# Research on the Impacts of Innovative Fenestration Materials on the Embodied and Operating Carbon of Buildings


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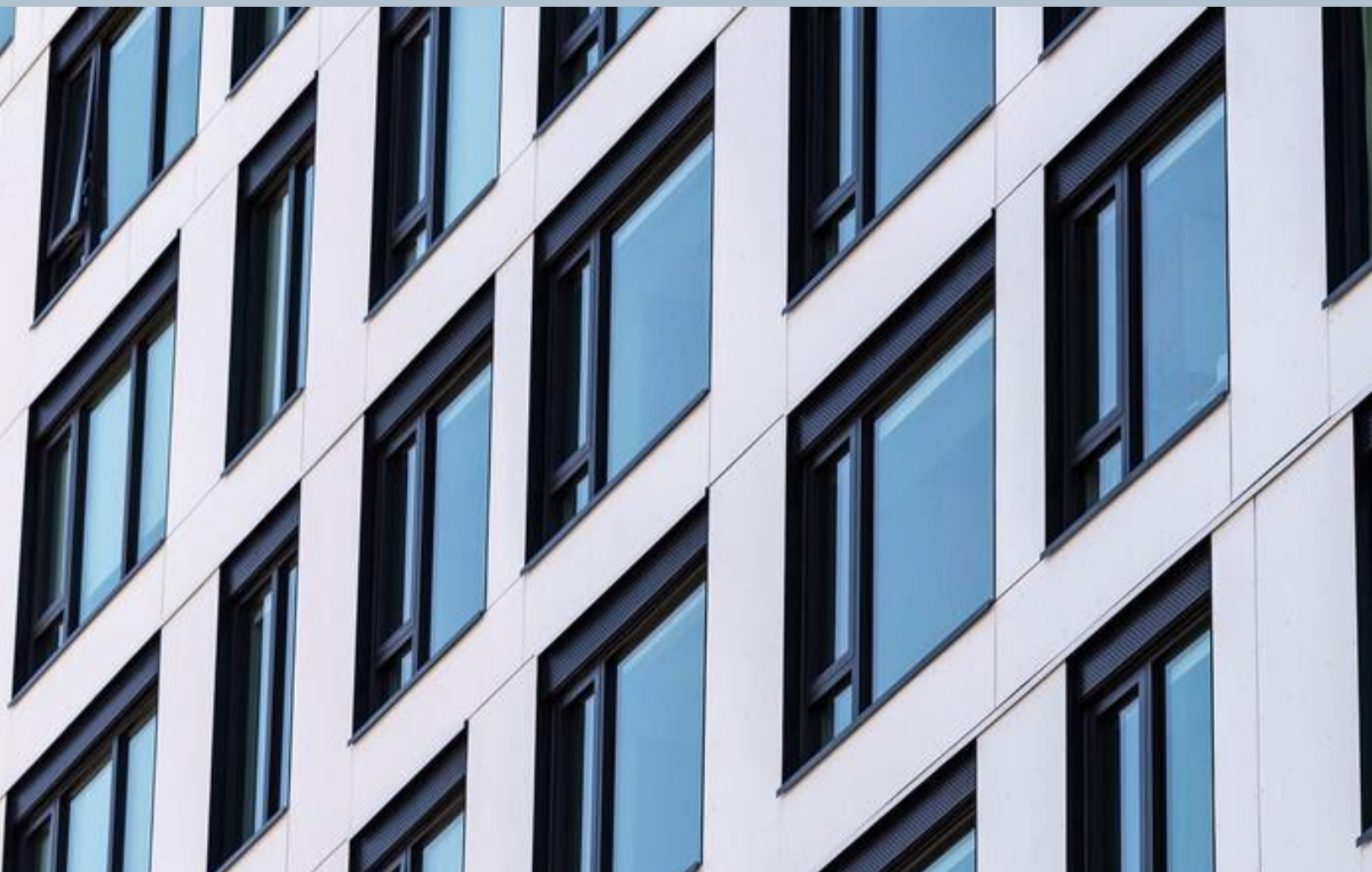
August 2022



This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Cascadia Windows and Doors staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the University of British Columbia.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## Acknowledgements

The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations. The author would also like to acknowledge the many Indigenous peoples who have been caretakers of the land since time immemorial. The ongoing discussion and efforts related to reconciliation are just the beginning of a long journey, with much more work to be done.

The author would like to thank the Sustainability Scholars Program for this opportunity to work on this project, and Karen Taylor for providing guidance and support. Special thanks to professor Qingshi Tu for his guidance and support. The author would also like to thank Solveig Rey for being a supportive mentor and for her insights and contribution.

Also, a special thank you to Michael Bousfield for his countless efforts in providing resources and data.

*Cover photo from Cascadia Windows and Doors*

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## Executive Summary

Buildings are estimated to account for approximately 40% of Global $CO_2$ emissions. Windows are one of the largest contributors to the embodied carbon emissions of buildings. Different types of windows have different environmental impacts. Innovative high-performance fenestration products such as fiberglass windows have been demonstrated to reduce the carbon impacts of buildings. However, research contrasting the embodied carbon emissions of traditional windows such as aluminum and PVC versus innovative materials such as fiberglass is lacking. Hence, this research project first evaluated the global warming potential (GWP) of fiberglass windows manufactured by Cascadia Windows and Doors, British Columbia, Canada; second, reviewed and listed the GWP of traditional window production reported in publicly available environmental product declaration (EPD)s; third, compared and contrasted the results of traditional windows versus innovative materials; and fourth, Conducted a survey to find out how the windows EPDs are used by architects. The results showed 84.91 kg $CO_2$eq for 1$m^2$ of fiberglass frame production at the gate of Cascadia Windows and Door manufacturer. Fiberglass windows have the potential to reduce the embodied carbon emissions of buildings compared to aluminum and PVC framed-windows. It is also found that architects use EPDs to assess and minimize the carbon impact of their material selection and to prioritize manufacturers that are committed to environmental impact reduction and significant level of transparency.

# 1. Introduction

Construction is a resource and energy intensive industry. Construction and demolition of buildings consume 40 percent of global raw materials and cause 40 percent of energy related carbon emissions [1, 2]. According to the Paris Agreement, by 2050 the embodied carbon emissions of new construction, infrastructure and renovations must be net-zero [3]. Hence controlling resource use and greenhouse gas emissions requires transforming the built environment from the main contributors of greenhouse gas emissions. One significant contributor to the embodied carbon emissions of buildings are windows. Windows are key components of sustainable buildings as they play technical, functional and aesthetic roles. Hence, understanding the embodied carbon emissions of a window itself is crucial in order to reduce the environmental impacts of construction sector.

Windows can be fixed (non-opening), or operable, (opening), but their main components include the frame, sash, and insulated glazing unit (IGU). Window frames can be made of various materials including aluminum, wood, PVC/vinyl, fiberglass or a combination of all [2]. Different type of windows have different environmental impacts. Innovative high-performance windows (e.g. fiberglass) have been shown to have lower embodied and operational carbon impacts compared to traditional windows (e.g. aluminum). Cascadia Windows and Doors designs and manufactures fiberglass windows featuring an innovative, commercial-grade fiberglass frame which improves the thermal performance[1]. This high-performance design translates into lower heating and cooling costs, as well as a more comfortable and resilient building. In addition, the windows will not sag, weaken or creep over time as they are made from high glass-to-resin, thermoset fiberglass; they are not susceptible to corrosion, rot, insect damage or UV degradation as they are made from non-organic, chemically inert pultruded fiberglass [4].

However, research contrasting traditional (e.g. aluminum, wood, PVC) and innovative (e.g. fiberglass) materials used in window framing is lacking. Therefore, this research project aims to

[1] https://www.cascadiawindows.com/

determine the embodied carbon emissions of commercial-grade fiberglass windows manufactured by Cascadia Windows and Doors, in British Columbia, Canada. Also, this research aims to compare the results of embodied carbon emissions of fiberglass windows with traditional windows. Results of this comparative study would help educate architects, policy makers, occupants and other stakeholders in the Architecture, Engineering & Construction (AEC) space about alternative fenestration options, and ultimately help speed up their adoption into built environments and help reduce the embodied carbon emissions of buildings.

### 1.1. Product description

The declared product is a punched opening fiberglass window; known as Universal Series Window with Hydro Tuff water-borne urethane coatings.

### 1.2. Technical Data

The technical data for a fiberglass window is provided in Table 1.

**Table 1: Technical Data**

| Name | Value | Unit |
|---|---|---|
| Area | 1.8 | $m^2$ |
| Frame Thickness | 0.05 | m |
| Glazing area | 1.65 | $m^2$ |

## 2. Methodology

This research method utilizes the published Product Category Rule (PCR) for windows to determine the required data for evaluating the embodied carbon of commercial-grade fiberglass windows manufactured by Cascadia Windows and Doors. Data is gathered from staff and suppliers of input materials to generate a cradle-to-gate Life Cycle Assessment (LCA) and a subsequent Environment Product Declaration (EPD) report through a third-party Program Operator. LCA methodology is a quantitative tool for evaluating the environmental impacts of a product or service. LCA framework consists of four distinct methodological phases; 1. Goal and

scope definition, 2. Life cycle inventory (LCI), 3. Life cycle impact assessment (LCIA), and 4. Life cycle interpretation [5, 6]. In the first phase of LCA, the goal and scope of the study should be clarified, including, declared or functional unit, system boundary, assumptions and limitations.

## 2.1. LCA: Calculation rules

### 2.1.1. Declared Unit

The declared unit is 1 square meter (1 $m^2$) of punched opening fiberglass window including the frame produced at Cascadia Windows and Doors manufacturing.

### 2.1.2. System Boundary

Following PCR guidelines, a cradle-to-gate system boundary should be considered for evaluating the LCA of a window. Table 2 provides a description of system boundary and the included parts in this study (A1-A3). The life cycle of windows starts with A1. Extraction, handling, and processing of input materials, which require energy, and causes waste. Then at A2. input materials are transported from suppliers to the gate of the Cascadia Windows and Doors manufacturing, and finally A3. Fiberglass windows at the facility are manufactured, meaning that frame pieces (fiberglass) are combined with two or more sheets of float glass (IGU), argon used for filling the space between panes, and sealant used for sealing the chamber.

**Table 2: Description of system boundary included in LCA**

| Product | | | Construction Installation | | Use | | | | | | | End-of-life | | | | Benefits Beyond the System Boundary | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw Material supply | Transport | Manufacturing | Transport | Construction / Installation | Use | Maintenance | Repair | Replacement | Refurbishment | Operational Energy Use | Operational Water Use | De-Construction/ Demolition | Transport | Waste processing | Disposal | Reuse | Recovery | Recycling |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D | D | D |

### 2.1.3. Completeness & Cutoff Criteria

All known input and output data and processes as well as known emissions to air, water, and soil are included. The sum of mass inputs and energy consumption in the system does not exceeded the 5% recommended cut-off criteria.

### 2.1.4. Inventory analysis

Life cycle inventory includes input and output data at the unit process level that are used to calculate the life cycle impact assessment [5, 7]. Data was provided by staff at Cascadia Windows and Doors based on the production at year 2022. The life cycle inventory and data source are shown in Table 1.

Table 1 Life cycle inventory and data source for producing 1 m² fiberglass frame

| A1. Raw material inputs | LCI data source | Unit | Amount |
|---|---|---|---|
| Fiberglass | Ecoinvent 3.7: Fiberglass production \| user-defined \| Cut-off, U | $m^2$ | 0.97 |
| Shearblock | Ecoinvent 3.7: Glass fiber reinforced plastic \|user-defined \|Cutoff, U | kg | 0.15 |
| Styrofoam | Ecoinvent 3.7: Styrofoam production \| user-defined \| Cut-off, U | $m^2$ | 1.93 |
| Gasket | Ecoinvent 3.7: Gasket production \| user-defined \| Cut-off, U | m | 5.67 |
| Paint | Ecoinvent 3.7: Alkyd paint production, white, water-based, product in 60% solution state\| Cutoff, U | kg | 0.52 |
| Sealant | Ecoinvent 3.7: Silicone product production \| silicone product \| Cutoff, U | kg | 0.13 |
| A2. Transportation | | | |
| Trucking | Ecoinvent 3.7: Transport, freight, lorry 7.5-16 metric ton, EURO3 \| Cutoff, U | kg*km | 44608 |
| A3. Manufacturing | | | |
| Natural gas | Ecoinvent 3.7: Heat and power co-generation, natural gas, conventional power plant, 100MW electrical\| Cutoff, U | MJ | 161.55 |
| Electricity | Ecoinvent 3.7: Market for electricity, medium voltage \| electricity, medium voltage \| Cutoff, U | kWh | 26.09 |

### 2.2. EPD: Comparing EPDs of Windows

To compare the embodied carbon emissions of fiberglass windows produced at Cascadia Windows and Doors with windows (aluminum, wood, PVC framing) produced by other manufacturers, available EPDs were reviewed. To find the windows related EPDs, a Google search was conducted by applying a set of keywords including EPD AND window, EPD AND fenestration, EPD AND window frame to find the available windows related EPDs. A total of 37 windows/framing EPDs including 80 products are retrieved. Among them, 21 EPDs are for aluminum framed windows (including 48 products), 6 EPDs for wood framed windows (including 20 products), 9 EPDs for PVC framed windows (including 11 products), and one fiberglass-framed window EPD (1 product).

# 3. Analysis and Results

## 3.1. Life cycle impact assessment

The third stage of LCA is life cycle impact assessment, which focuses on calculating the environmental impacts of a product (window) throughout its life cycle. Life cycle impact assessment translates life cycle inventory into environmental impacts using formalized impact assessment methods [5, 6]. The cradle-to-gate environmental impacts (GWP) of fiberglass window production are evaluated using US EPA TRACI method, Version 2.1. It is evaluated that the GWP of 1 $m^2$ Cascadia fiberglass frame production for the cradle-to-gate (A1-A3) product system is 84.91 kg $Co_2$eq. Figure 1 shows the contribution of each flow into the GWP impact category.

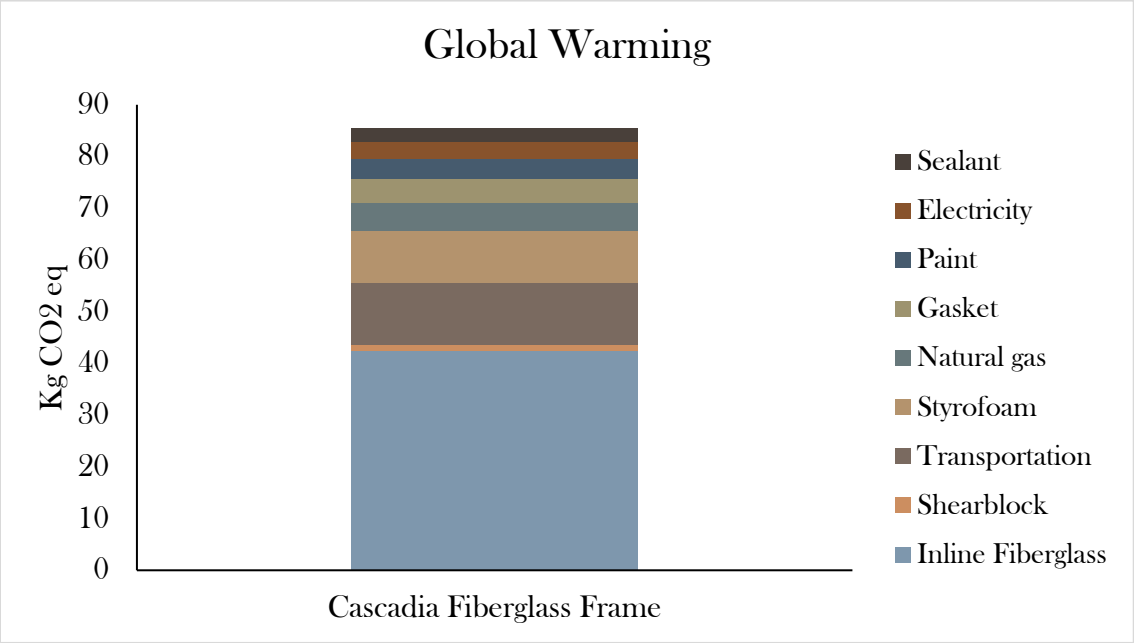


**Figure 1 Embodied carbon emissions (CO2eq) of 1 m² fiberglass frame made in Cascadia Windows and Doors manufacturer.**

In the production of a Cascadia fiberglass frame, the raw material supply (A1) has the highest impact on GWP with a 71% contribution. The second contributor is the energy consumption (electricity and natural gas) of manufacturing, which contributes 18% of GWP impact category

(both direct and indirect emissions). The third/last contributor is transportation of raw materials to the manufacturer (11%). Producing fiberglass windows with different types of insulated glazing unit (IGU) has different environmental impacts. Figure 2 shows GWP of fiberglass windows with a double pane and triple pane annealed IGU. The GWP results of fiberglass window with double pane and triple pane, annealed IGU were evaluated 121.20 and 145.22 kg $CO_2$eq, respectively. Application of triple pane IGU resulted in 15% higher carbon impact compared to the double pane IGU.

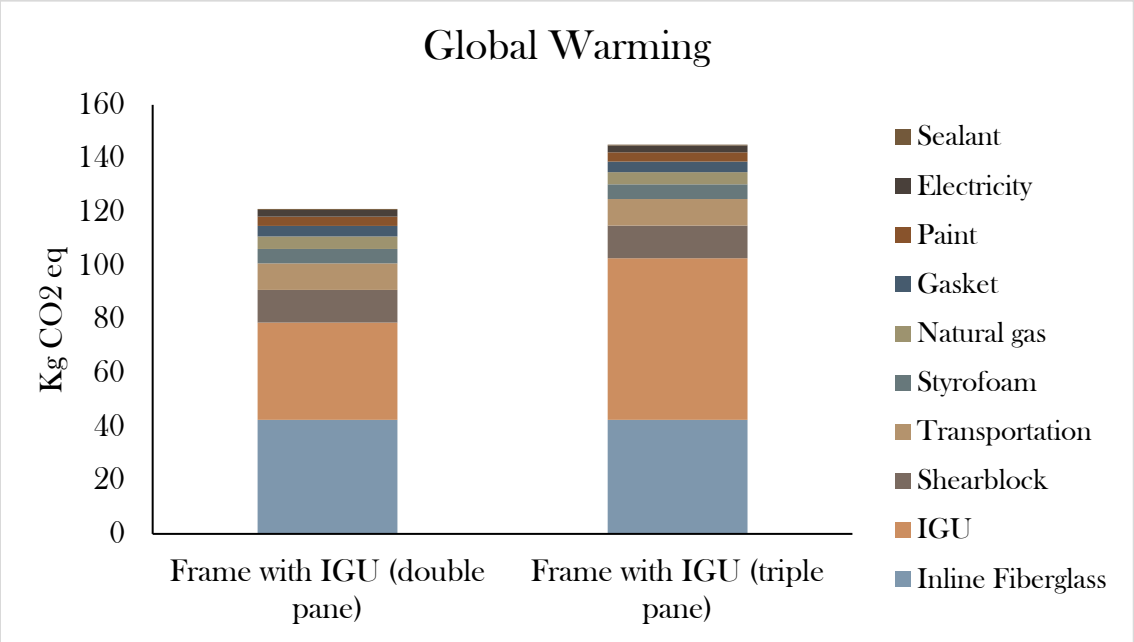


**Figure 2 Global warming potential (CO2eq) of 1 m2 fiberglass frame windows with double pane and triple pane IGU.**

### 3.2. Comparison of window EPDs

A list of aluminium, wood, PVC and fiberglass windows EPDs with their associated GWP are provided in Table 2-5, respectively. The results show that a fiberglass window might have lower or higher carbon impacts compared to the traditional windows such as aluminium, combination of aluminium & wood, and PVC that depends on which manufacturer the traditional windows are made by. However, compared to the wood only framed windows, fiberglass windows showed slightly higher carbon impacts.

**Table 2 List of aluminum framed window EPDs**

| EPD | Manufacturer | Product | Location | Declared unit | GWP (kg CO2 eq) |
|---|---|---|---|---|---|
| Link | Kawneer (UK) Ltd | Aluminium Window System | Runcorn, England | 1.23m x 1.48m | 109.65 |
| Link | AEA (Asociación Española de Aluminio0 members in Spain | Aluminium windows (Frame width: 45 -50) | Spain | 1 m² | 117 |
| Link | AEA (Asociación Española de Aluminio0 members in Spain | Aluminium windows (Frame width: 70 -75) | Spain | 1 m² | 146 |
| Link | European Aluminium | Aluminium window | Europe | 1 m² | 133.76 |
| Link | Hydro Building Systems Germany GmbH WICONA window series | Aluminium window system | Germany | 1.23m x 1.48m | 178.82 |
| Link | Hueck system GmbH & Co. KG | Aluminium window system (Depth 75 mm) | Germany | 1.23m x 1.48m | 25.99 |
| Link | Hueck system GmbH & Co. KG | Aluminium window system (Depth 90 mm) | Germany | 1.23m x 1.48m | 25.15 |
| Link | Norgesvinduet Kompetanse AS | Opening Window with aluminium cladding and wood frame | Norway | 1.23m x 1.48m | 130 |
| Link | EFCO | Aluminum windows | Monett, Missouri | 1 m² | 150 |
| Link | Arcadia Projected and Casement Windows | Aluminum windows | Vernon, CA, Las Vegas, NV, Stamford, CT | 1 m² | 125 |
| Link | Arcadia | Aluminum window Walls | Vernon, CA, Las Vegas, NV, Stamford, CT | 1 m² | 177 |
| Link | AluQuébec | Aluminium window | Québec, Canada | 1 m² | 136 |
| Link | Metra | Aluminium window NC-S120STH Montreal | Italy | 1 m² | 123.378 |
| Link | Metra | Aluminium window NC-S120STH Europa | Italy | 1 m² | 121.863 |
| Link | Metra | Aluminium window NC-S120STH SLIM | Italy | 1 m² | 133.408 |
| Link | Metra | Aluminium window NC-S150HES | Italy | 1 m² | 139.375 |

| | | | | | |
|---|---|---|---|---|---|
| Link | Metra | Aluminium window NC-S170HES | Italy | 1 m² | 144.88 |
| Link | Metra | Aluminium window NC-S175HES LUX | Italy | 1 m² | 152.127 |
| Link | YKK AP America | Aluminum window system | America | 1.23 m x 1.48 | 189 |
| Link | YKK AP America | Aluminum window wall system | America | 1 m² | 68.40 |
| Link | YKK AP America | Aluminum Curtain Wall Systems | America | 1 m² | 52.70 |
| Link | Reynaers Aluminium | Double glazing (2 X 6 mm of glass) aluminium window | Belgium | 1 m² | 84.36 |
| Link | Reynaers Aluminium | Double glazing (2 X 6 mm of glass) aluminium window | Belgium | 1 m² | 85.84 |
| Link | Reynaers Aluminium | Double glazing (2 X 6 mm of glass) aluminium window | Belgium | 1 m² | 61.54 |
| Link | Reynaers Aluminium | Double glazing (2 X 6 mm of glass) aluminium window | Belgium | 1 m² | 56.41 |
| Link | Reynaers Aluminium | Curtain wall Double glazing (8 mm glass – 15 mm gap – 10 mm glass) | Belgium | 1 m² | 115 |
| Link | Reynaers Aluminium | Curtain wall Double glazing (8 mm glass – 15 mm gap – 10 mm glass) | Belgium | 1 m² | 114 |
| Link | Reynaers Aluminium | Curtain wall Triple glazing | Belgium | 1 m² | 151 |
| Link | Reynaers Aluminium | Aluminium window 86-HI window –type SDOSo i.e. Standard size, Double glazing, Operable, Sobinco fittings | Belgium | 1 m² | 117.00 |

| | | | | | |
|---|---|---|---|---|---|
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type SDOSi<br>i.e. Standard size, Double glazing, Operable, Siegenia fittings | Belgium | 1 m² | 118.30 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type STOSo<br>i.e. Standard size, Double glazing, Operable, Sobinco fittings | Belgium | 1 m² | 118.95 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type STOSi<br>i.e. Standard size, Triple glazing, Operable, Siegenia fittings | Belgium | 1 m² | 124.15 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type LDOSo<br>i.e. Large size, Double glazing, Operable, Sobinco fittings | Belgium | 1 m² | 100.80 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type LTOSo<br>i.e. Large size, Triple glazing, Operable, Sobinco fittings | Belgium | 1 m² | 109.20 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type SDN<br>i.e. Standard size, Double glazing, Non-operable | Belgium | 1 m² | 75.58 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type STN<br>i.e. Standard size, Triple glazing, Non-operable | Belgium | 1 m² | 108 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type LDN<br>i.e. Large size, Double glazing, Non-operable | Belgium | 1 m² | 67.31 |

| | | | | | |
|---|---|---|---|---|---|
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type LTN<br>i.e. Large size, Triple glazing, Non-operable | Belgium | 1 m² | 77.85 |
| Link | Reynaers Aluminium | Aluminium window<br>86-HI window –type HV- LTOSo<br>i.e. Hidden Vent, Large size, Triple glazing, Operable, Sobinco fittings | Belgium | 1 m² | 102.09 |
| Link | Architectural & Metal Systems Ltd. | Aluminium window XT66<br>Performance Plus Tilt & Turn DG (double glazed) | Ireland | 1.23m x 1.48m | 327 |
| Link | Architectural & Metal Systems Ltd. | Aluminium window XT66<br>Performance Plus Tilt & Turn TG (triple glazed) | Ireland | 1.23m x 1.48m | 354 |
| Link | Architectural & Metal Systems Ltd. | Aluminium window XT66<br>Performance Plus Tilt & Turn DG (double glazed) | Ireland | 1.48m x 2.18m | 464 |
| Link | Architectural & Metal Systems Ltd. | Aluminium window XT66<br>Performance Plus Tilt & Turn TG (triple glazed) | Ireland | 1.48m x 2.18m | 517 |
| Link | Munster Joinery | Passiv AluClad double glazed window | Ireland | 1 m² | 158 |
| Link | Munster Joinery | Passiv AluClad triple glazed window | Ireland | 1 m² | 195 |
| Link | Munster Joinery | Passiv AluP double glazed window | Ireland | 1 m² | 230 |
| Link | Munster Joinery | Passiv AluP triple glazed window | Ireland | 1 m² | 220 |

Table 3 List of wood framed window EPDs

| EPD | Manufacturer | Product | Location | Declared unit | GWP (kg CO2 eq) |
|---|---|---|---|---|---|
| Link | Accoya Nederlandse Branchevereniging voor de Timmerindustrie | Fixed wooden window frame | Netherland | 1500x3300 mm | 8.76 |
| Link | Accoya Nederlandse Branchevereniging voor de Timmerindustrie | Wooden window frame with outward opening window | Netherland | 1200 x 1800mm | 23.30 |
| Link | Accoya Nederlandse Branchevereniging voor de Timmerindustrie | Wooden window frame with tilt and turn window | Netherland | 1400 x 1800mm | 24.20 |
| Link | Svenska Fönster AB, Sweden | Wood sidehung window | Sweden | 1 m² | 76.70 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum sidehung window | Sweden | 1 m² | 90.10 |
| Link | Svenska Fönster AB, Sweden | Wood fully reversable window | Sweden | 1 m² | 93.40 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum fully reversable window | Sweden | 1 m² | 106.90 |
| Link | Svenska Fönster AB, Sweden | Wood fixed window | Sweden | 1 m² | 62.10 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum fixed window | Sweden | 1 m² | 66.70 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum inward window | Sweden | 1 m² | 84.60 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum inward window | Sweden | 1 m² | 90.80 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum inward Kipp-dreh window | Sweden | 1 m² | 89.30 |
| Link | Svenska Fönster AB, Sweden | Wood/aluminum inward Kipp-dreh window | Sweden | 1 m² | 95.50 |
| Link | Elitfönster AB | An outward opening wooden window with external aluminum cladding | Sweden | 1 m² | 50.46 |

| | | | | | |
|---|---|---|---|---|---|
| Link | Munster Joinery | Hardwood double glazed window | Ireland | 1 $m^2$ | 79.50 |
| Link | Munster Joinery | Hardwood triple glazed window | Ireland | 1 $m^2$ | 114 |
| Link | Munster Joinery | Softwood double glazed window | Ireland | 1 $m^2$ | 79.40 |
| Link | Munster Joinery | Softwood triple glazed window | Ireland | 1 $m^2$ | 114 |
| Link | Kiwa BCS Öko-Garantie GmbH | Windows / fixed windows outward opened | Germany | 1 $m^2$ | -4.59 |
| Link | Mumford & Wood limted | Consevation on Casement Window | London | 1 $m^2$ | 105 |

Table 4 List of PVC framed window EPDs

| EPD | Manufacturer | Product | Location | Declared unit | GWP (kg CO2 eq) |
|---|---|---|---|---|---|
| Link | European PVC Window Profiles and Related Building Products Association ivzw & QKE - Qualitätsverband Kunststofferzeugnisse e.V. Am Hofgarten 1-2; 53113 Bonn Germany | UPVC | Europe | 1.23 m x 1.48 m | 116 |
| Link | Munster Joinery Ltd | Passiv PVC window | Ireland | 1.23 m x 1.48 m | 56.60 |
| Link | Firat Plastik Kauçuk San. | White PVC Doors and Window Profiles | Turkey | 1 kg of White PVC Windows | 4.97 |
| Link | QKE Qualitätsverband Kunststofferzeugnisse e.V. EPPA European PVC Window Profiles and Related Building Products Association ivzw | PVC-U single-sash window | Germany | 1.23 m x 1.48 m | 158 |
| Link | QKE - Qualitätsverband Kunststofferzeugnisse e.V. Am Hofgarten 1-2; 53113 Bonn Germany EPPA - European PVC Window Profiles and related Building Products Association ivzw Avenue de Cortenbergh 71; 1000 Brussels Belgium | PVC-U plastic windows | Germany | 1.23 m x 1.48 m | 146 |
| Link | QKE - Qualitätsverband Kunststofferzeugnisse e.V. Am Hofgarten 1-2; 53113 Bonn Germany EPPA - European PVC | PVC-U plastic windows | Germany | 1.23 m x 1.48 m | 158 |

| | | | | | |
|---|---|---|---|---|---|
| | Window Profiles and related Building Products Association ivzw Avenue de Cortenbergh 71; 1000 Brussels Belgium | | | | |
| Link | QKE - Qualitätsverband Kunststofferzeugnisse e.V. Am Hofgarten 1-2; 53113 Bonn Germany EPPA - European PVC Window Profiles and related Building Products Association ivzw Avenue de Cortenbergh 71; 1000 Brussels Belgium EPPA - Europeam PVC window profiles and related building proucts association ivzw Avenue de Cortenbergh 71; 1000 Brussels Belgium | Plastic window | Germany | 1.23 m x 1.48 m | 80 |
| Link | Munster Joinery Ltd | HP uPVC double glazed window | Ireland | 1 $m^2$ | 105 |
| Link | Munster Joinery Ltd | HP uPVC triple glazed window | Ireland | 1 $m^2$ | 139 |
| Link | Munster Joinery Ltd | Passiv uPVC double glazed window | Ireland | 1 $m^2$ | 123 |
| Link | Munster Joinery Ltd | Passiv uPVC triple glazed window | Ireland | 1 $m^2$ | 160 |

Table 5 List of fiberglass framed window EPDs

| EPD | Manufacturer | Product | Location | Declared unit | GWP (kg CO2 eq) |
|---|---|---|---|---|---|
| Link | Inline Fiberglass Windows | Fiberglass | Toronto, CA | 1 $m^2$ | 75.70 |

### 3.3. Windows EPDs used by architects

To understand how windows EPDs are used by architects and architecture firms, especially those participating in American Institute of Architects (AIA) 2030 commitment ("to design for energy efficiency and carbon neutrality by 2030"), an anonymous survey was conducted. The highlights of the survey include:

- Architects use EPDs to assess and minimize the carbon impact of their material selection and to prioritize manufacturers that are committed to a significant level of transparency and environmental impact reduction.
- Architects work with many clients that prioritize green building certifications like LEED and ILFI Living Building Challenge. These certifications often require a certain percentage of products to have EPDs in order for the project to earn credit.
- Architecture firms are working towards carbon neutrality by 2030, and EPDs allow them to make informed decisions towards that goal.
- Some firms are targeting a minimum 10% reduction in GWP per year for the entire portfolio so they rely heavily on EPDs and programs built on their databases such as Tally and EC3 tool to test, specify and procure products.
- Some architects haven't yet been able to make decisions on windows based on EPDs, nor have been able to calculate the potential embodied carbon savings of switching from aluminum to fiberglass. They said it would be immensely helpful to have an EPD available for Cascadia windows.
- EPDs help architects identify manufacturers who are trying to improve the environmental impact of their products, and they are working to prefer those manufacturers in their specifications.

- Although EPDs track several areas of impact, architects primarily use them to understand GWP to help reduce the embodied carbon footprint of buildings. In reality, architects mostly use EPDs indirectly through tools like EC3 and Tally, a Revit plug in embodied carbon calculator. There is also a LEED credit associated with the number of products that have EPDs and another for the number of those that can demonstrate improvement in the areas of impact covered by EPDs.
- Some architects mentioned that "We would be very interested in an EPD for Cascadia Windows"

## Recommendation

This report is the first step for Cascadia Windows and Doors to understand the carbon impacts of fiberglass window production and the potential emissions reduction over other products. Considering the low embodied carbon impacts of fiberglass windows and the need for providing architects with a transparent EPD, it is highly recommended that Cascadia Windows and Doors prepare an EPD via an external LCA reviewer and EPD verifier and include it in programs such as Tally and EC3 tool which are used by architects.

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