06	**6.49E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.45E-04	0.00E+00	3.54E-07	**3.45E-04**

5.1.6. Single Swing Door

Table 31. Resource use and waste flows for Universal Series™ Single Swing Door whole system (frame and glazing) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.28E+02	3.16E-01	2.02E+02	**3.29E+02**
Renewable primary resources with energy content used as material	MJ, NCV	3.30E+01	0.00E+00	0.00E+00	**3.30E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.61E+02	3.16E-01	2.02E+02	**3.62E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.26E+03	2.05E+02	3.86E+02	**1.85E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.12E+02	0.00E+00	0.00E+00	**2.12E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.47E+03	2.05E+02	3.86E+02	**2.07E+03**
Secondary materials	kg	1.10E+01	0.00E+00	1.93E+00	**1.30E+01**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	2.00E+01	**2.66E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	2.16E+01	5.36E-01	1.73E+00	**2.39E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.22E+03	1.93E+02	3.47E+02	**1.76E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	1.47E+00	4.30E-02	1.94E-03	**1.51E+00**
Non-hazardous waste disposed	kg	1.26E+01	1.76E-01	2.88E-02	**1.28E+01**
High-level radioactive waste, conditioned, to final repository	kg	5.78E-05	2.31E-06	1.64E-05	**7.64E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.16E-03	4.53E-06	8.52E-06	**1.17E-03**
Components for re-use	kg	0.00E+00	0.00E+00	1.93E+00	**1.93E+00**
Materials for recycling	kg	0.00E+00	0.00E+00	2.13E-01	**2.13E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	3.91E-01	0.00E+00	1.28E+00	**1.67E+00**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	3.91E-01	**3.91E-01**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 32. High and low-level radioactive waste reported by A1-A3 modules for Single Swing Door (frame only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	5.41E-05	2.09E-06	1.01E-05	**6.63E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.42E-04	4.08E-06	5.21E-06	**5.51E-04**

Table 33. High and low-level radioactive waste reported by A1-A3 modules for Single Swing Door (glazing only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	3.68E-06	2.13E-07	6.29E-06	**1.02E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.18E-04	4.14E-07	3.25E-06	**6.22E-04**

5.1.7. Double Swing Door

Table 34. Resource use and waste flows for Universal Series™ Double Swing Door whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.04E+02	2.46E-01	2.02E+02	**3.06E+02**
Renewable primary resources with energy content used as material	MJ, NCV	3.64E+01	0.00E+00	0.00E+00	**3.64E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.41E+02	2.46E-01	2.02E+02	**3.42E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.27E+03	1.60E+02	3.86E+02	**1.81E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.77E+02	0.00E+00	0.00E+00	**1.77E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.44E+03	1.60E+02	3.86E+02	**1.99E+03**
Secondary materials	kg	8.21E+00	0.00E+00	1.93E+00	**1.01E+01**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	4.96E+00	**4.96E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	1.99E+01	4.39E-01	1.74E+00	**2.21E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.19E+03	1.50E+02	3.47E+02	**1.69E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	1.33E+00	3.33E-02	1.94E-03	**1.36E+00**
Non-hazardous waste disposed	kg	1.09E+01	1.36E-01	2.88E-02	**1.11E+01**
High-level radioactive waste, conditioned, to final repository	kg	4.91E-05	1.80E-06	1.64E-05	**6.73E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.13E-03	3.53E-06	8.52E-06	**1.14E-03**
Components for re-use	kg	0.00E+00	0.00E+00	1.93E+00	**1.93E+00**
Materials for recycling	kg	0.00E+00	0.00E+00	3.97E-01	**3.97E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	7.28E-01	0.00E+00	1.28E+00	**2.01E+00**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	7.28E-01	**7.28E-01**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 35. High and low-level radioactive waste reported by A1-A3 modules for Double Swing Door (frame only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	4.54E-05	1.58E-06	9.07E-06	**5.60E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.95E-04	3.08E-06	4.69E-06	**5.03E-04**

Table 36. High and low-level radioactive waste reported by A1-A3 modules for Double Swing Door (glazing only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	3.78E-06	2.19E-07	7.28E-06	**1.13E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.36E-04	4.26E-07	3.76E-06	**6.40E-04**

5.1.8. Sliding Door

Table 37. Resource use and waste flows for Universal Series™ Sliding Door whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.09E+02	2.03E-01	1.27E+02	**2.37E+02**
Renewable primary resources with energy content used as material	MJ, NCV	2.41E+01	0.00E+00	0.00E+00	**2.41E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.33E+02	2.03E-01	1.27E+02	**2.61E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.34E+03	1.33E+02	2.44E+02	**1.71E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.26E+02	0.00E+00	0.00E+00	**1.26E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.46E+03	1.33E+02	2.44E+02	**1.84E+03**
Secondary materials	kg	6.60E+00	0.00E+00	1.17E+00	**7.77E+00**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	4.38E+00	**4.38E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net freshwater resources	m3	2.03E+01	3.48E-01	1.10E+00	**2.17E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.20E+03	1.24E+02	2.19E+02	**1.55E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	1.09E+02	2.80E-02	1.27E+02	**2.35E+00**
Non-hazardous waste disposed	kg	2.41E+01	1.14E-01	0.00E+00	**8.78E+00**
High-level radioactive waste, conditioned, to final repository	kg	4.39E-05	1.49E-06	1.03E-05	**5.58E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.14E-03	2.92E-06	5.39E-06	**1.15E-03**
Components for re-use	kg	0.00E+00	0.00E+00	1.17E+00	**1.17E+00**
Materials for recycling	kg	0.00E+00	0.00E+00	3.50E-01	**3.50E-01**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	6.42E-01	0.00E+00	7.74E-01	**1.42E+00**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	6.42E-01	**6.42E-01**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 38. High and low-level radioactive waste reported by A1-A3 modules for Sliding Door (frame only) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	3.96E-05	1.24E-06	4.57E-06	**4.55E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.24E-04	2.41E-06	2.36E-06	**4.29E-04**

Table 39. High and low-level radioactive waste reported by A1-A3 modules for Sliding Door (glazing only) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	4.28E-06	2.48E-07	5.77E-06	**1.01E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	7.19E-04	4.81E-07	2.98E-06	**7.22E-04**

5.1.9. Window Wall Vision Glass

Table 40. Resource use and waste flows for Universal Series™ Window Wall Vision Glass whole system (frame and glazing) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.04E+02	1.59E-01	8.51E+01	**1.89E+02**
Renewable primary resources with energy content used as material	MJ, NCV	1.30E+01	0.00E+00	0.00E+00	**1.30E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.17E+02	1.59E-01	8.51E+01	**2.02E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.39E+03	1.04E+02	1.63E+02	**1.65E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	7.66E+01	0.00E+00	0.00E+00	**7.66E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.46E+03	1.04E+02	1.63E+02	**1.73E+03**
Secondary materials	kg	3.92E+00	0.00E+00	8.12E-01	**4.73E+00**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	5.40E-01	**5.40E-01**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	2.23E+01	2.07E-01	7.29E-01	**2.32E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.23E+03	9.75E+01	1.47E+02	**1.47E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	5.97E+00	2.20E-02	8.21E-04	**6.00E+00**
Non-hazardous waste disposed	kg	5.97E+00	8.91E-02	1.22E-02	**6.07E+00**
High-level radioactive waste, conditioned, to final repository	kg	7.38E-05	1.16E-06	6.91E-06	**8.19E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	9.34E-04	2.26E-06	3.57E-06	**9.40E-04**
Components for re-use	kg	0.00E+00	0.00E+00	8.12E-01	**8.12E-01**
Materials for recycling	kg	0.00E+00	0.00E+00	4.30E-02	**4.30E-02**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	7.88E-02	0.00E+00	5.39E-01	**6.18E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	7.88E-02	**7.88E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 41. High and low-level radioactive waste reported by A1-A3 modules for Window Wall Vision Glass (frame only) per declared unit (1m²)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	7.38E-05	8.07E-07	2.50E-06	**7.71E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.36E-04	1.58E-06	1.30E-06	**2.39E-04**

Table 42. High and low-level radioactive waste reported by A1-A3 modules for Window Wall Vision Glass (glazing only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	3.57E-07	4.41E-06	**4.77E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	7.00E-04	6.94E-07	2.28E-06	**7.03E-04**

5.1.10. Window Wall Spandrel Glass

Table 43. Resource use and waste flows for Universal Series™ Window Wall Spandrel Glass whole system (frame and glazing) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	9.80E+01	1.38E-01	8.46E+01	**1.83E+02**
Renewable primary resources with energy content used as material	MJ, NCV	1.30E+01	0.00E+00	0.00E+00	**1.30E+01**
Total use of renewable primary resources with energy content	MJ, NCV	1.11E+02	1.38E-01	8.46E+01	**1.96E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	9.61E+02	9.00E+01	1.62E+02	**1.21E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.72E+02	0.00E+00	0.00E+00	**2.72E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.23E+03	9.00E+01	1.62E+02	**1.48E+03**
Secondary materials	kg	3.92E+00	0.00E+00	8.12E-01	**4.74E+00**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	5.40E-01	**5.40E-01**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	2.36E+01	1.78E-02	7.23E-01	**2.44E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.06E+03	8.45E+01	1.46E+02	**1.29E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	7.69E+00	4.05E-04	8.15E-04	**7.69E+00**
Non-hazardous waste disposed	kg	6.68E+00	5.33E-03	1.21E-02	**6.70E+00**
High-level radioactive waste, conditioned, to final repository	kg	9.24E-05	1.01E-06	6.86E-06	**1.00E-04**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	7.02E-04	1.62E-06	2.37E-06	**7.06E-04**
Components for re-use	kg	0.00E+00	0.00E+00	8.12E-01	**8.12E-01**
Materials for recycling	kg	0.00E+00	0.00E+00	4.30E-02	**4.30E-02**
Materials for energy recovery	kg	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**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	7.88E-02	0.00E+00	5.39E-01	**6.18E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	7.88E-02	**7.88E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 44. High and low-level radioactive waste reported by A1-A3 modules for Window Wall Spandrel Glass (frame only) per declared unit (1m2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	9.24E-05	8.31E-07	4.33E-06	**9.76E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.52E-04	1.62E-06	2.24E-06	**3.56E-04**

Table 45. High and low-level radioactive waste reported by A1-A3 modules for Window Wall Spandrel Glass (glazing only) per declared unit ($1m^2$)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	1.79E-07	2.53E-06	**2.71E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.50E-04	0.00E+00	1.33E-07	**3.50E-04**

5.1.11. Window Wall Bypass

Table 46. Resource use and waste flows for Universal Series™ Window Wall Bypass whole system (frame and glazing) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	4.88E+01	3.28E-02	4.23E+01	**9.11E+01**
Renewable primary resources with energy content used as material	MJ, NCV	6.09E+00	0.00E+00	0.00E+00	**6.09E+00**
Total use of renewable primary resources with energy content	MJ, NCV	5.48E+01	3.28E-02	4.23E+01	**9.72E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	7.93E+02	2.14E+01	8.10E+01	**8.95E+02**
Non-renewable primary resources with energy content used as material	MJ, NCV	7.21E-01	0.00E+00	0.00E+00	**7.21E-01**
Total use of non-renewable primary resources with energy content	MJ, NCV	7.93E+02	2.14E+01	8.10E+01	**8.96E+02**
Secondary materials	kg	0.00E+00	0.00E+00	4.06E-01	**4.06E-01**
Renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Non-renewable secondary fuels	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Recovered energy	MJ, NCV	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Use of net fresh water resources	m3	1.83E+01	5.43E-02	3.92E-01	**1.87E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	6.72E+02	2.01E+01	7.28E+01	**7.65E+02**
Output flows and waste category indicators					
Hazardous waste disposed	kg	5.09E+00	4.54E-03	4.08E-04	**5.10E+00**
Non-hazardous waste disposed	kg	3.48E+00	1.84E-02	6.05E-03	**3.51E+00**
High-level radioactive waste, conditioned, to final repository	kg	5.41E-05	2.40E-07	3.43E-06	**5.77E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.79E-04	4.67E-07	1.72E-06	**4.82E-04**
Components for re-use	kg	0.00E+00	0.00E+00	4.06E-01	**4.06E-01**
Materials for recycling	kg	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**
Exported energy	MJ	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Emission from Product	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Biogenic Carbon Removal from Packaging	kg CO_2	7.88E-02	0.00E+00	5.39E-01	**6.18E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0.00E+00	0.00E+00	7.88E-02	**7.88E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Calcination Carbon Emissions	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbonation Carbon Removals	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Table 47. High and low-level radioactive waste reported by A1-A3 modules for Window Wall Bypass **(frame only)** per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	5.41E-05	6.46E-08	1.10E-06	**5.52E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.30E-04	1.26E-07	5.14E-07	**1.30E-04**

Table 48. High and low-level radioactive waste reported by A1-A3 modules for Window Wall Bypass (glazing only) per declared unit (1m^2)

Parameter	Unit	A1	A2	A3	Total
High-level radioactive waste, conditioned, to final repository	kg	0.00E+00	1.75E-07	2.33E-06	**2.51E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.50E-04	3.40E-07	1.20E-06	**3.51E-04**

Significant data limitations currently exist within the LCI data used to generate waste metrics for Life Cycle Assessments and Environmental Product Declarations. The waste metrics were calculated in a way conformant with the requirements of ISO 21930:2017, but these values represent rough estimates and are for informational purposes only. As such, no decisions regarding actual cradle-gate waste performance between products should be derived from these reported values.

5.2 Life cycle impact assessment (LCIA)

It shall be reiterated at this point that the reported impact categories represent impact potentials; they are approximations of environmental impacts that could occur if the emitted molecules follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen declared unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

Life cycle impact assessment (LCIA) results are shown for the Universal Series™ Fixed & Operable Windows and Doors and Universal Series™ Window Wall. Unlike life cycle inventories, which only report sums for individual inventory flows, the LCIA includes a classification of individual emissions with regard to the impacts they are associated with and subsequently a characterization of the emissions by a factor expressing their respective contribution to the impact category indicator. The end result is a single metric for quantifying each potential impact, such as “Global Warming Potential”.

The impact assessment results are calculated using characterization factors published by the United States Environmental Protection Agency. The TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.1) methodology is the most widely applied impact assessment method for U.S. LCA studies. The SM2013 Methodology is also applied to come up with single score results for the sole purpose of representing total impacts per life cycle phase to explain where in the product life cycle greatest impacts are occurring and what is contributing to the impacts.

TRACI impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development; however, the EPD users shall not use additional measures for comparative purposes. All impact categories from TRACI are used to calculate single score millipoints using the SM2013 Methodology, but it should be noted that there are known limitations related to these impact categories due to their high degree of uncertainty.

5.2.1. Fixed Window

Table 49 shows the contributions, and Table 50and Figure 5 show the percent contribution of each stage of the production of the Universal Series™ Fixed Window configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Fixed Window (including frame and glazing) generated during the cradle-to-gate stage of window production are 68.3 kg (~0.068 tones). The fiberglass window frame generated 18.6 kg (~0.018 tones) CO_2-equivalent emissions, accounts for 27.1% of the carbon emission over whole unit (Table 52). And the window glazing generated 49.7 kg (~0.050 tones) CO_2-equivalent emissions, accounts for 72.9% of the carbon emission over whole unit (Table 53).

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 51). The raw material supply phase dominates the results (88.94%), followed by the transportation phase which accounts for 7.87% of the total.

Table 49. Life cycle impact assessment results for Universal Series™ Fixed Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.63E-06	1.12E-07	4.63E-08	**3.79E-06**
Global warming	kg CO_2 eq	5.59E+01	7.24E+00	5.10E+00	**6.83E+01**
Smog	kg O_3 eq	4.10E+00	1.40E-01	6.96E-02	**4.31E+00**
Acidification	kg SO_2 eq	3.51E-01	8.98E-03	3.00E-03	**3.63E-01**
Eutrophication	kg N eq	3.40E-02	6.42E-04	2.86E-04	**3.49E-02**
Carcinogenics	CTUh	1.21E-06	4.61E-09	1.04E-09	**1.21E-06**
Non carcinogenics	CTUh	5.51E-06	9.13E-07	6.94E-08	**6.49E-06**
Respiratory effects	kg PM2.5 eq	3.28E-02	2.27E-03	3.68E-04	**3.54E-02**
Additional environmental information					
Ecotoxicity	CTUe	3.71E+01	1.86E+01	1.18E-01	**5.59E+01**
Fossil fuel depletion	MJ surplus	8.20E+01	1.38E+01	1.22E+01	**1.08E+02**

Table 50. Percent contributions of each stage to each impact category for Universal Series™ Fixed Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	95.82%	2.96%	1.22%	**100%**
Global warming	81.92%	10.6%	7.47%	**100%**
Smog	95.15%	3.24%	1.61%	**100%**
Acidification	96.70%	2.47%	0.82%	**100%**
Eutrophication	97.34%	1.84%	0.82%	**100%**
Carcinogenics	99.53%	0.38%	0.09%	**100%**
Non-carcinogenics	84.87%	14.1%	1.07%	**100%**
Respiratory effects	92.54%	6.42%	1.04%	**100%**
Ecotoxicity	66.42%	33.4%	0.21%	**100%**
Fossil fuel depletion	75.90%	12.8%	11.28%	**100%**

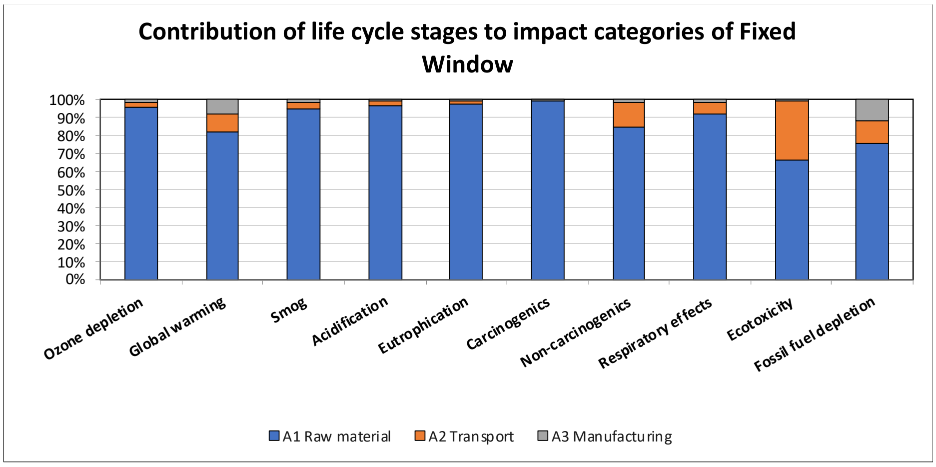

Figure 5. Contribution analysis of each impact category for Universal Series™ Fixed Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Table 51. Averaged SM millipoint scores for Universal Series™ Fixed Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	4.80E+00	4.25E-01	1.72E-01	**5.40E+00**

5.2.1.1. Fixed Window (Frame only)

Table 52 reports on the category impact for the frame component of the fenestration system, excluding any glazing component. The A1 stage makes the largest share of impacts across all impact categories.

Table 52. Life cycle impact assessment results for Universal Series™ Fixed Window (frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.69E-07	8.88E-08	1.66E-08	**4.74E-07**
Global warming	kg CO_2 eq	1.10E+01	5.73E+00	1.82E+00	**1.86E+01**
Smog	kg O_3 eq	5.72E-01	1.12E-01	2.49E-02	**7.09E-01**
Acidification	kg SO_2 eq	4.34E-02	7.18E-03	1.07E-03	**5.16E-02**
Eutrophication	kg N eq	9.45E-03	5.10E-04	1.02E-04	**1.01E-02**
Carcinogenics	CTUh	1.96E-07	3.65E-09	3.73E-10	**2.00E-07**
Non carcinogenics	CTUh	1.16E-06	7.21E-07	2.48E-08	**1.91E-06**
Respiratory effects	kg PM2.5 eq	6.53E-03	1.80E-03	1.32E-04	**8.46E-03**
Additional environmental information					
Ecotoxicity	CTUe	1.85E+01	1.47E+01	4.22E-02	**3.33E+01**
Fossil fuel depletion	MJ surplus	2.10E+01	1.09E+01	4.36E+00	**3.63E+01**

5.2.1.2. Fixed Window (Glazing only)

Table 53 reports on the category impact for the glazing component of the fenestration system, excluding any frame component. The A1 stage makes the largest share of impacts across all impact categories.

Table 53. Life cycle impact assessment results for Universal Series™ Fixed Window (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.26E-06	2.36E-08	2.97E-08	**3.32E-06**
Global warming	kg CO_2 eq	4.49E+01	1.52E+00	3.28E+00	**4.97E+01**
Smog	kg O_3 eq	3.53E+00	2.77E-02	4.47E-02	**3.60E+00**
Acidification	kg SO_2 eq	3.08E-01	1.80E-03	1.92E-03	**3.12E-01**
Eutrophication	kg N eq	2.45E-02	1.32E-04	1.83E-04	**2.48E-02**
Carcinogenics	CTUh	1.01E-06	9.67E-10	6.69E-10	**1.01E-06**
Non carcinogenics	CTUh	4.35E-06	1.92E-07	4.46E-08	**4.59E-06**
Respiratory effects	kg PM2.5 eq	2.63E-02	4.73E-04	2.37E-04	**2.70E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.86E+01	3.92E+00	7.57E-02	**2.26E+01**
Fossil fuel depletion	MJ surplus	6.09E+01	2.90E+00	7.83E+00	**7.17E+01**

5.2.2. Casement Window

Table 54 shows the contributions, and Table 55 and Figure 6. Contribution analysis of each impact category for Universal Series™ Casement Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing) show the percent contribution of each stage of the production of the Universal Series™ Casement Window configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Casement Window (including frame and glazing) generated during the cradle-to-gate stage of window production are 105.9 kg (~0.105 tones). The fiberglass window frame generated 65.9 kg (~0.066 tones) CO_2-equivalent emissions, accounts for 62.2% of the carbon emission over whole unit (Table 57). And the window glazing generated 40.1 kg (~0.040 tones) CO_2-equivalent emissions, accounts for 37.8% of the carbon emission over whole unit (Table 58).

Raw material supply contributes to 68.1 kg CO_2-eq, 64.3% of the total CO_2-equivalent emissions. 14.1% of the total CO_2-equivalent emissions is contributed from transportation of the raw materials and 21.6% from the manufacturing stage. Raw material supply accounts for 99.14% of carcinogenics, which is the highest contribution among ten impact categories. Transportation accounts for 20.9% of ecotoxicity, and 18.1% of non-carcinogenics, which are the highest contributions among ten impact categories for transportation phase.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 56). The raw material supply phase dominates the results (80.97%), followed by the transportation phase which accounts for 10.13% of the total.

Table 54. Life cycle impact assessment results for Universal Series™ Casement Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.30E-06	2.31E-07	2.08E-07	**3.74E-06**
Global warming	kg CO_2 eq	6.81E+01	1.49E+01	2.29E+01	**1.06E+02**
Smog	kg O_3 eq	4.44E+00	4.45E-01	3.13E-01	**5.20E+00**
Acidification	kg SO_2 eq	3.59E-01	2.69E-02	1.35E-02	**3.99E-01**
Eutrophication	kg N eq	5.11E-02	1.60E-03	1.16E-03	**5.39E-02**
Carcinogenics	CTUh	1.64E-06	9.47E-09	4.67E-09	**1.65E-06**
Non carcinogenics	CTUh	8.02E-06	1.84E-06	3.12E-07	**1.02E-05**
Respiratory effects	kg PM2.5 eq	4.19E-02	5.08E-03	1.66E-03	**4.86E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.42E+02	3.76E+01	5.29E-01	**1.80E+02**
Fossil fuel depletion	MJ surplus	1.06E+02	2.84E+01	5.48E+01	**1.90E+02**

Table 55. Percent contributions of each stage to each impact category for Universal Series™ Casement Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	88.25%	6.19%	5.56%	**100%**
Global warming	64.33%	14.08%	21.59%	**100%**
Smog	85.43%	8.56%	6.01%	**100%**
Acidification	89.90%	6.73%	3.37%	**100%**
Eutrophication	94.86%	2.98%	2.16%	**100%**
Carcinogenics	99.14%	0.57%	0.28%	**100%**
Non-carcinogenics	78.82%	18.12%	3.07%	**100%**
Respiratory effects	86.15%	10.44%	3.4%	**100%**
Ecotoxicity	78.81%	20.9%	0.29%	**100%**
Fossil fuel depletion	56.11%	14.99%	28.9%	**100%**

Table 56. Averaged SM millipoint scores for Universal Series™ Fixed & Operable Windows Casement Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	7.02E+00	8.78E-01	7.71E-01	**8.67E+00**

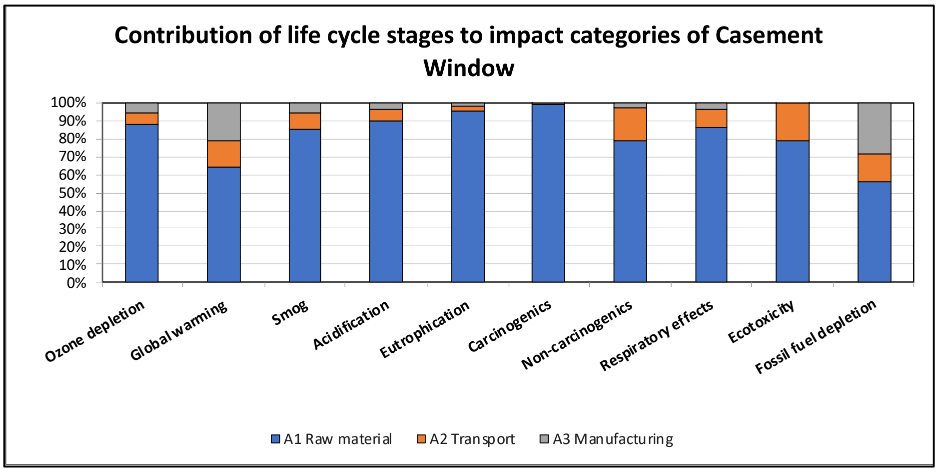

Figure 6. Contribution analysis of each impact category for Universal Series™ Casement Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.2.1. Casement Window (Frame only)

Table 57 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 57. Life cycle impact assessment results for Universal Series™ Casement Window (frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.00E-06	2.15E-07	1.41E-07	**1.36E-06**
Global warming	kg CO_2 eq	3.65E+01	1.38E+01	1.55E+01	**6.59E+01**
Smog	kg O_3 eq	1.96E+00	4.26E-01	2.12E-01	**2.60E+00**
Acidification	kg SO_2 eq	1.42E-01	2.56E-02	9.12E-03	**1.77E-01**
Eutrophication	kg N eq	3.38E-02	1.51E-03	7.89E-04	**3.61E-02**
Carcinogenics	CTUh	9.24E-07	8.79E-09	3.17E-09	**9.36E-07**
Non carcinogenics	CTUh	4.96E-06	1.71E-06	2.11E-07	**6.88E-06**
Respiratory effects	kg PM2.5 eq	2.34E-02	4.75E-03	1.12E-03	**2.93E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.29E+02	3.48E+01	3.58E-01	**1.64E+02**
Fossil fuel depletion	MJ surplus	6.36E+01	2.64E+01	3.72E+01	**1.27E+02**

5.2.2.2. Casement Window (Glazing only)

Table 58 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 58. Life cycle impact assessment results for Universal Series™ Casement Window (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.30E-06	1.66E-08	6.69E-08	**2.38E-06**
Global warming	kg CO_2 eq	3.16E+01	1.07E+00	7.36E+00	**4.01E+01**
Smog	kg O_3 eq	2.48E+00	1.95E-02	1.01E-01	**2.60E+00**
Acidification	kg SO_2 eq	2.17E-01	1.27E-03	4.33E-03	**2.22E-01**
Eutrophication	kg N eq	1.73E-02	9.28E-05	3.75E-04	**1.77E-02**
Carcinogenics	CTUh	7.11E-07	6.81E-10	1.50E-09	**7.13E-07**
Non carcinogenics	CTUh	3.06E-06	1.35E-07	1.00E-07	**3.30E-06**
Respiratory effects	kg PM2.5 eq	1.85E-02	3.33E-04	5.33E-04	**1.93E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.31E+01	2.76E+00	1.70E-01	**1.60E+01**
Fossil fuel depletion	MJ surplus	4.29E+01	2.04E+00	1.77E+01	**6.26E+01**

5.2.3. Tilt & Turn Window

Table 59 shows the contributions, and Table 60 and Figure 7 show the percent contribution of each stage of the production of the Universal Series™ Tilt & Turn Window configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Tilt & Turn Window (including frame and glazing) generated during the cradle-to-gate stage of window production are 82.2 kg (~0.082 tones). The fiberglass window frame generated 36.3 kg (~0.036 tones) CO_2-equivalent emissions, accounts for 44.2% of the carbon emission over whole unit (Table 62). And the window glazing generated 45.9 kg (~0.045 tones) CO_2-equivalent emissions, accounts for 55.8% of the carbon emission over whole unit (Table 63).

The transportation stage is the next highest impact contributors of all impact categories. For example, for global warming, non-carcinogenics, ecotoxicity, and fossil fuel depletion, the second largest impact contributor comes from manufacturing. It accounts for 12.7% of global warming, 18.2% of non-carcinogenics, 26.9% of ecotoxicity, and 22.3% of fossil fuel depletion.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 61). The raw material supply phase dominates the results (82.89%), followed by the transportation phase which accounts for 9.97% of the total accounted environmental impact.

Table 59. Life cycle impact assessment results for Universal Series™ Tilt & Turn Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.49E-06	1.62E-07	1.18E-07	**3.77E-06**
Global warming	kg CO_2 eq	5.88E+01	1.04E+01	1.30E+01	**8.22E+01**
Smog	kg O_3 eq	4.08E+00	2.63E-01	1.78E-01	**4.52E+00**
Acidification	kg SO_2 eq	3.41E-01	1.62E-02	7.66E-03	**3.65E-01**
Eutrophication	kg N eq	3.87E-02	1.04E-03	6.46E-04	**4.04E-02**
Carcinogenics	CTUh	1.16E-06	6.63E-09	2.66E-09	**1.17E-06**
Non carcinogenics	CTUh	5.67E-06	1.30E-06	1.78E-07	**7.14E-06**
Respiratory effects	kg PM2.5 eq	3.53E-02	3.43E-03	9.42E-04	**3.97E-02**
Additional environmental information					
Ecotoxicity	CTUe	7.16E+01	2.65E+01	3.01E-01	**9.84E+01**
Fossil fuel depletion	MJ surplus	8.92E+01	1.99E+01	3.12E+01	**1.40E+02**

Table 60. Percent contributions of each stage to each impact category for Universal Series™ Tilt & Turn Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	92.57%	4.29%	3.14%	**100%**
Global warming	71.48%	12.69%	15.83%	**100%**
Smog	90.23%	5.83%	3.94%	**100%**
Acidification	93.45%	4.45%	2.10%	**100%**
Eutrophication	95.84%	2.56%	1.60%	**100%**
Carcinogenics	99.20%	0.57%	0.23%	**100%**
Non-carcinogenics	79.32%	18.19%	2.49%	**100%**
Respiratory effects	88.98%	8.64%	2.37%	**100%**
Ecotoxicity	72.76%	26.94%	0.31%	**100%**
Fossil fuel depletion	63.57%	14.18%	22.25%	**100%**

Table 61. Averaged SM millipoint scores for Universal Series™ Tilt & Turn Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	5.10E+00	6.13E-01	4.39E-01	**6.15E+00**

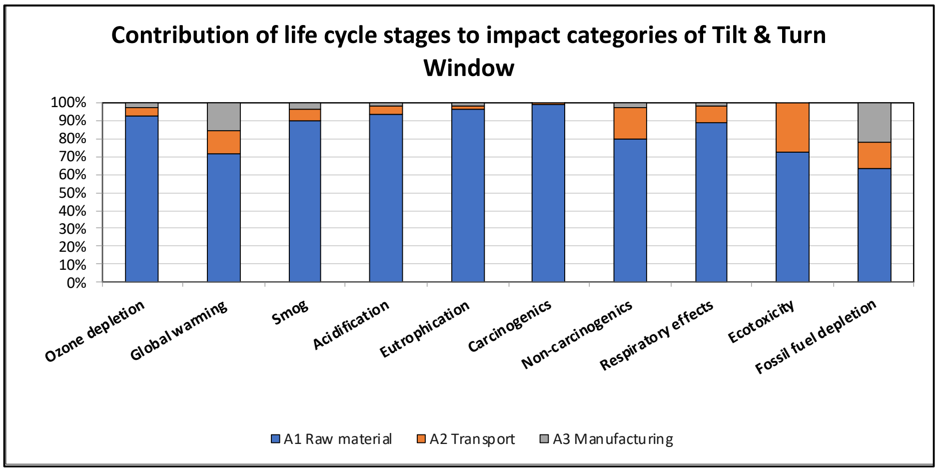

Figure 7. Contribution analysis of each impact category for Universal Series™ Tilt & Turn Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.3.1. Tilt & Turn Window (Frame only)

Table 62 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 62. Life cycle impact assessment results for Universal Series™ Tilt & Turn Window (frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	6.95E-07	1.42E-07	6.25E-08	**8.99E-07**
Global warming	kg CO_2 eq	2.03E+01	9.13E+00	6.88E+00	**3.63E+01**
Smog	kg O_3 eq	1.06E+00	2.39E-01	9.41E-02	**1.39E+00**
Acidification	kg SO_2 eq	7.78E-02	1.47E-02	4.05E-03	**9.65E-02**
Eutrophication	kg N eq	1.77E-02	9.22E-04	3.42E-04	**1.90E-02**
Carcinogenics	CTUh	2.93E-07	5.80E-09	1.41E-09	**3.00E-07**
Non carcinogenics	CTUh	1.94E-06	1.14E-06	9.39E-08	**3.17E-06**
Respiratory effects	kg PM2.5 eq	1.28E-02	3.03E-03	4.98E-04	**1.64E-02**
Additional environmental information					
Ecotoxicity	CTUe	5.57E+01	2.32E+01	1.59E-01	**7.90E+01**
Fossil fuel depletion	MJ surplus	3.70E+01	1.74E+01	1.65E+01	**7.10E+01**

5.2.3.2. Tilt & Turn Window (Glazing Only)

Table 63 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 63. Life cycle impact assessment results for Universal Series™ Tilt & Turn Window (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.79E-06	2.02E-08	5.57E-08	**2.87E-06**
Global warming	kg CO_2 eq	3.85E+01	1.30E+00	6.13E+00	**4.59E+01**
Smog	kg O_3 eq	3.02E+00	2.37E-02	8.38E-02	**3.13E+00**
Acidification	kg SO_2 eq	2.63E-01	1.54E-03	3.61E-03	**2.69E-01**
Eutrophication	kg N eq	2.10E-02	1.13E-04	3.04E-04	**2.14E-02**
Carcinogenics	CTUh	8.65E-07	8.28E-10	1.25E-09	**8.67E-07**
Non carcinogenics	CTUh	3.72E-06	1.64E-07	8.37E-08	**3.97E-06**
Respiratory effects	kg PM2.5 eq	2.25E-02	4.04E-04	4.44E-04	**2.33E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.59E+01	3.35E+00	1.42E-01	**1.94E+01**
Fossil fuel depletion	MJ surplus	5.21E+01	2.48E+00	1.47E+01	**6.93E+01**

5.2.4. Awning Window

Table 64 shows the contributions, and Table 65 and Figure 8 show the percent contribution of each stage of the production of the Universal Series™ Awning Window configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Awning Window (including frame and glazing) generated during the cradle-to-gate stage of window production are 106 kg (~0.011 tones). The fiberglass window frame generated 66.2 kg (~0.066 tones) CO_2-equivalent emissions, accounts for 62.4% of the carbon emission over whole unit (Table 67). And the window glazing generated 39.8 kg (~0.040 tones) CO_2-equivalent emissions, accounts for 37.6% of the carbon emission over whole unit (Table 68).

The manufacturing stage is the next highest impact contributor to the following impact categories. For example, for global warming and fossil fuel depletion, the manufacturing stage accounts for 21.3% to global warming, and 28.2% to fossil fuel depletion. Transportation accounts for 14% of global warming, 10.6% of respiratory effects, and 22.42% of ecotoxicity.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 66). The raw material supply phase dominates the results (80.8%), followed by the transportation phase which accounts for 10.2% of the total.

Table 64. Life cycle impact assessment results for Universal Series™ Awning Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.30E-06	2.31E-07	2.05E-07	**3.74E-06**
Global warming	kg CO_2 eq	6.86E+01	1.49E+01	2.25E+01	**1.06E+02**
Smog	kg O_3 eq	4.45E+00	4.29E-01	3.08E-01	**5.19E+00**
Acidification	kg SO_2 eq	3.60E-01	2.60E-02	1.33E-02	**3.99E-01**
Eutrophication	kg N eq	5.26E-02	1.57E-03	1.20E-03	**5.54E-02**
Carcinogenics	CTUh	1.61E-06	9.45E-09	4.61E-09	**1.62E-06**
Non carcinogenics	CTUh	7.87E-06	1.84E-06	3.07E-07	**1.00E-05**
Respiratory effects	kg PM2.5 eq	4.09E-02	5.03E-03	1.63E-03	**4.76E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.29E+02	3.76E+01	5.21E-01	**1.68E+02**
Fossil fuel depletion	MJ surplus	1.09E+02	2.84E+01	5.40E+01	**1.91E+02**

Table 65. Percent contributions of each stage to each impact category for Universal Series™ Awning Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	88.34%	6.18%	5.48%	**100%**
Global warming	64.70%	14.04%	21.27%	**100%**
Smog	85.81%	8.26%	5.93%	**100%**
Acidification	90.17%	6.51%	3.32%	**100%**
Eutrophication	95.00%	2.84%	2.16%	**100%**
Carcinogenics	99.13%	0.58%	0.28%	**100%**
Non-carcinogenics	78.54%	18.39%	3.07%	**100%**
Respiratory effects	86.00%	10.57%	3.43%	**100%**
Ecotoxicity	77.27%	22.42%	0.31%	**100%**
Fossil fuel depletion	56.95%	14.83%	28.22%	**100%**

Table 66. Averaged SM millipoint scores for Universal Series™ Awning Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	6.88E+00	8.76E-01	7.60E-01	**8.52E+00**

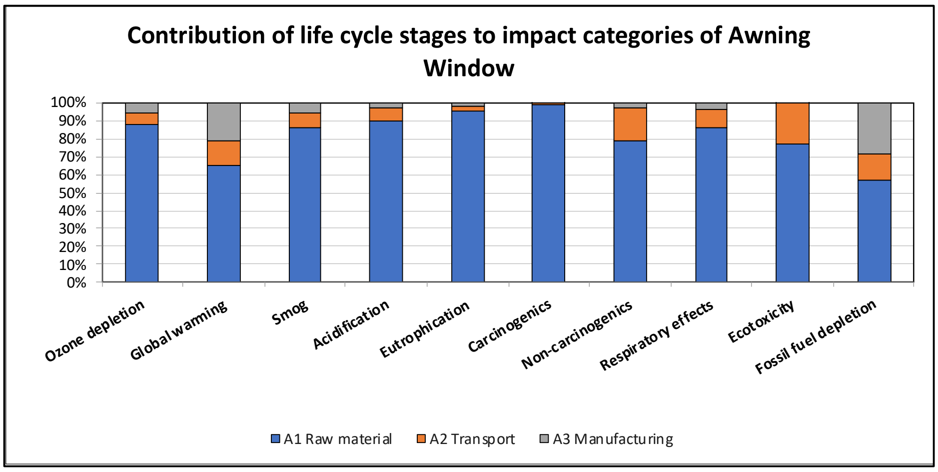

Figure 8. Contribution analysis of each impact category for Universal Series™ Awning Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.4.1. Awning Window (Frame only)

Table 67 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 67. Life cycle impact assessment results for Universal Series™ Awning Window (Frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.00E-06	2.14E-07	1.40E-07	**1.36E-06**
Global warming	kg CO_2 eq	3.70E+01	1.38E+01	1.54E+01	**6.62E+01**
Smog	kg O_3 eq	1.97E+00	4.09E-01	2.10E-01	**2.59E+00**
Acidification	kg SO_2 eq	1.44E-01	2.47E-02	9.05E-03	**1.77E-01**
Eutrophication	kg N eq	3.54E-02	1.48E-03	8.17E-04	**3.77E-02**
Carcinogenics	CTUh	8.95E-07	8.77E-09	3.14E-09	**9.07E-07**
Non carcinogenics	CTUh	4.80E-06	1.71E-06	2.10E-07	**6.72E-06**
Respiratory effects	kg PM2.5 eq	2.25E-02	4.70E-03	1.11E-03	**2.83E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.16E+02	3.48E+01	3.56E-01	**1.51E+02**
Fossil fuel depletion	MJ surplus	6.61E+01	2.63E+01	3.68E+01	**1.29E+02**

5.2.4.2. Awning Window (Glazing only)

Table 68 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 68. Life cycle impact assessment results for Universal Series™ Awning Window (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.30E-06	1.66E-08	6.50E-08	**2.38E-06**
Global warming	kg CO_2 eq	3.16E+01	1.07E+00	7.16E+00	**3.98E+01**
Smog	kg O_3 eq	2.48E+00	1.95E-02	9.77E-02	**2.60E+00**
Acidification	kg SO_2 eq	2.17E-01	1.27E-03	4.21E-03	**2.22E-01**
Eutrophication	kg N eq	1.73E-02	9.28E-05	3.80E-04	**1.77E-02**
Carcinogenics	CTUh	7.11E-07	6.81E-10	1.46E-09	**7.13E-07**
Non carcinogenics	CTUh	3.06E-06	1.35E-07	9.75E-08	**3.29E-06**
Respiratory effects	kg PM2.5 eq	1.85E-02	3.33E-04	5.18E-04	**1.93E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.31E+01	2.76E+00	1.65E-01	**1.60E+01**
Fossil fuel depletion	MJ surplus	4.29E+01	2.04E+00	1.71E+01	**6.20E+01**

5.2.5. Hopper Window

Table 69 shows the contributions, and Table 70 and Figure 9 show the percent contribution of each stage of the production of the Universal Series™ Hopper Window configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Hopper Window (including frame and glazing) generated during the cradle-to-gate stage of window production are 107.7 kg (~0.11 tones). The fiberglass window frame generated 65.9 kg (~0.066 tones) CO_2-equivalent emissions, accounts for 61.2% of the carbon emission over whole unit (Table 72). And the window glazing generated

41.8 kg (~0.042 tones) CO_2-equivalent emissions, accounts for 38.8% of the carbon emission over whole unit (Table 73).

The manufacturing stage is the next highest impact contributor to the following impact categories. For example, for global warming and fossil fuel depletion, the manufacturing stage accounts for 23.86% of global warming and 16.88% to fossil fuel depletion. Transportation accounts for 13.86% of global warming, 19.83% of non-carcinogenics, and 26.47% of ecotoxicity.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 71). The raw material supply phase dominates the results (78.48%), followed by both the transportation and manufacturing stages, which share an equal contribution at around 11% out of the total.

Table 69. Life cycle impact assessment results for Universal Series™ Fixed & Operable Windows Hopper Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.53E-06	2.32E-07	2.33E-07	**3.99E-06**
Global warming	kg CO_2 eq	6.71E+01	1.49E+01	2.57E+01	**1.08E+02**
Smog	kg O_3 eq	4.34E+00	3.70E-01	3.51E-01	**5.06E+00**
Acidification	kg SO_2 eq	3.57E-01	2.29E-02	1.51E-02	**3.95E-01**
Eutrophication	kg N eq	4.83E-02	1.47E-03	1.39E-03	**5.11E-02**
Carcinogenics	CTUh	1.48E-06	9.49E-09	5.25E-09	**1.50E-06**
Non carcinogenics	CTUh	7.18E-06	1.86E-06	3.50E-07	**9.39E-06**
Respiratory effects	kg PM2.5 eq	4.04E-02	4.89E-03	1.86E-03	**4.71E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.05E+02	3.80E+01	5.94E-01	**1.44E+02**
Fossil fuel depletion	MJ surplus	1.05E+02	2.85E+01	6.15E+01	**1.95E+02**

Table 70. Percent contributions of each stage to each impact category for Universal Series™ Hopper Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	88.37%	5.80%	5.84%	**100%**
Global warming	62.28%	13.86%	23.86%	**100%**
Smog	85.75%	7.32%	6.93%	**100%**
Acidification	90.37%	5.80%	3.83%	**100%**
Eutrophication	94.41%	2.88%	2.71%	**100%**
Carcinogenics	99.02%	0.63%	0.35%	**100%**
Non-carcinogenics	76.44%	19.83%	3.73%	**100%**
Respiratory effects	85.68%	10.38%	3.94%	**100%**
Ecotoxicity	73.12%	26.47%	0.41%	**100%**
Fossil fuel depletion	53.95%	14.58%	31.47%	**100%**

Table 71. Averaged SM millipoint scores for Universal Series™ Fixed & Operable Windows Hopper Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	6.36E+00	8.77E-01	8.66E-01	**8.10E+00**

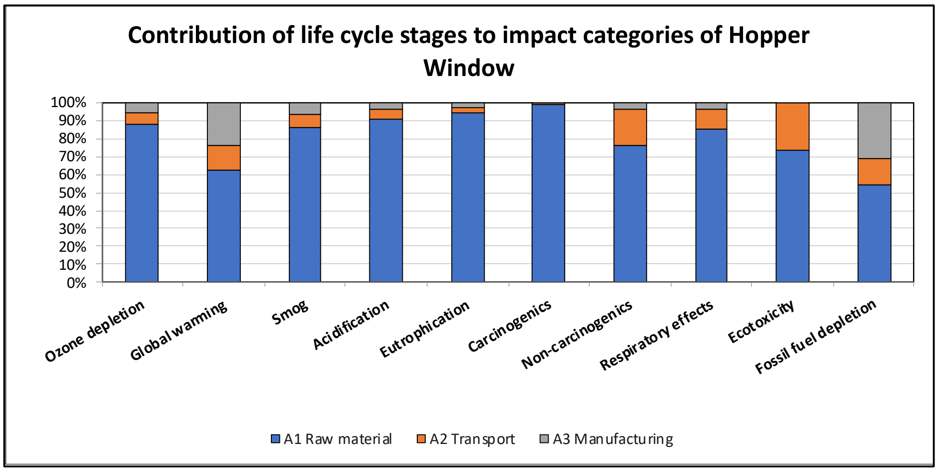

Figure 9. Contribution analysis of each impact category for Universal Series™ Fixed & Operable Windows Hopper Window per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.5.1. Hopper Window (Frame only)

Table 72 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 72. Life cycle impact assessment results for Universal Series™ Hopper Window (Frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.18E-06	2.15E-07	1.57E-07	**1.55E-06**
Global warming	kg CO_2 eq	3.48E+01	1.38E+01	1.73E+01	**6.59E+01**
Smog	kg O_3 eq	1.80E+00	3.50E-01	2.36E-01	**2.39E+00**
Acidification	kg SO_2 eq	1.35E-01	2.16E-02	1.02E-02	**1.67E-01**
Eutrophication	kg N eq	3.06E-02	1.38E-03	9.35E-04	**3.29E-02**
Carcinogenics	CTUh	7.57E-07	8.80E-09	3.54E-09	**7.69E-07**
Non carcinogenics	CTUh	4.05E-06	1.72E-06	2.36E-07	**6.01E-06**
Respiratory effects	kg PM2.5 eq	2.15E-02	4.55E-03	1.25E-03	**2.73E-02**
Additional environmental information					
Ecotoxicity	CTUe	9.16E+01	3.52E+01	4.00E-01	**1.27E+02**
Fossil fuel depletion	MJ surplus	6.16E+01	2.64E+01	4.14E+01	**1.29E+02**

5.2.5.2. Hopper Window (Glazing only)

Table 73 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 73. Life cycle impact assessment results for Universal Series™ Hopper Window (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.35E-06	1.69E-08	7.60E-08	**2.44E-06**
Global warming	kg CO_2 eq	3.23E+01	1.09E+00	8.38E+00	**4.18E+01**
Smog	kg O_3 eq	2.54E+00	1.99E-02	1.14E-01	**2.67E+00**
Acidification	kg SO_2 eq	2.21E-01	1.30E-03	4.92E-03	**2.28E-01**
Eutrophication	kg N eq	1.76E-02	9.48E-05	4.52E-04	**1.82E-02**
Carcinogenics	CTUh	7.27E-07	6.96E-10	1.71E-09	**7.29E-07**
Non carcinogenics	CTUh	3.13E-06	1.38E-07	1.14E-07	**3.38E-06**
Respiratory effects	kg PM2.5 eq	1.89E-02	3.40E-04	6.06E-04	**1.98E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.34E+01	2.82E+00	1.94E-01	**1.64E+01**
Fossil fuel depletion	MJ surplus	4.38E+01	2.09E+00	2.00E+01	**6.59E+01**

5.2.6. Single Swing Door

Table 74 shows the contributions, and Table 75 and Figure 10 show the percent contribution of each stage of the production of the Universal Series™ Single Swing Door configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Single Swing Door (including frame and glazing) generated during the cradle-to-gate stage of window production are 135.8 kg (~0.136 tones). The fiberglass window frame generated 64.1kg (~0.064 tones) CO_2-equivalent emissions, accounts for 47.2% of the carbon emission over whole unit (Table 77). And the window glazing generated 71.7 kg (~0.071 tones) CO_2-equivalent emissions, accounts for 52.8% of the carbon emission over whole unit (Table 78).

The manufacturing stage is the next highest impact contributors of following impact categories. For example, for global warming and fossil fuel depletion, the manufacturing stages account for 15.89% to global warming and 22.86% to fossil fuel depletion. Transportation accounts for 10.53% of global warming, 14.23% of non-carcinogenics, and 26.70% of ecotoxicity.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 76). The raw material supply phase dominates the results (85.41%), followed by the transportation phase and manufacturing stage which account for 7.81%, and 6.7% of the total, respectively.

Table 74. Life cycle impact assessment results for Universal Series™ Fixed & Operable Windows Single Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	5.71E-06	2.22E-07	1.96E-07	**6.13E-06**
Global warming	kg CO_2 eq	9.99E+01	1.43E+01	2.16E+01	**1.36E+02**
Smog	kg O_3 eq	6.76E+00	3.87E-01	2.96E-01	**7.44E+00**
Acidification	kg SO_2 eq	5.75E-01	2.36E-02	1.27E-02	**6.11E-01**
Eutrophication	kg N eq	6.04E-02	1.47E-03	9.87E-04	**6.29E-02**
Carcinogenics	CTUh	2.34E-06	9.09E-09	4.41E-09	**2.36E-06**
Non carcinogenics	CTUh	1.04E-05	1.78E-06	2.95E-07	**1.25E-05**
Respiratory effects	kg PM2.5 eq	6.07E-02	4.77E-03	1.57E-03	**6.70E-02**
Additional environmental information					
Ecotoxicity	CTUe	9.89E+01	3.62E+01	4.99E-01	**1.36E+02**
Fossil fuel depletion	MJ surplus	1.48E+02	2.73E+01	5.19E+01	**2.27E+02**

Table 75. Percent contributions of each stage to each impact category for Universal Series™ Single Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	93.18%	3.62%	3.20%	**100%**
Global warming	73.58%	10.53%	15.89%	**100%**
Smog	90.83%	5.20%	3.97%	**100%**
Acidification	94.05%	3.87%	2.08%	**100%**
Eutrophication	96.10%	2.33%	1.57%	**100%**
Carcinogenics	99.43%	0.39%	0.19%	**100%**
Non-carcinogenics	83.41%	14.23%	2.36%	**100%**
Respiratory effects	90.54%	7.12%	2.34%	**100%**
Ecotoxicity	72.93%	26.70%	0.37%	**100%**
Fossil fuel depletion	65.13%	12.01%	22.86%	**100%**

Table 76. Averaged SM millipoint scores for Universal Series™ Fixed & Operable Windows Single Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	9.19E+00	8.41E-01	7.29E-01	**1.08E+01**

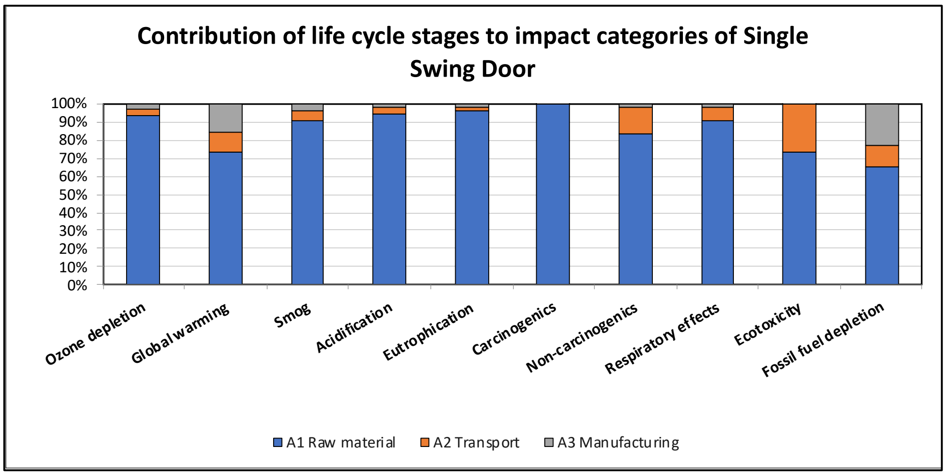

Figure 10. Contribution analysis of each impact category for Universal Series™ Fixed & Operable Windows Single Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.6.1. Single Swing Door (Frame only)

Table 77 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 77. Life cycle impact assessment results for Universal Series™ Single Swing Door (Frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.49E-06	2.01E-07	1.21E-07	**1.82E-06**
Global warming	kg CO_2 eq	3.78E+01	1.30E+01	1.33E+01	**6.41E+01**
Smog	kg O_3 eq	1.88E+00	3.63E-01	1.82E-01	**2.42E+00**
Acidification	kg SO_2 eq	1.53E-01	2.21E-02	7.83E-03	**1.83E-01**
Eutrophication	kg N eq	2.80E-02	1.35E-03	6.07E-04	**2.99E-02**
Carcinogenics	CTUh	1.05E-06	8.25E-09	2.71E-09	**1.06E-06**
Non carcinogenics	CTUh	4.79E-06	1.61E-06	1.82E-07	**6.58E-06**
Respiratory effects	kg PM2.5 eq	2.45E-02	4.36E-03	9.64E-04	**2.99E-02**
Additional environmental information					
Ecotoxicity	CTUe	7.45E+01	3.28E+01	3.07E-01	**1.08E+02**
Fossil fuel depletion	MJ surplus	6.23E+01	2.48E+01	3.20E+01	**1.19E+02**

5.2.6.2. Single Swing Door (Glazing only)

Table 78 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 78. Life cycle impact assessment results for Universal Series™ Single Swing Door (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	4.22E-06	2.05E-08	7.55E-08	**4.32E-06**
Global warming	kg CO_2 eq	6.21E+01	1.32E+00	8.30E+00	**7.17E+01**
Smog	kg O_3 eq	4.88E+00	2.41E-02	1.14E-01	**5.01E+00**
Acidification	kg SO_2 eq	4.22E-01	1.57E-03	4.89E-03	**4.28E-01**
Eutrophication	kg N eq	3.25E-02	1.15E-04	3.79E-04	**3.30E-02**
Carcinogenics	CTUh	1.29E-06	8.42E-10	1.69E-09	**1.30E-06**
Non carcinogenics	CTUh	5.62E-06	1.67E-07	1.13E-07	**5.90E-06**
Respiratory effects	kg PM2.5 eq	3.61E-02	4.11E-04	6.02E-04	**3.71E-02**
Additional environmental information					
Ecotoxicity	CTUe	2.44E+01	3.41E+00	1.92E-01	**2.80E+01**
Fossil fuel depletion	MJ surplus	8.56E+01	2.53E+00	2.00E+01	**1.08E+02**

5.2.7. Double Swing Door

Table 79 shows the contributions, and Table 80 and Figure 11 show the percent contribution of each stage of the production of the Universal Series™ Double Swing Door configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Double Swing Door (including frame and glazing) generated during the cradle-to-gate stage of window production are 131.3 kg (~0.131 tones). The fiberglass window frame generated 56.4 kg (~0.056 tones) CO_2-equivalent emissions, accounts for 42.9% of the carbon emission over whole unit (Table 82). And the window glazing generated 74.9 kg (~0.075 tones) CO_2-equivalent emissions, accounts for 57% of the carbon emission over whole unit (Table 83).

The manufacturing stage is the next highest impact contributor to the following impact categories: ozone depletion, global warming, and fossil fuel depletion. The manufacturing stage account for 3.23% to ozone depletion, 17.63% to global warming, and 25.78% to fossil fuel depletion.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 81). The raw material supply phase dominates the results (92.06%), followed by the manufacturing phase which accounts for 7.46% of the total.

Table 79. Life cycle impact assessment results for Universal Series™ Fixed & Operable Windows Double Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	5.70E-06	1.73E-07	1.96E-07	**6.07E-06**
Global warming	kg CO_2 eq	9.86E+01	1.11E+01	2.16E+01	**1.31E+02**
Smog	kg O_3 eq	6.70E+00	3.33E-01	2.95E-01	**7.33E+00**
Acidification	kg SO_2 eq	5.74E-01	2.01E-02	1.27E-02	**6.07E-01**
Eutrophication	kg N eq	5.90E-02	1.20E-03	9.86E-04	**6.12E-02**
Carcinogenics	CTUh	2.32E-06	7.07E-09	4.41E-09	**2.33E-06**
Non carcinogenics	CTUh	1.00E-05	1.37E-06	2.95E-07	**1.17E-05**
Respiratory effects	kg PM2.5 eq	5.90E-02	3.79E-03	1.56E-03	**6.44E-02**
Additional environmental information					
Ecotoxicity	CTUe	8.89E+01	2.80E+01	4.99E-01	**1.17E+02**
Fossil fuel depletion	MJ surplus	1.45E+02	2.12E+01	5.19E+01	**2.18E+02**

Table 80. Percent contributions of each stage to each impact category for Universal Series™ Double Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	93.93%	2.84%	3.23%	**100%**
Global warming	75.08%	8.48%	16.44%	**100%**
Smog	91.43%	4.54%	4.03%	**100%**
Acidification	94.59%	3.31%	2.10%	**100%**
Eutrophication	96.43%	1.96%	1.61%	**100%**
Carcinogenics	99.51%	0.30%	0.19%	**100%**
Non-carcinogenics	85.75%	11.74%	2.52%	**100%**
Respiratory effects	91.68%	5.89%	2.43%	**100%**
Ecotoxicity	75.71%	23.86%	0.42%	**100%**
Fossil fuel depletion	66.47%	9.73%	23.80%	**100%**

Table 81. Averaged SM millipoint scores for Universal Series™ Fixed & Operable Windows Double Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	8.99E+00	6.55E-01	7.29E-01	**1.04E+01**

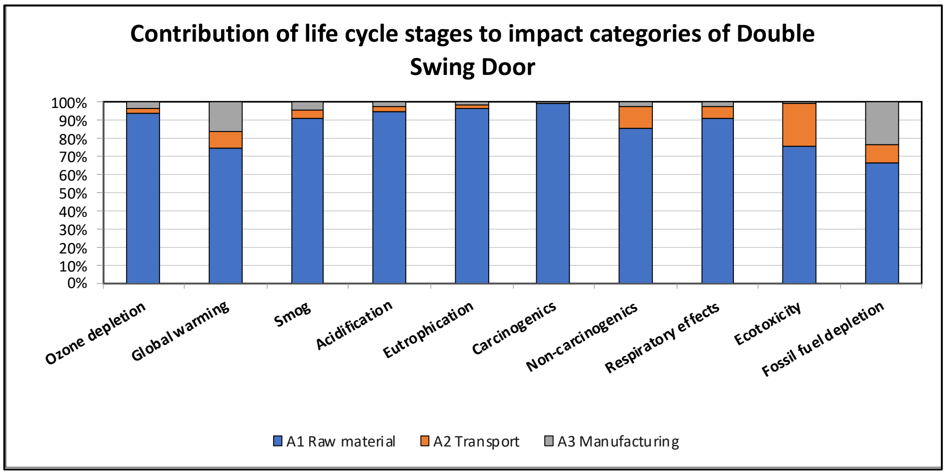

Figure 11. Contribution analysis of each impact category for Universal Series™ Fixed & Operable Windows Double Swing Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.7.1. Double Swing Door (Frame only)

Table 82 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 82. Life cycle impact assessment results for Universal Series™ Double Swing Door (Frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.36E-06	1.52E-07	1.09E-07	**1.62E-06**
Global warming	kg CO_2 eq	3.46E+01	9.77E+00	1.20E+01	**5.64E+01**
Smog	kg O_3 eq	1.68E+00	3.08E-01	1.64E-01	**2.15E+00**
Acidification	kg SO_2 eq	1.40E-01	1.85E-02	7.05E-03	**1.65E-01**
Eutrophication	kg N eq	2.56E-02	1.08E-03	5.17E-04	**2.72E-02**
Carcinogenics	CTUh	9.84E-07	6.20E-09	2.44E-09	**9.93E-07**
Non carcinogenics	CTUh	4.26E-06	1.20E-06	1.64E-07	**5.63E-06**
Respiratory effects	kg PM2.5 eq	2.19E-02	3.37E-03	8.68E-04	**2.61E-02**
Additional environmental information					
Ecotoxicity	CTUe	6.38E+01	2.45E+01	2.76E-01	**8.86E+01**
Fossil fuel depletion	MJ surplus	5.69E+01	1.86E+01	2.88E+01	**1.04E+02**

5.2.7.2. Double Swing Door (Glazing only)

Table 83 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 83. Life cycle impact assessment results for Universal Series™ Double Swing Door (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	4.34E-06	2.11E-08	8.73E-08	**4.45E-06**
Global warming	kg CO_2 eq	6.39E+01	1.36E+00	9.60E+00	**7.49E+01**
Smog	kg O_3 eq	5.02E+00	2.49E-02	1.32E-01	**5.17E+00**
Acidification	kg SO_2 eq	4.34E-01	1.62E-03	5.66E-03	**4.42E-01**
Eutrophication	kg N eq	3.34E-02	1.18E-04	4.15E-04	**3.39E-02**
Carcinogenics	CTUh	1.33E-06	8.67E-10	1.96E-09	**1.33E-06**
Non carcinogenics	CTUh	5.78E-06	1.72E-07	1.31E-07	**6.08E-06**
Respiratory effects	kg PM2.5 eq	3.72E-02	4.23E-04	6.97E-04	**3.83E-02**
Additional environmental information					
Ecotoxicity	CTUe	2.51E+01	3.51E+00	2.22E-01	**2.89E+01**
Fossil fuel depletion	MJ surplus	8.81E+01	2.60E+00	2.31E+01	**1.14E+02**

5.2.8. Sliding Door

Table 84 shows the contributions, and Table 85 and Figure 12 show the percent contribution of each stage of the production of the Universal Series™ Sliding Door configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Sliding Door (including frame and glazing) generated during the cradle-to-gate stage of window production are 126.8 kg (~0.13 tones). The fiberglass window frame generated 45.4 kg (~0.045 tones) CO_2-equivalent emissions, accounts for 35.8% of the carbon emission over whole unit (Table 87). And the window glazing generated 81.4 kg (~0.081 tones) CO_2-equivalent emissions, accounts for 64.2% of the carbon emission over whole unit (Table 88).

The manufacturing stage is the next highest impact contributor to following impact categories. For global warming and fossil fuel depletion, the manufacturing stages account for 10.76 % to global warming and 16.87% to fossil fuel depletion. The transportation stage accounts for 7.27% to global warming and 9.85% to non-carcinogenics.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 86). The raw material supply phase dominates the results (90.4%), followed by the transportation phase which accounts for 5.19 % of the total.

Table 84. Life cycle impact assessment results for Universal Series™ Fixed & Operable Windows Sliding Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	6.06E-06	1.43E-07	1.24E-07	**6.32E-06**
Global warming	kg CO_2 eq	1.04E+02	9.22E+00	1.36E+01	**1.27E+02**
Smog	kg O_3 eq	7.25E+00	2.01E-01	1.87E-01	**7.64E+00**
Acidification	kg SO_2 eq	6.21E-01	1.27E-02	8.04E-03	**6.41E-01**
Eutrophication	kg N eq	6.02E-02	8.59E-04	6.06E-04	**6.17E-02**
Carcinogenics	CTUh	2.37E-06	5.87E-09	2.79E-09	**2.38E-06**
Non carcinogenics	CTUh	1.04E-05	1.16E-06	1.87E-07	**1.17E-05**
Respiratory effects	kg PM2.5 eq	6.46E-02	2.95E-03	9.90E-04	**6.86E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.13E+02	2.36E+01	3.15E-01	**1.37E+02**
Fossil fuel depletion	MJ surplus	1.44E+02	1.76E+01	3.28E+01	**1.95E+02**

Table 85. Percent contributions of each stage to each impact category for Universal Series™ Sliding Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	95.78%	2.26%	1.96%	**100%**
Global warming	81.97%	7.27%	10.76%	**100%**
Smog	94.92%	2.64%	2.45%	**100%**
Acidification	96.77%	1.98%	1.25%	**100%**
Eutrophication	97.63%	1.39%	0.98%	**100%**
Carcinogenics	99.64%	0.25%	0.12%	**100%**
Non-carcinogenics	88.56%	9.85%	1.59%	**100%**
Respiratory effects	94.25%	4.31%	1.44%	**100%**
Ecotoxicity	82.53%	17.24%	0.23%	**100%**
Fossil fuel depletion	74.09%	9.04%	16.87%	**100%**

Table 86. Averaged SM millipoint scores for Universal Series™ Fixed & Operable Windows Sliding Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	9.44E+00	5.42E-01	4.61E-01	**1.04E+01**

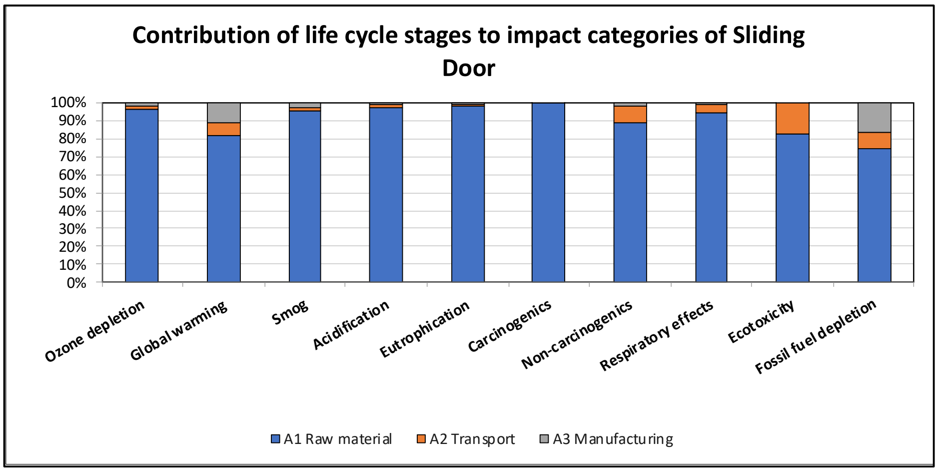

Figure 12. Contribution analysis of each impact category for Universal Series™ Fixed & Operable Windows Sliding Door per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.8.1. Sliding Door (Frame only)

Table 87 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 87. Life cycle impact assessment results for Universal Series™ Sliding Door (Frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.15E-06	1.19E-07	5.48E-08	**1.32E-06**
Global warming	kg CO_2 eq	3.17E+01	7.69E+00	6.03E+00	**4.54E+01**
Smog	kg O_3 eq	1.57E+00	1.73E-01	8.26E-02	**1.83E+00**
Acidification	kg SO_2 eq	1.30E-01	1.09E-02	3.55E-03	**1.44E-01**
Eutrophication	kg N eq	2.25E-02	7.26E-04	2.68E-04	**2.35E-02**
Carcinogenics	CTUh	8.67E-07	4.89E-09	1.23E-09	**8.73E-07**
Non carcinogenics	CTUh	3.87E-06	9.62E-07	8.24E-08	**4.91E-06**
Respiratory effects	kg PM2.5 eq	2.26E-02	2.48E-03	4.37E-04	**2.55E-02**
Additional environmental information					
Ecotoxicity	CTUe	8.46E+01	1.96E+01	1.39E-01	**1.04E+02**
Fossil fuel depletion	MJ surplus	4.46E+01	1.47E+01	1.45E+01	**7.38E+01**

5.2.8.2. Sliding Door (Glazing only)

Table 88 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 88. Life cycle impact assessment results for Universal Series™ Sliding Door (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	4.91E-06	2.39E-08	6.92E-08	**5.00E-06**
Global warming	kg CO_2 eq	7.23E+01	1.54E+00	7.61E+00	**8.14E+01**
Smog	kg O_3 eq	5.67E+00	2.81E-02	1.04E-01	**5.81E+00**
Acidification	kg SO_2 eq	4.91E-01	1.83E-03	4.49E-03	**4.97E-01**
Eutrophication	kg N eq	3.78E-02	1.34E-04	3.38E-04	**3.82E-02**
Carcinogenics	CTUh	1.51E-06	9.80E-10	1.55E-09	**1.51E-06**
Non carcinogenics	CTUh	6.53E-06	1.94E-07	1.04E-07	**6.83E-06**
Respiratory effects	kg PM2.5 eq	4.20E-02	4.79E-04	5.52E-04	**4.30E-02**
Additional environmental information					
Ecotoxicity	CTUe	2.84E+01	3.97E+00	1.76E-01	**3.26E+01**
Fossil fuel depletion	MJ surplus	9.96E+01	2.94E+00	1.83E+01	**1.21E+02**

5.2.9. Window Wall Vision Glass

Table 89 shows the contributions, and Table 90 and Figure 13 show the percent contribution of each stage of the production of the Universal Series™ Window Wall Vision Glass configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Window Wall Vision Glass (including frame and glazing) generated during the cradle-to-gate stage of window production are 128.7 kg (~0.13 tones). The fiberglass window frame generated 55.1 kg (~0.05 tones) CO_2-equivalent emissions, accounts for 42.8% of the carbon emission over whole unit (Table 92). And the window glazing generated 73.6 kg (~0.074 tones) CO_2-equivalent emissions, accounts for 57.2% of the carbon emission over whole unit (Table 93).

The manufacturing stage is the next highest impact contributor to the following impact categories: global warming and fossil fuel depletion. The manufacturing stages account for 7.08 % to global warming and 13.07% to fossil fuel depletion. Transportation accounts for 5.61% to global warming and 21.48% to ecotoxicity.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 91). The raw material supply phase dominates the results (96.27%), followed by the transportation phase which accounts for 4.48% of the total.

Table 89. Life cycle impact assessment results for Universal Series™ Window Wall Vision Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	5.52E-06	1.12E-07	8.29E-08	**5.72E-06**
Global warming	kg CO_2 eq	1.12E+02	7.22E+00	9.12E+00	**1.29E+02**
Smog	kg O_3 eq	8.04E+00	1.47E-01	1.25E-01	**8.31E+00**
Acidification	kg SO_2 eq	6.92E-01	9.35E-03	5.37E-03	**7.07E-01**
Eutrophication	kg N eq	5.93E-02	6.53E-04	4.12E-04	**6.04E-02**
Carcinogenics	CTUh	2.11E-06	4.60E-09	1.86E-09	**2.11E-06**
Non carcinogenics	CTUh	1.03E-05	9.08E-07	1.25E-07	**1.14E-05**
Respiratory effects	kg PM2.5 eq	7.90E-02	2.28E-03	6.61E-04	**8.20E-02**
Additional environmental information					
Ecotoxicity	CTUe	6.76E+01	1.85E+01	2.11E-01	**8.64E+01**
Fossil fuel depletion	MJ surplus	1.32E+02	1.38E+01	2.19E+01	**1.68E+02**

Table 90. Percent contributions of each stage to each impact category for Universal Series™ Window Wall Vision Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	96.59%	1.96%	1.45%	**100%**
Global warming	87.31%	5.61%	7.08%	**100%**
Smog	96.73%	1.76%	1.50%	**100%**
Acidification	97.92%	1.32%	0.76%	**100%**
Eutrophication	98.24%	1.08%	0.68%	**100%**
Carcinogenics	99.69%	0.22%	0.09%	**100%**
Non-carcinogenics	90.91%	7.99%	1.10%	**100%**
Respiratory effects	96.41%	2.79%	0.81%	**100%**
Ecotoxicity	78.28%	21.48%	0.24%	**100%**
Fossil fuel depletion	78.71%	8.22%	13.07%	**100%**

Table 91. Averaged SM millipoint scores for Universal Series™ Window Wall Vision Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	8.74E+00	4.24E-01	3.08E-01	**9.47E+00**

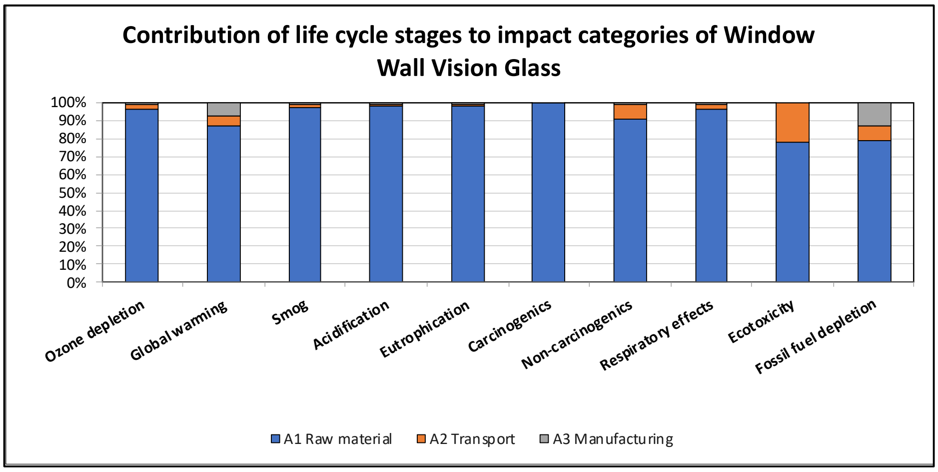

Figure 13. Contribution analysis of each impact category for Universal Series™ Window Wall Vision Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.9.1. Window Wall Vision Glass (Frame only)

Table 92 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 92. Life cycle impact assessment results for Universal Series™ Window Wall Vision Glass (frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	7.62E-07	7.76E-08	2.99E-08	**8.69E-07**
Global warming	kg CO_2 eq	4.68E+01	5.01E+00	3.29E+00	**5.51E+01**
Smog	kg O_3 eq	2.89E+00	1.06E-01	4.51E-02	**3.04E+00**
Acidification	kg SO_2 eq	2.43E-01	6.72E-03	1.94E-03	**2.51E-01**
Eutrophication	kg N eq	2.35E-02	4.61E-04	1.49E-04	**2.41E-02**
Carcinogenics	CTUh	6.31E-07	3.19E-09	6.73E-10	**6.34E-07**
Non carcinogenics	CTUh	3.98E-06	6.28E-07	4.50E-08	**4.66E-06**
Respiratory effects	kg PM2.5 eq	4.07E-02	1.59E-03	2.39E-04	**4.25E-02**
Additional environmental information					
Ecotoxicity	CTUe	4.04E+01	1.28E+01	7.61E-02	**5.33E+01**
Fossil fuel depletion	MJ surplus	4.31E+01	9.56E+00	7.93E+00	**6.06E+01**

5.2.9.2. Window Wall Vision Glass (Glazing only)

Table 93 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 93. Life cycle impact assessment results for Universal Series™ Window Wall Vision Glass (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	4.76E-06	3.44E-08	5.29E-08	**4.85E-06**
Global warming	kg CO_2 eq	6.56E+01	2.22E+00	5.82E+00	**7.36E+01**
Smog	kg O_3 eq	5.15E+00	4.05E-02	7.97E-02	**5.27E+00**
Acidification	kg SO_2 eq	4.49E-01	2.63E-03	3.43E-03	**4.55E-01**
Eutrophication	kg N eq	3.58E-02	1.92E-04	2.63E-04	**3.63E-02**
Carcinogenics	CTUh	1.47E-06	1.41E-09	1.19E-09	**1.48E-06**
Non carcinogenics	CTUh	6.35E-06	2.80E-07	7.96E-08	**6.71E-06**
Respiratory effects	kg PM2.5 eq	3.83E-02	6.90E-04	4.22E-04	**3.94E-02**
Additional environmental information					
Ecotoxicity	CTUe	2.72E+01	5.72E+00	1.35E-01	**3.30E+01**
Fossil fuel depletion	MJ surplus	8.89E+01	4.23E+00	1.40E+01	**1.07E+02**

5.2.10. Window Wall Spandrel Glass

Table 94 shows the contributions, and Table 95 and Figure 14 show the percent contribution of each stage of the production of the Universal Series™ Window Wall Spandrel Glass configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Window Wall Spandrel Glass (including frame and glazing) generated during the cradle-to-gate stage of window production are 112.5 kg (~0.11 tones). The fiberglass window frame generated 75.3 kg (~0.075 tones) CO_2-equivalent emissions, accounts for 66.9% of the carbon emission over whole unit (Table 97). And the window glazing generated 37.23 kg (~0.037 tones) CO_2-equivalent emissions, accounts for 33.1% of the carbon emission over whole unit (Table 98).

The manufacturing stage is the next highest impact contributor to the following impact categories. The manufacturing stages account for 8.04% to global warming and 16.11% to fossil fuel depletion of the total. Transportation accounts for 5.57% to global warming and 20.24% to ecotoxicity.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 96). The raw material supply phase dominates the results (91.14%), followed by the transportation phase which accounts for 4.84% of the total.

Table 94. Life cycle impact assessment results for Universal Series™ Window Wall Spandrel Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.70E-06	9.71E-08	8.23E-08	**3.88E-06**
Global warming	kg CO_2 eq	9.72E+01	6.26E+00	9.04E+00	**1.12E+02**
Smog	kg O_3 eq	6.50E+00	1.35E-01	1.24E-01	**6.76E+00**
Acidification	kg SO_2 eq	5.75E-01	8.56E-03	5.33E-03	**5.89E-01**
Eutrophication	kg N eq	4.90E-02	5.81E-04	3.92E-04	**5.00E-02**
Carcinogenics	CTUh	1.51E-06	3.99E-09	1.85E-09	**1.52E-06**
Non carcinogenics	CTUh	8.20E-06	7.86E-07	1.24E-07	**9.11E-06**
Respiratory effects	kg PM2.5 eq	8.71E-02	2.00E-03	6.56E-04	**8.98E-02**
Additional environmental information					
Ecotoxicity	CTUe	6.30E+01	1.60E+01	2.09E-01	**7.93E+01**
Fossil fuel depletion	MJ surplus	1.02E+02	1.20E+01	2.18E+01	**1.35E+02**

Table 95. Percent contributions of each stage to each impact category for Universal Series™ Window Wall Spandrel Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	95.38%	2.50%	2.12%	**100%**
Global warming	86.39%	5.57%	8.04%	**100%**
Smog	96.16%	2.00%	1.83%	**100%**
Acidification	97.64%	1.45%	0.91%	**100%**
Eutrophication	98.05%	1.16%	0.78%	**100%**
Carcinogenics	99.62%	0.26%	0.12%	**100%**
Non-carcinogenics	90.01%	8.63%	1.36%	**100%**
Respiratory effects	97.04%	2.23%	0.73%	**100%**
Ecotoxicity	79.50%	20.24%	0.26%	**100%**
Fossil fuel depletion	75.05%	8.84%	16.11%	**100%**

Table 96. Averaged SM millipoint scores for Universal Series™ Window Wall Spandrel Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	6.92E+00	3.68E-01	3.06E-01	**7.60E+00**

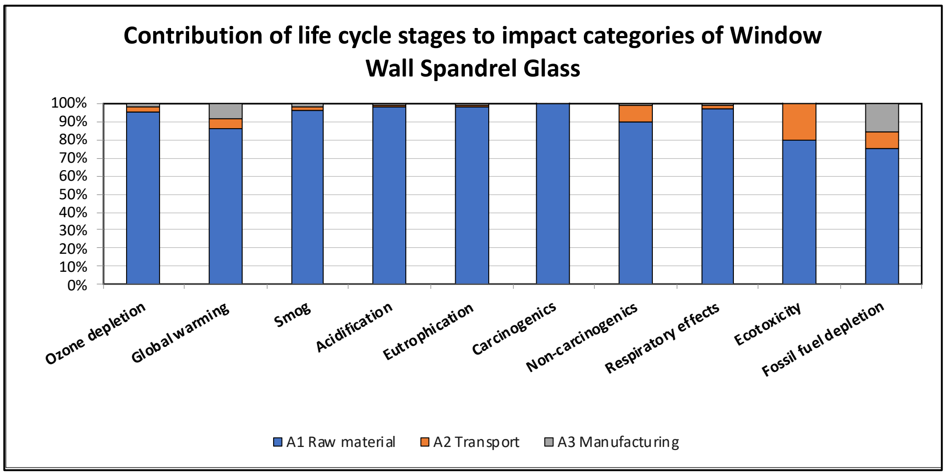

Figure 14. Contribution analysis of each impact category for Universal Series™ Window Wall Spandrel Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.10.1. Window Wall Spandrel Glass (Frame only)

Table 97 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 97. Life cycle impact assessment results for Universal Series™ Window Wall Spandrel Glass (frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.32E-06	8.00E-08	5.19E-08	**1.45E-06**
Global warming	kg CO_2 eq	6.44E+01	5.16E+00	5.71E+00	**7.53E+01**
Smog	kg O_3 eq	3.93E+00	1.15E-01	7.82E-02	**4.12E+00**
Acidification	kg SO_2 eq	3.50E-01	7.24E-03	3.37E-03	**3.61E-01**
Eutrophication	kg N eq	3.11E-02	4.85E-04	2.47E-04	**3.19E-02**
Carcinogenics	CTUh	7.73E-07	3.28E-09	1.17E-09	**7.77E-07**
Non carcinogenics	CTUh	5.02E-06	6.46E-07	7.81E-08	**5.75E-06**
Respiratory effects	kg PM2.5 eq	6.80E-02	1.66E-03	4.14E-04	**7.00E-02**
Additional environmental information					
Ecotoxicity	CTUe	4.94E+01	1.32E+01	1.32E-01	**6.27E+01**
Fossil fuel depletion	MJ surplus	5.71E+01	9.84E+00	1.38E+01	**8.06E+01**

5.2.10.2. Window Wall Spandrel Glass (Glazing only)

Table 98 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 98. Life cycle impact assessment results for Universal Series™ Window Wall Spandrel Glass (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.38E-06	1.72E-08	3.03E-08	**2.43E-06**
Global warming	kg CO_2 eq	3.28E+01	1.11E+00	3.34E+00	**3.72E+01**
Smog	kg O_3 eq	2.57E+00	2.02E-02	4.57E-02	**2.64E+00**
Acidification	kg SO_2 eq	2.25E-01	1.32E-03	1.97E-03	**2.28E-01**
Eutrophication	kg N eq	1.79E-02	9.62E-05	1.45E-04	**1.81E-02**
Carcinogenics	CTUh	7.37E-07	7.06E-10	6.81E-10	**7.39E-07**
Non carcinogenics	CTUh	3.17E-06	1.40E-07	4.56E-08	**3.36E-06**
Respiratory effects	kg PM2.5 eq	1.92E-02	3.45E-04	2.42E-04	**1.97E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.36E+01	2.86E+00	7.71E-02	**1.65E+01**
Fossil fuel depletion	MJ surplus	4.45E+01	2.12E+00	8.04E+00	**5.46E+01**

5.2.11. Window Wall Bypass

Table 99 shows the contributions, and Table 100 and Figure 15 show the percent contribution of each stage of the production of the Universal Series™ Window Wall Bypass configuration. The raw material supply stage dominates the results for all impact categories. The total potential CO_2-equivalent emissions of 1 m^2 of Universal Series™ Window Wall Bypass (including frame and glazing) generated during the cradle-to-gate stage of window production are 71.17kg (~0.071 tones). The fiberglass window frame generated 34.23 kg (~0.034 tones) CO_2-equivalent emissions, accounts for 48.1% of the carbon emission over whole unit (Table 102). And the window glazing generated 36.9 kg (~0.037 tones) CO_2-equivalent emissions, accounts for 51.9% of the carbon emission over whole unit (Table 103).

The manufacturing stage is the next highest impact contributors of all impact categories except global warming and fossil fuel depletion. For example, for global warming and fossil fuel depletion, the manufacturing stages account for 6.34% to global warming and 13.71% to fossil fuel depletion.

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 101). The raw material supply phase dominates the results (95.35%), followed by the manufacturing phase which accounts for 2.96% of the total.

Table 99. Life cycle impact assessment results for Universal Series™ Window Wall Bypass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.72E-06	2.31E-08	4.11E-08	**2.78E-06**
Global warming	kg CO_2 eq	6.52E+01	1.49E+00	4.51E+00	**7.12E+01**
Smog	kg O_3 eq	4.67E+00	2.72E-02	6.19E-02	**4.76E+00**
Acidification	kg SO_2 eq	4.04E-01	1.77E-03	2.66E-03	**4.09E-01**
Eutrophication	kg N eq	3.02E-02	1.29E-04	1.86E-04	**3.06E-02**
Carcinogenics	CTUh	1.19E-06	9.48E-10	9.22E-10	**1.19E-06**
Non carcinogenics	CTUh	5.91E-06	1.88E-07	6.18E-08	**6.16E-06**
Respiratory effects	kg PM2.5 eq	5.02E-02	4.63E-04	3.28E-04	**5.10E-02**
Additional environmental information					
Ecotoxicity	CTUe	3.66E+01	3.84E+00	1.04E-01	**4.05E+01**
Fossil fuel depletion	MJ surplus	6.57E+01	2.84E+00	1.09E+01	**7.95E+01**

Table 100. Percent contributions of each stage to each impact category for Universal Series™ Window Wall bypass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	97.70%	0.83%	1.48%	**100%**
Global warming	91.57%	2.09%	6.34%	**100%**
Smog	98.13%	0.57%	1.30%	**100%**
Acidification	98.92%	0.43%	0.65%	**100%**
Eutrophication	98.97%	0.42%	0.61%	**100%**
Carcinogenics	99.84%	0.08%	0.08%	**100%**
Non-carcinogenics	95.94%	3.05%	1.00%	**100%**
Respiratory effects	98.45%	0.91%	0.64%	**100%**
Ecotoxicity	90.28%	9.47%	0.26%	**100%**
Fossil fuel depletion	82.72%	3.58%	13.71%	**100%**

Table 101. Averaged SM millipoint scores for Universal Series™ Window Wall bypass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	4.92E+00	8.73E-02	1.53E-01	**5.16E+00**

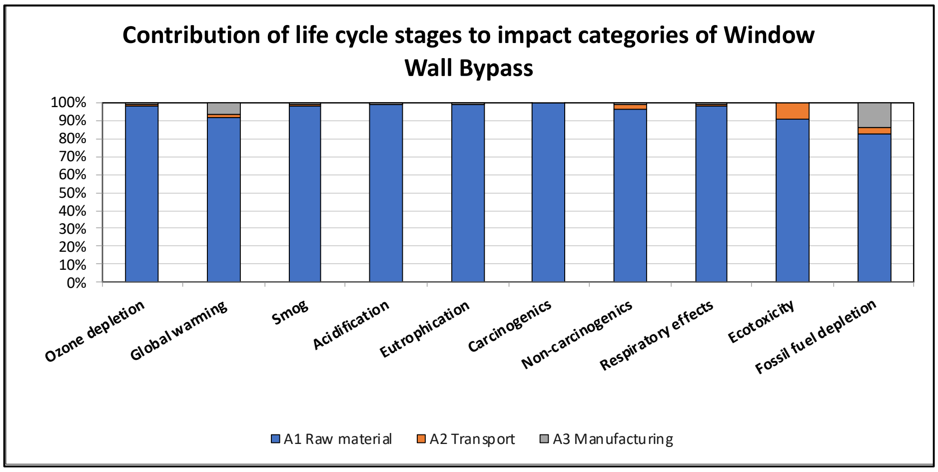

Figure 15. Contribution analysis of each impact category for Universal Series™ Window Wall Spandrel Glass per declared unit (1 m^2) of fenestration assemblies (including frame and glazing)

5.2.11.1. Window Wall Bypass (Frame only)

Table 102 reports on the category impact for the frame component of the fenestration system, excluding glazing. The A1 stage makes the largest share of impacts across all impact categories.

Table 102. Life cycle impact assessment results for Universal Series™ Window Wall Bypass (Frame only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	3.39E-07	6.21E-09	1.31E-08	**3.58E-07**
Global warming	kg CO_2 eq	3.24E+01	4.01E-01	1.44E+00	**3.42E+01**
Smog	kg O_3 eq	2.09E+00	7.32E-03	1.98E-02	**2.12E+00**
Acidification	kg SO_2 eq	1.80E-01	4.76E-04	8.52E-04	**1.81E-01**
Eutrophication	kg N eq	1.23E-02	3.48E-05	5.94E-05	**1.24E-02**
Carcinogenics	CTUh	4.53E-07	2.55E-10	2.95E-10	**4.54E-07**
Non carcinogenics	CTUh	2.73E-06	5.06E-08	1.98E-08	**2.80E-06**
Respiratory effects	kg PM2.5 eq	3.11E-02	1.25E-04	1.05E-04	**3.13E-02**
Additional environmental information					
Ecotoxicity	CTUe	2.30E+01	1.03E+00	3.34E-02	**2.41E+01**
Fossil fuel depletion	MJ surplus	2.13E+01	7.65E-01	3.49E+00	**2.55E+01**

5.2.11.2. Window Wall Bypass (Glazing only)

Table 103 reports on the category impact for the glazing component of the fenestration system, excluding frame. The A1 stage makes the largest share of impacts across all impact categories.

Table 103. Life cycle impact assessment results for Universal Series™ Window Wall Bypass (glazing only) per declared unit (1 m^2)

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	2.38E-06	1.69E-08	2.79E-08	**2.43E-06**
Global warming	kg CO_2 eq	3.28E+01	1.09E+00	3.07E+00	**3.69E+01**
Smog	kg O_3 eq	2.57E+00	1.99E-02	4.21E-02	**2.64E+00**
Acidification	kg SO_2 eq	2.25E-01	1.29E-03	1.81E-03	**2.28E-01**
Eutrophication	kg N eq	1.79E-02	9.45E-05	1.26E-04	**1.81E-02**
Carcinogenics	CTUh	7.37E-07	6.93E-10	6.27E-10	**7.39E-07**
Non carcinogenics	CTUh	3.17E-06	1.37E-07	4.20E-08	**3.35E-06**
Respiratory effects	kg PM2.5 eq	1.92E-02	3.39E-04	2.23E-04	**1.97E-02**
Additional environmental information					
Ecotoxicity	CTUe	1.36E+01	2.81E+00	7.10E-02	**1.65E+01**
Fossil fuel depletion	MJ surplus	4.45E+01	2.08E+00	7.41E+00	**5.39E+01**

5.2.12. Contributors in raw material acquisition stage

Since the raw material acquisition stage was the largest contributor to all stages across all impact categories, an analysis of the raw materials was performed. Figure 16 shows a breakdown of GWP results into contributions from each raw material for an average contribution to A1 GWP results from each raw material inputs across a broad spectrum of Universal Series™ products.

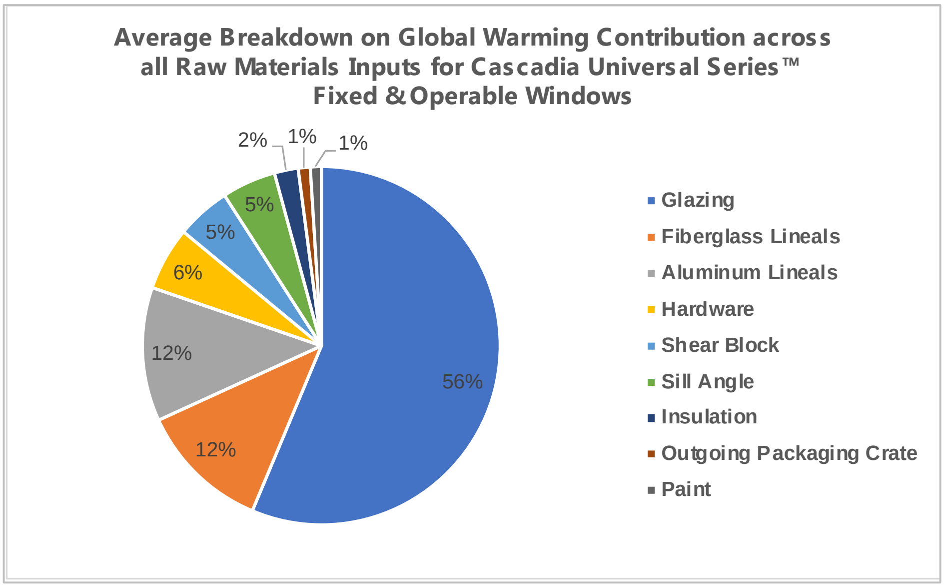

Figure 16. Average contributions to A1 GWP results from each raw material inputs across a broad spectrum of Universal Series™ products.

The window glazing shows an average of 58% contribution over the total Global Warming Potential within the raw materials input stage. Following by the fiberglass lineals and aluminum lineals at 12%, and all other raw materials combined making up the remaining 18%.

5.3 Scaling factors

In the case where architects, engineers, specifiers, or other EPD users are looking to calculate total results across an entire project, scaling factors can assist the user to incorporate different product choices such as double or triple-glazed products, or to incorporate the addition of operable windows and doors to window wall configurations.

Per the PCR, results in this report are presented per the declared unit, which is normalized from the NFRC size to one square meter (1 m^2) of fenestration assemblies (including frame and glazing).

Results in this report are presented assuming a default double-glazed option. In order to calculate results for triple-glazed products for the applicable product types, multiply the results in each impact category by their associated product-specific scaling factor shown in Table 104.

Table 104. Scaling factors for conversion of results from double-glazed product to triple-glazed product

	Universal Series™ Fixed Window	Universal Series™ Casement Window	Universal Series™ Tilt & Turn Window	Universal Series™ Awning Window	Universal Series™ Hopper Window	Universal Series™ Single Swing Door	Universal Series™ Double Swing Door	Universal Series™ Sliding Door	Universal Series™ Window Wall Vision Glass
Ozone depletion	1.43	1.31	1.37	1.31	1.31	1.34	1.36	1.43	1.42
Global warming	1.33	1.15	1.23	1.15	1.15	1.23	1.24	1.20	1.25
Smog	1.41	1.24	1.33	1.24	1.24	1.33	1.34	1.41	1.31
Acidification	1.42	1.27	1.36	1.27	1.27	1.34	1.36	1.45	1.32
Eutrophication	1.35	1.16	1.26	1.16	1.16	1.26	1.27	1.28	1.30
Carcinogenics	1.42	1.22	1.37	1.22	1.22	1.27	1.29	1.33	1.35
Non carcinogenics	1.34	1.15	1.26	1.15	1.15	1.22	1.25	1.20	1.28
Respiratory effects	1.37	1.19	1.28	1.19	1.19	1.27	1.29	1.34	1.23
Ecotoxicity	1.17	1.04	1.08	1.04	1.04	1.09	1.11	1.11	1.16
Fossil fuel depletion	1.28	1.11	1.19	1.11	1.11	1.19	1.20	1.08	1.26

The results in this report for Universal Series™ Window Wall Vision Glass are presented per 1 m^2 of Vision Glass including frame and glazing. To calculate results for 1m^2 of Vision Glass that can accommodate the addition of operable windows or doors into the window wall configuration, the portion of frame that is added to the window wall is captured by the below equations. This information enables EPD users to incorporate the addition of an operable window or a swinging or sliding door into the existing bank of Universal Series™ Window Wall products.

Since the NFRC sizing for the Tilt & Turn Window is the same as the Fixed Window, the addition of operable windows to a window wall configuration can be approximated by calculating the difference in results between the Tilt & Turn and Fixed Window frames. To calculate the results of 1m^2 of Window Wall Vision Glass in a window wall configuration that includes operable windows (Casement Window, Awning Window, Tilt & Turn Window, and Hopper Window), use the following equation:

$$\boldsymbol{Results\ per\ 1m^2\ Window\ Wall\ Vision\ Glass\ that\ allows\ for\ addition\ of\ operable\ windows} = Window\ Wall\ Vision\ Glass\ results\ (\boldsymbol{Table\ 90}) + [Tilt\ \&\ Turn\ frame\ results\ (\boldsymbol{Table\ 63}) - Fixed\ Window\ frame\ results\ (\boldsymbol{Table\ 53})]$$

To calculate the results of a window wall configuration which includes single or double swing doors, use the following equation:

$$\boldsymbol{Results\ per\ 1m^2\ Window\ Wall\ Vision\ Glass\ that\ allows\ for\ addition\ of\ swing\ doors} = Window\ Wall\ Vision\ Glass\ results\ (\boldsymbol{Table\ 90}) + [Single\ Swing\ Door\ frame\ results\ (\boldsymbol{Table\ 78}) - Fixed\ Window\ frame\ results\ (\boldsymbol{Table\ 53})]$$

To calculate the results of a window wall configuration which includes sliding doors, use the following equation:

$$\textbf{Results per } 1m^2 \textbf{ Window Wall Vision Glass that allows for addition of sliding doors} = \text{Window Wall Vision Glass results } (\textbf{Table } 90) + [\text{Sliding Door frame results } (\textbf{Table } 88) - \text{Fixed Window frame results } (\textbf{Table } 53)]$$

When operable windows and doors are added to the window wall configuration using these equations, total results are artificially inflated since the window wall results already account for more glazing than will be used; when the sash is introduced, it takes up some area and reduces the amount of glass needed. Therefore, this is a conservative approach for calculating total results across an entire project.

5.4 Sensitivity analyses

These sensitivity analyses were performed to address the differences in results using different supplier, packaging, and product configuration options.

5.4.1. Switch to 100% reusable steel racks

A sensitivity analysis was performed to evaluate the impact of switching the current practice of using single use wood crates for one third of product shipments to using reusable steel racks for all shipments by evaluating the change in potential CO_2-equivalent emissions. The results are shown in Table 105, which shows that moving to steel racks for all shipments would reduce potential CO_2-eq emissions by about 1%.

Table 105. Sensitivity analysis of switching packaging methods on results per declared unit

Product name	A1-A3 GWP results (kg CO2-eq)		% change
	Baseline (One third of shipments using wood crates)	After switching to 100% reusable steel racks	
Universal Series™ Double Swing Door	9.47E+01	9.34E+01	-1.37%

5.4.2. Triple glazing option

A sensitivity analysis was performed to evaluate the impact of choosing a triple-glazed product configuration rather than the double-glazed option presented for the products in this study by evaluating the change in potential CO_2-equivalent emissions. The Fixed Window product was chosen for the analysis since it has the highest percentage of glazing and therefore provides the most conservative estimate of change. The results are shown in Table 106, which shows that choosing the triple-glazed configuration would increase potential CO_2-eq emissions by about 29.6%.

Table 106. Sensitivity analysis of choosing a triple-glazed configuration on results per declared unit

Product name	A1-A3 GWP results (kg CO2-eq)		% change
	Baseline (Double-glazed IGU)	Triple-glazed IGU	
Universal Series™ Fixed Window	6.83E+01	9.08E+01	+32.9%

These results show that the choice of double-glazed or triple-glazed windows does significantly contribute to the overall environmental impacts from cradle to gate.

5.5 Overview of relevant findings

This study assessed a multitude of inventory and environmental indicators. The primary finding for Cascadia Universal Series™ Fixed & Operable Windows and Doors and for Cascadia Universal Series™ Window Wall, across all environmental indicators in all product configurations, was that the raw material extraction and upstream production stage (A1) is responsible for the majority of impacts in each impact category.

The manufacturing stage (A3) shares the next highest contributions depending on the impact category or product configuration. For fixed window configurations which do not require additional manufacturing activities for completing the window frame assembly, the upstream transportation stage (A2) has relatively higher contribution in impact categories such as global warming. Whereas for the remaining window, door, and window wall configurations, the manufacturing stage (A3) is the next highest contributor to global warming. Within the manufacturing stage, ozone depletion, global warming, and fossil fuel depletion are the top three major impact categories that have the highest impact compared to others.

5.6 Discussion of data quality

Inventory data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from SimaPro Analyst 9.5, and the ecoinvent v3.10 and US-EI 2.2 databases were used.

Precision and completeness

- Precision: As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, precision is considered to be high. Background data are from ecoinvent v3.10 and US-EI 2.2 databases with documented precision to the extent available.

- Completeness: The product system was checked for mass balance and completeness of the inventory. Capital equipment was excluded as required by the PCR. Otherwise, no data was knowingly omitted.

Consistency and reproducibility

- Consistency: Primary data were collected with a similar level of detail, while background data were sourced primarily from the ecoinvent database, and other databases were used if data were not available in ecoinvent or the data set was judged to be more representative. Other methodological choices were made consistently throughout the model.

- Reproducibility: Reproducibility is warranted as much as possible through the disclosure of input-output data, dataset choices, and modeling approaches in this report. Based on this information, a knowledgeable third party should be able to approximate the results of this study using the same data and modeling approaches.

Representativeness

- Temporal: All primary data were collected for May 2022 – April 2023 in order to ensure the representativeness of the manufacturing process. Secondary data were obtained from the ecoinvent v3.10 and US-EI 2.2 databases and are typically representative of the recent years.

- Geographical: Primary data are representative of Cascadia production in Canada. Differences in the electric grid mix are considered with appropriate secondary data. In general, secondary data were collected specific to the country under study. Where country-specific data were unavailable, proxy data were used. Geographical representativeness is considered to be high.

- Technological: All primary and secondary data were modeled to be specific to the technologies under study. Technological representativeness is considered to be high.

5.7 Conclusions and recommendations

The goal of this study was to conduct a cradle-to-gate LCA on the Cascadia Universal Series™ Fixed & Operable Windows and Doors and Cascadia Universal Series™ Window Wall products so as to develop Transparency Reports [EPDs]™. The creation of these Transparency Reports [EPDs]™ will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose.

Overall, the study found that environmental performance is primarily driven by raw material extraction and preprocessing, which make up 60-80% of the total impacts across all product types. Collectively, the transportation and manufacturing stages account for the remaining 20-40% of the total impacts. The distribution of impacts between the transportation stage and the manufacturing stage varies across different product types, considering different material component weights and sourcing locations. Manufacturing activities are allocated differently based on the labor units assigned to each product type, contributing differences to manufacturing impact. The potential impacts of both transportation and manufacturing activities at the Cascadia facility are noticeable but lower overall when compared to the impacts generated from the raw material extraction stage.

The results show that the greatest opportunity for reducing each product's environmental impact is in the raw material extraction phase. Particularly, the glazing that Cascadia purchases from upstream suppliers accounts for an average of 58% of the A1 raw material CO_2-eq emissions. However, glazing production technologies are similar among glazing manufacturers and are not expected to significantly change in the coming years. While Cascadia can seek out alternative glazing suppliers to help reduce these emissions, they have no direct control over changes to the standard practices in the glazing industry. The next highest contribution to emissions comes from the fiberglass lineals, also purchased by upstream suppliers. Since reducing the amount of fiberglass would only decrease the total cradle-to-gate CO_2-eq emissions, it would be beneficial for Cascadia to explore new product designs that utilize less fiberglass. In addition, it would be beneficial for Cascadia to seek suppliers who use sustainable materials or manufacturing techniques or integrate more renewable energy or other energy-saving measures into their manufacturing processes.

It is recommended that during the next update to this LCA, Cascadia reaches out to its lineals supplier to gather supplier-specific data on the production of the fiberglass portion of the Universal Series™ products. This may help identify areas of improvement in the raw materials stage. Additionally, an update to this LCA and the associated Transparency Reports [EPDs]™ would enable high-quality year-to-year comparisons and serve as the basis for potential optimized EPDs. A post-project review could provide opportunities for improving the data collection process in future years and for continuing to align with Cascadia's goals for sustainability.

6 REFERENCES

[1] ISO 14044, “Environmental management - Life cycle assessment - Requirements and guidelines”, ISO14044:2006.

[2] ISO 21930, “Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services”, ISO 21930:2017.

[3] NSF 1102-23 Product Category Rule for Environmental Product Declarations: PCR for Fenestration Assemblies, NSF International, 2024.

[4] Salazar, J. (2014). Life cycle assessment (LCA) of windows and window materials. In *Eco-efficient construction and building materials* (pp. 502-527). Woodhead Publishing.

[5] ISO 14025, “Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures”, ISO14025:2006

[6] Joep Meijer, Sustainable Minds SM2013 Methodology and Database, April 25, 2013. For a summary, see the Sustainable Minds single score page: http://www.sustainableminds.com/showroom/shared/learn-single-score.html

[7] Bare, J. 2014. Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) TRACI version 2.1 User’s Guide. US EPA Office of Research and Development, Washington, DC, EPA/600/R-12/554, http://nepis.epa.gov/Adobe/PDF/P100HN53.pdf

[8] Ryberg, M., Vieira, M.D.M., Zgola, M. et al. (2014). ‘Updated US and Canadian normalization factors for TRACI 2.1.’ Clean Technologies and Environmental Policy 16: 329. doi:10.1007/s10098-013-0629-z

[9] Gloria, T. P., B. C. Lippiatt & J. Cooper (2007). ‘Life cycle impact assessment weights to support environmentally preferable purchasing in the United States.’ Environmental Science & Technology, 41(21), 7551-7557

[10] "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017”, ACLCA PCR committee working group for ISO 21930 metric calculation guidance, May 2019.

[11] 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.

ACRONYMS

BOM	Bill of materials
IGU	Insulating glass unit
ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact analysis
MND	Module Not Declared
PCR	Product Category Rule document
TR	Transparency Report [EPD]™

GLOSSARY

For the purposes of this report, the terms and definitions given in ISO 14020, ISO 14025, the ISO 14040 series, and ISO 21930 apply. The most important ones are included here:

Allocation	Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems
Close loop & open loop	A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials. An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.
Cradle to grave	Addresses the environmental aspects and potential environmental impacts (e.g., use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life
Cradle to gate	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process ("gate of the factory"). It may also include transportation until use phase
Declared unit	Quantity of a product for use as a reference unit in an EPD based on one or more information modules
Functional unit	Quantified performance of a product system for use as a reference unit
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal
Life cycle assessment - LCA	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
Life cycle impact assessment - LCIA	Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product
Life cycle inventory - LCI	phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle
Life cycle interpretation	Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations

APPENDIX

- [redacted]