Environmental Product Declaration

HYBRID WINDOWS

ALUMINIUM/PVC AND ALUMINIUM/PVC/ ALUMINIUM

This environmental product declaration (EPD) covers ten types of hybrid windows (aluminium/PVC and aluminium/PVC/aluminium) with PVC profiles manufactured by Thermoplast Nextrusions. The EPD was prepared by CT Consultant in accordance with CAN/CSA-ISO 14025:2006 and ISO 21930:2017 and verified by Marie Bellemare Consulting.

This EPD includes the results of the life cycle assessment (LCA) for the raw material supply and manufacturing stages (i.e., cradle to gate).

For more information on Thermoplast Nextrusions, please visit www.thermoplast.com

Date of publication: 21 April 2026

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NEXTRUSIONS

EPD SUMMARY SHEET

HYBRID WINDOWS (ALUMINIUM/PVC AND ALUMINIUM/PVC/ALUMINIUM)

Goal of the summary sheet

This summary sheet aims to present the company, the product, the main methodological aspects and the results of the environmental product declaration (EPD) for hybrid windows made with the PVC profiles manufactured by Thermoplast Nextrusions.

Presentation of the company

Thermoplast Nextrusions is Quebec's largest extruder of PVC profiles for the door and window industry.

Product description

The EPD includes ten types of hybrid windows (aluminium/PVC (H1) and aluminium/PVC/aluminium (H2)): awning, casement, fixed and panoramic (H1 and H2) as well as sliding and double-hung (H1). The hybrid windows are intended for the residential and commercial building markets.

Product composition

The hybrid windows are made up of PVC profiles, aluminium extrusions, sealed units (double glazing) and hardware (stainless steel components).

Administrative information

- **Validity period**

  April 2026 – April 2031
- **Product category rules**

  NSF 1102-23 Product Category Rule for Environmental Product Declarations: Fenestration Assemblies. 2024 - 2028
- **EPD development**

  CT Consultant
- **EPD verification**

  Marie Bellemare Consulting

Methodological aspects

- **Declared unit**

  1 m^2 of window (frame and glazing) corresponding to the categories presented in the ANSI/NFRC 100 standard
- **System boundaries**

  Cradle to gate (A1 – A3)
- **Impact assessment method**

  TRACI 2.1

Certifications

AAMA Proud Member

NFRC National Fenestration Rating Council® CERTIFIED

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EPD SUMMARY SHEET

HYBRID WINDOWS (ALUMINIUM/PVC AND ALUMINIUM/PVC/ALUMINIUM)

Environmental life cycle impacts - 1 m^2 of hybrid window

IMPACT CATEGORY	INDICATOR	AWNING		CASEMENT		FIXED		PANORAMIC		SLIDING	DOUBLE-HUNG
		H1	H2	H1	H2	H1	H2	H1	H2	H1	H1
Global warming potential	kg CO_2 eq	7.80E+1	9.48E+1	7.80E+1	9.48E+1	5.62E+1	6.39E+1	4.71E+1	5.37E+1	6.39E+1	6.33E+1
Acidification of soil and water sources potential	kg SO_2 eq	4.15E-1	5.03E-1	4.15E-1	5.03E-1	3.15E-1	3.55E-1	2.86E-1	3.21E-1	3.37E-1	3.39E-1
Eutrophication potential	kg N eq	1.13E-1	1.38E-1	1.13E-1	1.38E-1	9.15E-2	1.02E-1	5.44E-2	6.28E-2	1.22E-1	1.10E-1
Smog formation potential	kg O_3 eq	5.40E+0	6.15E+0	5.40E+0	6.15E+0	4.22E+0	4.55E+0	3.84E+0	4.13E+0	4.68E+0	4.69E+0
Ozone depletion potential	kg CFC-11 eq	8.21E-6	8.90E-6	8.21E-6	8.90E-6	8.88E-6	9.03E-6	3.62E-6	3.69E-6	1.30E-5	1.13E-5

Contribution analysis

The contribution analysis shows the share of impacts attributable to the frame and the glazing. The manufacturing of the frame is the main process contributing to the impacts for all the impact categories for the awning, casement, sliding and double-hung windows (51.1 to 93.4% of the total impacts). For the other types of windows, the manufacturing of the frame is also the primary contributing process (55.3 to 89.4%) with a few exceptions for fixed and panoramic windows in the *Smog formation*, *Global Warming* and *Acidification* categories, which contain a smaller proportion of PVC profiles and stainless steel.

Additional environmental information

Thermoplast Nextrusions holds the two following recognitions:

- "Performance +" rating from Recyc-Québec's ICI on recycle + program for the 2022-2025 period;
- Carbon Care® certification from Enviro-Acces for the 2022-2023 period.

Contact details

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ASTM INTERNATIONAL

1 | GENERAL INFORMATION

Product name and description	Hybrid windows. Description in section 3.1 of the EPD.
Manufacturer name and address	Thermoplast Nextrusions 3035 Le Corbusier Boulevard Laval, Quebec, Canada H7L 4C3 1 800 361-9261 www.thermoplast.com
Program operator	ASTM International 100 Barr Harbor Drive, West Conshohocken, PA 19428 United States www.astm.org
General program instructions	ASTM International (2024) Environmental Product Declarations https://www.astm.org/products-services/certification/environmental-product-declarations/epd-pcr.html
Declaration number	EPD 1159
Declared unit	1 m² of hybrid window
Product Category Rules (PCR) used	NSF 1102-23 Product Category Rule for Environmental Product Declarations: Fenestration Assemblies. 2024 - 2028 [1]
Product's intended application and use	Residential and commercial buildings
Bill of materials (BOM)	Presented in section 3.4 of the EPD
Markets of applicability	North America
Date of issue	21 April 2026
Period of validity	April 2026 – April 2031
Type of EPD and scope of application	Specific cradle-to-gate EPD
Reference year	2021
Assumptions	Presented in section 4.4 of the EPD
Cut-off criteria	Presented in sections 4.4 and 4.5 of the EPD
Allocation rules	Presented in section 4.6 of the EPD
Data quality	Presented in section 4.7 of the EPD
LCA software	OpenLCA v2.4.1 [2]
Database	Ecoinvent v3.11 [3]
Impact assessment method	TRACI 2.1 [4]
This life cycle assessment was conducted in accordance with ISO 14044:2006 and the reference PCR by	CT Consultant www.ctconsultant.ca
The PCR review was conducted by	Thomas Gloria, Ph.D. Industrial Ecology Consultants 35 Bracebridge Road, Newton, Massachusetts, United States t.gloria@industrial-ecology.com
The life cycle assessment was independently verified in accordance with ISO 14044:2006 and the reference PCR, and the declaration was independently verified in accordance with ISO 14025:2006 by: **ISO 21930:2017 serves as the core PCR and NSF 1102-23 Product Category Rule for Environmental Product Declarations: Fenestration Assemblies is used as the specific PCR.** **☐ Internal ☒ External**	Digitally signed by Marie Bellemare Date: 2026.04.29 16:18:30 -04'00' Marie Bellemare, Marie Bellemare Consulting
Further information may be obtained from:	Thermoplast Nextrusions www.thermoplast.com

Comparability of EPDs

This environmental product declaration (EPD) complies with CAN/CSA-ISO 14025:2006 [5] as well as the above-mentioned PCR. This EPD meets all comparability requirements stated in ISO 14025:2006. However, differences in certain assumptions, data quality, and variability between LCA data sets may still exist. As such, caution should be exercised when evaluating EPDs from different manufacturers or programs, as the EPD results may not be entirely comparable. Any EPD comparison must be carried out at building or infrastructure level per ISO 21930:2017 guidelines [6]. The results presented in this EPD reflect an average performance of the product and its actual impacts may vary on a case-by-case basis.

2 | PRESENTATION OF THERMOPLAST NEXTRUSIONS

A key player in Canada's door and window industry, Thermoplast Nextrusions stands out as a leader among PVC profile manufacturers, specifically targeting the Quebec and Maritime markets. Thermoplast Nextrusions PVC profiles are used for several types of windows: awning, casement, fixed, panoramic, sliding and double-hung. The company has facilities to respond to market demands and customize its products to meet specific customer requirements. This EPD focuses on the production activities of Thermoplast Nextrusions' manufacturing plant located at 3035 Le Corbusier Boulevard in Laval (Quebec, Canada).

3 | PRODUCT DESCRIPTION

3.1 | Summary description of the product and its applications

The hybrid windows (H1 and H2 versions) made with the PVC profiles manufactured by Thermoplast Nextrusions are intended for the residential and commercial building markets. This EPD includes ten window models: awning, casement, fixed and panoramic (aluminium/PVC-H1 and aluminium/PVC/aluminium-H2), as well as sliding and double-hung (aluminium/PVC-H1) (Figure 1). The hybrid windows consist of four constituents: PVC profiles, aluminium extrusions, sealed units (double glazing) and hardware (stainless steel components). The PVC profiles are manufactured using virgin and recycled raw materials. The PVC profiles emit no VOCs over their service life. The aluminium extrusions are made from AA6063 alloy and can be used on the exterior side of the window (aluminium/PVC-H1) or on both the interior and exterior sides of the window (aluminium/PVC/aluminium-H2). The sealed units consist of two 3 mm- thick glass panes separated by an air space.

Figure 1: Cross-section of an aluminium/ PVC/aluminium (H2) hybrid window

3.2 | Products covered by the EPD

This EPD covers ten types of hybrid windows: awning (H1/H2), casement (H1/H2), fixed (H1/H2), panoramic (H1/H2), sliding (H1) and double-hung (H1) (Figure 2).

Awning window (H1/H2)

Casement window (H1/H2)

Fixed window (H1/H2)

Panoramic window (H1/H2)

Sliding window (H1)

Double-hung window (H1)

Figure 2: Hybrid windows included in the EPD

3.3 | Technical specifications of the hybrid windows

The hybrid windows meet the performance standards listed in Table 1 [1].

Table 1: Standards met by the hybrid windows

STANDARD ABBREVIATION	NAME OF STANDARD
AAMA/WDMA/CSA 101/I.S.2/A440	North American window standard
CSA A440S1	Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440
CSA A440.4	Window installation
CSA A440.2	Energy efficiency of fenestration systems
ANSI/NFRC100	Procedure for determining the fenestration U-factors
ASTM D4726	Rigid PVC exterior profile extrusion for assembled windows
AAMA 303	Voluntary specification for rigid polyvinyl chloride (PVC) exterior profile
CAN/ULC S134	Standard method of fire tests of exterior wall assemblies containing Energi Fenestration Solution Hybrid 4600

The hybrid windows are recognized by window system certifications from the AAMA (American Architectural Manufacturers Association), which has become the FGIA (Fenestration & Glazing Industry Alliance), the NFRC (National Fenestration Rating Council) and Energy Star [7].

Thermoplast Nextrusions guarantees that PVC door and window profiles will be free from manufacturing defects that could cause rotting, cracking, curling, pitting, corrosion, peeling, blistering or non-uniform colour for a period of 20 years from the date of purchase [8].

3.4 | Composition of hybrid windows

The ten types of hybrid windows are made up of PVC profiles (virgin and recycled), aluminium extrusions, double glazing and hardware (stainless steel components). The mass composition of the windows is presented at Table 2.

Table 2: Mass of constituents per 1 m² of hybrid window

CONSTITUENT	VIRGIN PVC PROFILES	RECYCLED PVC PROFILES	ALUMINIUM EXTRUSIONS	DOUBLE GLAZING	STAINLESS STEEL COMPONENTS	TOTAL
MASS (KG)						
AWNING H1	3.49	4.97	4.97	10.03	1.74	25.20
AWNING H2	3.22	4.97	8.03	10.03	1.74	27.99
CASEMENT H1	3.49	4.97	4.97	10.03	1.74	25.20
CASEMENT H2	3.22	4.97	8.03	10.03	1.74	27.99
FIXED H1	4.61	0.00	3.07	11.49	0.08	19.25
FIXED H2	4.34	0.00	4.54	11.49	0.08	20.45
PANORAMIC H1	0.72	3.69	2.88	12.36	0.08	19.73
PANORAMIC H2	0.44	3.69	4.18	12.36	0.08	20.75
SLIDING H1	7.75	0.00	2.58	10.78	0.31	21.42
DOUBLE-HUNG H1	6.47	0.00	2.45	11.08	0.78	20.78
SHARE OF TOTAL WINDOW MASS						
AWNING H1	13.9%	19.7%	19.7%	39.8%	6.9%	100.0%
AWNING H2	11.5%	17.8%	28.7%	35.8%	6.2%	100.0%
CASEMENT H1	13.9%	19.7%	19.7%	39.8%	6.9%	100.0%
CASEMENT H2	11.5%	17.8%	28.7%	35.8%	6.2%	100.0%
FIXED H1	23.9%	0.0%	16.0%	59.7%	0.4%	100.0%
FIXED H2	21.2%	0.0%	22.2%	56.2%	0.4%	100.0%
PANORAMIC H1	3.7%	18.7%	14.6%	62.6%	0.4%	100.0%
PANORAMIC H2	2.1%	17.8%	20.1%	59.6%	0.4%	100.0%
SLIDING H1	36.2%	0.0%	12.1%	50.3%	1.4%	100.0%
DOUBLE-HUNG H1	31.1%	0.0%	11.8%	53.3%	3.7%	100.0%

There are no other materials (sealants, weatherstripping, adhesives) except those listed.

3.5 | Hybrid windows manufacturing

The PVC used to manufacture profiles at the Thermoplast Nextrusions plant contains a portion of virgin material and a portion of recycled material. The virgin PVC (primary) is mainly sourced from two suppliers, one located in

Concord (Ontario, Canada) and the other in Westlake (Texas, USA). The recycled PVC (secondary material) comes from manufacturing losses (scrap) of fenestration products. These manufacturing losses are recovered by a recycler who transforms them into granules using a granulator. The PVC profiles are produced via an extrusion process (Figure 3). The PVC granules are heated and pressurized to pass through a customized die to form a profile which can be used to make a window frame. The material is extracted from the die using a haul-off machine to obtain a profile with constant dimensions. The scraps generated by the extrusion process are reprocessed and reintroduced into the extrusion process. The extrusion scraps that cannot be reused are sent to a recycler. The resulting profiles are then cut with a saw and packaged. Finally, Thermoplast Nextrusions manufactures its own equipment for the extrusion process. The waste cardboard, metal and wood are sent for recycling. Saw shavings, contaminated cardboard and office waste from the Thermoplast Nextrusions plant are sent to landfill.

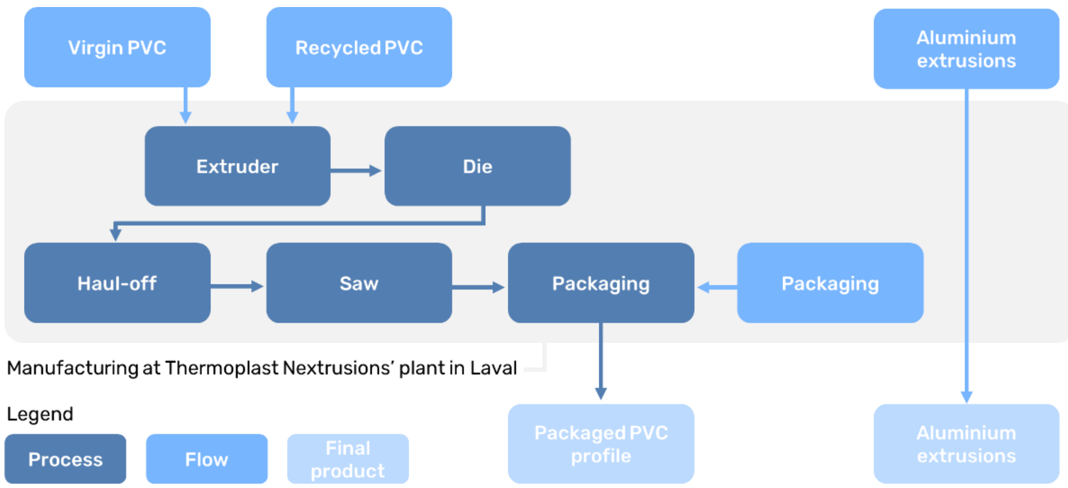

Figure 3: Production stages of the PVC profiles at the Thermoplast Nextrusions plant (Laval, Quebec, Canada)

The aluminium extrusions are manufactured from aluminium billets, then painted when required before being shipped to the Thermoplast Nextrusions manufacturing plant.

The PVC profiles manufactured at the Thermoplast Nextrusions plant (available in different sizes according to the requirements of window manufacturer) as well as the aluminium extrusions are shipped by truck to window manufacturing plants. The window manufacturing process consists of assembling the four constituents: PVC profiles, aluminium extrusions, sealed units (double glazing) and hardware (stainless steel components) (Figure 4). It should be noted that only Thermoplast Nextrusions provided primary data for carrying out this EPD.

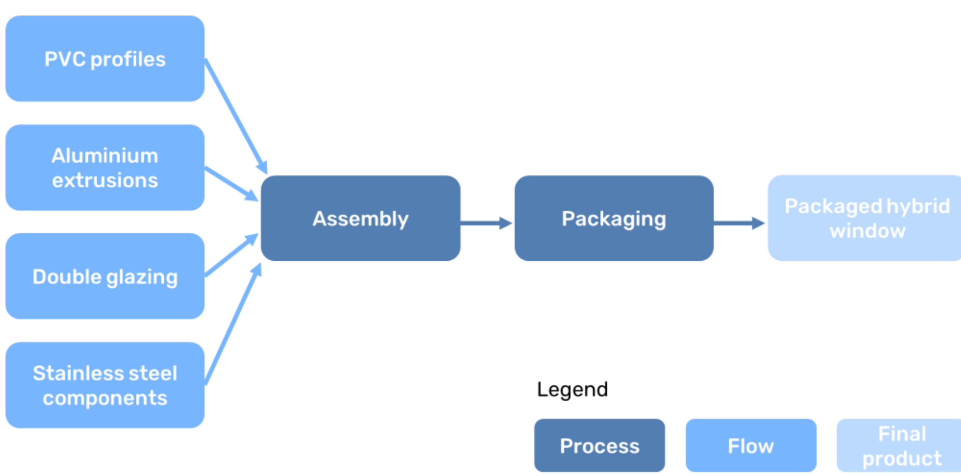

Figure 4: Manufacturing stages of the hybrid windows at the window assembly plant

3.6 | Packaging

Before shipping, the PVC profiles are packaged with cardboard, plastic film and bags, nylon straps, polypropylene tape and newspaper. In the case of the aluminium extrusions, no additional packaging is added. The windows are packaged with plastic film (0.08 kg/m^2 of window) and cardboard wedges (0.04 kg/m^2 of window) for transport to the point of sale.

4 | METHODOLOGY USED FOR THE LIFE CYCLE ASSESSMENT

4.1 | Declared unit

The declared unit is defined according to the PCR [1] as follows:

"1 m^2 of window (frame and glazing) corresponding to the categories presented in the ANSI/NFRC 100 standard." [1]

The declared unit refers to the 10 types of hybrid windows (aluminium/PVC and aluminium/PVC/aluminium) and their packaging (Table 3). The mass of the windows were calculated based on the standard dimensions from the PCR [1] then standardised to 1 m^2 (Table 4).

Table 3: Names and categories of the ten types of hybrid windows

NAME OF THE HYBRID WINDOW	WINDOW TYPE ACCORDING TO TABLE 1 OF THE PCR	WINDOW DIMENSIONS (WIDTH X HEIGHT)	SOURCE
Awning H1	Projecting (Awning – single)	1500 x 600 mm	NSF PCR for Fenestration Assemblies [1]
Awning H2	Projecting (Awning – single)	1500 x 600 mm	
Casement H1	Casement - single	600 x 1500 mm	
Casement H2	Casement - single	600 x 1500 mm	
Fixed H1	Fixed	1200 x 1500 mm	
Fixed H2	Fixed	1200 x 1500 mm	
Panoramic H1	Fixed	1200 x 1500 mm	
Panoramic H2	Fixed	1200 x 1500 mm	
Sliding H1	Horizontal slider	1500 x 1200 mm	
Double-hung H1	Vertical slider	1200 x 1500 mm	

Table 4: Key parameters of the hybrid windows' declared unit

PARAMETER		VALUE	UNIT
Declared unit	1 m² of window (frame and glazing) corresponding to the categories presented in the ANSI/NFRC 100 standard		
Window mass	Awning H1	25.20	kg
	Awning H2	27.99	kg
	Casement H1	25.20	kg
	Casement H2	27.99	kg
	Fixed H1	19.25	kg
	Fixed H2	20.45	kg
	Panoramic H1	19.73	kg
	Panoramic H2	20.75	kg
	Sliding H1	21.42	kg
	Double-hung H1	20.78	kg
Window packaging mass		0.13	kg

4.2 | System boundaries

The cradle-to-gate LCA includes the production stage of hybrid windows comprising life cycle modules A1, A2 and A3 (ISO 21930:2017 [6]). Thus, the other life cycle modules as identified by these standards are excluded from the assessed system.

Table 5: Life cycle modules included and excluded from the LCA

PRODUCTION STAGE (A1-A3)			CONSTRUCTION STAGE (A4-A5)		USE STAGE (B1-B7)							END-OF-LIFE STAGE (C1-C4)				BEYOND THE LIFE CYCLE (D)
Production of raw materials	Transport of raw materials	Product manufacturing	Transport to the construction site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Energy use	Water use	Deconstruction	Transport to the waste treatment site	Waste treatment	Disposal	Benefits associated with reuse / recycling / energy recovery
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME

Legend

X: Life cycle module included in the LCA

ME: Life cycle module excluded from the LCA

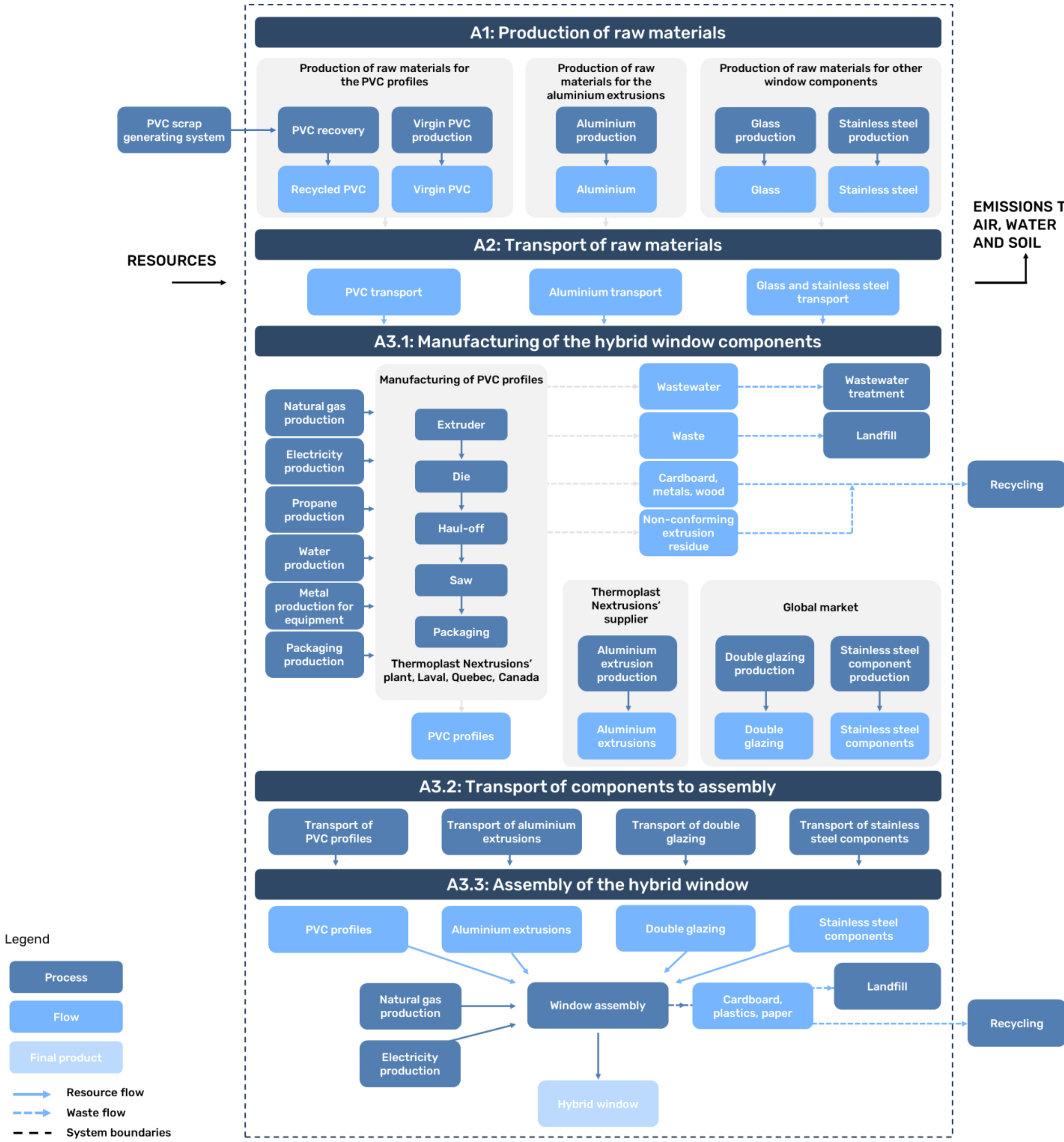

Figure 5: System boundary – Hybrid window

4.3 | Reference period

The reference period considered is the calendar year 2021 (from 1 January 2021 to 31 December 2021).

4.4 | Assumptions

Carrying out an LCA involves making assumptions when data is incomplete or missing. The following assumptions were applied with respect to the present LCA:

- **Aluminium production (A1)**. To represent the production of aluminium, the impact and inventory results of an EPD representing aluminum billet production in Arvida (Quebec, Canada) were used [9]. Since this EPD provided no results for the inventory categories “Use of renewable material resources” and “Radioactive waste,” scores of the data “aluminum production, primary, ingot, Canada” from the Ecoinvent database were used as a proxy for these categories.
- **Double glazing production (A1 - A3.1)**. The data from the Ecoinvent database "market for glazing, double, U<1.1 W/m^{2}K | Cutoff, S - GLO" used to model the glazing considers a mass of 20 kg of glazing for 1 m^2 of double glazing. An proportional scaling was carried out to model the impacts corresponding to the mass of glazing in the windows under study [3].
- **Double glazing production (A1 - A3.1).** The Ecoinvent process "market for glazing, double, U<1.1 W/m^2 K - GLO" was separated in two parts attributed to distinct modules to respect the ISO 21930:2017 standard. Thus, the impacts of glass production were attributed to module A1 - Production of raw materials and the impacts of glazing production were attributed to module A3.1 - Manufacturing of hybrid window components [6].
- **Aluminium extrusion painting production (A3.1).** To model the production of the paint applied to aluminium extrusions, the flow for paint from the Ecoinvent database "window frame production, aluminium, U=1.6 W/m^{2}K" was used.
- **Transport of raw materials to glazing and steel component manufacturers (A2).** The distances and transport modes were taken from the PCR [1].
- **Transport of the PVC profiles, aluminium extrusions, glazing and stainless steel components to the assembly plant (A3.2).** The distances and modes of transport from the PCR were used [1].
- **Transport by truck (A1 – A3).** In line with the PCR, transport by truck includes empty returns [1].
- **Assembly losses’ end of life (A3.3).** In line with the PCR, material losses during assembly are considered to be landfilled [1].

4.5 | Cut-off criteria

In accordance with ISO 21930:2017 [6] and the PCR [1], all input and output flows whose mass and/or energy and/or environmental impacts account for more than 1% of the total cumulative mass and/or energy and/or impacts have been included. Also in accordance with the standard, at least 95% of mass, energy and environmental impact flows were considered. Equipment and infrastructure maintenance, administrative activities and employee transportation were not included in the LCA model. No known mass or energy flows were deliberately excluded.

4.6 | Allocation

When a process in the life cycle of a product generates several outputs (multifunctional processes) or is linked to another system (life cycle of a product outside the boundaries of the system under study), the environmental impact of the process must be allocated to the different products, co-products and systems. The allocation methods considered for this study are:

- **Allocation for end-of-life processes.** The cut-off approach was chosen in accordance with ISO 21930:2017 [6]. This approach specifies that the impacts associated with secondary materials entering the system are to be attributed to the system that generated them, and that the benefits associated with the recycling materials leaving the system are not included. In this study, this means that the only impacts associated with the recycled PVC used in the manufacturing of the profiles are that of its preparation (grinding and extrusion) and transport to Thermoplast Nextrusions’ manufacturing plant. Using the same principle, no environmental benefits associated with waste materials generated by the Thermoplast Nextrusions plant intended for recycling (cardboard, metals, plastics, paper, wood) were accounted for.

- **Allocation approach in Ecoinvent data.** The Ecoinvent data used is "Allocation, cut-off by classification" which attributes the impacts of secondary materials entering the system to those that generated them and excludes the benefits associated with recycling materials. This is in line with the cut-off rule specified in ISO 21930:2017.
- **Allocation for multifunctional processes.** During the window assembly process, four constituents (PVC profiles, aluminium extrusions, glazing and hardware) are combined to manufacture the windows. Thus, the impacts of electricity and natural gas consumption associated with the assembly process must be allocated between these different constituents in order to present the impacts distributed between the frame and the glazing [1]. Based on the ISO 21930:2017 standard, the impacts were distributed according to mass allocation (Figure 3) [6]. As window manufacturing does not generate any co-products, no other allocation of this type is considered in relation to window manufacturing.

4.7 | Data sources and quality

Table 6: Sources of inventory data for window manufacturing

TYPE OF DATA	SOURCE
Foreground data	Primary foreground data was provided by Thermoplast Nextrusions for the year 2021. This includes measured data concerning: • the manufacturing of PVC profiles used for window frames and their packaging; • the composition of hybrid windows and their packaging. • transport distances for aluminium extrusions at Thermoplast Nextrusions' manufacturing plant.
	Secondary foreground data comes from the following sources: • scientific report (window assembly energy); • PCR (distance and modes of transport of window constituents) [1].
Background data	Background data comes from the following sources: • Ecoinvent v3.11 database [3]; • EPD [9].

Table 7: Qualitative assessment of inventory data quality

CRITERION	EVALUATION
Geographical representativeness	The primary foreground data related to the production stages of PVC profiles represents the specific context of Thermoplast Nextrusions and therefore has a high geographical representativeness. The secondary foreground data from the PCR are representative of North America and thus are considered to have a satisfactory representativeness. The secondary foreground data from the scientific report (window assembly energy) relates to the Spanish context and is considered to be acceptable in terms of representativeness. The geographical representativeness of the background data for aluminium production derived from an EPD is high because these data are representative of the plant where are the aluminium billets used for extrusions are produced, located in Arvida (Quebec, Canada). The geographical representativeness of the main background data (Ecoinvent) such as the electricity grid mix, natural gas production and packaging cardboard production is considered satisfactory, and sufficient for the production of virgin and secondary PVC, glass, steel and plastic packaging as well as transport processes. The foreground and background data are considered to have a satisfactory geographical representativeness to meet the objective of the study.
Technological representativeness	The primary foreground data regarding the production of PVC profiles and the composition of the windows are based on measurements carried out by Thermoplast Nextrusions and are therefore considered to be high in their level of technological representativeness. The secondary foreground data regarding the electricity for window assembly are taken from a scientific report [10] and are deemed to be acceptable in terms of technological representativeness. The technological representativeness of the background data for aluminium production derived from an EPD is high because it is representative of aluminium billet production in Quebec. The technological representativeness of the main background data (Ecoinvent) is also considered to be satisfactory for PVC, packaging, electricity and natural gas production, and sufficient for steel and glass production and transport. The foreground and background data are considered to have a satisfactory technological representativeness to reach the objective of the study.

CRITERION	EVALUATION
Temporal representativeness	The primary foreground data supplied by Thermoplast Nextrusions is representative of the reference period (year 2021) which is considered to be highly representative. The secondary foreground data comes from the PCR published in 2024 and a scientific report published in 2005 (amount of electricity for the assembly). The latter is the best available data specific to PVC-containing frames and follows a conservative approach, as it is likely that assembly technology consumes less electricity than in 2005. This data is therefore considered to have an acceptable temporal representativeness to meet the objectives of the study. The background data comes mainly from the Ecoinvent database v3.11 (2024). This version is based on version 3.0, released annually since 2013. It should be noted that some of the data in version 3.0 comes from earlier versions (1991-2012), but the data are considered to be satisfactorily representative. The background data for the production of aluminium billets used for the manufacturing of the aluminium extrusions comes from an EPD [9] published in 2024 and from the Ecoinvent database v3.11 (2024). The foreground and background data are considered to have a satisfactory temporal representativeness to meet the objective of the study.
Precision	The primary foreground data are the results of calculations, realistic estimates and measured data and are considered to be sufficiently accurate. The secondary background data come from documented and reliable sources (scientific report, PCR), which means that their precision is considered satisfactory. For the background data used for the production of raw materials, energy and transport, the precision is deemed to be sufficient. The level of precision for the primary and secondary data is considered sufficient to reach the objective of the study.
Completeness	All processes whose mass, energy or environmental impacts are above the cut-off threshold (1%) have been included in the LCA in accordance with the PCR "NSF Product Category Rule for Environmental Product Declarations: Fenestration Assemblies" [1]. No known flows were deliberately excluded. The study is considered to have a satisfactory level of completeness.
Consistency	For the methodological aspects of the LCA (e.g., assumptions, allocation methods, impact assessment method, data sources and modelling approaches), the aim was to achieve maximum consistency. The only methodological inconsistency observed, although justified by an improvement in technological and geographical representativeness, is that surrounding the use of three types of life cycle inventory data for window assembly (Ecoinvent, an EPD and a scientific report) [10]. Another inconsistency concerns the use of inventory results from Ecoinvent data for three categories related to aluminium production, as the aluminium EPD does not provide results for these categories. The study is considered to have a sufficient level of consistency.
Reproducibility	Information on the assumptions, allocation methods, impact assessment methods, data sources and modelling data references, quantities and processes used is provided in the LCA report [11]. The reproducibility is considered satisfactory for the purpose of the study.
Reliability	The primary data are considered to have a low uncertainty as they are based on measured data from Thermoplast Nextrusions. The secondary data are considered to have a sufficiently low uncertainty to meet the objective of the study. This assessment of data quality considers that reliability is high and uncertainty low.

5 | ENVIRONMENTAL IMPACTS AND INVENTORY RESULTS

5.1 | Environmental impact assessment and life cycle inventory indicators

The environmental life cycle impacts and the inventory results are expressed on the basis of the declared unit, i.e. "*1 m² of window (frame and glazing) corresponding to the categories presented in the ANSI/NFRC 100 standard*". The environmental impacts of the ten types of windows were expressed according to five impact categories of the TRACI 2.1 assessment method. The environmental impacts are also presented for the three life cycle modules selected for the LCA: A1 – Production of raw materials; A2 - Transport of raw materials; and A3 - Product manufacturing [4,12].

Table 8: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid awning H1 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	7.80E+1	5.10E+1	3.72E+0	2.33E+1
Acidification of soil and water sources potential	kg SO_2 eq	4.15E-1	2.85E-1	1.99E-2	1.10E-1
Eutrophication potential	kg N eq	1.13E-1	8.42E-2	1.72E-3	2.75E-2
Smog formation potential	kg O_3 eq	5.40E+0	2.99E+0	5.35E-1	1.88E+0
Ozone depletion potential	kg CFC-11 eq	8.21E-6	6.57E-6	5.31E-8	1.59E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	5.01E+2	3.95E+2	8.50E-1	1.05E+2
Renewable primary resources used as raw materials[2]	MJ	6.91E+0	0.00E+0	0.00E+0	6.91E+0
Total renewable primary resources[3]	MJ	5.08E+2	3.95E+2	8.50E-1	1.12E+2
Non-renewable primary resources used as energy [2]	MJ	7.26E+2	3.55E+2	5.52E+1	3.15E+2
Non-renewable primary resources used as raw materials[2]	MJ	8.89E+1	7.60E+1	0.00E+0	1.29E+1
Total non-renewable primary resources[4]	MJ	8.14E+2	4.31E+2	5.52E+1	3.28E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	5.02E+0	5.02E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	2.48E+0	9.80E-1	1.63E-2	1.48E+0
Freshwater consumption[8]	m^3	1.97E+0	1.41E+0	7.21E-3	5.49E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	7.73E-1	N/A	N/A	7.73E-1
Radioactive waste - high level[10,11]	kg	2.92E-4	1.50E-4	3.47E-6	1.39E-4
Radioactive waste – low and medium level[10,11]	kg	5.43E-4	3.40E-4	8.48E-6	1.95E-4
Materials for recycling[12]	kg	4.38E-1	0.00E+0	0.00E+0	4.38E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 9: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid awning H2 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	9.48E+1	6.40E+1	3.96E+0	2.69E+1
Acidification of soil and water sources potential	kg SO_2 eq	5.03E-1	3.59E-1	2.09E-2	1.24E-1
Eutrophication potential	kg N eq	1.38E-1	1.06E-1	1.81E-3	2.98E-2
Smog formation potential	kg O_3 eq	6.15E+0	3.49E+0	5.60E-1	2.11E+0
Ozone depletion potential	kg CFC-11 eq	8.90E-6	7.22E-6	5.69E-8	1.62E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	7.33E+2	6.08E+2	9.00E-1	1.25E+2
Renewable primary resources used as raw materials[2]	MJ	6.70E+0	0.00E+0	0.00E+0	6.70E+0
Total renewable primary resources[3]	MJ	7.40E+2	6.08E+2	9.00E-1	1.31E+2
Non-renewable primary resources used as energy [2]	MJ	7.71E+2	3.46E+2	5.91E+1	3.66E+2
Non-renewable primary resources used as raw materials[2]	MJ	8.25E+1	7.00E+1	0.00E+0	1.25E+1
Total non-renewable primary resources[4]	MJ	8.53E+2	4.16E+2	5.91E+1	3.79E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	5.02E+0	5.02E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	2.89E+0	1.16E+0	1.71E-2	1.71E+0
Freshwater consumption[8]	m^3	2.76E+0	2.09E+0	7.71E-3	6.61E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	7.83E-1	N/A	N/A	7.83E-1
Radioactive waste - high level[10,11]	kg	3.32E-4	1.68E-4	3.69E-6	1.60E-4
Radioactive waste – low and medium level[10,11]	kg	6.10E-4	3.82E-4	9.02E-6	2.19E-4
Materials for recycling[12]	kg	4.24E-1	0.00E+0	0.00E+0	4.24E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 10: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid casement H1 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	7.80E+1	5.10E+1	3.72E+0	2.33E+1
Acidification of soil and water sources potential	kg SO_2 eq	4.15E-1	2.85E-1	1.99E-2	1.10E-1
Eutrophication potential	kg N eq	1.13E-1	8.42E-2	1.72E-3	2.75E-2
Smog formation potential	kg O_3 eq	5.40E+0	2.99E+0	5.35E-1	1.88E+0
Ozone depletion potential	kg CFC-11 eq	8.21E-6	6.57E-6	5.31E-8	1.59E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	5.01E+2	3.95E+2	8.50E-1	1.05E+2
Renewable primary resources used as raw materials[2]	MJ	6.91E+0	0.00E+0	0.00E+0	6.91E+0
Total renewable primary resources[3]	MJ	5.08E+2	3.95E+2	8.50E-1	1.12E+2
Non-renewable primary resources used as energy [2]	MJ	7.26E+2	3.55E+2	5.52E+1	3.15E+2
Non-renewable primary resources used as raw materials[2]	MJ	8.89E+1	7.60E+1	0.00E+0	1.29E+1
Total non-renewable primary resources[4]	MJ	8.14E+2	4.31E+2	5.52E+1	3.28E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	5.02E+0	5.02E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	2.48E+0	9.80E-1	1.63E-2	1.48E+0
Freshwater consumption[8]	m^3	1.97E+0	1.41E+0	7.21E-3	5.49E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	7.73E-1	N/A	N/A	7.73E-1
Radioactive waste - high level[10,11]	kg	2.92E-4	1.50E-4	3.47E-6	1.39E-4
Radioactive waste – low and medium level[10,11]	kg	5.43E-4	3.40E-4	8.48E-6	1.95E-4
Materials for recycling[12]	kg	4.38E-1	0.00E+0	0.00E+0	4.38E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 11: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid casement H2 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	9.48E+1	6.40E+1	3.96E+0	2.69E+1
Acidification of soil and water sources potential	kg SO_2 eq	5.03E-1	3.59E-1	2.09E-2	1.24E-1
Eutrophication potential	kg N eq	1.38E-1	1.06E-1	1.81E-3	2.98E-2
Smog formation potential	kg O_3 eq	6.15E+0	3.49E+0	5.60E-1	2.11E+0
Ozone depletion potential	kg CFC-11 eq	8.90E-6	7.22E-6	5.69E-8	1.62E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	7.33E+2	6.08E+2	9.00E-1	1.25E+2
Renewable primary resources used as raw materials[2]	MJ	6.70E+0	0.00E+0	0.00E+0	6.70E+0
Total renewable primary resources[3]	MJ	7.40E+2	6.08E+2	9.00E-1	1.31E+2
Non-renewable primary resources used as energy [2]	MJ	7.71E+2	3.46E+2	5.91E+1	3.66E+2
Non-renewable primary resources used as raw materials[2]	MJ	8.25E+1	7.00E+1	0.00E+0	1.25E+1
Total non-renewable primary resources[4]	MJ	8.53E+2	4.16E+2	5.91E+1	3.79E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	5.02E+0	5.02E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	2.89E+0	1.16E+0	1.71E-2	1.71E+0
Freshwater consumption[8]	m^3	2.76E+0	2.09E+0	7.71E-3	6.61E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	7.83E-1	N/A	N/A	7.83E-1
Radioactive waste - high level[10,11]	kg	3.32E-4	1.68E-4	3.69E-6	1.60E-4
Radioactive waste – low and medium level[10,11]	kg	6.10E-4	3.82E-4	9.02E-6	2.19E-4
Materials for recycling[12]	kg	4.24E-1	0.00E+0	0.00E+0	4.24E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 12: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid fixed H1 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	5.62E+1	3.85E+1	2.82E+0	1.49E+1
Acidification of soil and water sources potential	kg SO_2 eq	3.15E-1	2.22E-1	1.64E-2	7.69E-2
Eutrophication potential	kg N eq	9.15E-2	7.32E-2	1.36E-3	1.70E-2
Smog formation potential	kg O_3 eq	4.22E+0	2.46E+0	4.41E-1	1.32E+0
Ozone depletion potential	kg CFC-11 eq	8.88E-6	7.39E-6	3.99E-8	1.46E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	2.95E+2	2.33E+2	6.72E-1	6.10E+1
Renewable primary resources used as raw materials[2]	MJ	4.02E+0	0.00E+0	0.00E+0	4.02E+0
Total renewable primary resources[3]	MJ	2.99E+2	2.33E+2	6.72E-1	6.51E+1
Non-renewable primary resources used as energy [2]	MJ	5.57E+2	3.11E+2	4.17E+1	2.05E+2
Non-renewable primary resources used as raw materials[2]	MJ	1.08E+2	1.00E+2	0.00E+0	7.95E+0
Total non-renewable primary resources[4]	MJ	6.65E+2	4.11E+2	4.17E+1	2.13E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	1.63E+0	6.47E-1	1.31E-2	9.74E-1
Freshwater consumption[8]	m^3	1.25E+0	9.18E-1	5.61E-3	3.23E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	4.80E-1	N/A	N/A	4.80E-1
Radioactive waste - high level[10,11]	kg	1.89E-4	9.58E-5	2.82E-6	9.04E-5
Radioactive waste – low and medium level[10,11]	kg	3.82E-4	2.38E-4	6.91E-6	1.36E-4
Materials for recycling[12]	kg	2.39E-1	0.00E+0	0.00E+0	2.39E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 13: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid fixed H2 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	6.39E+1	4.44E+1	2.92E+0	1.66E+1
Acidification of soil and water sources potential	kg SO_2 eq	3.55E-1	2.56E-1	1.68E-2	8.29E-2
Eutrophication potential	kg N eq	1.02E-1	8.23E-2	1.40E-3	1.79E-2
Smog formation potential	kg O_3 eq	4.55E+0	2.69E+0	4.51E-1	1.42E+0
Ozone depletion potential	kg CFC-11 eq	9.03E-6	7.51E-6	4.15E-8	1.47E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	4.06E+2	3.35E+2	6.92E-1	6.97E+1
Renewable primary resources used as raw materials[2]	MJ	3.82E+0	0.00E+0	0.00E+0	3.82E+0
Total renewable primary resources[3]	MJ	4.09E+2	3.35E+2	6.92E-1	7.35E+1
Non-renewable primary resources used as energy [2]	MJ	5.73E+2	3.01E+2	4.32E+1	2.29E+2
Non-renewable primary resources used as raw materials[2]	MJ	1.02E+2	9.42E+1	0.00E+0	7.60E+0
Total non-renewable primary resources[4]	MJ	6.75E+2	3.96E+2	4.32E+1	2.36E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	1.82E+0	7.30E-1	1.34E-2	1.08E+0
Freshwater consumption[8]	m^3	1.62E+0	1.24E+0	5.82E-3	3.72E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	4.80E-1	N/A	N/A	4.80E-1
Radioactive waste - high level[10,11]	kg	1.89E-4	9.58E-5	2.82E-6	9.04E-5
Radioactive waste – low and medium level[10,11]	kg	3.82E-4	2.38E-4	6.91E-6	1.36E-4
Materials for recycling[12]	kg	2.25E-1	0.00E+0	0.00E+0	2.25E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 14: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid panoramic H1 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	4.71E+1	2.90E+1	3.07E+0	1.50E+1
Acidification of soil and water sources potential	kg SO_2 eq	2.86E-1	1.89E-1	1.78E-2	7.84E-2
Eutrophication potential	kg N eq	5.44E-2	3.59E-2	1.48E-3	1.69E-2
Smog formation potential	kg O_3 eq	3.84E+0	2.03E+0	4.78E-1	1.34E+0
Ozone depletion potential	kg CFC-11 eq	3.62E-6	2.13E-6	4.33E-8	1.45E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	2.77E+2	2.17E+2	7.29E-1	5.91E+1
Renewable primary resources used as raw materials[2]	MJ	3.88E+0	0.00E+0	0.00E+0	3.88E+0
Total renewable primary resources[3]	MJ	2.81E+2	2.17E+2	7.29E-1	6.30E+1
Non-renewable primary resources used as energy [2]	MJ	4.42E+2	1.90E+2	4.53E+1	2.07E+2
Non-renewable primary resources used as raw materials[2]	MJ	2.34E+1	1.57E+1	0.00E+0	7.70E+0
Total non-renewable primary resources[4]	MJ	4.65E+2	2.06E+2	4.53E+1	2.14E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	3.73E+0	3.73E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	1.48E+0	5.13E-1	1.44E-2	9.51E-1
Freshwater consumption[8]	m^3	1.10E+0	7.83E-1	6.01E-3	3.12E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	4.78E-1	N/A	N/A	4.78E-1
Radioactive waste - high level[10,11]	kg	1.39E-4	5.63E-5	2.94E-6	8.01E-5
Radioactive waste – low and medium level[10,11]	kg	2.69E-4	1.33E-4	7.19E-6	1.28E-4
Materials for recycling[12]	kg	2.28E-1	0.00E+0	0.00E+0	2.28E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 15: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid panoramic H2 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	5.37E+1	3.41E+1	3.16E+0	1.65E+1
Acidification of soil and water sources potential	kg SO_2 eq	3.21E-1	2.19E-1	1.81E-2	8.35E-2
Eutrophication potential	kg N eq	6.28E-2	4.36E-2	1.51E-3	1.77E-2
Smog formation potential	kg O_3 eq	4.13E+0	2.22E+0	4.87E-1	1.43E+0
Ozone depletion potential	kg CFC-11 eq	3.69E-6	2.18E-6	4.45E-8	1.47E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	3.74E+2	3.06E+2	7.46E-1	6.64E+1
Renewable primary resources used as raw materials[2]	MJ	3.67E+0	0.00E+0	0.00E+0	3.67E+0
Total renewable primary resources[3]	MJ	3.77E+2	3.06E+2	7.46E-1	7.01E+1
Non-renewable primary resources used as energy [2]	MJ	4.54E+2	1.80E+2	4.66E+1	2.27E+2
Non-renewable primary resources used as raw materials[2]	MJ	1.70E+1	9.65E+0	0.00E+0	7.34E+0
Total non-renewable primary resources[4]	MJ	4.71E+2	1.90E+2	4.66E+1	2.35E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	3.73E+0	3.73E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	1.64E+0	5.83E-1	1.46E-2	1.04E+0
Freshwater consumption[8]	m^3	1.43E+0	1.07E+0	6.18E-3	3.54E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	4.70E-1	N/A	N/A	4.70E-1
Radioactive waste - high level[10,11]	kg	1.53E-4	6.22E-5	3.01E-6	8.83E-5
Radioactive waste – low and medium level[10,11]	kg	2.92E-4	1.47E-4	7.37E-6	1.38E-4
Materials for recycling[12]	kg	2.14E-1	0.00E+0	0.00E+0	2.14E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 16: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid sliding H1 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	6.39E+1	4.47E+1	3.09E+0	1.61E+1
Acidification of soil and water sources potential	kg SO_2 eq	3.37E-1	2.37E-1	1.72E-2	8.22E-2
Eutrophication potential	kg N eq	1.22E-1	9.92E-2	1.46E-3	2.10E-2
Smog formation potential	kg O_3 eq	4.68E+0	2.78E+0	4.63E-1	1.43E+0
Ozone depletion potential	kg CFC-11 eq	1.30E-5	1.14E-5	4.42E-8	1.49E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	2.86E+2	2.09E+2	7.22E-1	7.68E+1
Renewable primary resources used as raw materials[2]	MJ	6.37E+0	0.00E+0	0.00E+0	6.37E+0
Total renewable primary resources[3]	MJ	2.93E+2	2.09E+2	7.22E-1	8.32E+1
Non-renewable primary resources used as energy [2]	MJ	6.89E+2	4.23E+2	4.60E+1	2.19E+2
Non-renewable primary resources used as raw materials[2]	MJ	1.80E+2	1.68E+2	0.00E+0	1.19E+1
Total non-renewable primary resources[4]	MJ	8.69E+2	5.92E+2	4.60E+1	2.31E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	1.92E+0	7.56E-1	1.39E-2	1.15E+0
Freshwater consumption[8]	m^3	1.32E+0	9.14E-1	6.13E-3	4.04E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	7.04E-1	N/A	N/A	7.04E-1
Radioactive waste - high level[10,11]	kg	2.22E-4	1.22E-4	2.95E-6	9.70E-5
Radioactive waste – low and medium level[10,11]	kg	4.42E-4	3.00E-4	7.23E-6	1.35E-4
Materials for recycling[12]	kg	4.01E-1	0.00E+0	0.00E+0	4.01E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

Table 17: Environmental impacts and inventory results - Manufacturing of 1 m² of hybrid double-hung H1 window

CATEGORY	INDICATOR	TOTAL	A1	A2	A3
ENVIRONMENTAL IMPACT					
Global warming potential	kg CO_2 eq	6.33E+1	4.34E+1	3.04E+0	1.69E+1
Acidification of soil and water sources potential	kg SO_2 eq	3.39E-1	2.36E-1	1.74E-2	8.58E-2
Eutrophication potential	kg N eq	1.10E-1	8.82E-2	1.45E-3	2.06E-2
Smog formation potential	kg O_3 eq	4.69E+0	2.76E+0	4.67E-1	1.46E+0
Ozone depletion potential	kg CFC-11 eq	1.13E-5	9.70E-6	4.32E-8	1.52E-6
RESOURCE USE[1]					
Renewable primary resources used as energy[2]	MJ	2.76E+2	2.04E+2	7.19E-1	7.12E+1
Renewable primary resources used as raw materials[2]	MJ	5.41E+0	0.00E+0	0.00E+0	5.41E+0
Total renewable primary resources[3]	MJ	2.82E+2	2.04E+2	7.19E-1	7.66E+1
Non-renewable primary resources used as energy [2]	MJ	6.85E+2	4.11E+2	4.51E+1	2.30E+2
Non-renewable primary resources used as raw materials[2]	MJ	1.51E+2	1.41E+2	0.00E+0	1.04E+1
Total non-renewable primary resources[4]	MJ	8.36E+2	5.51E+2	4.51E+1	2.40E+2
Use of renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of secondary materials	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Recovered energy[5]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Depletion of non-renewable material resources[6]	kg	INA	INA	INA	INA
Use of renewable material resources[7]	kg	1.89E+0	7.87E-1	1.39E-2	1.09E+0
Freshwater consumption[8]	m^3	1.24E+0	8.67E-1	6.04E-3	3.70E-1
WASTE					
Hazardous waste disposed[9,10]	kg	0.00E+0	N/A	N/A	0.00E+0
Non-hazardous waste disposed[9,10]	kg	6.11E-1	N/A	N/A	6.11E-1
Radioactive waste - high level[10,11]	kg	2.24E-4	1.25E-4	2.93E-6	9.62E-5
Radioactive waste – low and medium level[10,11]	kg	4.55E-4	3.03E-4	7.17E-6	1.45E-4
Materials for recycling[12]	kg	3.35E-1	0.00E+0	0.00E+0	3.35E-1
Components for reuse[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[13]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[13]	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
BIOGENIC CARBON IN THE PACKAGING[14]					
Biogenic carbon removal from packaging	kg CO_2	7.33E-2	0.00E+0	0.00E+0	7.33E-2
Biogenic carbon emission from packaging	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Legend: A1 – Production of raw materials; A2 - Transport of raw materials; A3 - Product manufacturing
For table footnotes 1 to 14, refer to the notes on inventory calculation methods presented after the results tables.

It should be noted that the life cycle impact assessment results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. These five 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, EPD users should not use additional measures for comparative purposes.

The term "potential" means that the impact scores do not represent actual measured impacts but are the results of theoretical modelling using an impact assessment method such as TRACI 2.1. To lighten the text, the term "potential" will not be used in the rest of the EPD.

Notes on the methods used to calculate inventory results

[1] The resource use categories represented based on energy (MJ) refer to the lower heating value (LHV).

[2] Category meeting the requirements of ISO 21930:2017. The results of this inventory category were calculated with the CED LHV method [13] following the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14].

[3] Category meeting the requirements of ISO 21930:2017 and the PCR. The results of this indicator were calculated using the "Renewable, biomass", "Renewable, water" and "Renewable, wind, solar, geothermal" from the Cumulative Energy Demand (LHV) method [13] following the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14].

[4] Category meeting the requirements of ISO 21930:2017 and the PCR. The results of this indicator were calculated using the "Non-renewable, fossil", "Non-renewable, biomass" and "Non-renewable, nuclear" indicators from the Cumulative Energy Demand (LHV) method [13].

[5] Category meeting the requirements of ISO 21930:2017. The hybrid windows are not recovered for energy purposes, so this inventory category is zero.

[6] In the absence of a calculation method in the LCA software for the Depletion of non-renewable material resources (kg) category, the results for this indicator are not assessed (INA: Indicator not assessed).

[7] Category meeting the PCR requirements. The results for this indicator were calculated by adding up the masses of biotic materials listed in the inventory flows.

[8] Category meeting the requirements of ISO 21930:2017 and the PCR. The results of this indicator were calculated using the "Water consumption" indicator from the ReCiPe 2016 Midpoint (H) impact assessment method [13].

[9] The results of these indicators were calculated according to the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14]. Following this methodology, only the foreground waste flows provided by the manufacturer are included, whereas the background waste flows are excluded.

[10] The life cycle inventory data used to generate waste indicators for life cycle assessments and environmental product declarations currently have significant limitations. The waste indicators were calculated by following the requirements of ISO 21930:2017 [6] but these results 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.

[11] The results of these indicators were calculated according to the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14] using background inventory data. It is important to note that the foreground data in this LCA does not include radioactive waste, i.e. the window manufacturing process does not directly generate radioactive waste.

[12] The results of these indicators were calculated according to the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14] using foreground data provided by the manufacturer.

[13] The system does not contain any reused or energy-recovered materials, nor any exported energy flows.

[13] The biogenic carbon is in the cardboard packaging. The product does not contain any biogenic carbon.

5.2 | Interpretation of life cycle impacts

A contribution analysis was carried out to identify the contribution to the impacts of the two components of the hybrid window:

1. The **frame** includes PVC profiles, aluminium extrusions, stainless steel components and their respective packaging, transport and waste;
2. The **glazing** includes the double glazing as well as its packaging, transport and waste.

The following tables show the environmental impacts of the frame and glazing in absolute values (impact score) and relative values (%) of the total impacts for the ten types of windows.

Table 18: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid awning H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	7.80E+1	5.91E+1	75.7%	1.89E+1	24.3%
Acidification of soil and water sources potential	kg SO_2 eq	4.15E-1	2.78E-1	67.0%	1.37E-1	33.0%
Eutrophication potential	kg N eq	1.13E-1	1.03E-1	90.4%	1.09E-2	9.6%
Smog formation potential	kg O_3 eq	5.40E+0	3.35E+0	61.9%	2.06E+0	38.1%
Ozone depletion potential	kg CFC-11 eq	8.21E-6	7.50E-6	91.4%	7.09E-7	8.6%

Table 19: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid awning H2 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	9.48E+1	7.60E+1	80.1%	1.88E+1	19.9%
Acidification of soil and water sources potential	kg SO_2 eq	5.03E-1	3.67E-1	72.9%	1.36E-1	27.1%
Eutrophication potential	kg N eq	1.38E-1	1.27E-1	92.2%	1.08E-2	7.8%
Smog formation potential	kg O_3 eq	6.15E+0	4.10E+0	66.7%	2.05E+0	33.3%
Ozone depletion potential	kg CFC-11 eq	8.90E-6	8.24E-6	92.5%	6.63E-7	7.5%

Table 20: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid casement H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	7.80E+1	5.91E+1	75.7%	1.89E+1	24.3%
Acidification of soil and water sources potential	kg SO_2 eq	4.15E-1	2.78E-1	67.0%	1.37E-1	33.0%
Eutrophication potential	kg N eq	1.13E-1	1.03E-1	90.4%	1.09E-2	9.6%
Smog formation potential	kg O_3 eq	5.40E+0	3.35E+0	61.9%	2.06E+0	38.1%
Ozone depletion potential	kg CFC-11 eq	8.21E-6	7.50E-6	91.4%	7.09E-7	8.6%

Table 21: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid casement H2 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	9.48E+1	7.60E+1	80.1%	1.88E+1	19.9%
Acidification of soil and water sources potential	kg SO_2 eq	5.03E-1	3.67E-1	72.9%	1.36E-1	27.1%
Eutrophication potential	kg N eq	1.38E-1	1.27E-1	92.2%	1.08E-2	7.8%
Smog formation potential	kg O_3 eq	6.15E+0	4.10E+0	66.7%	2.05E+0	33.3%
Ozone depletion potential	kg CFC-11 eq	8.90E-6	8.24E-6	92.5%	6.63E-7	7.5%

Table 22: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid fixed H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	5.62E+1	3.42E+1	60.8%	2.20E+1	39.2%
Acidification of soil and water sources potential	kg SO_2 eq	3.15E-1	1.56E-1	49.4%	1.59E-1	50.6%
Eutrophication potential	kg N eq	9.15E-2	7.85E-2	85.8%	1.30E-2	14.2%
Smog formation potential	kg O_3 eq	4.22E+0	1.83E+0	43.4%	2.39E+0	56.6%
Ozone depletion potential	kg CFC-11 eq	8.88E-6	7.88E-6	88.7%	1.00E-6	11.3%

Table 23: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid fixed H2 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	6.39E+1	4.19E+1	65.7%	2.19E+1	34.3%
Acidification of soil and water sources potential	kg SO_2 eq	3.55E-1	1.97E-1	55.3%	1.59E-1	44.7%
Eutrophication potential	kg N eq	1.02E-1	8.87E-2	87.3%	1.29E-2	12.7%
Smog formation potential	kg O_3 eq	4.55E+0	2.17E+0	47.7%	2.38E+0	52.3%
Ozone depletion potential	kg CFC-11 eq	9.03E-6	8.07E-6	89.4%	9.60E-7	10.6%

Table 24: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid panoramic H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	4.71E+1	2.35E+1	49.8%	2.36E+1	50.2%
Acidification of soil and water sources potential	kg SO_2 eq	2.86E-1	1.15E-1	40.1%	1.71E-1	59.9%
Eutrophication potential	kg N eq	5.44E-2	4.04E-2	74.4%	1.39E-2	25.6%
Smog formation potential	kg O_3 eq	3.84E+0	1.28E+0	33.3%	2.56E+0	66.7%
Ozone depletion potential	kg CFC-11 eq	3.62E-6	2.57E-6	70.8%	1.06E-6	29.2%

Table 25: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid panoramic H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	5.37E+1	3.01E+1	56.1%	2.36E+1	43.9%
Acidification of soil and water sources potential	kg SO_2 eq	3.21E-1	1.50E-1	46.8%	1.70E-1	53.2%
Eutrophication potential	kg N eq	6.28E-2	4.90E-2	78.0%	1.38E-2	22.0%
Smog formation potential	kg O_3 eq	4.13E+0	1.57E+0	38.0%	2.56E+0	62.0%
Ozone depletion potential	kg CFC-11 eq	3.69E-6	2.67E-6	72.3%	1.02E-6	27.7%

Table 26: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid sliding H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	6.39E+1	4.34E+1	67.9%	2.05E+1	32.1%
Acidification of soil and water sources potential	kg SO_2 eq	3.37E-1	1.88E-1	55.9%	1.48E-1	44.1%
Eutrophication potential	kg N eq	1.22E-1	1.10E-1	90.1%	1.20E-2	9.9%
Smog formation potential	kg O_3 eq	4.68E+0	2.45E+0	52.4%	2.23E+0	47.6%
Ozone depletion potential	kg CFC-11 eq	1.30E-5	1.21E-5	93.4%	8.50E-7	6.6%

Table 27: Share of environmental impacts related to the frame and glazing - Manufacturing of 1 m² of hybrid double-hung H1 window

IMPACT CATEGORY	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Global warming potential	kg CO_2 eq	6.33E+1	4.22E+1	66.6%	2.11E+1	33.4%
Acidification of soil and water sources potential	kg SO_2 eq	3.39E-1	1.86E-1	54.9%	1.53E-1	45.1%
Eutrophication potential	kg N eq	1.10E-1	9.79E-2	88.8%	1.24E-2	11.2%
Smog formation potential	kg O_3 eq	4.69E+0	2.40E+0	51.1%	2.29E+0	48.9%
Ozone depletion potential	kg CFC-11 eq	1.13E-5	1.03E-5	91.9%	9.16E-7	8.1%

The contribution analysis shows that the manufacturing of the frame is the main process contributing to the impacts for all the impact categories for the awning, casement, sliding and double-hung windows (51.1 to 93.4% of the total impacts). For the other types of windows, the manufacturing of the frame is also the primary contributing process (55.3 to 89.4%) with a few exceptions for fixed and panoramic windows, which contain a smaller proportion of PVC profiles and stainless steel. In the *Smog formation* category, the frame contributes most to the impacts of the fixed and panoramic windows (between 52.3 and 66.7% of the impacts in this category). In the *Acidification* category, the glazing represents the primary contributor to the impacts of the panoramic and fixed H1 windows (50.6 and 59.9%, respectively). Finally, the glazing is the dominant contributor to the impacts of the panoramic H1 window in the *Global Warming* category (50.2%).

Furthermore, the PCR requires that inventory results for radioactive waste be presented for the frame and glazing (Table 28). It is important to note that the foreground data in this LCA does not include radioactive waste, i.e. the window manufacturing process does not directly generate radioactive waste. According to ISO 21930:2017 [6], radioactive waste, when generated for electricity production, consists mainly of spent fuel from reactors (high-level radioactive waste) and routine maintenance and operation of the facilities (low- and medium-level radioactive waste).

Table 28: Share of inventory results relating to radioactive waste associated with the frame and glazing

INVENTORY CATEGORY	TYPE OF WINDOW	INDICATOR	WINDOW (FRAME + GLAZING)	FRAME		GLAZING	
Radioactive waste - high level	Awning H1	kg	2.92E-4	2.45E-4	83.8%	4.75E-5	16.2%
	Awning H2	kg	3.32E-4	2.84E-4	85.6%	4.76E-5	14.4%
	Casement H1	kg	2.92E-4	2.45E-4	83.8%	4.75E-5	16.2%
	Casement H2	kg	3.32E-4	2.84E-4	85.6%	4.76E-5	14.4%
	Fixed H1	kg	1.72E-4	1.18E-4	68.6%	5.41E-5	31.4%
	Fixed H2	kg	1.89E-4	1.35E-4	71.3%	5.42E-5	28.7%
	Panoramic H1	kg	1.39E-4	8.16E-5	58.5%	5.78E-5	41.5%
	Panoramic H2	kg	1.53E-4	9.56E-5	62.3%	5.79E-5	37.7%
	Sliding H1	kg	2.22E-4	1.71E-4	77.0%	5.11E-5	23.0%
	Double-hung H1	kg	2.24E-4	1.72E-4	76.7%	5.21E-5	23.3%
Radioactive waste – low and medium level	Awning H1	kg	5.43E-4	4.23E-4	77.8%	1.20E-4	22.2%
	Awning H2	kg	6.10E-4	4.90E-4	80.3%	1.20E-4	19.7%
	Casement H1	kg	5.43E-4	4.23E-4	77.8%	1.20E-4	22.2%
	Casement H2	kg	6.10E-4	4.90E-4	80.3%	1.20E-4	19.7%
	Fixed H1	kg	3.53E-4	2.14E-4	60.5%	1.40E-4	39.5%
	Fixed H2	kg	3.82E-4	2.42E-4	63.5%	1.39E-4	36.5%
	Panoramic H1	kg	2.69E-4	1.19E-4	44.3%	1.50E-4	55.7%
	Panoramic H2	kg	2.92E-4	1.43E-4	48.9%	1.49E-4	51.1%
	Sliding H1	kg	4.42E-4	3.12E-4	70.5%	1.30E-4	29.5%
	Double-hung H1	kg	4.55E-4	3.21E-4	70.5%	1.34E-4	29.5%

6 | ADDITIONAL ENVIRONMENTAL INFORMATION

6.1 | Regulated hazardous substances

The hybrid windows contain PVC, aluminium, glass and stainless steel. These materials are not on Canada's list of hazardous substances [15]. Therefore, no regulated hazardous substances are associated with the manufacturing of the product.

6.2 | Health and environment during manufacturing

As the manufacturing of PVC profiles may involve a risk of injury or splashes to the arms or face during certain maintenance processes or production start-up tasks, workers are provided with personal protective equipment (visor, gloves, helmet). In addition, safety glasses must be worn at the Thermoplast Nextrusions plant. As the extrusion operations do not emit any dust, no respiratory protection is provided.

6.3 | Delayed emissions and unexpected adverse effects

In the case that the cardboard packaging is landfilled, delayed carbon emissions from the degradation of the cardboard can be expected. There are no unexpected adverse effects resulting from combustion, degradation by water or mechanical alteration of the hybrid windows.

6.4 | Participation in environmental programs

Thermoplast Nextrusions' commitment to the environment is also reflected in the establishment of its *Solution Zéro Déchet* recovery and recycling program, leading to the award of the "*Performance +*" rating under Recyc-Québec's *ICI on recycle +* recognition program for the 2022-2025 period [16,17]. The company also holds the Carbon Care® certification from Enviro-Access for 2022-2023 [18,19].

6.5 | Additional information

Further information can be obtained at the following link: https://www.thermoplast.com/

7 | DEFINITION OF IMPACT AND INVENTORY CATEGORIES

Table 29: Impact categories used in the study, definitions and units [4]

IMPACT CATEGORY	DEFINITION	UNIT
Global warming potential	This impact category measures the impact of an increase in global average temperature caused by greenhouse gas emissions on the world's climate. The main greenhouse gases are CO_2, CH_4, and N_2O.	kg CO_2 eq
Acidification of soil and water sources potential	This impact category measures the impact of an increase in the concentration of hydrogen ions (H^+) in soil or water environments caused by emissions of acidifying substances (for example, sulfuric acid).	kg SO_2 eq
Eutrophication potential	This impact category measures the consequences of an enrichment of water by nutrients (nitrates and phosphates), thus increasing the growth of algae that deteriorate the aquatic ecosystem.	kg N eq
Smog formation potential	This impact category measures the formation of smog (ground-level ozone (O_3)), which is a pollutant that impacts the respiratory system. Smog is produced by the exposure of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) to solar radiation.	kg O_3 eq
Ozone depletion potential	This impact category measures the impact of the depletion of the ozone layer, which protects living organisms from solar radiation. Ozone depletion is mainly caused by chlorofluorocarbon (CFC) and halon emissions.	kg CFC-11 eq

Table 30: Inventory categories used in the study, definitions and units [1]

INVENTORY CATEGORY	DEFINITION	UNIT
Renewable primary resources used as energy /material	Use of renewable resources as a source of energy (hydroelectric, solar, wind) or as a material (wood, hemp).	MJ
Non-renewable primary resources used as energy /material	Use of fossil resources (peat, oil, gas, coal) as a source of energy or as a material (plastics).	MJ
Freshwater consumption	Freshwater that is consumed, i.e. by evaporation (cooling towers), evapotranspiration, the freshwater contained in the product or water flowing into the ocean.	m^3
Depletion of non-renewable material resources	Depletion of non-fossil mineral resources (e.g., aluminium, iron).	kg
Use of renewable material resources	Consumption of renewable natural resources (e.g., wood, peat).	kg
Hazardous, non-hazardous and radioactive waste disposed	Generation of hazardous (solvents, engine oil, acids), non-hazardous (concrete, plastic, glass) or radioactive (radioactive fuels, products contaminated by radioactive substances) disposed waste.	kg

8 | ABBREVIATIONS, ACRONYMS AND RAW FORMULAS

- CFC Chlorofluorocarbon
- CFC-11 Trichlorofluoromethane
- CH_4 Methane
- CO_2 Carbon dioxide
- EPD Environmental product declaration
- eq Equivalent
- INA Indicator not assessed
- LCA Life cycle assessment
- LHV Lower heating value
- N Nitrogen
- N/A Not applicable
- NO_x Nitrogen oxides
- O_3 Ozone
- PCR Product category rules
- PVC Polyvinyl chloride
- SO_2 Sulphur dioxide
- VOCs Volatile organic compounds

9 | GLOSSARY

- **Cut-off threshold.** Criteria for excluding inputs and outputs based on their contribution (%) to the total mass and energy. If this contribution is lower than a certain threshold (cut-off), these flows can be ignored [6].
- **Declared unit.** Quantity of construction product used as a reference unit for presenting environmental information by life cycle module. The term “declared unit” is used instead of “functional unit” when the performance of the product in use is not known [1].
- **Ecoinvent.** Life cycle inventory database for materials, chemicals, power generation systems, transport and waste treatment processes [3].
- **Environmental impact.** Any negative or beneficial modification of the environment, resulting wholly or in part from environmental aspects [20] that is to say elements of the activities, products or services of an organization that can interact with the environment [21].
- **Environmental Product Declaration (EPD).** Environmental declaration providing quantified environmental data using predetermined parameters based on the ISO 14040:2006 and ISO 14044:2006 standards [6,21,22].
- **Life cycle assessment (LCA).** Compilation and evaluation of the inputs and outputs (inventory) as well as the assessment of potential environmental impacts of a product during its life cycle [21].
- **Product Category Rules (PCR).** A set of specific rules, requirements and guidelines for the development of EPDs [6]. The PCR referenced in this EPD is based on the PCR "NSF Product Category Rule for Environmental Product Declarations: Fenestration Assemblies".
- **Reference flow.** Quantity of process outputs in a given product system required to fulfill the function as expressed by the declared unit [21].

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