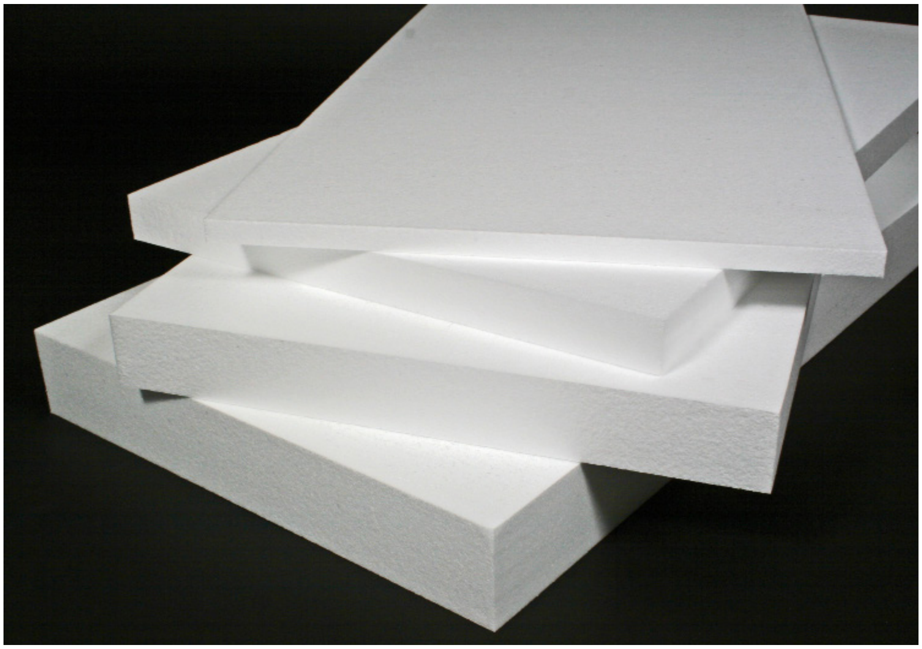
Environmental Product Declaration

Expanded Polystyrene Insulation

MOLDED, CLOSED-CELL FOAM PLASTIC INSULATION



Expanded polystyrene (EPS) is a versatile, high-performance building material engineered to deliver reliable energy efficiency through a long-term, stable R-value. EPS insulation is an ideal choice for green building design, offering numerous environmental advantages, including reduced energy consumption, recycled content, localized distribution, and improved indoor air quality.

EPS Industry Alliance

The EPS Industry Alliance (EPS-IA), which represents manufacturers and distributors of expanded polystyrene (EPS) products throughout North America, facilitates educational outreach on the technical, environmental, and performance advancements of EPS.

The EPS industry is committed to sustainability through innovation. We demonstrate this dedication through lean manufacturing processes, a comprehensive recycling system, and by harnessing new technologies to conserve raw materials and reduce waste. The EPS industry is continuously seeking to further market applications, reduce impacts, and raise performance.

EPS-IA has invested significant time and resources in life-cycle analysis. This Environmental Product Declaration is part of our goal to provide life-cycle information on all EPS insulation applications.

www.epsindustry.org

UL CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

Specific data from the following EPS-IA insulation manufacturers was used for this industry-average life cycle assessment.

PARTICIPANTS
Atlas Molded Products
Beaver Plastics Ltd.
Insulfoam, LLC
Insulation Technology, Inc.
Groupe Isolofoam
Le Groupe Legerlite
Plasti-Fab EPS Product Solutions
Polar Industries
Progressive Foam Technologies
Thermal Foams, Inc.

EPD Program and Program Operator Name, Address, Logo, and Website	UL Environment 333 Pfingsten Rd, Northbrook, IL 60062 www.ul.com www.spot.ul.com
General Program Instructions and Version Number	Program Operator Rules v 2.7 2022
Manufacturer Name and Address	EPS Industry Alliance, 1298 Cronson Blvd, Ste 201, Crofton, MD 21114 Products are manufactured by EPS-IA member companies.
Declaration Number	4790678084.101.1
Declared Product & Functional Unit or Declared Unit	EPS Thermal Insulation 1 m² of insulation material with a thickness that gives an average thermal resistance of RSI = 1 m² K/W and with a building service life of 75 years.
Reference PCR and Version Number	Part A: LCA Calculation Rules and Report Requirements (UL, v3.1, 2018) Part B: Building Envelope Thermal Insulation EPD Requirements (UL, v2.0, 2018)
Description of product application/use	Thermal Insulation Used in Residential & Commercial Building Envelope Applications such as Exterior Continuous Insulation, Below-Grade Insulation, Roofs, and Exterior Insulation Finishing Systems.
Product RSL Description (if Appl.)	75 Years
Markets of Applicability	North America
Date of Issue	March 1, 2023
Period of Validity	5 Years
EPD Type	Industry-average
Range of Dataset Variability	Industry-average
EPD Scope	Cradle-to-Grave
Year(s) of reported primary data	2021
LCA Software & Version Number	SimaPro v9.4
LCI Database(s) & Version Number	Ecoinvent v3.8
LCIA Methodology & Version Number	TRACI 2.1 and CML-IA v4.7 (2016)
The PCR review was conducted by:	UL Environment PCR Review Panel epd@ul.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum, UL Environment
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Intertek Assuris
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	James Mellentine, Thrive ESG

Limitations

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds (e.g. Type 1 certifications, health assessments and declarations, and environmental impact assessments, etc.).

Accuracy of Results: EPDs regularly rely on estimations of impacts; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to different results upstream or downstream of the declared life cycle stages.

1. Product Definition and Information

1.1 Description of Company/Organization

The EPS Industry Alliance (EPS-IA) is the North American trade association for the expanded polystyrene (EPS) foam products industry. This Type III Environmental Product Declaration (EPD) is an industry-average declaration prepared according to ISO 14025 and Part B: Building Envelope Thermal Insulation Product Category Rule (PCR), version 2.0, and is representative of EPS insulation products produced by EPS-IA member companies. The EPD is based on Life Cycle Inventory (LCI) inputs from three EPS resin manufacturers covering four sites and 26 EPS insulation manufacturing sites across 10 companies.

1.2 Product Description

Product Identification

Expanded polystyrene (EPS) thermal insulation is a closed-cell foam plastic that is 98% air. EPS resin contains a pentane blowing agent that is replaced by air after processing. EPS from post-industrial or post-consumer sources may be reincorporated into the manufacturing process.

Figure 1. EPS Insulation

Product Specification

The UNSPSC code for EPS thermal insulation is 30141514; the CSI code is 07 21 13.13.01. EPS insulation products conform to ASTM C578 Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation or CAN/ULC S701.1 Standard for Thermal Insulation, Polystyrene Boards. The EPS thermal insulation evaluated in the study met the ASTM C578, Type I specification.

Table 1. ASTM C578 EPS Material Specification

Property	Units	Test Method	ASTM C578 Types						
			XI	I	VIII	II	IX	XIV	XV
Thermal Resistance (R-value/RSI per inch)	**F•ft²•h/Btu, min**	ASTM C518	**3.1**	**3.6**	**3.8**	**4.0**	**4.2**	**4.2**	**4.3**
	K•m²/W		*0.55*	*0.63*	*0.67*	*0.70*	*0.74*	*0.74*	*0.76*
Compressive Strength (at 10% deformation or yield)	**psi, min**	ASTM D1621 or C165	**5**	**10**	**13**	**15**	**25**	**40**	**60**
	kPa		*35*	*69*	*90*	*104*	*173*	*276*	*414*
Water Vapor Permeance (per inch)	**perm, max**	ASTM E96	**5.0**	**5.0**	**3.5**	**3.5**	**2.5**	**2.5**	**2.5**
	ng/Pa•s•m²		*287*	*287*	*201*	*201*	*143*	*143*	*143*
Water Absorption (by immersion)	**vol%, max**	ASTM C272	**4.0**	**4.0**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**
Flexural Strength	**psi, min**	ASTM C203	**10**	**25**	**30**	**35**	**50**	**60**	**75**
	kPa		*70*	*173*	*208*	*240*	*345*	*414*	*517*
Dimensional Stability	**% change, max**	ASTM D2126	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**
Density	**lb/ft³, min**	ASTM C303 or D1622	**0.70**	**0.90**	**1.15**	**1.35**	**1.80**	**2.40**	**3.00**
	kg/m³		*12*	*15*	*18*	*22*	*29*	*38*	*48*

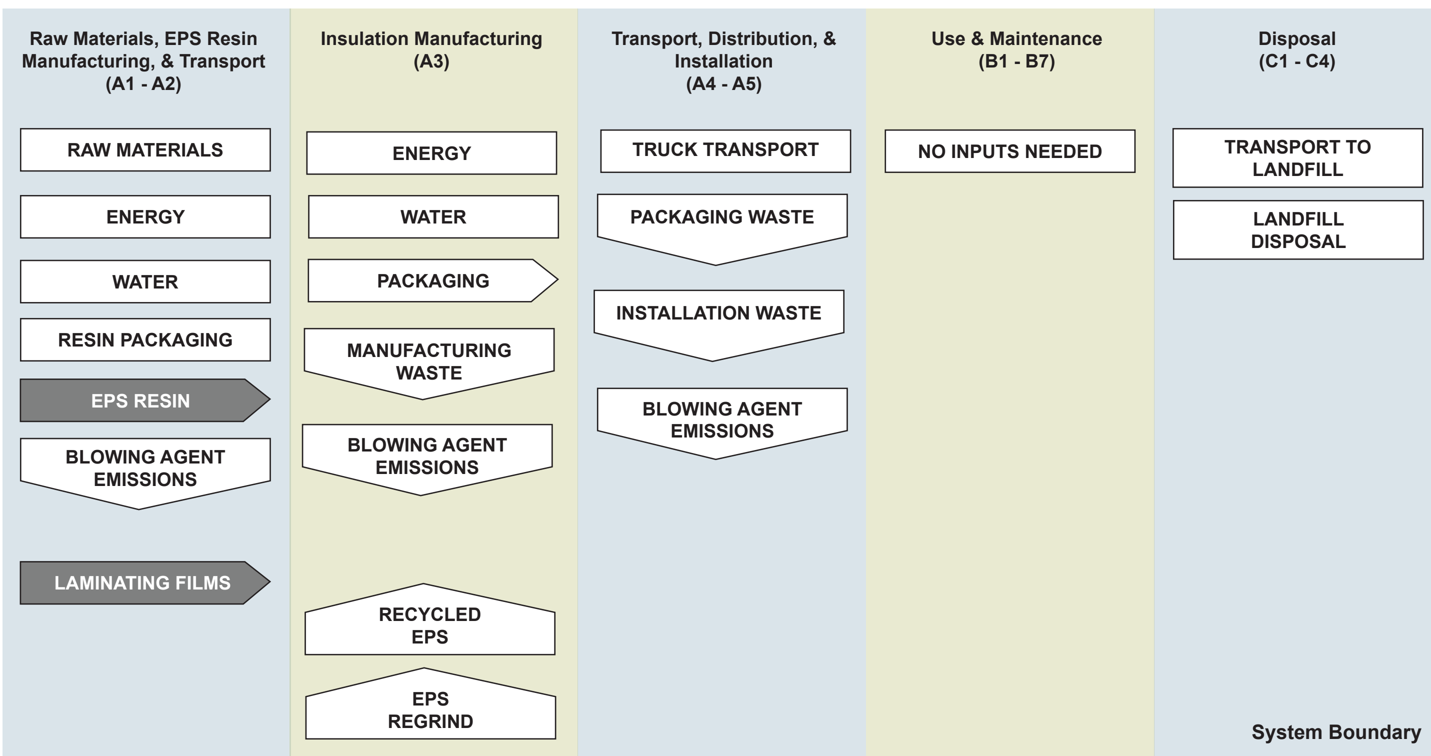
Table 2. CAN/ULC S701.1 EPS Material Specification

Property	Units	Test Method	CAN/ULC-S701 Types		
			1	2	3
Thermal Resistance (RSI per 25 mm/R-value per inch)	*F•ft²•h/BTU*	ASTM C518	*3.75*	*4.04*	*4.27*
	K•m²/W, min		**0.65**	**0.70**	**0.74**
Compressive Strength (at 10% deformation or yield)	*psi*	ASTM D1621 or C165	*10*	*16*	*20*
	kPa, min		**70**	**110**	**140**
Water Vapor Permeance (per 25 mm)	*perm*	ASTM E96	*5.2*	*3.5*	*2.3*
	ng/Pa•s•m², max		**300**	**200**	**130**
Water Absorption (by immersion)	**vol%, max**	ASTM D2842	**6.0**	**4.0**	**2.0**
Flexural Strength	*psi*	ASTM C203	*25*	*35*	*44*
	kPa, min		**170**	**240**	**300**
Dimensional Stability	**% change, max**	ASTM D2126	**1.5**	**1.5**	**1.5**

Thermal Performance

The long-term thermal resistance for EPS insulation is unchanged from its initial value because the closed cell structure of EPS contains atmospheric air. The minimum RSI/R-value of EPS insulation provided for each product type may be used as a design value without any adjustment for age. Whether used as a standalone component or part of a highly engineered building system, EPS insulation provides a permanent, lifetime R-value that delivers maximum energy efficiency.

Flow Diagram



Product Average

This industry average EPD is based on the horizontally weighted average LCA results of production volumes across 26 EPS insulation manufacturing plants of 10 different companies representing 45.8% of the EPS insulation volume produced in the US and Canada in 2021. From a geographical perspective, 70% of the volumes were represented by US plants with the balance from Canadian plants.

A quantitative statistical assessment of industry LCI data can be gained from a comparison of the key statistics for the primary raw material, EPS resin. Compared to the horizontally weighted average of 963.0 kg for the production of 1,000 kg of EPS insulation, the arithmetic mean was 994.4 kg; the median, 1,000.7 kg; and the standard deviation, 35.6 kg. A normal distribution provides the best fit probability distribution for the EPS resin.

Finally, sensitivity analyses were conducted for variations in 1) the US and Canadian electrical grid, and 2) energy use. In the electrical grid analysis, the Canadian grid has LCIA impacts of zero to -6.0% compared to the baseline (US) grid. In energy use among manufacturers, the sensitivity analysis ranged +/-1.4% from the baseline (horizontal average) for a +/-10% variation in energy use.

1.3 Application

Foundations

EPS insulation provides dependable, long-term performance for interior and exterior foundation applications. Its closed-cell structure results in minimal water absorption and moderate vapor permeability. Density, strength, and thickness can be specified to meet compressive loading forces and thermal resistance requirements.

- Sub-Slab Insulation
- Exterior Perimeter Foundation Walls
- Interior Foundation Walls

Walls/Ceilings/Floors

Versatility, lasting value, and performance make EPS insulation ideal for a variety of wall, ceiling, and floor applications that substantially increase the thermal efficiency of the building structure.

- Walls & Ceilings
- Exterior Insulation Finish Systems (EIFS)
- Continuous Insulation/Sheathing

Roofing

Roofing systems using EPS can meet the needs of the most demanding building requirements. EPS insulation is compatible with all commercial roofing systems, including but not limited to built-up roofing, modified bitumen systems, and single-ply membrane systems that are either ballasted, mechanically fastened, or fully adhered.

- Flat, Tapered, Composite, & Flute Fill
- Built-Up & Modified Bitumen Membrane Systems
- Single-Ply Membrane Systems

1.4 Declaration of Methodological Framework

The EPD is based on a Cradle-to-Grave analysis and includes the following life cycle stages: A1-A2 (raw materials), A3 (manufacturing), A4-A5 (delivery and installation), B1 (use), and C1-C4 (disposal). The reference service life applied is 75 years. A mass allocation approach was followed for the primary data; in some cases, an economic allocation was relied upon for generic Ecoinvent LCI data. A 1% mass cut-off of the weighted average products was applied to the material inventory. No known flows were deliberately excluded from this EPD.

1.5 Technical Requirements

Table 3. Technical Requirements for ASTM C578 Type I EPS Insulation

Property	Test Method	Value	Unit
Thermal Resistance	ASTM C518	3.6	F•ft²•h/Btu•in, min
Compressive Strength	ASTM D1621 or C165	10.0	psi, min
Water Vapor Permeance	ASTM E96	5.0	perm/in, max
Water Absorption	ASTM C272	4.0	volume %, max
Flexural Strength	ASTM C203	25	psi, min
Dimensional Stability	ASTM D2126	2.0	% change, max
Density	ASTM C303 or D1622	0.90	lb/ft³, min
Flame Spread Index	ASTM E84	< 25	-
Smoke Developed Index	ASTM E84	< 450	-

1.6 Properties of Declared Product as Delivered

EPS insulation is delivered as bundles of stacked insulation boards of thickness and dimensions as required by the customer. Insulation board dimensions of 4 ft wide by 8 ft long are most common. Packaging for the bundles may vary but includes stretch wrap, bags, or shrouds.

1.7 Material Composition

EPS insulation consists primarily of polystyrene, including EPS regrind, as well as optional laminated films. Minor additives make up the balance of the formulation.

Table 4. Material Composition

Raw Material	Composition (%)
EPS Resin	93.2%
EPS Regrind	4.2%
Laminating Films (Various)	2.5%

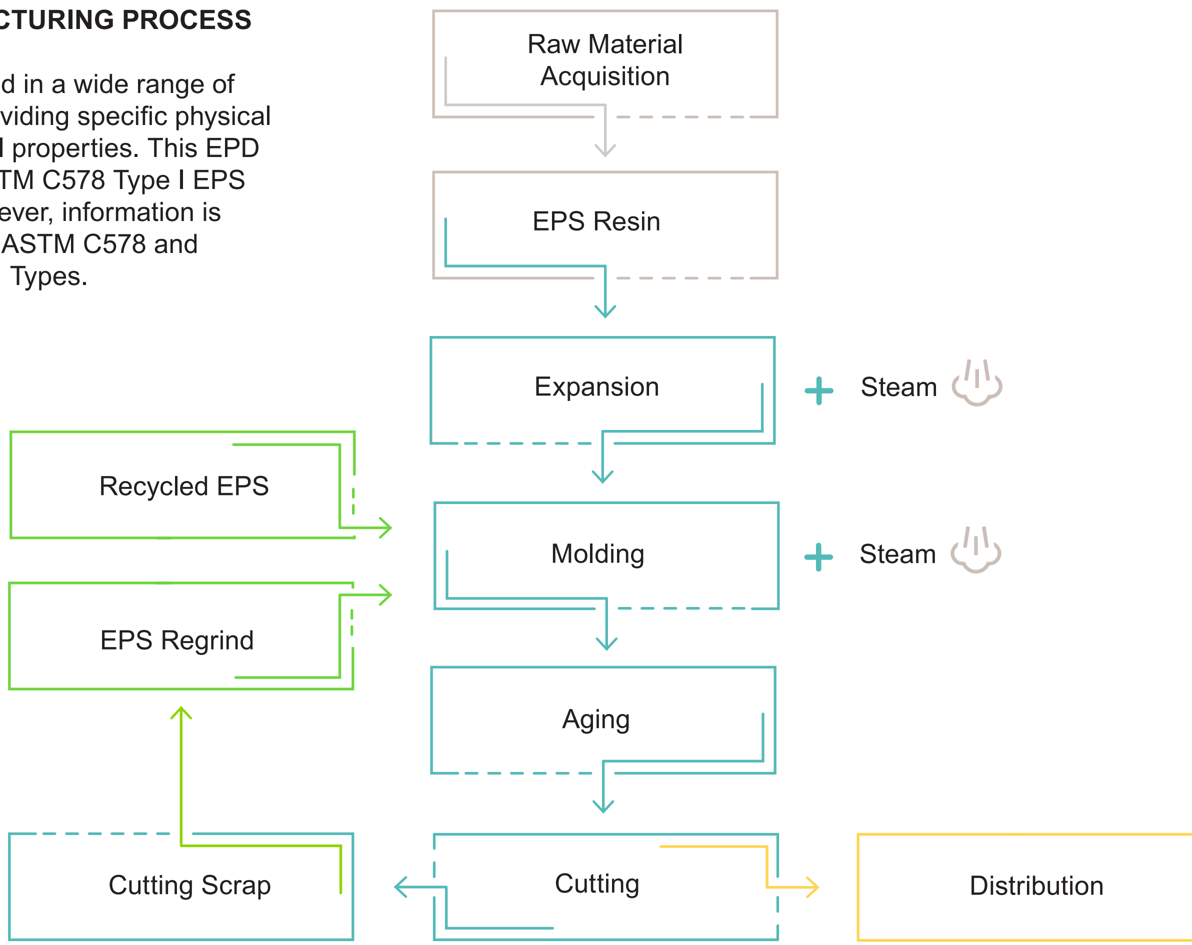
EPS resin contains < 1% flame retardant.

1.8 Manufacturing

EPS insulation is created in a two-stage process. First, EPS resin is loaded into an expander and exposed to steam, which causes it to expand. After aging, the expanded material is transferred into a block mold where, once again, steam is used to further expand and fuse the material into a solid, homogeneous block. Recycled EPS may be incorporated into the molded product. Following a short aging process, the EPS block is cut into sheets or various shapes to suit all insulation applications. Cutting scrap is reground in-house and reused in the production cycle. The basic EPS product is white, although it can be colored.

EPS MANUFACTURING PROCESS

EPS is produced in a wide range of types, each providing specific physical and mechanical properties. This EPD is based on ASTM C578 Type I EPS insulation. However, information is available for all ASTM C578 and CAN/ULC S701 Types.



1.9 Packaging

The packaging for 1,000 kg of EPS insulation is provided in the below table.

Table 5. Packaging Materials per 1,000 kg of Product

Packaging Materials	Quantity (kg)
Bags/shrouds	6.88
Stretch Wrap	3.82
Other Plastic	2.02
Paper Boxes/Labels	0.26
Pallets	0.21
Tape	0.14

1.10 Transportation

Distribution of the EPS insulation is split between transport directly to end users and transport to distribution centers, then to end-users. The product is shipped by road, and the average transportation distance is 269 kilometers.

1.11 Product Installation

Installation is accomplished manually by installers cutting and shaping the insulation as necessary. No special installation equipment is required. Building codes and industry standards establish best practices for product specification and installation. Strict adherence to proper installation requirements ensures that the EPS insulation is effective, ensuring the expected performance and level of safety.

1.12 Use

As the insulation is expected to remain in place and continue to perform for the life of the building, no replacements are necessary during the projected life of the building.

1.13 Reference Service Life and Estimated Building Service Life

As noted in the PCR Guidance for Building Related Products and Services Part A, the estimated service life for buildings is 75 years. The reference service life for EPS insulation is 75 years, as no insulation replacement is expected.

1.14 Reuse, Recycling, and Energy Recovery

Recycling is an integral part of operations at EPS processing plants. Cutting scrap is reground and incorporated into the production process to make new EPS insulation. Recycled EPS can also be processed into new products such as plastic lumber. Post-consumer recycling is available where facilities exist.

1.15 Disposal

In the United States, municipal solid waste (MSW) that is not recovered for recycling or composting is managed 82% by weight to landfill (LF) and 18% by weight to waste-to-energy (WTE) incineration. This applies to the packaging only in this analysis. Thus, the calculations of the impacts for discarded packaging are based on a scenario in which 82% of the post-consumer packaging goes to landfill and 18% to WTE combustion. The EPS insulation is recycled from building installations at a rate of much less than 1% of its production. Therefore, all EPS insulation is discarded to a landfill, known as a Construction and Demolition landfill, for this analysis. The average transport distance from the building to the landfill site is assumed to be 100 km.

2. Life Cycle Assessment Background Information

2.1 Functional Unit

The functional unit is 1 m^2 of EPS insulation with a thickness that provides an average thermal resistance of RSI = 1 m^2 K/W with a building service life of 75 years. For ASTM C578 Type I products, the mass and thickness required is shown in the table below.

Table 6. Functional Unit for ASTM C578 Type I EPS Insulation

Name	Value	Unit
Functional Unit	1 m^2 of insulation material with a thickness that gives an average thermal resistance of RSI = 1 m^2 K/W	
Mass	0.578	kg
Thickness to achieve functional unit	0.0401	m

2.2 System Boundary

This EPD is a Cradle-to-Grave analysis. The life cycle modules included in the analysis are identified in the table below. No infrastructure flows were included in the analysis.

Table 7. Life Cycle Modules within System Boundary

Life Cycle Stage	Module	Description	Details
Production	A1	Raw material supply	EPS resin based on LCA with primary data; resin raw materials based on secondary data
	A2	Transport	Transport mode and distance of resin based on average of primary data
	A3	Manufacturing	Material and energy inputs for insulation manufacturing and blowing agent losses and waste generated
Construction	A4	Transport to site	Transport via truck to distribution center or job site
	A5	Installation	Done manually with no added energy or resources needed, although waste generated and residual blowing agent losses occur
Use	B1	Use	No inputs required
	B2	Maintenance	No inputs needed
	B3	Repair	No inputs needed
	B4	Replacement	No inputs needed
	B5	Refurbishment	No inputs needed
	B6	Operational energy use	No energy flows for in-service product use
	B7	Operational water use	No water flows for in-service product use
End-of-Life	C1	Deconstruction	No inputs needed
	C2	Transport	Transport via truck from building to landfill
	C3	Waste processing	Processing based on disposal in landfill
	C4	Disposal	All product is disposed of in landfill per Part A (US disposal pathway)
Beyond System Boundary	D	Reuse, recovery, recycling potential	Module not declared

2.3 Estimates and Assumptions

This industry average EPD is based on the material and energy inputs from 26 North American insulation manufacturing plants. The EPS resin that the insulation manufacturers convert was modeled with input from four EPS resin plants across the United States, Canada, and Mexico. The remaining pentane blowing agent following manufacturing is emitted during transport to the site and installation. Electricity is assumed to be from the US electricity grid, although several insulation manufacturing plants and resin plants were outside the U.S.

EPS insulation is cut to the specific dimensions required by the installation. Therefore, it is assumed that there is no waste generated during installation. Upon deconstruction, all insulation is assumed to be disposed of in a Construction and Demolition landfill. The average distance to the landfill is assumed to be 100 km.

The R-value for the ASTM Type I EPS insulation examined in this study was conservatively modeled at the specification minimum of R-3.6 per inch.

2.4 Cut-off Criteria

Cut-off criteria were applied in accordance with the requirements of ISO 21930 Section 7.1.8 and PCR Part A Section 2.9. A 1% mass cut-off was used for material inputs to maintain an efficient calculation procedure for all LCI data provided. Where generic data was used to address data gaps, conservative, worst-case estimates were used. No known flows were excluded from this EPD.

2.5 Data Sources

This study relied on a combination of primary (specific) data supplied by participants and secondary (generic) data obtained from Ecoinvent v3.8 (2021) datasets. The EPS resin study served as the primary raw material data input for the insulation manufacturing. Where available, the Ecoinvent datasets relied upon were for the United States or the Rest of the World (ROW). If unavailable, Global or European Ecoinvent datasets were used.

2.6 Data Quality

The LCI data provided was for calendar year 2021 for all participating plants. The EPS insulation manufacturing is representative for North America (United States and Canada). The technology and manufacturing processes used for the EPS resin production and insulation manufacturing represent the most commonplace technologies. Data quality was monitored according to the requirements of ISO 14044.

2.7 Period Under Review

The primary data collected was for calendar year 2021.

2.8 Allocation

Mass allocation was used for the primary, specific data provided in the LCIs for the EPS resin and insulation by the manufacturers. For the secondary (generic) data obtained from the Ecoinvent v3.8 datasets, the default is economic allocation, but where possible this was converted to a mass allocation (if a physical relationship exists). For the end-of-life stage, the Ecoinvent allocation applied a cut-off by classification end-of-life allocation method.

2.9 Comparability

Care should be taken in comparing EPDs of similar insulation products. Environmental declarations from different programs based upon differing PCRs may not be comparable. Further, when comparing EPDs created using the same PCR, variations and deviations are possible. Example of variations include different LCA software and background LCI datasets that may lead to different results upstream or downstream of the declared life cycle stages. Comparison of the environmental performance of thermal insulation products using EPD information shall be based on the product's use and impacts at the building level. In general, EPDs may not be used for comparability purposes unless considered in a building energy use context. Given this PCR ensures products meet the same functional requirements, comparability is permissible provided the information given for such comparison is transparent and the limitations of comparability are explained.

3. Life Cycle Assessment Scenarios

Table 8. Transport to the Building Site (A4)

Name	Value	Unit
Fuel Type	Diesel	-
Liters of Fuel	2.55E-3	L/100km
Vehicle Type	Lorry (truck-trailer), 7.5-16 mt freight, Euro6	-
Transport Distance	269	km
Capacity Utilization (including empty runs, mass based)	50	%
Weight of Products Transported	0.578	kg
Capacity Utilization Volume Factor	1	-

Table 9. Installation into the Building (A5)

Name	Value	Unit
Ancillary materials	0.00	kg
Net freshwater consumption specified by water source and fate	0.00	m^3
Other resources	0.00	kg
Electricity consumption	0.00	kWh
Other energy carriers	0.00	MJ
Product loss per functional unit	0.00	kg
Waste materials at the construction site before waste processing, generated by product installation	0.00786	kg
Output materials resulting from on-site waste processing	0.00	kg
Biogenic carbon contained in packaging	0.00	kg CO^2
Direct emissions to ambient air, soil, and water	0.00685	kg
VOC content	1715	$\mu g/m^3$

Table 10. Reference Service Life

Name	Value	Unit
RSL	75	Years
Declared product properties (at the gate) and finishes	See Table 3 for product properties	N/A
Design application parameters (if instructed by the manufacturer), including references to the appropriate practices and application codes	Per manufacturer's instructions	N/A
An assumed quality of work, when installed in accordance with the manufacturer's instructions	Meets the R-value specification	N/A
Outdoor environment, if relevant for outdoor applications, (e.g., weathering, pollutants, UV and wind exposure, building orientation, shading, and temperature)	May be exposed during normal construction activities, but should be protected from weathering due to sun or rain exposure if outdoors for extended periods	N/A
Indoor environment, if relevant for indoor applications (e.g., temperature, moisture, and chemical exposure)	Interior use requires covering with a 15-min thermal barrier per local building code, except for limited exceptions documented in manufacturer's evaluation reports	N/A
Use conditions (e.g., frequency of use and mechanical exposure)	N/A	N/A
Maintenance (e.g., required frequency, type, and quality of replacement components)	None needed	N/A

Table 11. End-of-Life (C1-C4)

Name	Value	Unit
Assumptions for scenario development	While end-of-life recycling of EPS insulation is possible, limited amounts are collected, so all disposed product is assumed to be landfilled	N/A
Collection process–Collection with mixed construction waste	0.578	kg
Recovery to landfill	0.578	kg
Disposal–Product or material for final deposition	0.578	kg
Removal of biogenic carbon (excluding packaging)	0	kg CO_2

Tables for life cycle modules B2–B7 and D are not applicable for EPS insulation and thus are not provided here.

4. Life Cycle Assessment Results

Table 12. Description of System Boundary Modules

	PRODUCT STAGE			CONSTRUCTION PROCESS 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	
	Raw Material Supply	Transport	Manufacturing	Transport from Gate to Site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Deconstruction	Transport	Waste Processing	Disposal	Reuse, Recovery, Recycling Potential	Reference Service Life
						B6 Building Operational Energy Use During Product Use										
						B7 Building Operational Water Use During Product Use										
Cradle to Grave	x	x	x	x	x	x	x	x	x	x	x	x	x	x	MND	75 years

4.1 Life Cycle Impact Assessment Results

The LCIA results in Tables 13–16 are according to the functional unit: 1 m^2 of ASTM C578 Type I EPS insulation with a thickness that provides a thermal resistance of RSI = 1 m^2K/W over 75 years. LCIA results are relative expressions and do not predict impacts on category endpoints, threshold excesses, safety margins, or risks.

Table 13. TRACI v2.1 and IPCC AR5 Impact Categories

Impact Category	Abbreviation	Unit
Global Warming Potential, IPCC 2013, AR5, GWP 100 years	GWP100	kg CO_2 eq.
Ozone Depletion Potential	ODP	kg CFC-11 eq.
Acidification Potential	AP	kg SO_2 eq.
Eutrophication Potential	EP	kg N eq.
Smog Formation Potential	SFP	kg O_3 eq.
Abiotic Resource Depletion Potential of Nonrenewable (Fossil) Energy Resources	ADP_{fossil}	MJ, LHV

Table 14. North American Impact Assessment Results

TRACI v2.1 and IPCC AR5	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
GWP 100 [kg CO_2 eq.]	2.53E+00	2.62E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.33E-02	0.00E+00	7.01E-03
ODP [kg CFC-11 eq.]	2.11E-07	6.02E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-08	0.00E+00	1.33E-09
AP [kg SO_2 eq.]	8.35E-03	6.59E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.22E-04	0.00E+00	2.67E-05
EP [kg N eq.}	3.97E-03	2.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.36E-05	0.00E+00	8.95E-05
SFP [kg O_3 eq.]	1.25E-01	9.78E-04	8.99E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	0.00E+00	6.63E-04
ADP_{fossil} [MJ, LHV]	5.82E+01	3.86E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	8.64E-02

Table 15. CML-IA v4.7 Impact Categories

Impact Category	Abbreviation	Unit
Global Warming Potential, IPCC 2013, AR5, GWP 100 years	GWP 100	kg CO_2 eq.
Ozone Depletion Potential	ODP	kg CFC-11 eq.
Acidification Potential	AP	kg SO_2 eq.
Eutrophication Potential	EP	kg PO_4^{-3} eq.
Photochemical Oxidant Creation Potential	POCP	kg ethene eq.
Abiotic Resource Depletion for Elements	$ADP_{element}$	kg Sb eq.
Abiotic Resource Depletion Potential of Nonrenewable (Fossil) Energy Resources	ADP_{fossil}	MJ, LHV

Table 16. EU Impact Assessment Results

CML-IA v4.7	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
GWP 100 [kg CO_2 eq.]	2.50E+00	2.62E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.32E-02	0.00E+00	6.96E-03
ODP [kg CFC-11 eq.]	1.71E-07	4.52E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-08	0.00E+00	9.97E-10
AP [kg SO_2 eq.]	8.35E-03	6.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.41E-04	0.00E+00	2.26E-05
EP [kg PO_4^{-3} eq.]	2.11E-03	1.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.30E-05	0.00E+00	3.58E-05
POCP [kg ethene eq.]	6.73E-03	3.17E-06	2.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-05	0.00E+00	1.03E-06
$ADP_{element}$ [kg Sb eq.]	8.55E-06	9.18E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.44E-08	0.00E+00	7.43E-09
ADP_{fossil} [MJ, LHV]	5.82E+01	3.86E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	8.64E-02

4.2 Life Cycle Inventory Results

The results in Tables 17–22 are according to the following functional unit: 1 m^2 of ASTM C578 Type I EPS insulation with a thickness that provides a thermal resistance of RSI = 1 m^2 K/W over 75 years.

Table 17. Resource Parameters

Parameter	Abbreviation	Unit
Renewable primary energy used as energy carrier (excluding raw materials)	RPE_E	MJ, LHV
Renewable primary energy resources used as raw materials	RPR_M	MJ, LHV
Total use of renewable primary energy resources	RPR_T	MJ, LHV
Nonrenewable primary energy used as energy carrier (excluding raw materials)	$NRPR_E$	MJ, LHV
Nonrenewable primary energy resources used as raw materials	$NRPR_M$	MJ, LHV
Total use of nonrenewable primary energy resources	$NRPR_T$	MJ, LHV
Use of secondary material	SM	kg
Use of renewable secondary fuels	RSF	MJ, LHV
Use of nonrenewable secondary fuels	NRSF	MJ, LHV
Recovered energy	RE	MJ, LHV
Use of net freshwater resources	FW	m^3

Table 18. Resource Use

Parameter	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
RPE_E [MJ, LHV]	9.66E-01	4.56E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-03	0.00E+00	7.83E-04
RPR_M [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RPR_T [MJ, LHV]	9.66E-01	4.56E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-03	0.00E+00	7.83E-04
$NRPR_E$ [MJ, LHV]	4.25E+01	4.15E-01	2.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+00	0.00E+00	9.03E-02
$NRPR_M$ [MJ, LHV]*	2.26E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$NRPR_T$ [MJ, LHV]	6.51E+01	4.15E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+00	0.00E+00	9.27E-02
SM [kg]	2.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m^3]	2.52E-02	4.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.74E-05	0.00E+00	9.78E-05

*Note - EPS resin calorific value is considered as 40 MJ/kg.

Table 19. Output Flows & Waste Categories

Parameter	Abbreviation	Unit
Hazardous waste, disposed	HWD	kg
Nonhazardous waste, disposed	NHWD	kg
High-level radioactive waste, conditioned, to final repository	HLRW	kg
Intermediate- and low-level radioactive waste, conditioned, to final repository	ILLRW	kg
Components for reuse	CRU	kg
Materials for recycling	MR	kg
Materials for energy recovery	MER	kg
Recovered energy exported from the product system	EE	MJ, LHV

Table 20. Output Flows & Waste Categories

Parameter	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
HWD [kg]	1.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD [kg]	1.17E-02	0.00E+00	6.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.78E-01
HLRW [kg]*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ILLRW [kg]*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR [kg]	1.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	1.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

*Note - This inventory metric on the background data is not available; therefore zero values are reported.

Table 21. Carbon Emissions & Removals

Parameter	Abbreviation	Unit
Biogenic Carbon Removal from Product	BCRP	kg CO_2
Biogenic Carbon Emission from Product	BCEP	kg CO_2
Biogenic Carbon Removal from Packaging	BCRK	kg CO_2
Biogenic Carbon Emission from Packaging	BCEK	kg CO_2
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	BCEW	kg CO_2
Calcination Carbon Emissions	CCE	kg CO_2
Carbonation Carbon Removals	CCR	kg CO_2
Carbon Emissions from Combustion of Waste from Nonrenewable Sources Used in Production Processes	CWNR	kg CO_2

Table 22. Carbon Emissions & Removals

Parameter	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
BCRP [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEP [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRK [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEK [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEW [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

4.3 Results for Other EPS Insulation Type Classifications

The EPD is based on a functional unit of 1 m² of Type I EPS insulation with a thickness that gives an average thermal resistance of RSI = 1 m² K/W and with a building service life of 75 years. For this functional unit, the EPS insulation thickness would be 0.0401 m (4.01 cm) with a mass of 0.578 kg. However, this functional unit does not represent all EPS insulation Types that might be used. Therefore, EPS Type factors have been calculated for use with the Type I results to calculate results for other Types based on their densities and R-values.[1]

Table 23 provides the available Types of EPS insulation with the Product Type Factors and relevant physical properties according to ASTM C578 and for Canadian Types per CAN/ULC S701.1. The factors were calculated using the ratios of the densities and R-values to those of Product Type I as per ASTM C578.

Table 23. Property Specifications & Product Type Factors

Product Type	Density (lbs/ft³)	R-Value per inch thickness (ft²•hr•F/Btu•in)	Product Type Factor
US ASTM C578			
XI	0.70	3.10	0.90
I	0.90	3.60	1.00
VIII	1.15	3.80	1.21
II	1.35	4.00	1.35
IX	1.80	4.20	1.71
XIV	2.40	4.20	2.29
XV	3.00	4.30	2.79
CAN/ULC S701.1[2]			
1	0.90	3.75	0.96
2	1.35	4.04	1.34
3	1.80	4.27	1.69

A sample calculation of calculating the Product Type Factor for Type XV is as follows:

Thermal resistivity$_{XV}$ = R-value per 1 inch thickness (from table) = 4.30 ft²·hr·F/Btu
= (4.30 ft²·hr·F/Btu)/5.678 = 0.757 m²·K/W per inch

Thermal resistance$_{XV}$ = (0.757 m²·K/W)/0.0254 m = 29.8 m·K/W

Density (from table) = 3.00 lbs/ft³
= (3.00 lbs/ft³) x 16.02 = 48.06 kg/m³

Mass of Type XV EPS required for the Functional Unit (FU) = M_{XV}
= Density (kg/m³) x Area (m²) x [Thermal Resistivity$_{FU}$ (m²·K/W) / Thermal Resistance (W/m·K)]
= 48.06 x 1 x 1 / 29.8 = 1.612 kg

Product Type Factor = Ratio of FU masses = M_{XV} / MI = 1.612 kg / 0.578 kg = 2.79

[1] While the EPS insulation manufacturers produce a range of product densities (Types), ASTM Type I EPS insulation is the most prevalent.
[2] CAN/ULC S701.1 does not specify density. Density shown is a calculated value based on R-value and functional unit.

Sample calculation: Type XV GWP = Type I GWP x Product Type Factor = 2.64 kg CO_2e x 2.79 = 7.37 kg CO_2e

Table 24. LCIA & LCI Results for Other EPS Insulation Types

	US ASTM C578							CAN/ULC S701.1		
PARAMETERS	XI	I	VIII	II	IX	XIV	XV	1	2	3
NORTH AMERICA (TRACI 2.1) AND IPCC AR5 LCIA RESULTS										
GWP 100 [kg CO_2 eq.]	2.38E+00	2.64E+00	3.19E+00	3.56E+00	4.51E+00	6.05E+00	7.37E+00	2.53E+00	3.54E+00	4.46E+00
ODP [kg CFC-11 eq.]	2.12E-07	2.35E-07	2.84E-07	3.17E-07	4.02E-07	5.38E-07	6.56E-07	2.26E-07	3.15E-07	3.97E-07
AP [kg SO_2 eq.]	7.97E-03	8.86E-03	1.07E-02	1.20E-02	1.52E-02	2.03E-02	2.47E-02	8.51E-03	1.19E-02	1.50E-02
EP [kg N eq.]	3.72E-03	4.13E-03	5.00E-03	5.58E-03	7.06E-03	9.46E-03	1.15E-02	3.96E-03	5.53E-03	6.98E-03
SFP [kg O_3 eq.]	1.33E-01	1.48E-01	1.79E-01	2.00E-01	2.53E-01	3.39E-01	4.13E-01	1.42E-01	1.98E-01	2.50E-01
ADP_{fossil} [MJ, LHV]	5.36E+01	5.96E+01	7.21E+01	8.05E+01	1.02E+02	1.36E+02	1.66E+02	5.72E+01	7.99E+01	1.01E+02
CML-IA V4.7 LCIA RESULTS										
GWP 100 [kg CO_2 eq.]	2.35E+00	2.61E+00	3.16E+00	3.52E+00	4.46E+00	5.98E+00	7.28E+00	2.51E+00	3.50E+00	4.41E+00
ODP [kg CFC-11 eq.]	1.70E-07	1.89E-07	2.29E-07	2.55E-07	3.23E-07	4.33E-07	5.27E-07	1.81E-07	2.53E-07	3.19E-07
AP [kg SO_2 eq.]	7.89E-03	8.77E-03	1.06E-02	1.18E-02	1.50E-02	2.01E-02	2.45E-02	8.42E-03	1.18E-02	1.48E-02
EP [kg PO_4^{-3} eq.]	2.02E-03	2.24E-03	2.71E-03	3.02E-03	3.83E-03	5.13E-03	6.25E-03	2.15E-03	3.00E-03	3.79E-03
POCP [kg ethene eq.]	8.51E-03	9.45E-03	1.14E-02	1.28E-02	1.62E-02	2.16E-02	2.64E-02	9.07E-03	1.27E-02	1.60E-02
$ADP_{element}$ [kg Sb eq.]	7.84E-06	8.71E-06	1.05E-05	1.18E-05	1.49E-05	1.99E-05	2.43E-05	8.36E-06	1.17E-05	1.47E-05
ADP_{fossil} [MJ, LHV]	5.36E+01	5.96E+01	7.21E+01	8.05E+01	1.02E+02	1.36E+02	1.66E+02	5.72E+01	7.99E+01	1.01E+02
RESOURCES										
RPR_T [MJ, LHV]	8.78E-01	9.75E-01	1.18E+00	1.32E+00	1.67E+00	2.23E+00	2.72E+00	9.36E-01	1.31E+00	1.65E+00
$NRPR_T$ [MJ, LHV]	6.00E+01	6.67E+01	8.07E+01	9.00E+01	1.14E+02	1.53E+02	1.86E+02	6.40E+01	8.94E+01	1.13E+02
SM [kg]	2.31E-03	2.57E-03	3.11E-03	3.47E-03	4.39E-03	5.89E-03	7.17E-03	2.47E-03	3.44E-03	4.34E-03
FW [m^3]	2.29E-02	2.54E-02	3.07E-02	3.43E-02	4.34E-02	5.82E-02	7.09E-02	2.44E-02	3.40E-02	4.29E-02
OUTPUT FLOWS/WASTE										
HWD [kg]	1.26E-04	1.40E-04	1.69E-04	1.89E-04	2.39E-04	3.21E-04	3.91E-04	1.34E-04	1.88E-04	2.37E-04
NHWD [kg]	5.36E-01	5.96E-01	7.21E-01	8.05E-01	1.02E+00	1.36E+00	1.66E+00	5.72E-01	7.99E-01	1.01E+00
MR [kg]	1.05E-02	1.17E-02	1.42E-02	1.58E-02	2.00E-02	2.68E-02	3.26E-02	1.12E-02	1.57E-02	1.98E-02
MER [kg]	1.27E-03	1.41E-03	1.71E-03	1.90E-03	2.41E-03	3.23E-03	3.93E-03	1.35E-03	1.89E-03	2.38E-03

5. Life Cycle Assessment Interpretation

The LCA upon which this EPD is based represents an industry-average approach with LCI data contributed by 10 EPS insulation manufacturers across 26 plants. Further, the raw material inputs for the Insulation LCA were based, in large part, on primary industry average LCI data supplied for four EPS resin manufacturing plants. EPS resin accounts for the majority of raw materials for EPS insulation.

From the TRACI v2.1 results, raw materials (A1) represent the largest contributor to environmental impacts and resources used, ranging from about 50% to 92% of the total impacts. Insulation manufacturing is generally the second largest contributor at 5% to 27% of the total. Most of the manufacturing impacts range from 10%-17% with acidification potential and water consumption falling below and ozone depletion exceeding this range.

Transportation of raw materials (A2), insulation distribution (A4), and end-of-life transport (C2) combined are notable contributors to ozone depletion potential (25%), smog formation potential (17%), and acidification potential (12%) due to fossil fuel combustion. Smog formation potential is a contributor to the impacts during the installation stage (A5) with the loss of the residual pentane blowing agent; packaging waste represents the balance of impacts for A5.

GLOBAL WARMING POTENTIAL

Table 25 and Figure 2 show life cycle GWP results for the insulation systems. The raw material acquisition of the insulation system accounts for the largest share of GWP (74%), followed by insulation manufacturing at 17%. The GWP emissions from the raw material stage are mainly associated with fossil fuel resources used as fuel and as feedstocks for the resin and blowing agent. GWP from insulation manufacturing includes emissions from energy uses, emissions from operation of a thermal oxidizer used to destroy blowing agent emissions at the manufacturing plant (including carbon dioxide from combustion of both the fuel and pentane burned in the thermal oxidizer), and emissions associated with production of the electricity used in the insulation manufacturing processes. More than 6% comes from combustion of the fuels used to transport the resin, as well as the insulation during distribution. End-of-life management of disposed EPS insulation contributes a 3% of the total GWP for the insulation system; this is largely carbon dioxide emissions from the combustion of the fuels used to transport and distribute the insulation during landfilling.

Table 25. Global Warming Potential

Basis: 1 m² of EPS insulation with a thermal resistance of RSI = 1 m²K/W and with a building service life of 75 years		
PARAMETER	GLOBAL WARMING IN *kg CO_2 eq.*	GLOBAL WARMING IN %
Raw Material Acquisition	1.95E+00	73.88%
Packaging of EPS Resin and Insulation	2.34E-02	0.89%
Transportation-Resin to Insulation	1.24E-01	4.72%
Insulation Manufacturing	4.34E-01	16.47%
Distribution	2.62E-02	0.99%
Installation and Use	0.00E+00	0.00%
End-of-Life	8.03E-02	3.05%
Total	2.64E+00	100.00%

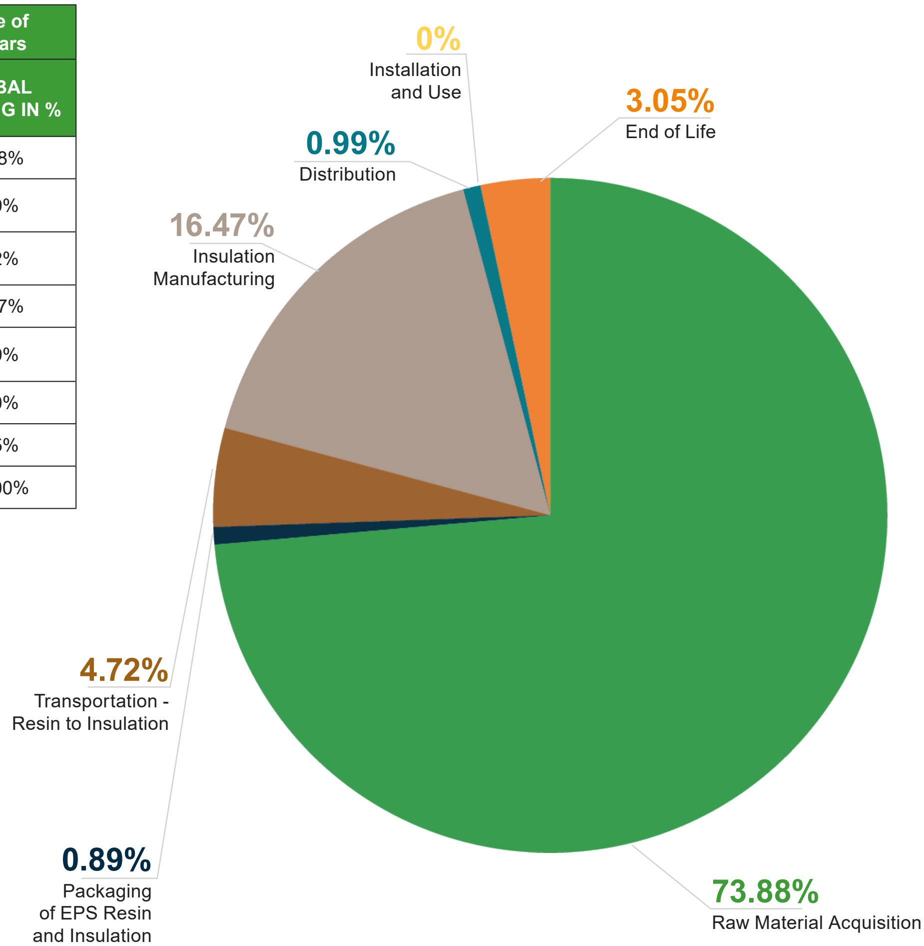


Figure 2. Global Warming Potential

ACIDIFICATION POTENTIAL

Acidification assesses the potential of emissions to contribute to the formation and deposit of acid rain on soil and water, which can cause serious harm to plant and animal life as well as damage to infrastructure. Acidification potential modeling in TRACI considers the increasing concentration of hydrogen ions (H+) within a local environment. The addition of acids or ammonia can increase the acidity of the environment from various chemical reactions or by natural circumstances.

Table 26 shows total acidification potential results for the insulation systems. Results are shown graphically in Figure 3. For the EPS insulation system, raw material production accounts for the majority of the acidification potential impacts (81%), followed by the combined transportation impacts from resin, distribution, and end-of-life (12%). About 94% of the total end-of-life impact is due to transport.

Table 26. Acidification Potential

Basis: 1 m² of EPS insulation with a thermal resistance of RSI = 1 m² K/W and with a building service life of 75 years		
PARAMETER	**Acidification in *kg SO_2 eq.***	**Acidification in %**
Raw Material Acquisition	7.10E-03	80.13%
Packaging of EPS Resin and Insulation	9.24E-05	1.04%
Transportation-Resin to Insulation	5.94E-04	6.70%
Insulation Manufacturing	5.60E-04	6.32%
Distribution	6.59E-05	0.74%
Installation and Use	0.00E+00	0.00%
End-of-Life	4.48E-04	5.06%
Total	8.86E-03	100.00%

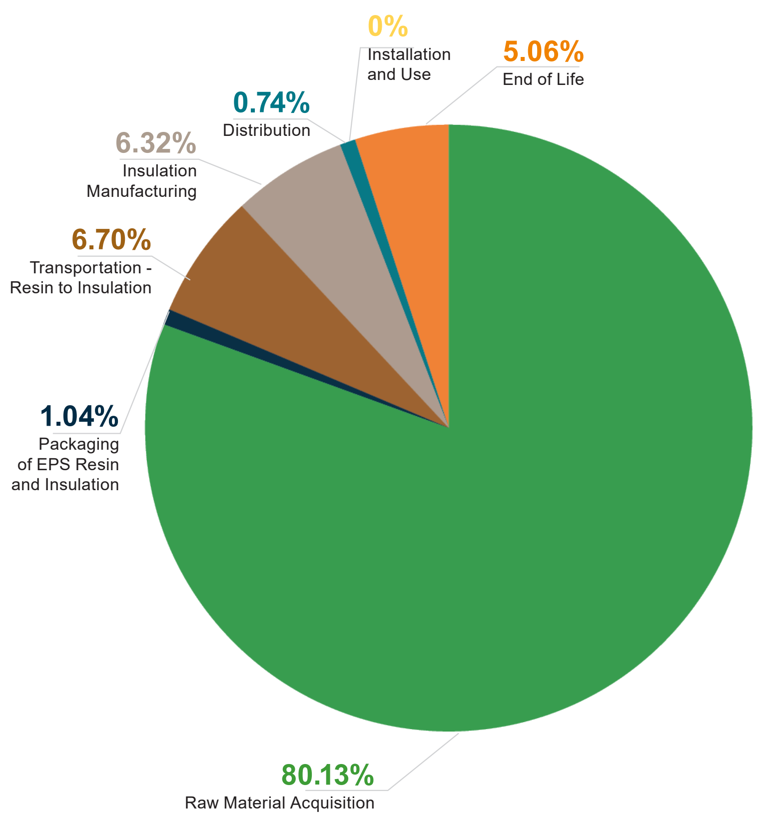


Figure 3. Acidification Potential

SMOG FORMATION POTENTIAL

The smog formation impact category characterizes the potential of airborne emissions to cause photochemical smog. The creation of photochemical smog occurs when sunlight reacts with NOx and volatile organic compounds (VOCs), resulting in tropospheric (ground-level) ozone and particulate matter. Endpoints of such smog creation can include increased human mortality, asthma, and deleterious effects on plant growth.

Smog formation impacts, like the other atmospheric impact indicators included in this study, are generally dominated by emissions associated with fuel combustion, so that impacts are higher for life cycle stages and components that have higher-process fuel and transportation fuel requirements. For EPS insulation that uses pentane (a VOC) as the blowing agent, the release of pentane also has a smog formation potential. Pentane is primarily released (or captured and destroyed by emissions controls) during manufacturing, but a minor residual remains to be lost during installation (6% of the total SFP impact).

Table 27 shows total smog potential results for the ASTM C578 Type I EPS insulation system broken out by life cycle phase. The results are shown graphically in Figure 4. Smog formation impacts for the EPS insulation system are dominated by raw material production, contributing almost 58% of the total impacts, followed by manufacturing process (18%). Transportation of raw materials and distribution of insulation accounts for 9% of the total impacts, installation and use accounts for 6% of the total impacts, and end of life of the insulation accounts for 8% of the total impacts.

Table 27. Smog Formation Potential

Basis: 1 m² of EPS insulation with a thermal resistance of RSI = 1 m² K/W and with a building service life of 75 years		
PARAMETER	Smog Formation in *kg O_3 eq.*	Smog Formation in %
Raw Material Acquisition	8.44E-02	57.13%
Packaging of EPS Resin and Insulation	1.32E-03	0.90%
Transportation-Resin to Insulation	1.26E-02	8.53%
Insulation Manufacturing	2.68E-02	18.15%
Distribution	9.78E-04	0.66%
Installation and Use	8.99E-03	6.09%
End-of-Life	1.26E-02	8.54%
Total	1.48E-01	100.00%

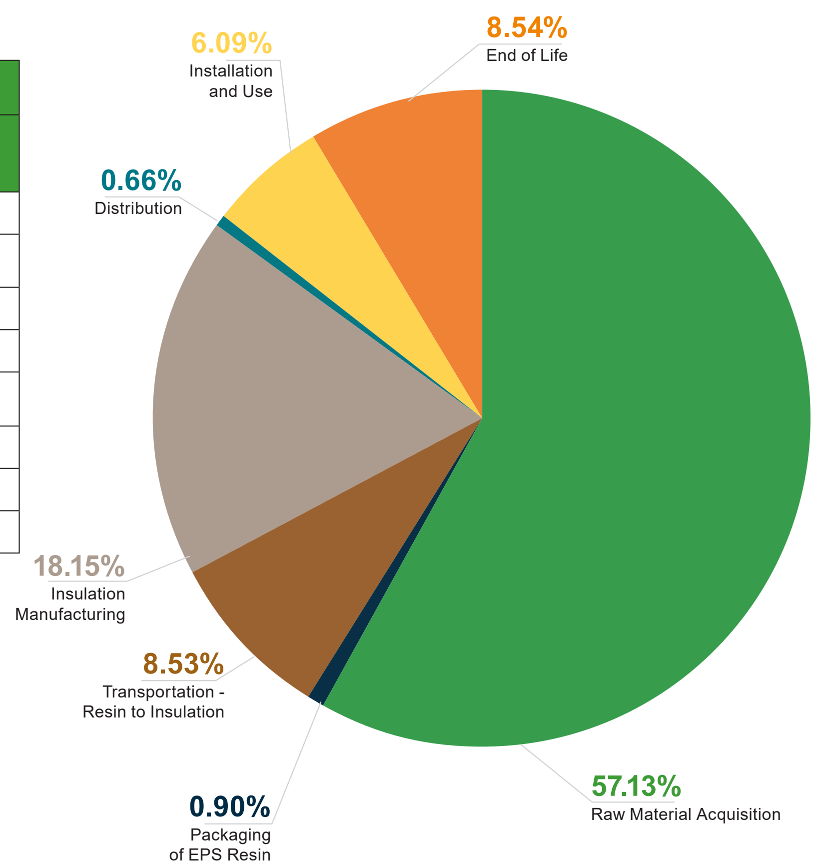


Figure 4. Smog Formation Potential

6. Additional Environmental Information

6.1 Energy Savings During Use

The use of EPS insulation in building envelopes reduces the energy consumption (and carbon emissions) of the building during its operational life. This reduced environmental impact is not included in the Life Cycle Impact Assessment. However, as prescribed in PCR v2.0 Part B, by applying energy simulation software, the energy savings can be quantified, which can then be compared to the total primary (embodied) energy used to produce the insulation. The payback on the energy savings relative to the embodied energy will depend on the energy simulation software used, the model building selected, and the climate zone location of the building.

6.2 Extraordinary Effects

FIRE

EPS insulation boards are evaluated for their fire performance in the United States according to ASTM E84 "Standard Test Method for Surface Burning Characteristics of Building Materials" or the equivalent method (UL723). EPS insulation meets the criteria for a Class A material with a Flame Spread Index ≤ 25 and a Smoke Developed Index < 450. In Canada, the insulation is evaluated per CAN/ULC S102.2 "Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies."

In addition to being tested as a stand-alone building product, EPS insulation incorporated into wall or roof assemblies may be evaluated in system or assembly tests. For wall assemblies of Type I–IV construction in the United States, the assembly's fire performance is tested according to NFPA 285 "Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components." In Canada, wall assemblies are evaluated according to CAN/ULC S134 "Standard Method of Fire Test of Exterior Wall Assemblies."

In a similar fashion, EPS insulation-containing roof assemblies are often evaluated for their system fire performance for fire originating either within the building or external to the building. For internal fire sources, the assemblies may be tested according to UL 1256 "Fire Test of Roof Deck Construction," NFPA 276 "Standard Method of Fire Test for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components", or (in Canada) CAN/ULC S126 "Standard Method of Test for Fire Spread Under Roof-Deck Assemblies." Exposure to external fire sources may be evaluated per UL 790 "Standard Test Methods for Fire Tests of Roof Coverings," ASTM E108 "Standard Test Methods for Fire Tests of Roof Coverings," or (in Canada) CAN/ULC S107 "Methods of Fire Tests of Roof Coverings."

WATER and MECHANICAL DESTRUCTION

There are no extraordinary effects or environmental impacts anticipated during events involving water or mechanical destruction.

6.3 Environmental Certifications

EPS insulation products have a low volatile nature and are interior friendly. Many EPS insulation manufacturers make products that are certified for indoor air quality and qualify as low-emitting products by UL GREENGUARD. Individual UL GREENGUARD listings can be viewed on SPOT.

6.4 Further Information

Additional information may be found at epsindustry.org.

7. References

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- ISO (2006b), ISO 14040:2006, Environmental management – Life cycle assessment – Principles and framework.
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- Product Category Rules (PCR) Guidance for Building-Related Products and Services - Part B: Building Envelope Thermal Insulation EPD Requirements, UL 10010-1 Version 2.0, Second Edition, UL Environment, April 10, 2018.
- Product Category Rules for Building Related Products and Services - Part A: Life Cycle Assessment Calculation Rules and Report Requirements, UL 10010, v3.1, Fourth Edition, UL Environment, 2018.
- UL General Program Rules v2.7, UL Environment, March 2022.