LIFE CYCLE ASSESSMENT (LCA) OF CASCADIA CLIP® FIBERGLASS THERMAL SPACER

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1 INTRODUCTION

1.1 Opportunity

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

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

To understand the true impact of its building solutions, Cascadia commissioned Sustainable Minds to help develop an LCA for its Cascadia Clip® fiberglass thermal spacer products using a cradle-to-gate approach. Cascadia is looking forward to having guidance for future product improvements that can be informed by the results of this study.

Serving as a thermal break between the structure and exterior cladding, the Cascadia Clip® fiberglass spacer can be used with steel framed concrete, and wood construction buildings. It integrates with a wide range of insulation types, including semi-rigid mineral wool, rigid foam, and spray foam.

This LCA is dedicated to analyzing the environmental impact of the Cascadia Clip® fiberglass thermal spacer as a cladding support system, incorporating plant-specific data from Cascadia's British Columbia, Canada facility. This comprehensive approach to LCA will enable Cascadia to make informed decisions and further their commitment to sustainable practices across their operations.

Cascadia is interested in having LCA data available for its Cascadia Clip® fiberglass thermal spacer products to be able to obtain a Sustainable Minds Transparency Report / EPD™ (TR), an ISO 14025 Type III environmental declaration that can be used for communication with and amongst other companies, architects, and consumer communication, and that can also be utilized in whole building LCA tools in conjunction with the LCA background report and life cycle inventory (LCI). This study aims to comply with the requirements of ISO 14040/14044 [1], ISO 21930:2017 [2], and the Sustainable Minds Part A and Part B for cladding support components and systems [3, 4].

1.2 Life cycle assessment

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

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

A critical review of the LCA and an independent verification of the TR are required for Type III Environmental Declarations. Both are included in this project.

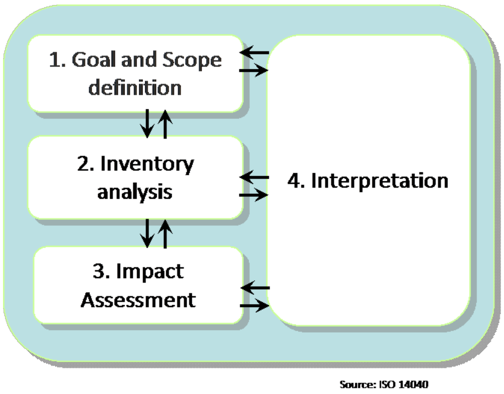

Figure 1. Phases in an LCA

1.3 Status

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

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

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

The LCA review and verification of the Sustainable Minds Transparency Report / EPD™ were carried out by Jack Geibig, President, Ecoform and found to be conformant to ISO 14040/14044 and the relevant PCR.

1.4 Team

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

1.5 Structure

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

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

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

2 GOAL AND SCOPE

This chapter explains the goal and scope of the study. The aim of the goal and scope is to define the product under study and the depth and breadth of the analysis.

2.1 Intended application and audience

This report intends to define the specific application of the LCA methodology to the life cycle of the Cascadia Clip® fiberglass thermal spacer. The report serves both internal and external purposes and is intended for a diverse audience. The intended audience includes the program operator (Sustainable Minds) and reviewers who will be assessing the LCA for conformance to the PCR, as well as Cascadia's internal stakeholders involved in marketing and communications, operations, and design.

The results presented in this document are not meant to support comparative claims. The outcomes will be made available to the public in a Sustainable Minds Transparency Report / EPD™ (Type III environmental declaration per ISO 14025), which is intended for communication between businesses and consumers (B2C).

2.2 Product description

The Cascadia Clip® fiberglass thermal spacer is a thermal insulation product created by combining glass fibers and catalyzed polyester resin in the pultrusion process. It creates a thermal break separating the interior of the building from the exterior. The barrier created by the cladding support reduces thermal transfer through the building envelope. In accordance with the PCR, the cladding support system consists of the thermal spacer clip and pre-punched Galvalume™ rails (z-girts or hat channels).

The clip is available in eight different depths ranging from 2 to 8 inches. Each clip is shaped such that each end can be attached to the rail and to the substrate, and the middle section is extended according to the various depths. Therefore, the different clip sizes would maintain the same shape and mass as the 4-inch clip when modified to accommodate a 4-inch cavity depth as required by the PCR. Therefore, the results per declared unit represent all available sizes of the Cascadia Clip® thermal spacer.

The Cascadia Clip® fiberglass thermal spacer accommodates multiple insulation thicknesses to support different wall depths and customized insulation requirements. The support systems can be used in steel frame, concrete, and wood construction buildings. During production, the long profiles of fiberglass are shipped to the manufacturing facility for fabrication. The fabrication processes of fiberglass include cutting, drilling, packaging, and cleaning.

Cladding support systems are utilized to support exterior cladding and limit thermal transfer through the building envelope. To maintain consistency in reporting results across the product category, the report also considers the continuous linear element attached to the exterior cavity – sheet steel is coated with Galvalume™ corrosion-resistant coating and then fabricated into metal rails, which are then distributed to the Cascadia facility from two locations in China and Canada.

Cascadia Clip® fiberglass thermal spacer products are utilized to create thermal space between the building interior and exterior as presented in Figure 2, and they include the fiberglass clips and metal rails. Table 1 lists the product information in accordance with PCR, including the declaration name, product included in the declaration, CSI MasterFormat® classification, manufacturing location, and the type of declaration. Table 2 lists the product properties as required by the PCR.

System of clips and rails

Single clip attached to length of rail

Figure 2. Visual representation of Cascadia Clip® fiberglass thermal spacer support system

Table 1. Declared product information and type of declaration

Transparency Report name	Product name	CSI MasterFormat® classification	Manufacturing location(s)	Type of declaration
Cascadia Clip®	Cascadia Clip® fiberglass thermal spacer	07 05 43	British Columbia, Canada	Product-specific, plant-specific declaration for one manufacturer

Table 2. Product properties

Name	Value	Unit
Cladding support type	Clip and metal rails	
Exterior cavity depth (from sheathing to face of the girt)	102 (4.00)	mm (inch)
Mass per declared unit	0.869	kg
Number of clips per declared unit	1	piece
Length of rails, hat channels, and/or girts per declared unit	0.610 (24.0)	m (inch)

For more information about the fiberglass thermal spacer, including details about the materials that conform to the relevant standards, visit the link below:
https://www.cascadiawindows.com/products/cascadia-clip

2.3 Declared unit

This LCA covers the cradle-to-gate stage for Cascadia Clip® fiberglass thermal spacer products. According to the PCR, the declared unit in this study was determined to be 0.6096 m (24 linear inches) of cladding support system, consisting of a single clip unit and 24 inches length of metal rails with the clip spaced at one per 24 inches. The exterior cavity depth is sufficient to accommodate 101.6 mm (4 inches) of insulation plus depth of support components outboard of the insulation layer to which the cladding is attached. Fasteners are excluded.

2.4 System boundary

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

Figure 3 illustrates all the life cycle phases included in this study. This LCA's system boundary is from cradle to gate. Therefore, the life cycle activities and related processes shall include modules A1, A2, and A3. This includes raw materials extraction and preprocessing, transportation, and manufacturing and final assembly for both the product and its associated packaging. Table 3 lists specific inclusions and exclusions for the system boundary.

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

Figure 3. Applied system boundary

Table 3. System boundary inclusions and exclusions

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

2.4.1. Production stage (A1-A3)

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

The production stage includes three product life cycle modules:

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

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

III. **Manufacturing (A3)**
   - Energy and water consumption for product manufacturing
   - Product packaging inputs

- Releases to environmental media (air, soil, ground, & surface water)
- Manufacturing waste, scrap
- Manufacturing waste transportation from plant to disposal sites
- Manufacturing waste disposal/recycling/reuse/energy recovery

3 LIFE CYCLE INVENTORY ANALYSIS

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

3.1 Data collection procedures

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

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

- **Background data:** The model was constructed in SimaPro with consistency in mind. Expert judgment was used in selecting appropriate datasets to model the materials and energy for this study and has been noted in the preceding sections. Databases adopted in the model include ecoinvent v3.9, Industry data 2.0, and US-EI 2.2 databases.

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

3.2 Primary data

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

Cascadia Clip® fiberglass thermal spacer products are produced in Cascadia's facility in British Columbia, Canada. The fiberglass is shipped from two facilities: one in Wisconsin, US, and another in Manitoba, Canada. Fiberglass is produced by combining glass fibers and catalyzed polyester resin via a pultrusion process. After being shipped to the Cascadia facility, the long profiles of fiberglass are fabricated to the thermal clip. The manufacturing process at Cascadia involves fabricating the fiberglass with cutting, drilling, packaging, and cleaning. The metal rails are produced and coated with Galvalume™ corrosion-resistant coating and shipped to Cascadia for distribution.

The flow chart in Figure 4 illustrates the cradle-to-gate cladding support flow diagram for Cascadia Clip® fiberglass thermal spacer products. Glass fibers and polyester resin used for clip production are ordered and supplied by local suppliers. Metal rails for z-girts and hat-tracks are primarily sourced from a local supplier in Wisconsin, United States, and the rest are from China. This study has included all upstream energy and material flows related to production.

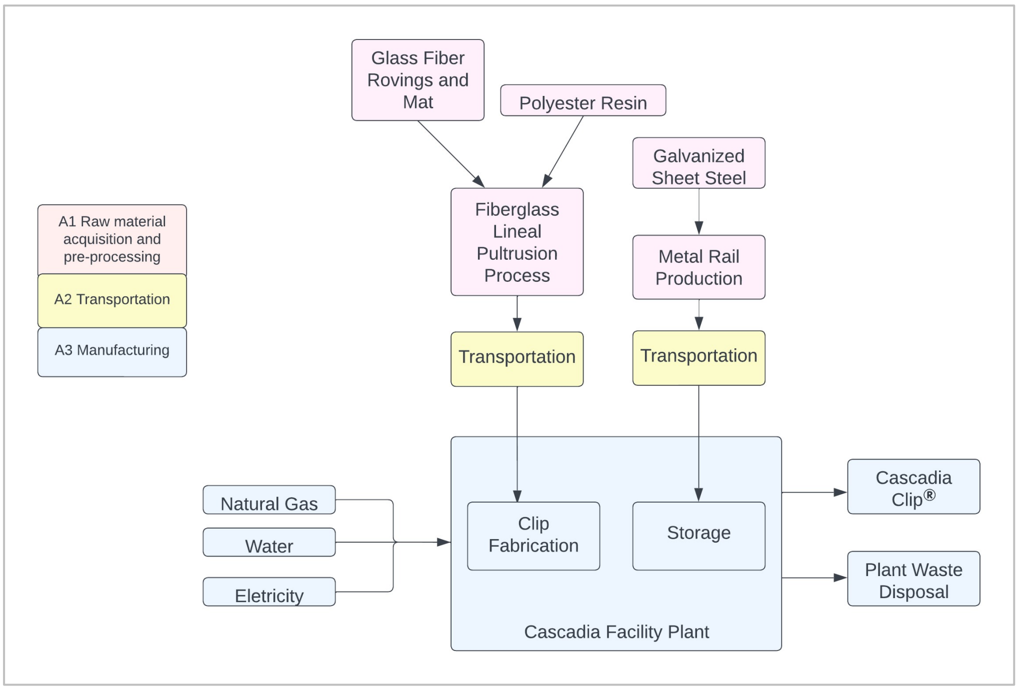

Figure 4. Life cycle flow diagram of Cascadia Clip® fiberglass thermal spacer manufactured at Cascadia's facility

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

Raw materials extraction, preprocessing, and transportation represent the first stage of the Cascadia Clip® thermal spacer life cycle. The full bills of material (BOMs) were provided by Cascadia with a detailed breakdown of the raw materials for their products. The Cascadia Clip® does not contain hazardous substances according to the standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C

Raw materials are extracted and manufactured by material suppliers. Suppliers then transport raw materials along with their associated packaging to Cascadia's manufacturing plants. Most of the ingredients sourced in North America are transported by semi-truck, whereas materials sourced from overseas follow a mix of road transport by semi-truck and sea transport by ship. The materials sourced in North America were assumed to come directly from the supplier and not go through a distribution center. Transportation modes and distances for each of the raw materials supplied for Cascadia Clip® fiberglass thermal spacer products are listed in Table 4.

Table 4. Cascadia Clip® fiberglass thermal spacer raw material and packaging inputs with transportation mode per declared unit

Raw material	Mass percentage	Transportation mode	Road distance (mi)	Ocean distance (mi)
Galvanized steel	60-65%	[redacted]	[redacted]	[redacted]
Glass fiber	15-20%	[redacted]	[redacted]	[redacted]
Resin	10-15%	[redacted]	[redacted]	[redacted]
Packaging	1-5%	[redacted]	[redacted]	[redacted]

3.2.2. Manufacturing (A3)

The fiberglass and metal materials are transported to Cascadia's facility and stored before processing. After the lineals are transported to the Cascadia facility with associated packaging, the long profiles of fiberglass are used to fabricate the Cascadia Clip® on site. The fabrication process includes cutting the fiberglass, drilling, packaging, and cleaning. The sheet steel for the metal rail component is coated with Galvalume™ corrosion-resistant coating. The coated steel is then imported and distributed to a fabrication facility where it is punched and cut into metal rails, which are then shipped to Cascadia. About half of steel was imported from overseas, with the other half coming from within Canada. Manufacturing inputs and outputs for Cascadia Clip® production are shown in Table 4.

In the case of clips manufactured in the Cascadia facility, fiberglass production waste, incoming material packaging waste, and non-hazardous waste are transported to the nearest disposal site for landfill. The used metal straps are gathered and shipped to the nearest recycling facility. Wood pallets for incoming materials are reused within the plant or burned for firewood. The transportation vehicles for shipping landfill waste and recycling waste are trucks.

Table 5. Cascadia Clip® fiberglass thermal spacer manufacturing inputs and outputs per declared unit

Resource category	Flow	Amount	Unit
Electricity	Electricity	[redacted]	kWh
Water	Water	[redacted]	l
Raw materials	Clip	[redacted]	kg
	Metal rail	[redacted]	kg
Waste generation	Landfill disposal – fiberglass dust and packaging materials	[redacted]	kg
	Recycled steel metal strap	[redacted]	kg
	Reused	[redacted]	kg
Waste transport	Transportation for landfill – manufacturing scrap	[redacted]	lbmi

3.3 Background data

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

3.3.1. Raw materials production

Data representing up- and down-stream raw materials were obtained from the ecoinvent v3.9 and Industry data 2.0 databases. Data sets matching each raw material were found in the available databases. Where country-specific data were unavailable, global or rest-of-world averages were used as proxies to represent production in those locations. Table 6 lists the most relevant LCI data sets used in modeling the raw materials.

Table 4. Key material data sets used in inventory analysis

Raw material	Data set	Database	Reference year	Geography
Resin	Polyester resin, unsaturated {RoW}| market for polyester resin, unsaturated | Cut-off, U	ecoinvent v3.9	2022	Rest of World (non-Europe)
Glass fiber	Glass fibre reinforced plastic, polyamide, injection moulded {GLO}| market for glass fibre reinforced plastic, polyamide, injection moulded | Cut-off, U	ecoinvent v3.9	2022	Global (GLO)
Galvanized steel	Steel hot dip galvanised {RAS} | blast furnace route and electric arc furnace route | production mix, at plant | 1kg, typical thickness between 0.3 - 3 mm. typical width between 600 - 2100 mm | LCI result	Industry data 2.0	2021	Asia and the Pacific (RAS)
Galvanized steel	Steel hot dip galvanised {GLO} | blast furnace route and electric arc furnace route | production mix, at plant | 1kg, typical thickness between 0.3 - 3 mm. typical width between 600 - 2100 mm | LCI result	Industry data 2.0	2021	Global (GLO)
Cardboard box	Corrugated board box {US}| market for corrugated board box | Cut-off, U	ecoinvent v3.9	2022	United States
Plastic wraps	Packaging film, low density polyethylene {GLO}| market for packaging film, low density polyethylene | Cut-off, U	ecoinvent v3.9	2022	Global (GLO)
Wood pallet	EUR-flat pallet {RoW}| EUR-flat pallet production | Cut-off, U	ecoinvent v3.9	2022	Rest of World (non-Europe)
Metal strap	Steel, low-alloyed {GLO}| market for steel, low-alloyed | Cut-off, U	ecoinvent v3.9	2022	Global (GLO)
Packaging paper	Kraft paper {RoW}| market for kraft paper | Cut-off, U	ecoinvent v3.9	2022	Rest of World (non-Europe)

3.3.2. Transportation

Average transportation distances and modes of transport are included for the transportation of raw materials to the Cascadia manufacturing facility. The typical vehicle used for shipment is a semi-truck. Raw materials sourced from overseas are transported through container ships. Transportation distances from the production facility to the adjacent ports and from the destination port to the Cascadia facility are included and occur via semi-trucks. As the transportation data sets represent load factors as an average of empty and fully loaded (i.e., average load factor), empty backhauls are accounted for in the model. Data sets matching each transportation mode were found in the available databases. Where country-specific data were unavailable, global or rest-of-world averages were used as proxies to represent transportation in those locations. Table 7 shows the most relevant LCI datasets used in modeling transportation.

Table 5. Transportation data sets used in inventory analysis

Vehicle type	Data set	Database	Reference year	Geography
Semi-truck	Transport, freight, lorry 16-32 metric ton, EURO6 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	ecoinvent v3.9	2022	Rest of World (non-Europe)
Container ship	Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, U	ecoinvent v3.9	2022	Global (GLO)

3.3.3. Fuels and energy

Electricity at the facility was modeled using regionally specific inventory data based on the electricity market consumption mix in British Columbia, Canada. The fuel inputs and electricity grid mix were obtained accordingly using the databases available in SimaPro. Table 8 shows the most relevant LCI datasets used in modeling the product systems. For the manufacturing stage, the ecoinvent v3.3 database was used to represent natural gas consumption in British Columbia. Electricity was modeled using the provincial and territorial energy production and consumption profile in British Columbia, made available through the Canada Energy Regulator [6]. This data set showcases the electricity generation by sources ranging from hydrocarbon to petroleum in 2019.

Table 8. Key energy datasets used in inventory analysis

Energy source	Data set	Facility location	Database	Reference year
Electricity	Electricity mix, British Columbia/CA U	British Columbia, Canada	Canada Energy Regulator	2019
Natural gas	Heat, district or industrial, natural gas {CA-QC}| market for heat, district or industrial, natural gas | Cut-off, U	British Columbia, Canada	ecoinvent v3.3	2022

3.3.4. Disposal

Disposal processes were obtained from the ecoinvent v3.9 database. These processes were selected to correspond to the disposal of fiberglass dust waste and packaging waste. Table 9 lists the relevant disposal data sets used in the model.

Table 9. Key disposal data sets used in inventory analysis

Material disposed	Data set	Database	Reference year	Geography
Fiberglass dust	Disposal, inert material, 0% water, to sanitary landfill/US* US-EI U	US-EI 2.2	2018	United States
Cardboard box	Disposal, packaging cardboard, 0% water, to sanitary landfill/US* US-EI U	US-EI 2.2	2018	United States
Plastic wraps	Disposal, polyethylene, to US sanitary landfill/US US-EI U	US-EI 2.2	2018	United States
Kraft paper	Disposal, paper, to US sanitary landfill/US US-EI U	US-EI 2.2	2018	United States

3.4 Comparability

ISO 21930:2017 section 5.5 highlights the following limitations and clarifications in EPD comparability [2].

- EPDs are comparable only if they use the same PCR (or sub-category PCR where applicable), include all relevant information modules, and are based on equivalent scenarios with respect to the context of construction works.
- The PCR for Cladding Support Components and Systems allows EPD comparability only when the same functional requirements between products are ensured and the requirements of ISO 21930:2017 §5.5 are met.

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

3.5 Limitations

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

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

3.6 Cut-off criteria

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

- All inputs and outputs to a (unit) process shall be included in the calculation of the pre-set parameters results, for which data are available. Data gaps shall be filled by conservative assumptions with average, generic or proxy data. Any assumptions for such choices shall be documented.
- Mass – If a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern.
- Energy – If a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern.
- Environmental relevance – If a flow meets the above criteria for exclusion, yet it is thought to potentially have a significant environmental impact, it is included.
- Hazardous and toxic materials – The study shall include all hazardous and toxic materials in the inventory therefore the cutoff rules shall not apply to such substances.
- The sum of the neglected material flows does not exceed 5% of mass, energy or environmental relevance for flows indirectly related to the process (e.g., operating materials).

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

3.7 Allocation

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

- The Cascadia facility produces various types of window products in any given year. To accurately allocate electricity and natural gas used at the facility to clip production, the total annual energy consumption was calculated through mass allocation, which proportionally assesses the percentage of production for the Cascadia Clip® in mass versus total site annual production.

- Although there are no co-products produced during the manufacturing processes, the production in the Cascadia facility includes different types of window products. Therefore, the manufacturing inputs that needed allocation were electricity, water, and natural gas consumption, which were allocated based on mass.

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

3.8 Software and database

The LCA model was created using SimaPro Analyst 9.5. The ecoinvent database and ecoinvent v3.9, Industry data 2.0, and US-EI 2.2 databases provided the life cycle inventory data of the raw materials and processes for modeling the products.

3.9 Critical review

This is a supporting LCA report for the Cascadia Transparency Report / EPD™ and was evaluated for conformance to the PCR according to ISO 14025 [5] and the ISO 14040/14044 [1] standards. Critical review was performed by Jack Geibig, President, Ecoform, and access to a public version of this critically reviewed report can be found linked in the references section of the Transparency Report.

4 IMPACT ASSESSMENT METHODS

4.1 Impact assessment characterization

The environmental indicators as required by the PCR are included as well as other indicators required to use the SM2013 Methodology [7] (see Table 1). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [8]. Long-term emissions (>100 years) are not taken into consideration in the impact estimate. USEtox indicators[2] are used to evaluate toxicity. Emissions from waste disposal are considered part of the product system under study, according to the "polluter pays principle".

Table 10. Selected impact categories and units

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

With respect to global warming potential, biogenic carbon is included in impact category calculations. The biogenic carbon measured in this study originate from packaging materials, and no raw materials in the cladding support system are expected to contain biogenic carbon. Greenhouse gas emissions from land-use change are expected to be insignificant and were not reported. Carbon emissions during carbonation and calcination are also considered in this study, and no

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

[2] USEtox is available in TRACI and at http://www.usetox.org/

carbonation or calcination are expected to occur during the production and manufacture of the thermal spacer products.

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

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

4.2 Normalization and weighting

To arrive at a single score indicator, normalization [9] and weighting [10] as shown in Table 11 conforming to the SM 2013 Methodology were applied. The SM 2013 Methodology uses TRACI 2.1 impact categories developed by the U.S. EPA, and North American normalization and weighting values developed by the EPA and NIST respectively, to calculate single figure LCA results. Sustainable Minds recognizes that weighting is socially defined based on the importance that society attaches to the different environmental impact categories. However, these single score indicators serve as an easy starting point to get to know the product under consideration across all impact categories, rather than focusing all efforts on just one impact category (like global warming potential). The interpretation of the results starts with the Sustainable Minds single score results and then allows users to further explore the underlying impact categories individually. Details including the characterization models, factors, and methods used, including all assumptions and limitations, can be found in the SM 2013 Methodology Report [7].

Table 11. Normalization and weighting factors

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

5 ASSESSMENT AND INTERPRETATION

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

5.1 Resource use and waste flows

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

LCI flows were calculated with the help of American Center for Life Cycle Assessment's (ACLCA) guidance to the ISO 21930:2017 metrics [11]. The consumption of freshwater indicator, which was calculated in accordance with this guidance, is reported in compliance with ISO 14046. Abiotic depletion potential was calculated using the CML impact assessment methodology [12]. LCI flows were reported in conformance to ISO 21930:2017 [2].

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

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

Non-hazardous wastes are calculated based on the amount of waste generated during the manufacturing based on Cascadia's record. All waste treatments in models were considered based on the local waste management code and the assumptions mentioned in the PCR. Waste treatments included within the system boundary are reported. Unrecyclable wastes are picked up from the facility and end up in landfills. Table 12 show resource use and waste flows for all products per declared unit.

Table 12. Resource use and waste flows for Cascadia Clip® thermal spacer per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.49E+01	1.47E+01	4.36E-03	**2.97E+01**
Renewable primary resources with energy content used as material	MJ, NCV	1.58E-01	0	0	**1.58E-01**
Total use of renewable primary resources with energy content	MJ, NCV	1.51E+01	1.47E+01	4.36E-03	**2.98E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	5.81E+01	5.34E+01	2.99E+00	**1.14E+02**
Non-renewable primary resources with energy content used as material	MJ, NCV	4.33E-02	0	0	**4.33E-02**
Total use of non-renewable primary resources with energy content	MJ, NCV	5.81E+01	5.34E+01	2.99E+00	**1.14E+02**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net fresh water resources	m^3	3.27E+00	2.00E-02	2.98E-02	**3.32E+00**
Output flows and waste category indicators					
Hazardous waste disposed	kg	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.92E-02	**1.92E-02**
High-level radioactive waste, conditioned, to final repository	kg	3.66E+02	2.90E+00	8.23E+00	**3.77E+02**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.63E-01	1.51E-03	9.24E-04	**2.66E-01**
Components for re-use	kg	0	0	2.00E-02	**2.00E-02**
Materials for recycling	kg	0	0	9.95E-05	**9.95E-05**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO2	1.99E-02	0	1.12E-02	**3.11E-02**
Biogenic Carbon Emission from Packaging	kg CO2	0	0	0	**0**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO2	0	0	0	**0**
Calcination Carbon Emissions	kg CO2	0	0	0	**0**
Carbonation Carbon Removals	kg CO2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO2	0	0	0	**0**

5.2 Life cycle impact assessment (LCIA)

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

Life cycle impact assessment (LCIA) results are shown for the Cascadia Clip® fiberglass thermal spacer. Unlike life cycle inventories, which only report sums for individual inventory flows, the LCIA includes a classification of individual emissions with regard to the impacts they are associated with and subsequently a characterization of the emissions by a factor expressing their respective contribution to the impact category indicator. The end result is a single metric for quantifying each potential impact, such as “Global Warming Potential”.

The impact assessment results are calculated using characterization factors published by the United States Environmental Protection Agency. The TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.1) methodology is the most widely applied impact assessment method for U.S. LCA studies. The SM 2013 Methodology is also applied to come up with single score results for the sole purpose of representing total impacts per life cycle phase to explain where in the product life cycle greatest impacts are occurring and what is contributing to the impacts.

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

Cladding support components and systems are often composed of pieces that are purchased by the number of units for clips, and by linear length for rails, hat-track, or continuous girt. Per the PCR, the manufacturer shall report the impacts for clip components and metal rails individually. Therefore, life cycle impact assessment results are reported per the declared unit, and also per a single clip component and per 0.3048 m (12 inch) length of metal rail (z-girt or hat-track) [4].

5.2.1. Cascadia Clip® fiberglass thermal spacer

The LCIA results of the Cascadia Clip® fiberglass thermal spacer per declared unit are shown in Table 13. The percent contribution of each of the cradle-to-gate life cycle stages to the total impacts is tabulated in Table 14 and is also presented in Figure 5.

Table 13. Life cycle impact assessment results for Cascadia Clip® fiberglass thermal spacer per declared unit

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	5.09E-08	3.40E-09	1.07E-09	**5.54E-08**
Global warming	kg CO_2 eq	3.61E+00	2.15E-01	1.14E-01	**3.94E+00**
Smog	kg O_3 eq	1.57E-01	4.84E-02	1.69E-03	**2.08E-01**
Acidification	kg SO_2 eq	1.09E-02	2.62E-03	6.18E-05	**1.36E-02**
Eutrophication	kg N eq	2.38E-03	1.13E-04	1.94E-05	**2.52E-03**
Carcinogenics	CTUh	2.95E-08	1.67E-10	1.91E-11	**2.97E-08**
Non carcinogenics	CTUh	1.57E-07	1.86E-08	8.71E-10	**1.77E-07**
Respiratory effects	kg PM2.5 eq	1.35E-03	1.79E-04	4.79E-06	**1.54E-03**
Additional environmental information					
Ecotoxicity	CTUe	2.54E+00	3.53E-01	1.50E-03	**2.89E+00**
Fossil fuel depletion	MJ surplus	4.65E+01	2.80E+00	1.52E+00	**5.08E+01**

Table 14. Percent contributions of each stage to each impact category for Cascadia Clip® fiberglass thermal spacer per declared unit

Impact category	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
Ozone depletion	91.94%	6.14%	1.93%	**100%**
Global warming	91.63%	5.47%	2.90%	**100%**
Smog	75.86%	23.33%	0.81%	**100%**
Acidification	80.22%	19.32%	0.46%	**100%**
Eutrophication	94.74%	4.49%	0.77%	**100%**
Carcinogenics	99.37%	0.56%	0.06%	**100%**
Non-carcinogenics	88.98%	10.53%	0.49%	**100%**
Respiratory effects	88.03%	11.66%	0.31%	**100%**
Additional environmental information				
Ecotoxicity	87.72%	12.23%	0.05%	**100%**
Fossil fuel depletion	91.50%	5.51%	2.99%	**100%**

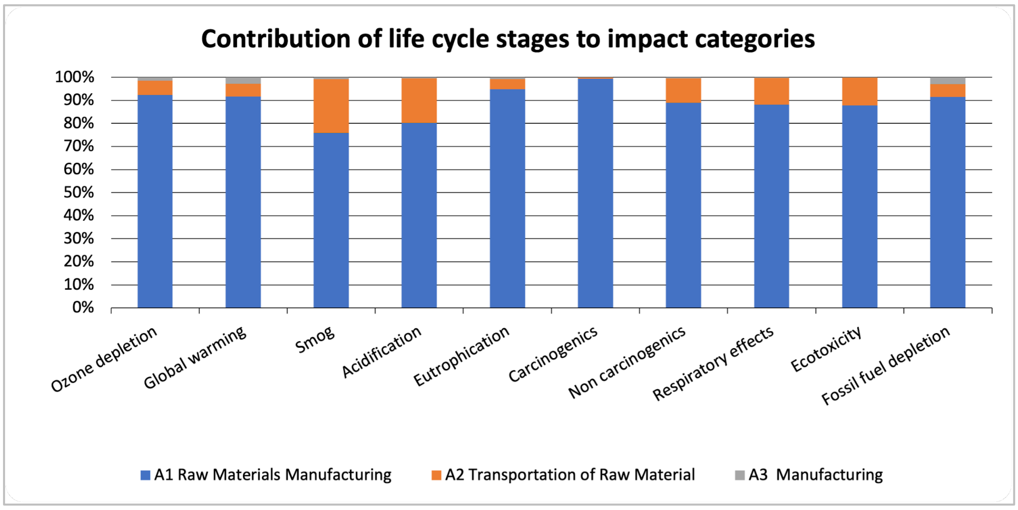

Figure 5. Contribution analysis of each impact category for Cascadia Clip® fiberglass thermal spacer per declared unit

The SM2013 Methodology single figure millipoint (mPts) score by life cycle phase for this product is presented in Table 15. The raw material supply phase dominates the results (91.56%), followed by the upstream transportation phase which accounts for 6.68 % of the total.

Table 15. Averaged SM millipoint scores for Cascadia Clip® fiberglass thermal spacer by life cycle stage per declared unit

Impact category	Unit	A1 Raw material supply	A2 Transport	A3 Manufacturing	Total
SM single figure score	mPts	1.92E-01	1.40E-02	3.70E-03	**2.10E-01**

In the cradle-to-gate life cycle of the product, the raw material supply stage dominates the results for all impact categories. Among all impact categories, carcinogenics and eutrophication are the two most impacted categories in the A1 stage, at 99.37% and 94.74%, respectively. The results for carcinogenics across all stages totals 2.07 E-08 CTUh with the raw materials extraction stage accounting for 2.95 E-08 CTUh of that total. The results for acidification across all stages totals 2.52 E-03 kg N eq, with the raw materials extraction stage accounting for 2.38 E-03 kg N eq. Additionally, the total potential CO_2-equivalent emissions generated during the cradle-to-gate stage is 3.94 kg. Raw material supply contributes to 3.61 kg CO_2 eq, which accounts for 91.63 % of the total CO_2 equivalent emissions. All indicators show that the raw material supply stage is the most dominant stage, primarily stemming from activities such as polyester resin, glass fibers, and galvanized steel production processes.

The second most dominant stage is transport, stemming from transporting raw materials to the Cascadia manufacturing facility. Upstream transportation from raw material suppliers contributed ~ 23.3% to smog, ~19.32% to acidification, and ~11.66% to respiratory effects. The distances traveled by truck contributed to 1.57E-01 kg O_3 eq of ozone depletion potential results and 1.09E-02 kg SO_2 eq to acidification. The results indicate that during the transportation stage, smog, acidification, non-carcinogenics, respiratory effects, and ecotoxicity account for more than 10% of contributions.

Lastly, the highest impacts coming from the A3 manufacturing stage are in the ozone depletion, global warming, and fossil fuel depletion impact categories. The impact categories overall showcase smaller percentages in comparison to the other two life cycle stages. The manufacturing impacts primarily stem from electricity and natural gas used to fabricate the Cascadia Clip® fiberglass thermal spacer.

5.2.2. Single clip component only

Table 16 reports on the category impact for a single clip component, excluding any fasteners and rails. The A1 stage makes the largest share of impacts across all impact categories.

Table 16. Life cycle impact assessment results for a single Cascadia Clip® component

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	4.82E-08	1.81E-09	1.06E-09	**5.11E-08**
Global warming	kg CO2 eq	1.97E+00	1.16E-01	1.14E-01	**2.20E+00**
Smog	kg O3 eq	9.41E-02	2.48E-03	1.69E-03	**9.82E-02**
Acidification	kg SO2 eq	6.95E-03	1.57E-04	6.18E-05	**7.17E-03**
Eutrophication	kg N eq	2.14E-03	1.91E-05	1.94E-05	**2.18E-03**
Carcinogenics	CTUh	1.73E-08	1.02E-10	1.91E-11	**1.74E-08**
Non carcinogenics	CTUh	5.54E-08	1.54E-08	8.70E-10	**7.17E-08**
Respiratory effects	kg PM2.5 eq	9.21E-04	3.63E-05	4.78E-06	**9.62E-04**
Additional environmental information					
Ecotoxicity	CTUe	2.07E+00	3.12E-01	1.48E-03	**2.39E+00**
Fossil fuel depletion	MJ surplus	2.84E+01	1.56E+00	1.54E+00	**3.14E+01**

5.2.3. Metal rails only

Table 17 reports the impacts for a 0.3048 m (12 inch) length of metal rail (z-girt or hat-track). The A1 stage makes the largest share of impacts across all impact categories.

Table 17. Life cycle impact assessment results for 12 inches of metal rail

Impact category	Unit	A1 Raw materials	A2 Transport	A3 Manufacturing	Total
Ozone depletion	kg CFC-11 eq	1.35E-09	7.96E-10	1.71E-12	**2.15E-09**
Global warming	kg CO2 eq	8.17E-01	4.99E-02	6.74E-05	**8.67E-01**
Smog	kg O3 eq	3.17E-02	2.30E-02	1.89E-06	**5.47E-02**
Acidification	kg SO2 eq	1.96E-03	1.23E-03	4.04E-08	**3.19E-03**
Eutrophication	kg N eq	1.20E-04	4.69E-05	5.76E-09	**1.67E-04**
Carcinogenics	CTUh	6.09E-09	3.24E-11	1.81E-14	**6.12E-09**
Non carcinogenics	CTUh	5.10E-08	1.58E-09	1.89E-13	**5.26E-08**
Respiratory effects	kg PM2.5 eq	2.16E-04	7.15E-05	5.00E-09	**2.88E-04**
Additional environmental information					
Ecotoxicity	CTUe	2.32E-01	2.08E-02	6.15E-06	**2.52E-01**
Fossil fuel depletion	MJ surplus	9.08E+00	6.23E-01	5.18E-05	**9.71E+00**

5.3 Sensitivity analysis

A sensitivity analysis was performed to check the impact of switching the current Chinese steel supplier to a North American supplier by evaluating the change in potential CO_2-equivalent emissions.

Currently, steel from China represents ~44% of the total incoming steel in the Cascadia facility, with the remaining shipped within North America. A sensitivity analysis was conducted for a scenario where all the steel comes from the same North American supplier, with no share coming from the Chinese supplier. The mass of North American steel was scaled to meet the declared unit, and the packaging and shipping info were also changed accordingly. The results are tabulated in Table 18, which show that only using North American steel would reduce potential CO_2-eq emissions by about 3%.

Table 6. Sensitivity analyses of LCIA results per declared unit

Product name	Scenario evaluated	Life cycle impacts ($kgCO_2$-eq)		Range of change
		Baseline	After switching to North American supplier only	
Cascadia Clip® thermal spacer	Purchasing steel from only North American supplier	3.93E+00	3.80E+00	-3.32%

5.4 Overview of relevant findings

This study assessed a multitude of inventory and environmental indicators. The primary finding for Cascadia Clip® fiberglass thermal spacer products, across all environmental indicators, was that the raw material extraction and upstream production stage (A1) is responsible for the majority of the impacts in each impact category.

The upstream transportation stage (A2) is the next highest contributor for all categories. Clip manufacturing stage (A3) accounts for relatively smaller environmental impacts compared to the A1 and A2 stages across all categories. Within the manufacturing stage, ozone depletion, global warming, and fossil fuel depletion are the top three major impact categories that have the highest impact compared to others.

5.5 Discussion of data quality

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

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from SimaPro Analyst 9.5, and the ecoinvent v3.9, Industry data 2.0, and US-EI 2.2 databases were used.

Precision and completeness

- Precision: As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, precision is considered to be high. Background data are from ecoinvent v3.9, Industry data 2.0, and US-EI 2.2 databases with documented precision to the extent available.

- Completeness: Sustainable Minds worked with Cascadia to obtain a comprehensive set of primary data associated with the manufacturing processes. The product system was checked for mass balance and completeness of the inventory. The data set was considered complete based on our understanding of the manufacturing site and a review with key stakeholders on the Cascadia team, and cut-off criteria were observed consistent with those prescribed in the PCR. Capital equipment was excluded as required by the PCR. Otherwise, no data was knowingly omitted.

Consistency and reproducibility

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

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

Representativeness

- Temporal: All primary data were collected for May 2022 – April 2023 in order to ensure the representativeness of the manufacturing process. Secondary data were obtained from the ecoinvent v3.9, Industry data 2.0, and US-EI 2.2 databases and are typically representative of the recent years.

- Geographical: Primary data are representative of Cascadia production in Canada. Differences in the electric grid mix are considered with appropriate secondary data. In general, secondary data were collected specific to the country under study. Where country-specific data were unavailable, global or rest-of-world averages were used as proxies to represent production in those locations. Geographical representativeness is considered to be high.

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

5.6 Conclusions and recommendations

The goal of this study was to conduct a cradle-to-gate LCA on the Cascadia Clip® fiberglass thermal spacer so as to develop a Transparency Report / EPD™. The creation of this Transparency Report will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose.

Overall, the study found that environmental performance is driven primarily by raw material extraction and preprocessing, making up 80-90% of the total impacts. Additionally, the raw material transportation to the manufacturing facility also accounts for a notable contribution to impacts at around 10-20%. The potential impacts of manufacturing activities at the Cascadia facility represent an insignificant share when compared to the impacts generated from the other stages.

The results show that the greatest opportunity for reducing each product's environmental impact is in the raw material extraction and upstream transportation phase. This is an important area for Cascadia to focus its efforts on and one which it can influence. Particularly, Cascadia should explore opportunities to identify alternative raw material sources to shorten the transportation distance or utilize strategies that allow energy-efficient transportation modes. In addition, it would be beneficial for Cascadia to seek suppliers who use sustainable manufacturing techniques or integrate more renewable energy into their manufacturing processes.

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

6 REFERENCES

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

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

[3] Sustainable Minds, PCR Part A: LCA calculation rules and report requirements, 2023

[4] Sustainable Minds, PCR Part B: Product group definition | Cladding Support Components and Systems, 2022

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

[6] Government of Canada, Canada Energy Regulator (2023). Provincial and Territorial Energy Profiles. Electricity Generation in Canada (2019), https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-explore.html

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

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

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

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

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

[12] Heijungs R., Guinée J.B., Huppes G., Lankreijer R.M., Udo de Haes H.A., Wegener Sleeswijk A. Environmental Life Cycle Assessment of Products: Guide and Backgrounds. CML. Leiden University, Leiden, 1992.

ACRONYMS

BOM	Bill of materials
ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact analysis
PCR	Product Category Rule document
TR	Transparency Report / EPD™

GLOSSARY

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

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

APPENDIX

- SM_Cascadia_Data collection form_LCA_cradle-to-gate_raw primary data.xlsx
- SM_Cascadia_Data collection form_LCA_primary data with calculations.xlsx
- Cascadia Clip LCI-LCA Modeling Data and Results.xlsx