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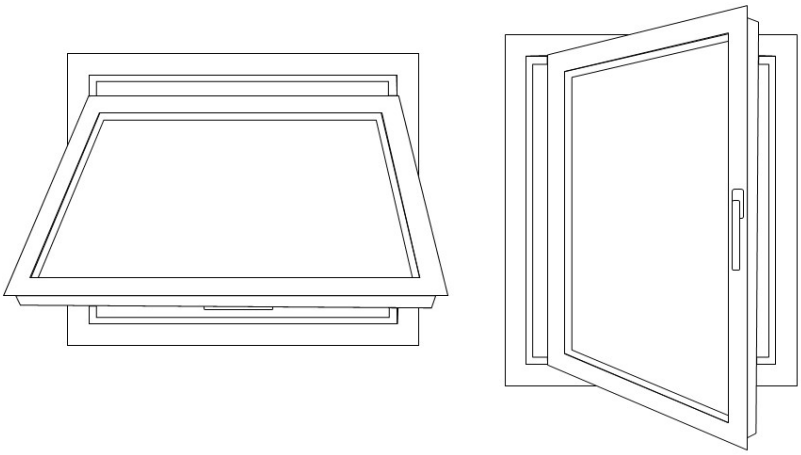
TO WHOM IT MAY CONCERN

We are pleased to confirm that

Smart Architectural Aluminium

is a member of the Council for Aluminium in Building and has our permission to use the Environmental Product Declaration reference EPD-2023-0014.

Nigel Headford
Chief Executive



ENVIRONMENTAL PRODUCT DECLARATION

in accordance with ISO 14025 and EN 15804:2012 + A2:2019

Side hung and Top hung aluminium window systems (“standard” and “enhanced” versions)

Owner of the declaration:	
Publisher and Programme holder:	EUROPEAN ALUMINIUM
Declaration number:	EPD-2023-0014
Issue date:	2023-09-21
Valid until	2028-09-20

www.european-aluminium.eu

GENERAL INFORMATION

Owner of the declaration	Council for Aluminium in Building (CAB) Bank House Bond's Mill Stonehouse Gloucestershire GL10 3RF https://c-a-b.org.uk/
Publisher and Programme holder	EUROPEAN ALUMINIUM AISBL Avenue des Nerviens 85 1040 Brussels, Belgium EUROPEAN ALUMINIUM Avenue des Nerviens 85 1040 Etterbeek – Belgium VAT : BE 0480.720.716 info@european-aluminium.eu www.european-aluminium.eu Paul Voss, Director General
The declaration is based on the Product Category Rules	European Aluminium General Programme Instructions version 3, 23rd of September 2020
Declared Unit	1 m^2 of Side hung and Top hung window system
Scope of the Environmental Product Declaration	This EPD covers 1 m^2 of Side hung or Top hung window system - double and triple glazed. These EPD results have been calculated from an LCA tool for EPD, based on the LCA for Experts database, initially realised by Thinkstep in 2013 and updated by Ecoinnovazione in 2019. Four representative products have been selected and corresponding EPD results have been calculated based on each bill of materials. These four products are Side hung and Top hung window systems – both as "standard" (double glazed) and "enhanced" (triple glazed) products. The results generated by the collective tool can be considered as a good proxy to model windows produced by CAB members. The EPD may be used in a B2B context within the European Market.
Liability	The owner of the declaration is liable for the underlying manufacturing information and European Aluminium is not liable in this respect.
Disclaimers	The owner of this EPD is the Council for Aluminium in Building (CAB) and reflects their members' products on the UK market. This EPD can be used by CAB members only with written permission from CAB. This EPD cannot be used as a guarantee of the recycled content of the actual product sold on the market. A specific declaration may be asked for from the supplier. The use of this EPD within BIM tools is in principle limited to the products explicitly included in the EPD. The scaling of results to model similar products can only be done if justified and transparently reported in the project report. Any responsibility regarding the misuse of this EPD by third parties is not accepted by the Programme Operator.

Verification

EN15804:2012 +A2:2019 serves as core PCR complemented by EN 17213:2020 and European Aluminium PCR 03/2020	
Verification of the EPD by an independent third party in accordance with ISO 14025	
☐ Internally	☒ Externally

Verifier

1 PRODUCT

1.1 Product description and applications

This Environmental Product Declaration (EPD) is concerned with aluminium framed windows consisting of one opening light – both side hung (inwards opening) and top hung (outwards opening) configurations. Data are presented for both of these window configurations, each as either "standard" or "enhanced" variants in terms of thermal performance, where the "standard" variant is double glazed and the "enhanced" variant is triple glazed, with the frame depths varied accordingly, and types of insulating glass units (IGUs) overall including clear glass plus low-e, as well double glazed units (DGUs) with 4 mm clear glass and a 16 mm argon-filled gap adjacent to 4 mm low-e glass, while triple glazed units (TGUs) featuring 4 mm glass thickness separated by two 16 mm argon-filled gaps, each adjacent to a 4 mm low-e glass layer. These are considered representative of aluminium windows that are sold on the UK commercial and domestic markets.

The Council for Aluminium in Building (CAB) was formed in 1994 by bringing together three existing UK-based trade associations: the Aluminium Window Association, the Architectural Aluminium Association and the Patent Glazing Contractors' Association. Its members include fabricators, installers, systems companies, consultants and many specialist product supply and manufacturing companies. CAB became a company limited by guarantee in January 2006.

CAB is now the largest UK aluminium-in-building trade association, with over 100 members across the supply chain. Throughout its history CAB has continued to expand its services to members. In addition to technical information, guidance on regulations and standards, industry best practice advice and its publications, all led by its Technical Committee, CAB's ambitious events programme includes Spring and Autumn Forum meetings, an Annual Dinner and Golf Day, mini-conferences and networking events. The association is highly proactive in several aluminium and sustainability initiatives in the UK and internationally, including membership of the Aluminium Stewardship Initiative.

In the UK, CAB is a member of the Construction Products Association and the Centre for Window and Cladding Technology. The association also works closely with many of the principal trades bodies in UK and in Europe, where we are members of the Metals for Buildings alliance via the Federation of Associations in Europe for Curtain walling and Fenestration manufacturers (FAECF).

This document is referring to an association EPD, owned by the Council for Aluminium in Building (CAB) and prepared using data from systems companies that are CAB members.
The windows used as the basis for this EPD (side hung – inwards opening – and top hung – outwards opening – both in "standard" and "enhanced" variants in terms of thermal performance) are average products and representative of aluminium windows that are sold on the UK commercial and domestic markets.
Based on the information shared by CAB, data used are representative of more than 50% of the UK market, with a wide cross-section of systems companies providing the data (e.g. overseas-owned, UK-owned, aluminium frames-only, aluminium and other framing materials).

The resulted representative products are side hung or top hung window system - double and triple glazed of 1.48 m high by 1.23 m wide. EPD results have been calculated for four representative products, which are detailed in Table 1. The BoM of each average product is given in section 2.1.

Table 1 Details for representative products

ID	Model	Size (W x H)	Glazing	Surface area (m^2)	Glass thickness (mm)
1	Side hung - Standard	1.23 m x 1.48 m	Double	1.43	8
2	Side hung - Enhanced	1.23 m x 1.48 m	Triple	1.41	12
3	Top hung - Standard	1.23 m x 1.48 m	Double	1.39	8
4	Top hung - Enhanced	1.23 m x 1.48 m	Triple	1.38	12

1.2 Technical Data

The most relevant technical data are reported in Table 2.

Table 2 Most relevant technical data

Performance	Test standard(s)	"Standard"	"Enhanced"
U_w	EN ISO 10077-1 EN ISO 10077-2	1.4 W/m^2K	1 W/m^2K
Watertightness	EN 1027 EN 12208	Up to Class 9A (4A min)	E1200
Durability [open & close] **Operating forces** **Mechanical strength**	EN 1191/ EN 12400 EN 13115 EN 13115	Up to 20,000 cycles (min 10k) Class 1 Class 2	Up to 20,000 cycles (min 10k) Class 1 Class 2
Air permeability	EN 1026 EN 12207	Up to Class 4 (min Class 2)	Up to Class 4 (min Class 2)
Resistance to wind load	EN 12211 EN 12210	Up to Class C5 (min Class B1)	Class C5

The most relevant standard for applications of aluminium window systems in buildings is EN 14351-1

1.3 Process description

The entire installation process is typically performed at the job site.

The following operations are carried out to produce the main parts:

1. aluminium profile (powder coated) preparation mainly via sawing and milling.
2. frame production by assembling the various profiles via connectors and fixing via bolting or gluing. Connectors used are mostly composed of aluminium.
3. positioning and fixing the various gaskets.
4. infill application (e.g., glazing, opaque panels).
5. hardware integration.

The main background production processes are reported in Figure 1.

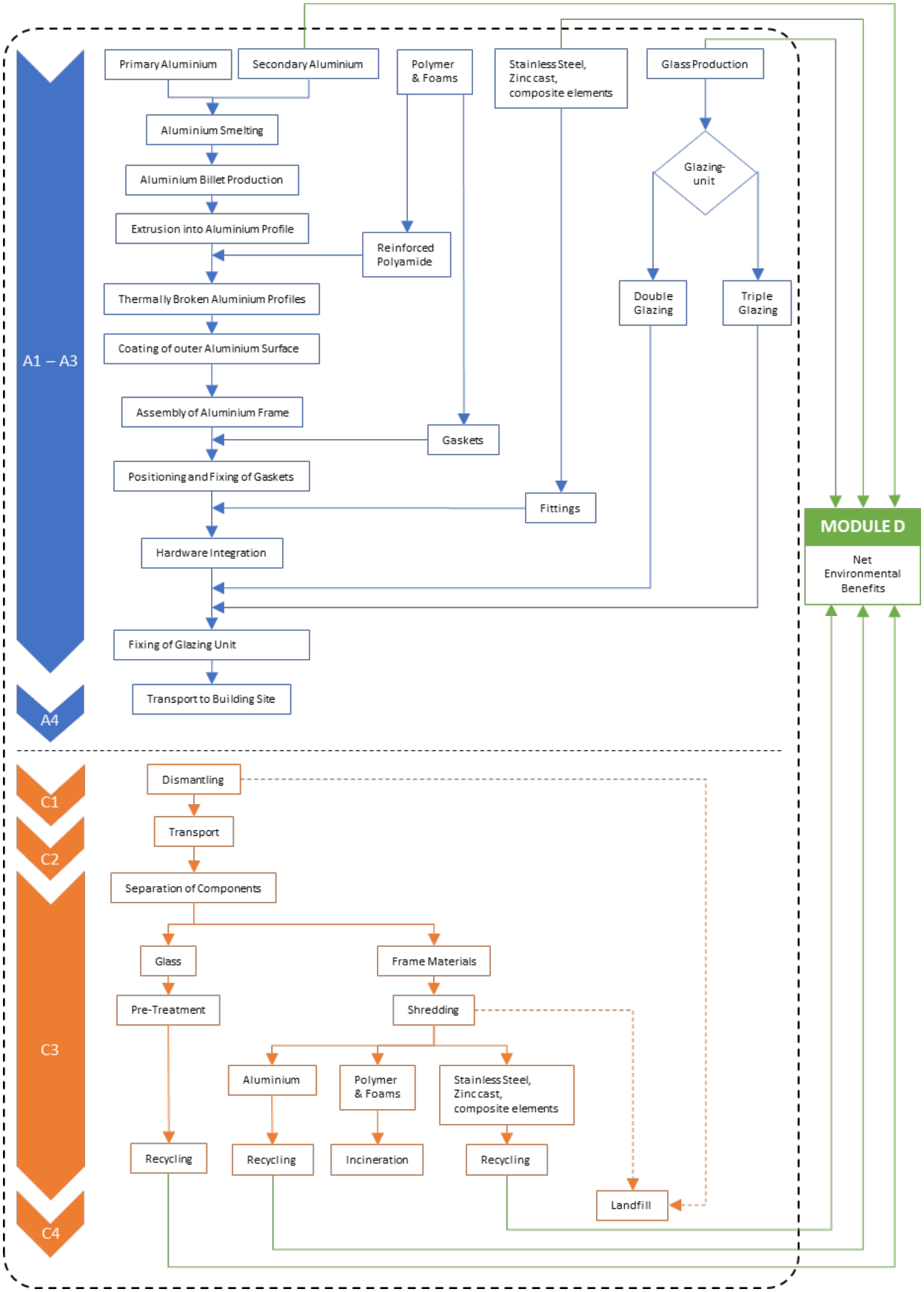


Figure 1 Main production processes and components of the window

The upstream aluminium processes have been modelled using European Aluminium LCI datasets for the primary aluminium production, recycling and remelting as described in the European Aluminium Environmental Profile Report 2018.

For the other processes and materials, e.g., gaskets, glass unit or hardware, datasets from the LCA for Experts database have been used. The powder coating of aluminium profiles has been modelled using LCA for Experts datasets as well.

At end-of-life, thanks to their high price value (i.e., about 50% of the London Metal Exchange (LME) price) aluminium frames and profiles are systematically dismantled and collected for sending on for recycling. After being collected, the window system profiles are treated through shredding and sorting. However, the glazing unit might not be systematically collected at the building renovation or demolition site. Hence, two extreme end-of-life scenarios have been used for flat glass: 100% recycling or 100% landfilling.

1.4 Health and safety aspects during production and installation

There are no critical health and safety aspects during the production of aluminium window systems. The pre-treatments used for the pre-treatment of aluminium profile for powder coating do not contain chromium nor other substances of very high concern (SVHC substances), and this process is followed by a coating process realised using a powder without VOC.

There are no relevant aspects of occupational health and safety during the further processing and installation of CAB members' window systems. Under normal installation, no measurable environmental impacts can be associated with the use of CAB members' aluminium window systems. The appropriate safety measures need to be taken at the building site, especially if installation takes place on a high-rise building.

1.5 Reference service life

Since the use phase is not modelled, no specific information is provided about the Reference Service Life. In normal use, aluminium building products are not altered or corroded over time. Regular cleaning (e.g. once a year) of the product suffices to secure a long service life. However, the use of highly alkaline (pH >10) or highly acidic (pH < 4) cleaning solutions should be avoided. In practice, a service life of 50 years can be assumed in normal use for such application, except for the IGU (Insulated Glass Unit) which needs to be replaced usually after 30 years, due to slow degradation of its performance.

2 LCA – CALCULATION RULES

2.1 Declared unit & bill of materials

The Bill of Materials of the four analysed representative products is reported in Table 3. The declared unit corresponds to 1 m^2 of window system.

Table 3 Bill of materials (BoM) (kg) of the declared unit for four products

Reference								
Type	**Side hung – Standard**		**Side hung – Enhanced**		**Top hung – Standard**		**Top hung – Enhanced**	
	kg	**%**	**kg**	**%**	**kg**	**%**	**kg**	**%**
Glass	15.70	59.06%	23.20	66.85%	15.30	56.63%	22.70	64.97%
Aluminium	7.58	28.51%	8.16	23.51%	8.49	31.42%	8.55	24.47%
Metal parts	1.31	4.93%	1.05	3.03%	1.37	5.07%	1.53	4.38%
Thermal break	1.11	4.18%	1.39	4.01%	1.18	4.37%	1.26	3.61%
Gasket	0.75	2.83%	0.67	1.93%	0.60	2.24%	0.72	2.05%
Polymers	0.08	0.29%	0.20	0.58%	0.00	0.01%	0.06	0.18%
Foams	0.05	0.20%	0.03	0.09%	0.07	0.27%	0.12	0.34%
Total	**26.58**	**100%**	**34.71**	**100%**	**27.02**	**100%**	**34.94**	**100%**

2.2 System boundary

This EPD is from cradle to gate with modules C1-C4 and module D, as reported in Table 4.

The production stage (modules A1-A3) includes processes that provide materials and energy input for the system, manufacturing and transport processes up to the factory gate, as well as waste processing. For the end-of-life, the default scenario defined in the General Product Instructions and detailed in 3.2 is applied.

Table 4 Modules declared

Production			Installation		Use stage							End-of-Life				Next product system
Raw material	Transport	Manufacturing	Transport to	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy	Operational water	Deconstruction	Transport	Waste processing	Disposal	Reuse, recovery, recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	X	X	X	X	X

Note: ND: Not Declared; X: Module included in the LCA.

Module A4 is declared for a distance of 1 km to give the possibility to adjust the resulting environmental impact depending on the specific distance at hand.

2.3 Energy mix

In the model developed the background electricity mix used is the European electricity mix (EU-28 Electricity grid mix (2019)). Details about the electricity modelling in the datasets: production of primary aluminium, extrusion, rolling and recycling please refer to the European Aluminium Environmental Profile Report 2018.

2.4 Allocation

The scrap which are produced along the production chain are recycled into the same production chain and are modelled as "closed-loop" within Module A. This recycling loop has been modelled in the LCA for Experts model so that the window system is the only product exiting the gate. Hence, the production process does not deliver any co-products.

At the end-of-life stage, the window systems are sent to an end-of-life treatment which is modelled according to the scenario reported in 3.2. The environmental burdens and benefits of recycling and energy recovery are calculated in module D accordingly.

2.5 Assumptions and Cut-off criteria

The aluminium profiles were composed of a mix of 60% primary aluminium and 40% recycled aluminium. For the primary aluminium, a primary aluminium ingot consumption mix was considered (European production + net fraction of imports into Europe). Alloying elements were not considered, and a pure aluminium profile has been assumed as a proxy. In the fabrication stage a 5% of scrap is assumed.

2.6 Data quality

Representativeness

Technological: All primary and secondary data were modelled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used. For the aluminium production, extrusion profiles and recycling, the datasets described in the Environmental Profile Report 2018 of European Aluminium have been used and integrated with the EPD profile of the low carbon primary aluminium. The modelling reflects the specific BoM of the analysed products. Technological representativeness is considered to be very good.

Geographical: All primary data were collected specifically to the county under study. Regarding secondary data, where EU region-specific data were unavailable, UK datasets were used. For the aluminium production, extrusion profiles and recycling, the datasets described in the Environmental Profile Report 2018 of European Aluminium have been used. Geographical representativeness is considered to be good.

Temporal: Primary data refer to the year 2023, and all secondary data come from the LCA for Experts version 2021.2, including those on aluminium production, which are the most recent ones as described in the Environmental Profile Report 2018 of European Aluminium.

Completeness

All known operating data was taken into consideration in the analysis. Based on earlier studies conducted by European Aluminium, it can be assumed that the ignored processes or flows contribute to much less than 5% of the impact categories under review.

The process chain is considered sufficiently complete regarding the goal and scope of this study.

Overall, the data quality can be described as good.

2.7 Software and databases

These EPD results have been calculated from an LCA tool for EPD, based on the LCA for Experts database. Currently, the EPD software is using the software LCA for Experts version 2021.2.

2.8 Comparability

As a general rule, a comparison or evaluation of EPD data may be possible when all of the data to be compared has been drawn up in accordance with EN 15804 and the building context or product-specific characteristics are taken into consideration.

3 LCA – SCENARIOS AND ADDITIONAL INFORMATION

3.1 Scenario for additional modules

Module A4 is taken into consideration in this Declaration, and it has been modelled according to the information reported in Table 5.

Table 5 Module A4 – Transport to the building site

Scenario information	Unit (expressed per DU)
Fuel type and consumption of vehicle or vehicle type used for transport e.g. long-distance truck, boat, etc.	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity, diesel driven
Distance	1 km
Capacity utilisation (including empty returns)	61 %
Bulk density of transported products	-
Volume capacity utilisation factor (factor = 1 or <1 or ≥1 for compressed or nested packaged products)	Not applicable

3.2 Scenario for Mod. C1-C4

The default scenario for the end-of-life of the window system, as reported in the General Programme Instructions, is the following:

- collection rate: 99%;
- shredding efficiency: 95%;
- scrap recycled through refining process: 96,5%
- overall aluminium recycling rate: 91%

For the glass used in the window, two extreme end-of-life scenarios were modelled: one with 100% recycling of the glass and one with 100% landfill of the glass.

Table 6 reports the main parameters of the end-of-life scenarios for the main materials and components.

Table 6 Parameters of the end-of-life scenarios for the main materials and components, related to the DU

Processes	Unit (expressed per FU or DU of components, products or materials and by type of material)		Side hung window – Standard		Side hung window – Enhanced	
			Scenario 100% glass landfill	Scenario 100% glass recycling	Scenario 100% glass landfill	Scenario 100% glass recycling
Collection process specified by type	Kg collected separately		Glass: 15.7 kg		Glass: 23.2 kg	
			Aluminium frame: 7.5 kg		Aluminium frame: 8.08 kg	
			Gasket: 0.75 kg		Gasket: 0.67 kg	
			Metal fittings and others: 2.53 kg		Metal fittings and others: 2.64 kg	
	Kg collected with mixed construction waste		0		0	
Recovery system specified by type	Kg for re-use		0		0	
	Kg for recycling		0	Glass: 15.2 kg	0	Glass: 22.5 kg
			Aluminium frame: 6.71 kg		Aluminium frame: 7.23 kg	
			Metal fittings: 1.03 kg		Metal fittings: 0.90 kg	
	Kg for energy recovery		Gasket: 0 kg		Gasket: 0 kg	
			Others: 0 kg		Others: 0 kg	
Disposal specified by type	Kg product or material for final deposition	Landfill (aluminium)	Aluminium frame: 0.42 kg		Aluminium frame: 0.46 kg	
		Landfill (inert materials)	Fittings and others: 0.20 kg		Fittings and others: 0.21 kg	
		Waste incineration	Gasket: 0.71 kg		Gasket: 0.63 kg	
		Waste incineration (plastics)	Fittings and others: 1.16 kg		Fittings and others: 1.52 kg	
		Landfill	Glass: 15.7 kg	0	Glass: 23.2 kg	0

Table 7 Parameters of the end-of-life scenarios for the main materials and components, related to the DU

Processes	Unit (expressed per FU or DU of components, products or materials and by type of material)		Top hung window – Standard		Top hung window – Enhanced	
			Scenario 100% glass landfill	Scenario 100% glass recycling	Scenario 100% glass landfill	Scenario 100% glass recycling
Collection process specified by type	Kg collected separately		Glass: 15.3 kg		Glass: 22.7 kg	
			Aluminium frame: 8.40 kg		Aluminium frame: 8.47 kg	
			Gasket: 0.60 kg		Gasket: 0.71 kg	
			Metal fittings and others: 2.60 kg		Metal fittings and others: 2.94 kg	
	Kg collected with mixed construction waste		0		0	
Recovery system specified by type	Kg for re-use		0		0	
	Kg for recycling		0	Glass: 14.8 kg	0	Glass: 22 kg
			Aluminium frame: 7.5 kg		Aluminium frame: 7.57 kg	
			Metal fittings: 1.2 kg		Metal fittings: 1.37 kg	
	Kg for energy recovery		Gasket: 0 kg		Gasket: 0 kg	
			Others: 0 kg		Others: 0 kg	
Disposal specified by type	Kg product or material for final deposition	Landfill (aluminium)	Aluminium frame: 0.48 kg		Aluminium frame: 0.48 kg	
		Landfill (inert materials)	Fittings and others: 0.20 kg		Fittings and others: 0.23 kg	
		Waste incineration	Gasket: 0.57 kg		Gasket: 0.67 kg	
		Waste incineration (plastics)	Fittings and others: 1.18 kg		Fittings and others: 1.35 kg	
		Landfill	Glass: 15.3 kg	0	Glass: 22.7 kg	0

Note to Table 6 and 7:

Material collected separately: This amount refers to the waste stream collected separately per material before being subjected to shredding

Material for recycling: This amount refers to the waste stream sent to recycling per material after the shredding and/or sorting process.

Material for final deposition – aluminium: this amount includes the aluminium not collected separately and the shredding losses.

3.3 Scenario: Module D

Module D includes:

- a transport from the scrap dealers to the recycling plants, considering an average distance of 200 km;
- recycling of aluminium through refining;
- a net credit for the avoided production of primary aluminium;
- a net credit for the avoided production of flat glass (for 100% glass recycling scenario).

The calculation of module D has been implemented in line with the General Programme Instructions of European Aluminium, thus based on the difference between the scrap used at the input and output side. In some cases, this may result in environmental burdens instead of environmental benefits if the product system is a net consumer of valuable secondary material.

3.4 Additional environmental information

In case of fire, aluminium is a non-combustible construction material (European Fire Class A1) in accordance with Commission Decision 96/603/EC (later amended by European Commission Decision 2000/605/EC to follow the new classification system defined in Commission Decision 2000/147/EC, where Class A1 substituted the former Class A), and does therefore not make any contribution to fire.

4 LCA RESULTS – window system Side hung – Standard

4.1 Result of the LCA – Environmental impact

The tables below report the results of the LCA study for the two glass scenarios: 100% recycling and 100% landfill.

4.1.1 Core environmental impact indicators

Scenario 100% glass recycling

Table 8 Core environmental impact indicators for 1 m² window system Side hung – Standard, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	9.92E+01	1.64E-03	8.22E-02	3.42E-01	1.04E+00	4.18E+00	-3.10E+01
GWP – fossil	kg CO_2 eq.	9.88E+01	1.64E-03	8.15E-02	3.42E-01	8.75E-01	4.18E+00	-3.09E+01
GWP – biogenic	kg CO_2 eq.	3.54E-01	-6.06E-06	6.64E-04	-1.27E-03	1.57E-01	7.24E-05	-8.39E-02
GWP - luluc	kg CO_2 eq.	3.83E-02	9.85E-06	1.02E-04	2.06E-03	5.34E-03	8.28E-05	-7.64E-03
ODP	kg CFC 11 eq.	5.44E-10	2.88E-16	1.19E-12	6.02E-14	-1.10E-12	5.71E-13	-1.60E-10
AP	mol H^+ eq.	4.45E-01	1.14E-05	2.17E-04	2.37E-03	1.59E-03	3.90E-03	-1.63E-01
EP - freshwater	kg PO_4^{3-} eq.	3.52E-04	3.84E-09	2.78E-07	8.01E-07	2.89E-06	2.02E-06	-2.59E-05
EP - marine	kg N eq.	1.07E-01	5.67E-06	7.07E-05	1.18E-03	8.44E-04	1.92E-03	-2.50E-02
EP - terrestrial	mol N eq.	1.18E+00	6.26E-05	7.63E-04	1.31E-02	9.56E-03	2.16E-02	-3.14E-01
POCP	kg NMVOC eq.	2.93E-01	1.08E-05	1.94E-04	2.24E-03	1.53E-03	4.93E-03	-6.98E-02
ADP-MM (**)	kg Sb eq.	1.72E-03	1.17E-10	1.11E-08	2.43E-08	1.37E-07	6.40E-09	-2.06E-03
ADPF (**)	MJ	1.39E+03	2.23E-02	1.57E+00	4.66E+00	4.40E+00	2.01E+00	-3.84E+02
WDP (**)	m^3	2.48E+01	8.57E-06	1.45E-02	1.79E-03	6.65E-02	4.35E-01	-4.61E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 9 Core environmental impact indicators for 1 m² window system Side hung – Standard, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	9.92E+01	1.64E-03	8.22E-02	1.97E-01	3.32E-01	4.41E+00	-2.15E+01
GWP – fossil	kg CO_2 eq.	9.88E+01	1.64E-03	8.15E-02	1.97E-01	3.29E-01	4.42E+00	-2.14E+01
GWP – biogenic	kg CO_2 eq.	3.54E-01	-6.06E-06	6.64E-04	-7.29E-04	2.04E-03	-6.83E-03	-7.83E-02
GWP - luluc	kg CO_2 eq.	3.83E-02	9.85E-06	1.02E-04	1.18E-03	8.01E-04	7.80E-04	-4.41E-03
ODP	kg CFC 11 eq.	5.44E-10	2.88E-16	1.19E-12	3.46E-14	1.03E-14	5.72E-13	-1.48E-10
AP	mol H^+ eq.	4.45E-01	1.14E-05	2.17E-04	1.36E-03	5.64E-04	5.59E-03	-1.14E-01
EP - freshwater	kg PO_4^{3-} eq.	3.52E-04	3.84E-09	2.78E-07	4.61E-07	1.39E-06	2.42E-06	-1.81E-05
EP - marine	kg N eq.	1.07E-01	5.67E-06	7.07E-05	6.81E-04	1.58E-04	2.36E-03	-1.56E-02
EP - terrestrial	mol N eq.	1.18E+00	6.26E-05	7.63E-04	7.53E-03	1.65E-03	2.65E-02	-1.70E-01
POCP	kg NMVOC eq.	2.93E-01	1.08E-05	1.94E-04	1.29E-03	3.98E-04	6.26E-03	-4.77E-02
ADP-MM (**)	kg Sb eq.	1.72E-03	1.17E-10	1.11E-08	1.40E-08	1.25E-07	2.88E-08	-2.06E-03
ADPF (**)	MJ	1.39E+03	2.23E-02	1.57E+00	2.68E+00	4.16E+00	5.16E+00	-2.79E+02
WDP (**)	m^3	2.48E+01	8.57E-06	1.45E-02	1.03E-03	7.38E-03	4.61E-01	-3.68E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

4.1.2 Additional environmental impact indicators

Scenario 100% glass recycling

Table 10 Additional environmental impact indicators for 1 m² window system Side hung – Standard, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	4.76E-06	3.77E-11	2.07E-09	7.86E-09	4.30E-09	1.43E-08	-2.09E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	8.77E+00	2.41E-06	3.59E-02	5.03E-04	-3.06E-02	9.25E-03	-3.64E+00
Eco-toxicity (freshwater) (**)	[CTUe]	1.70E+03	1.66E-02	7.59E-01	3.47E+00	5.22E+00	9.38E-01	-9.47E+02
Human toxicity - cancer effects (**)	[CTUh]	4.82E-07	3.32E-13	2.32E-11	6.92E-11	7.39E-11	5.72E-11	-1.55E-09
Human toxicity - non-cancer effects (**)	[CTUh]	2.61E-06	1.79E-11	6.78E-10	3.73E-09	5.42E-09	3.71E-09	3.97E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.26E+02	7.93E-03	6.09E-01	1.66E+00	4.27E+00	3.97E-01	-2.87E+01

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

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 11 Core environmental impact indicators for 1 m² window system Side hung – Standard, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	4.76E-06	3.77E-11	2.07E-09	4.53E-09	4.16E-09	3.53E-08	-1.56E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	8.77E+00	2.41E-06	3.59E-02	2.89E-04	3.86E-02	1.27E-02	-3.36E+00
Eco-toxicity (freshwater) (**)	[CTUe]	1.70E+03	1.66E-02	7.59E-01	2.00E+00	1.66E+00	2.73E+00	-9.87E+01
Human toxicity - cancer effects (**)	[CTUh]	4.82E-07	3.32E-13	2.32E-11	3.98E-11	2.29E-10	3.22E-10	-2.19E-11
Human toxicity - non-cancer effects (**)	[CTUh]	2.61E-06	1.79E-11	6.78E-10	2.15E-09	1.89E-09	3.29E-08	5.70E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.26E+02	7.93E-03	6.09E-01	9.53E-01	2.06E+00	1.03E+00	-2.15E+01

(*) **Disclaimer**: This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.
(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

4.2 Result of the LCA – Resource use

The tables below report the results of the resource use for the two glass scenarios: 100% recycling and 100% landfill.

Scenario 100% glass recycling

Table 12 Resource use for 1 m² window system Side hung – Standard, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.60E+02	1.44E-03	8.26E-01	3.01E-01	1.32E+00	3.53E-01	-1.30E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.60E+02	1.44E-03	8.26E-01	3.01E-01	1.32E+00	3.53E-01	-1.30E+02
PENRE	MJ	1.31E+03	2.23E-02	1.57E+00	4.66E+00	4.41E+00	2.01E+00	-3.85E+02
PENRM	MJ	7.23E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.39E+03	2.23E-02	1.57E+00	4.66E+00	4.41E+00	2.01E+00	-3.85E+02
SM	kg	3.23E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	8.04E-01	1.31E-06	6.68E-04	2.75E-04	1.50E-03	1.03E-02	-3.07E-01

Note: PERE – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

Scenario 100% glass landfill

Table 13 Core environmental impact indicators for 1 m² window system Side hung – Standard, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.60E+02	1.44E-03	8.26E-01	1.74E-01	2.25E+00	7.77E-01	-1.22E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.60E+02	1.44E-03	8.26E-01	1.74E-01	2.25E+00	7.77E-01	-1.22E+02
PENRE	MJ	1.31E+03	2.23E-02	1.57E+00	2.69E+00	4.16E+00	5.16E+00	-2.79E+02
PENRM	MJ	7.23E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.39E+03	2.23E-02	1.57E+00	2.69E+00	4.16E+00	5.16E+00	-2.79E+02
SM	kg	3.23E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	8.04E-01	1.31E-06	6.68E-04	1.58E-04	1.21E-03	1.11E-02	-2.82E-01

Note: PERE – use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

4.3 Result of the LCA – Output flows, waste categories

Scenario 100% glass recycling

Table 14 Output flows, waste categories for 1 m² window system Side hung – Standard, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	5.60E-06	5.98E-14	-1.06E-10	1.25E-11	2.81E-09	1.70E-10	-1.35E-07
NHWD	kg	1.68E+01	3.26E-06	1.03E-03	6.80E-04	1.39E-02	9.19E-01	-5.58E+00
RWD	kg	5.35E-02	2.34E-08	2.16E-04	4.88E-06	2.81E-05	6.20E-05	-2.09E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E+01	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.18E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy

Scenario 100% glass landfill

Table 15 Output flows, waste categories for 1 m² window system Side hung – Standard, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	5.60E-06	5.98E-14	-1.06E-10	7.19E-12	3.23E-09	5.04E-10	-1.39E-07
NHWD	kg	1.68E+01	3.26E-06	1.03E-03	3.92E-04	4.30E-03	1.66E+01	-5.21E+00
RWD	kg	5.35E-02	2.34E-08	2.16E-04	2.81E-06	3.92E-04	9.50E-05	-1.92E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.74E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.18E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy

5 LCA RESULTS – window system Side hung – Enhanced

5.1 Result of the LCA – Environmental impact

The tables below report the results of the LCA study for the two glass scenarios: 100% recycling and 100% landfill.

5.1.1 Core environmental impact indicators

Scenario 100% glass recycling

Table 16 Core environmental impact indicators for 1 m² window system Side hung – Enhanced, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	1.17E+02	2.14E-03	8.72E-02	4.44E-01	1.39E+00	4.38E+00	-3.58E+01
GWP – fossil	kg CO_2 eq.	1.17E+02	2.14E-03	8.64E-02	4.43E-01	1.16E+00	4.38E+00	-3.57E+01
GWP – biogenic	kg CO_2 eq.	3.26E-01	-7.92E-06	6.50E-04	-1.64E-03	2.31E-01	1.16E-04	-8.86E-02
GWP - luluc	kg CO_2 eq.	4.94E-02	1.29E-05	1.31E-04	2.67E-03	7.56E-03	1.05E-04	-8.99E-03
ODP	kg CFC 11 eq.	6.08E-10	3.76E-16	1.19E-12	7.80E-14	-1.63E-12	7.59E-13	-1.68E-10
AP	mol H^+ eq.	4.99E-01	1.48E-05	2.42E-04	3.07E-03	2.11E-03	4.35E-03	-1.89E-01
EP - freshwater	kg PO_4^{3-} eq.	3.95E-04	5.01E-09	2.89E-07	1.04E-06	3.69E-06	2.22E-06	-2.98E-05
EP - marine	kg N eq.	1.38E-01	7.40E-06	8.23E-05	1.53E-03	1.18E-03	2.15E-03	-2.98E-02
EP - terrestrial	mol N eq.	1.55E+00	8.18E-05	8.91E-04	1.70E-02	1.34E-02	2.41E-02	-3.87E-01
POCP	kg NMVOC eq.	3.81E-01	1.40E-05	2.26E-04	2.91E-03	2.09E-03	5.51E-03	-8.14E-02
ADP-MM (**)	kg Sb eq.	2.21E-03	1.52E-10	1.15E-08	3.16E-08	1.50E-07	8.13E-09	-2.06E-03
ADPF (**)	MJ	1.61E+03	2.92E-02	1.64E+00	6.05E+00	4.75E+00	2.49E+00	-4.38E+02
WDP (**)	m^3	2.58E+01	1.12E-05	1.45E-02	2.32E-03	9.53E-02	4.64E-01	-5.09E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 17 Core environmental impact indicators for 1 m² window system Side hung – Enhanced, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	1.17E+02	2.14E-03	8.72E-02	2.29E-01	3.51E-01	4.73E+00	-2.18E+01
GWP – fossil	kg CO_2 eq.	1.17E+02	2.14E-03	8.64E-02	2.29E-01	3.48E-01	4.74E+00	-2.17E+01
GWP – biogenic	kg CO_2 eq.	3.26E-01	-7.92E-06	6.50E-04	-8.47E-04	2.16E-03	-1.01E-02	-8.02E-02
GWP - luluc	kg CO_2 eq.	4.94E-02	1.29E-05	1.31E-04	1.38E-03	8.47E-04	1.14E-03	-4.22E-03
ODP	kg CFC 11 eq.	6.08E-10	3.76E-16	1.19E-12	4.03E-14	1.09E-14	7.60E-13	-1.51E-10
AP	mol H^+ eq.	4.99E-01	1.48E-05	2.42E-04	1.59E-03	5.96E-04	6.85E-03	-1.15E-01
EP - freshwater	kg PO_4^{3-} eq.	3.95E-04	5.01E-09	2.89E-07	5.36E-07	1.47E-06	2.81E-06	-1.83E-05
EP - marine	kg N eq.	1.38E-01	7.40E-06	8.23E-05	7.92E-04	1.67E-04	2.80E-03	-1.60E-02
EP - terrestrial	mol N eq.	1.55E+00	8.18E-05	8.91E-04	8.75E-03	1.74E-03	3.12E-02	-1.74E-01
POCP	kg NMVOC eq.	3.81E-01	1.40E-05	2.26E-04	1.50E-03	4.21E-04	7.47E-03	-4.86E-02
ADP-MM (**)	kg Sb eq.	2.21E-03	1.52E-10	1.15E-08	1.63E-08	1.32E-07	4.13E-08	-2.06E-03
ADPF (**)	MJ	1.61E+03	2.92E-02	1.64E+00	3.12E+00	4.40E+00	7.15E+00	-2.82E+02
WDP (**)	m^3	2.58E+01	1.12E-05	1.45E-02	1.20E-03	7.80E-03	5.02E-01	-3.72E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

5.1.2 Additional environmental impact indicators

Scenario 100% glass recycling

Table 18 Additional environmental impact indicators for 1 m² window system Side hung – Enhanced, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	5.20E-06	4.92E-11	2.35E-09	1.02E-08	4.60E-09	1.65E-08	-2.36E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	8.96E+00	3.14E-06	3.60E-02	6.52E-04	-6.16E-02	1.08E-02	-3.75E+00
Eco-toxicity (freshwater) (**)	[CTUe]	2.43E+03	2.17E-02	8.08E-01	4.50E+00	7.02E+00	1.22E+00	-1.35E+03
Human toxicity - cancer effects (**)	[CTUh]	4.67E-07	4.33E-13	2.42E-11	8.98E-11	1.26E-11	6.93E-11	-1.99E-09
Human toxicity - non-cancer effects (**)	[CTUh]	3.15E-06	2.33E-11	7.35E-10	4.84E-09	7.22E-09	4.84E-09	3.13E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.63E+02	1.04E-02	6.33E-01	2.15E+00	5.45E+00	4.90E-01	-3.22E+01

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

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 19 Core environmental impact indicators for 1 m² window system Side hung – Enhanced, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	5.20E-06	4.92E-11	2.35E-09	5.26E-09	4.40E-09	4.76E-08	-1.58E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	8.96E+00	3.14E-06	3.60E-02	3.36E-04	4.08E-02	1.59E-02	-3.35E+00
Eco-toxicity (freshwater) (**)	[CTUe]	2.43E+03	2.17E-02	8.08E-01	2.32E+00	1.75E+00	3.88E+00	-9.78E+01
Human toxicity - cancer effects (**)	[CTUh]	4.67E-07	4.33E-13	2.42E-11	4.63E-11	2.42E-10	4.61E-10	2.63E-10
Human toxicity - non-cancer effects (**)	[CTUh]	3.15E-06	2.33E-11	7.35E-10	2.50E-09	2.00E-09	4.80E-08	5.69E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.63E+02	1.04E-02	6.33E-01	1.11E+00	2.17E+00	1.43E+00	-2.16E+01

(*) **Disclaimer**: This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.
(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

5.2 Result of the LCA – Resource use window system Side hung – Enhanced, 1 m²

The tables below report the results of the resource use for the two glass scenarios: 100% recycling and 100% landfill.

Scenario 100% glass recycling

Table 20 Resource use for 1 m² window system Side hung – Enhanced, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.93E+02	1.89E-03	8.30E-01	3.91E-01	1.00E+00	4.52E-01	-1.35E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.93E+02	1.89E-03	8.30E-01	3.91E-01	1.00E+00	4.52E-01	-1.35E+02
PENRE	MJ	1.53E+03	2.92E-02	1.64E+00	6.05E+00	4.76E+00	2.50E+00	-4.38E+02
PENRM	MJ	7.93E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.61E+03	2.92E-02	1.64E+00	6.05E+00	4.76E+00	2.50E+00	-4.38E+02
SM	kg	3.61E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	8.73E-01	1.72E-06	6.72E-04	3.56E-04	1.71E-03	1.10E-02	-3.23E-01

Note: PERE – use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

Scenario 100% glass landfill

Table 21 Core environmental impact indicators for 1 m² window system Side hung – Enhanced, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.93E+02	1.89E-03	8.30E-01	2.02E-01	2.37E+00	1.08E+00	-1.24E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.93E+02	1.89E-03	8.30E-01	2.02E-01	2.37E+00	1.08E+00	-1.24E+02
PENRE	MJ	1.53E+03	2.92E-02	1.64E+00	3.12E+00	4.40E+00	7.16E+00	-2.82E+02
PENRM	MJ	7.93E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.61E+03	2.92E-02	1.64E+00	3.12E+00	4.40E+00	7.16E+00	-2.82E+02
SM	kg	3.61E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	8.73E-01	1.72E-06	6.72E-04	1.84E-04	1.28E-03	1.22E-02	-2.86E-01

Note: PERE – use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

5.3 Result of the LCA – Output flows, waste categories

Scenario 100% glass recycling

Table 22 Output flows, waste categories for 1 m² window system Side hung – Enhanced, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	3.13E-06	7.82E-14	-1.06E-10	1.62E-11	2.79E-09	1.88E-10	-1.36E-07
NHWD	kg	1.78E+01	4.26E-06	1.04E-03	8.82E-04	1.88E-02	1.07E+00	-5.86E+00
RWD	kg	5.61E-02	3.05E-08	2.16E-04	6.33E-06	-1.24E-04	7.42E-05	-2.17E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E+01	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.47E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy.

Scenario 100% glass landfill

Table 23 Output flows, waste categories for 1 m² window system Side hung – Enhanced, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	3.13E-06	7.82E-14	-1.06E-10	8.36E-12	3.42E-09	6.83E-10	-1.41E-07
NHWD	kg	1.78E+01	4.26E-06	1.04E-03	4.55E-04	4.55E-03	2.43E+01	-5.31E+00
RWD	kg	5.61E-02	3.05E-08	2.16E-04	3.27E-06	4.14E-04	1.23E-04	-1.91E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.13E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.47E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy.

6 LCA RESULTS – window system Top hung – Standard

6.1 Result of the LCA – Environmental impact

The tables below report the results of the LCA study for the two glass scenarios: 100% recycling and 100% landfill.

6.1.1 Core environmental impact indicators

Scenario 100% glass recycling

Table 24 Core environmental impact indicators for 1 m² window system Top hung – Standard, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	1.05E+02	1.66E-03	8.25E-02	3.44E-01	1.04E+00	3.70E+00	-3.23E+01
GWP – fossil	kg CO_2 eq.	1.04E+02	1.66E-03	8.17E-02	3.44E-01	8.84E-01	3.70E+00	-3.22E+01
GWP – biogenic	kg CO_2 eq.	2.15E-01	-6.15E-06	6.63E-04	-1.27E-03	1.52E-01	9.34E-06	-8.66E-02
GWP - luluc	kg CO_2 eq.	4.26E-02	9.99E-06	1.04E-04	2.07E-03	5.27E-03	6.97E-05	-7.67E-03
ODP	kg CFC 11 eq.	5.85E-10	2.92E-16	1.19E-12	6.05E-14	-1.07E-12	4.33E-13	-1.71E-10
AP	mol H^+ eq.	4.78E-01	1.15E-05	2.18E-04	2.38E-03	1.60E-03	3.70E-03	-1.72E-01
EP - freshwater	kg PO_4^{3-} eq.	3.83E-04	3.89E-09	2.78E-07	8.05E-07	2.95E-06	1.76E-06	-2.62E-05
EP - marine	kg N eq.	1.11E-01	5.75E-06	7.13E-05	1.19E-03	8.36E-04	1.83E-03	-2.62E-02
EP - terrestrial	mol N eq.	1.22E+00	6.35E-05	7.69E-04	1.31E-02	9.46E-03	2.06E-02	-3.26E-01
POCP	kg NMVOC eq.	3.04E-01	1.09E-05	1.95E-04	2.26E-03	1.53E-03	4.69E-03	-7.36E-02
ADP-MM (**)	kg Sb eq.	2.23E-03	1.18E-10	1.11E-08	2.45E-08	1.46E-07	5.21E-09	-2.06E-03
ADPF (**)	MJ	1.44E+03	2.27E-02	1.58E+00	4.69E+00	4.70E+00	1.68E+00	-3.99E+02
WDP (**)	m^3	2.77E+01	8.69E-06	1.45E-02	1.80E-03	6.54E-02	3.92E-01	-4.87E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 25 Core environmental impact indicators for 1 m² widnow system Top hung – Standard, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	1.05E+02	1.66E-03	8.25E-02	2.03E-01	3.56E-01	3.92E+00	-2.31E+01
GWP – fossil	kg CO_2 eq.	1.04E+02	1.66E-03	8.17E-02	2.03E-01	3.53E-01	3.93E+00	-2.30E+01
GWP – biogenic	kg CO_2 eq.	2.15E-01	-6.15E-06	6.63E-04	-7.51E-04	2.19E-03	-6.69E-03	-8.11E-02
GWP - luluc	kg CO_2 eq.	4.26E-02	9.99E-06	1.04E-04	1.22E-03	8.61E-04	7.47E-04	-4.53E-03
ODP	kg CFC 11 eq.	5.85E-10	2.92E-16	1.19E-12	3.57E-14	1.11E-14	4.34E-13	-1.60E-10
AP	mol H^+ eq.	4.78E-01	1.15E-05	2.18E-04	1.41E-03	6.06E-04	5.34E-03	-1.24E-01
EP - freshwater	kg PO_4^{3-} eq.	3.83E-04	3.89E-09	2.78E-07	4.75E-07	1.49E-06	2.15E-06	-1.86E-05
EP - marine	kg N eq.	1.11E-01	5.75E-06	7.13E-05	7.02E-04	1.70E-04	2.25E-03	-1.71E-02
EP - terrestrial	mol N eq.	1.22E+00	6.35E-05	7.69E-04	7.75E-03	1.77E-03	2.52E-02	-1.86E-01
POCP	kg NMVOC eq.	3.04E-01	1.09E-05	1.95E-04	1.33E-03	4.28E-04	5.98E-03	-5.20E-02
ADP-MM (**)	kg Sb eq.	2.23E-03	1.18E-10	1.11E-08	1.44E-08	1.34E-07	2.70E-08	-2.06E-03
ADPF (**)	MJ	1.44E+03	2.27E-02	1.58E+00	2.77E+00	4.47E+00	4.74E+00	-2.97E+02
WDP (**)	m^3	2.77E+01	8.69E-06	1.45E-02	1.06E-03	7.93E-03	4.16E-01	-3.97E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

6.1.2 Additional environmental impact indicators

Scenario 100% glass recycling

Table 26 Additional environmental impact indicators for 1 m² window system Top hung – Standard, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	5.29E-06	3.82E-11	2.08E-09	7.90E-09	4.60E-09	1.28E-08	-2.22E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	9.42E+00	2.44E-06	3.59E-02	5.05E-04	-2.58E-02	7.79E-03	-3.75E+00
Eco-toxicity (freshwater) (**)	[CTUe]	1.75E+03	1.68E-02	7.62E-01	3.49E+00	5.24E+00	7.33E-01	-9.28E+02
Human toxicity - cancer effects (**)	[CTUh]	9.62E-07	3.36E-13	2.32E-11	6.96E-11	9.54E-11	4.90E-11	-1.83E-09
Human toxicity - non-cancer effects (**)	[CTUh]	2.79E-06	1.81E-11	6.80E-10	3.75E-09	5.46E-09	3.07E-09	3.92E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.50E+02	8.05E-03	6.11E-01	1.66E+00	4.36E+00	3.23E-01	-2.86E+01

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

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 27 Core environmental impact indicators for 1 m² window system Top hung – Standard, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	5.29E-06	3.82E-11	2.08E-09	4.66E-09	4.47E-09	3.32E-08	-1.70E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	9.42E+00	2.44E-06	3.59E-02	2.98E-04	4.14E-02	1.12E-02	-3.49E+00
Eco-toxicity (freshwater) (**)	[CTUe]	1.75E+03	1.68E-02	7.62E-01	2.06E+00	1.78E+00	2.48E+00	-1.04E+02
Human toxicity - cancer effects (**)	[CTUh]	9.62E-07	3.36E-13	2.32E-11	4.11E-11	2.46E-10	3.06E-10	-3.54E-10
Human toxicity - non-cancer effects (**)	[CTUh]	2.79E-06	1.81E-11	6.80E-10	2.21E-09	2.03E-09	3.14E-08	5.60E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.50E+02	8.05E-03	6.11E-01	9.82E-01	2.21E+00	9.41E-01	-2.16E+01

(*) **Disclaimer**: This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.
(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

6.2 Result of the LCA – Resource use

The tables below report the results of the resource use for the two glass scenarios: 100% recycling and 100% landfill.

Scenario 100% glass recycling

Table 28 Resource use for 1 m² window system Top hung – Standard, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.89E+02	1.46E-03	8.26E-01	3.03E-01	1.51E+00	2.78E-01	-1.38E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.89E+02	1.46E-03	8.26E-01	3.03E-01	1.51E+00	2.78E-01	-1.38E+02
PENRE	MJ	1.38E+03	2.27E-02	1.58E+00	4.69E+00	4.71E+00	1.68E+00	-4.00E+02
PENRM	MJ	6.79E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.45E+03	2.27E-02	1.58E+00	4.69E+00	4.71E+00	1.68E+00	-4.00E+02
SM	kg	3.85E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	8.77E-01	1.33E-06	6.68E-04	2.76E-04	1.58E-03	9.25E-03	-3.31E-01

Note: PERE – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

Scenario 100% glass landfill

Table 29 Core environmental impact indicators for 1 m² window system Top hung – Standard, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.89E+02	1.46E-03	8.26E-01	1.79E-01	2.41E+00	6.90E-01	-1.31E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.89E+02	1.46E-03	8.26E-01	1.79E-01	2.41E+00	6.90E-01	-1.31E+02
PENRE	MJ	1.38E+03	2.27E-02	1.58E+00	2.77E+00	4.47E+00	4.74E+00	-2.97E+02
PENRM	MJ	6.79E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.45E+03	2.27E-02	1.58E+00	2.77E+00	4.47E+00	4.74E+00	-2.97E+02
SM	kg	3.85E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	8.77E-01	1.33E-06	6.68E-04	1.63E-04	1.30E-03	1.00E-02	-3.06E-01

Note: PERE – use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

6.3 Result of the LCA – Output flows, waste categories

Scenario 100% glass recycling

Table 30 Output flows, waste categories for 1 m² window system Top hung – Standard, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	2.88E-06	6.07E-14	-1.06E-10	1.26E-11	3.06E-09	1.63E-10	-1.46E-07
NHWD	kg	1.80E+01	3.31E-06	1.03E-03	6.84E-04	1.40E-02	8.81E-01	-6.06E+00
RWD	kg	5.75E-02	2.37E-08	2.16E-04	4.90E-06	6.76E-05	5.13E-05	-2.15E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.35E+01	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.65E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy

Scenario 100% glass landfill

Table 31 Output flows, waste categories for 1 m² window system Top hung – Standard, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	2.88E-06	6.07E-14	-1.06E-10	7.41E-12	3.47E-09	4.88E-10	-1.50E-07
NHWD	kg	1.80E+01	3.31E-06	1.03E-03	4.03E-04	4.62E-03	1.61E+01	-5.70E+00
RWD	kg	5.75E-02	2.37E-08	2.16E-04	2.89E-06	4.21E-04	8.34E-05	-1.98E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.72E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.65E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy

7 LCA RESULTS – window system Top hung – Enhanced

7.1 Result of the LCA – Environmental impact

The tables below report the results of the LCA study for the two glass scenarios: 100% recycling and 100% landfill.

7.1.1 Core environmental impact indicators

Scenario 100% glass recycling

Table 32 Core environmental impact indicators for 1 m² window system Top hung – Enhanced, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	1.21E+02	2.16E-03	8.74E-02	4.46E-01	1.39E+00	4.28E+00	-3.75E+01
GWP – fossil	kg CO_2 eq.	1.21E+02	2.15E-03	8.66E-02	4.45E-01	1.16E+00	4.28E+00	-3.74E+01
GWP – biogenic	kg CO_2 eq.	3.06E-01	-7.98E-06	6.50E-04	-1.65E-03	2.26E-01	3.91E-05	-1.01E-01
GWP - luluc	kg CO_2 eq.	5.28E-02	1.30E-05	1.32E-04	2.67E-03	7.47E-03	8.42E-05	-9.73E-03
ODP	kg CFC 11 eq.	6.36E-10	3.79E-16	1.19E-12	7.83E-14	-1.60E-12	5.59E-13	-1.78E-10
AP	mol H^+ eq.	5.27E-01	1.49E-05	2.42E-04	3.08E-03	2.11E-03	3.95E-03	-1.98E-01
EP - freshwater	kg PO_4^{3-} eq.	4.11E-04	5.05E-09	2.89E-07	1.04E-06	3.74E-06	2.04E-06	-3.27E-05
EP - marine	kg N eq.	1.40E-01	7.46E-06	8.26E-05	1.54E-03	1.17E-03	1.94E-03	-3.10E-02
EP - terrestrial	mol N eq.	1.58E+00	8.24E-05	8.94E-04	1.70E-02	1.33E-02	2.19E-02	-3.99E-01
POCP	kg NMVOC eq.	3.89E-01	1.41E-05	2.27E-04	2.92E-03	2.09E-03	4.98E-03	-8.52E-02
ADP-MM (**)	kg Sb eq.	3.07E-03	1.53E-10	1.15E-08	3.17E-08	1.58E-07	6.40E-09	-2.70E-03
ADPF (**)	MJ	1.67E+03	2.94E-02	1.64E+00	6.07E+00	5.03E+00	2.00E+00	-4.60E+02
WDP (**)	m^3	2.78E+01	1.13E-05	1.45E-02	2.33E-03	9.39E-02	4.46E-01	-5.57E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 33 Core environmental impact indicators for 1 m² window system Top hung – Enhanced, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
GWP - total	kg CO_2 eq.	1.21E+02	2.16E-03	8.74E-02	2.35E-01	3.73E-01	4.62E+00	-2.38E+01
GWP – fossil	kg CO_2 eq.	1.21E+02	2.15E-03	8.66E-02	2.35E-01	3.70E-01	4.63E+00	-2.37E+01
GWP – biogenic	kg CO_2 eq.	3.06E-01	-7.98E-06	6.50E-04	-8.70E-04	2.30E-03	-9.95E-03	-9.29E-02
GWP - luluc	kg CO_2 eq.	5.28E-02	1.30E-05	1.32E-04	1.41E-03	9.01E-04	1.09E-03	-5.05E-03
ODP	kg CFC 11 eq.	6.36E-10	3.79E-16	1.19E-12	4.13E-14	1.16E-14	5.60E-13	-1.61E-10
AP	mol H^+ eq.	5.27E-01	1.49E-05	2.42E-04	1.63E-03	6.34E-04	6.40E-03	-1.27E-01
EP - freshwater	kg PO_4^{3-} eq.	4.11E-04	5.05E-09	2.89E-07	5.50E-07	1.56E-06	2.61E-06	-2.14E-05
EP - marine	kg N eq.	1.40E-01	7.46E-06	8.26E-05	8.13E-04	1.78E-04	2.58E-03	-1.74E-02
EP - terrestrial	mol N eq.	1.58E+00	8.24E-05	8.94E-04	8.98E-03	1.86E-03	2.89E-02	-1.90E-01
POCP	kg NMVOC eq.	3.89E-01	1.41E-05	2.27E-04	1.54E-03	4.48E-04	6.91E-03	-5.31E-02
ADP-MM (**)	kg Sb eq.	3.07E-03	1.53E-10	1.15E-08	1.67E-08	1.40E-07	3.88E-08	-2.70E-03
ADPF (**)	MJ	1.67E+03	2.94E-02	1.64E+00	3.20E+00	4.68E+00	6.56E+00	-3.08E+02
WDP (**)	m^3	2.78E+01	1.13E-05	1.45E-02	1.23E-03	8.30E-03	4.83E-01	-4.23E+00

Note: GWP – Global Warming Potential; ODP – Ozone Depletion; AP – acidification potential for soil and water; EP – Eutrophication potential; POCP – formation potential of tropospheric ozone; ADP - MM – abiotic depletion potential for non fossil resources; ADPF – Abiotic depletion potential for fossil resources; WDP – Water deprivation potential.

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

7.1.2 Additional environmental impact indicators

Scenario 100% glass recycling

Table 34 Additional environmental impact indicators for 1 m² window system Top hung – Enhanced, ***scenario 100% glass recycling***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	5.65E-06	4.95E-11	2.36E-09	1.02E-08	4.88E-09	1.44E-08	-2.49E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	9.56E+00	3.17E-06	3.60E-02	6.54E-04	-5.68E-02	9.27E-03	-4.02E+00
Eco-toxicity (freshwater) (**)	[CTUe]	2.45E+03	2.18E-02	8.10E-01	4.51E+00	7.03E+00	9.27E-01	-1.34E+03
Human toxicity - cancer effects (**)	[CTUh]	9.60E-07	4.36E-13	2.42E-11	9.01E-11	3.30E-11	5.83E-11	-7.16E-10
Human toxicity - non-cancer effects (**)	[CTUh]	3.16E-06	2.35E-11	7.36E-10	4.85E-09	7.23E-09	3.78E-09	5.36E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.81E+02	1.04E-02	6.34E-01	2.15E+00	5.52E+00	3.95E-01	-3.56E+01

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

(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

Scenario 100% glass landfill

Table 35 Core environmental impact indicators for 1 m² window system Top hung – Enhanced, ***scenario 100% glass landfill***

Impact category	Unit	A1-A3	A4	C1	C2	C3	C4	D
Particular Matter emissions	Disease incidence	5.65E-06	4.95E-11	2.36E-09	5.40E-09	4.68E-09	4.48E-08	-1.72E-06
Ionising radiation - human health (*)	[kBq U235 eq.]	9.56E+00	3.17E-06	3.60E-02	3.45E-04	4.34E-02	1.43E-02	-3.62E+00
Eco-toxicity (freshwater) (**)	[CTUe]	2.45E+03	2.18E-02	8.10E-01	2.38E+00	1.87E+00	3.53E+00	-1.09E+02
Human toxicity - cancer effects (**)	[CTUh]	9.60E-07	4.36E-13	2.42E-11	4.76E-11	2.58E-10	4.42E-10	1.49E-09
Human toxicity - non-cancer effects (**)	[CTUh]	3.16E-06	2.35E-11	7.36E-10	2.56E-09	2.13E-09	4.61E-08	7.86E-07
Land Use related impacts/ Soil quality (**)	dimensionless	2.81E+02	1.04E-02	6.34E-01	1.14E+00	2.31E+00	1.32E+00	-2.52E+01

(*) **Disclaimer**: This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.
(**) **Disclaimer**: the results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

7.2 Result of the LCA – Resource use window system Top hung – Enhanced, 1 m^2

The tables below report the results of the resource use for the two glass scenarios: 100% recycling and 100% landfill.

Scenario 100% glass recycling

Table 36 Resource use for 1 m^2 window system Top hung – Enhanced, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	4.18E+02	1.90E-03	8.30E-01	3.92E-01	1.18E+00	3.49E-01	-1.47E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	4.18E+02	1.90E-03	8.30E-01	3.92E-01	1.18E+00	3.49E-01	-1.47E+02
PENRE	MJ	1.59E+03	2.94E-02	1.64E+00	6.07E+00	5.04E+00	2.00E+00	-4.61E+02
PENRM	MJ	7.84E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.67E+03	2.94E-02	1.64E+00	6.07E+00	5.04E+00	2.00E+00	-4.61E+02
SM	kg	3.92E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	9.26E-01	1.73E-06	6.72E-04	3.57E-04	1.78E-03	1.05E-02	-3.49E-01

Note: PERE – use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

Scenario 100% glass landfill

Table 37 Core environmental impact indicators for 1 m^2 window system Top hung – Enhanced, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	4.18E+02	1.90E-03	8.30E-01	2.07E-01	2.53E+00	9.63E-01	-1.35E+02
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	4.18E+02	1.90E-03	8.30E-01	2.07E-01	2.53E+00	9.63E-01	-1.35E+02
PENRE	MJ	1.59E+03	2.94E-02	1.64E+00	3.20E+00	4.68E+00	6.57E+00	-3.08E+02
PENRM	MJ	7.84E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.67E+03	2.94E-02	1.64E+00	3.20E+00	4.68E+00	6.57E+00	-3.08E+02
SM	kg	3.92E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	9.26E-01	1.73E-06	6.72E-04	1.89E-04	1.36E-03	1.17E-02	-3.12E-01

Note: PERE – use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM – use of renewable primary energy resources used as raw materials; PERT – Total use of renewable primary energy resources; PENRE – use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM – use of non-renewable primary energy resources used as raw materials; PENRT – Total use of non-renewable primary energy resources; SM – Use of secondary materials; RSF – Use of renewable secondary fuels; NRSF – use of non-renewable secondary fuels; FW – use of net fresh water.

7.3 Result of the LCA – Output flows, waste categories

Scenario 100% glass recycling

Table 38 Output flows, waste categories for 1 m² window system Top hung – Enhanced, ***scenario 100% glass recycling***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	2.76E-06	7.87E-14	-1.06E-10	1.63E-11	3.02E-09	1.73E-10	-1.50E-07
NHWD	kg	1.89E+01	4.29E-06	1.04E-03	8.85E-04	1.88E-02	9.85E-01	-6.27E+00
RWD	kg	6.00E-02	3.07E-08	2.16E-04	6.35E-06	-8.58E-05	6.19E-05	-2.35E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E+01	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.47E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy.

Scenario 100% glass landfill

Table 39 Output flows, waste categories for 1 m² window system Top hung – Enhanced, ***scenario 100% glass landfill***

Parameter	Unit	A1-A3	A4	C1	C2	C3	C4	D
HWD	kg	2.76E-06	7.87E-14	-1.06E-10	8.58E-12	3.64E-09	6.58E-10	-1.55E-07
NHWD	kg	1.89E+01	4.29E-06	1.04E-03	4.67E-04	4.84E-03	2.37E+01	-5.73E+00
RWD	kg	6.00E-02	3.07E-08	2.16E-04	3.35E-06	4.41E-04	1.10E-04	-2.10E-02
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.94E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.47E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+01	0.00E+00

Note: HWD – hazardous waste disposed; NHWD – Non-hazardous waste disposed; RWD – Radioactive waste disposed; CRU – Components for re-use; MFR – Materials for recycling; MER – Materials for energy recovery; EEE – Exported electrical energy; EET – Exported thermal energy.

8 LCA – INTERPRETATION

The results are analysed and interpreted for modules A1-A3 and modules C1-D for the product with the highest LCIA results within this EPD. In case the selected product has double and triple glazing variants, a comparison between these two options is provided. Results for module A4 are not further interpreted, as calculated only for 1 km. Finally, the end-of-life modules are compared to the most impactful modules (A1-A3) for the product with the highest LCIA results. This allows a comparison of the impacts of the two extreme end-of-life scenarios for glass: 100% glass recycling and 100% glass to landfill.

Production stages: modules A1 to A3.

The biggest contributor to the environmental impacts is aluminium production which is influenced by the mass of aluminium in the declared unit: the higher the aluminium mass, the higher the indicator. Hence, the GWP indicator evolves from 1.05E+02 [kg CO2-eq] for the double glazed Top hung window to 1.21E+02 [kg CO2-eq] for the triple glazed Top hung window.

Within the aluminium production processes, the primary aluminium production is dominant, especially the alumina production and the electrolysis. The recycled ingot production, which presents a much lower impact than the primary ingot production, is used in Module A1-A3 for the fraction of aluminium coming from recycling. The extrusion process which converts ingot, i.e. billets, into profile is much less significant. The LCA modelling and the impact of the primary aluminium production are detailed in the Environmental Profile Report 2018 of European Aluminium.

End-of-life stage: modules C1-C4 and module D

Modules C1-C3: they are negligible for all products compared to modules A1-A3 (<1.6% for scenario 100% glass recycling and <0.6% for scenario 100% glass landfill).

Module C4: the contribution of module C4 (disposal) is very limited (<3.8%) compared to modules A1-A3 and module D.

Module D: environmental benefits come from the recycling of aluminium. About 31% of GWP savings, for scenario 100% glass recycling, are obtained in Module D compared to the value calculated for module A1-A3 and 19.7% for scenario 100% glass landfill. These calculations show the relevance to consider Module D in the full assessment of the window system in the building context.

9 OTHER INFORMATION

These EPD results have been calculated from an LCA tool for EPD, based on the LCA for Experts database, initially realised by thinkstep GmbH in 2013 and updated by Ecoinnovazione in 2019 and 2022 (Ecoinnovazione S.r.l. – spin-off ENEA Via della Liberazione, 6/c, 40128 Bologna BO www.ecoinnovazione.it)

10 REFERENCES

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