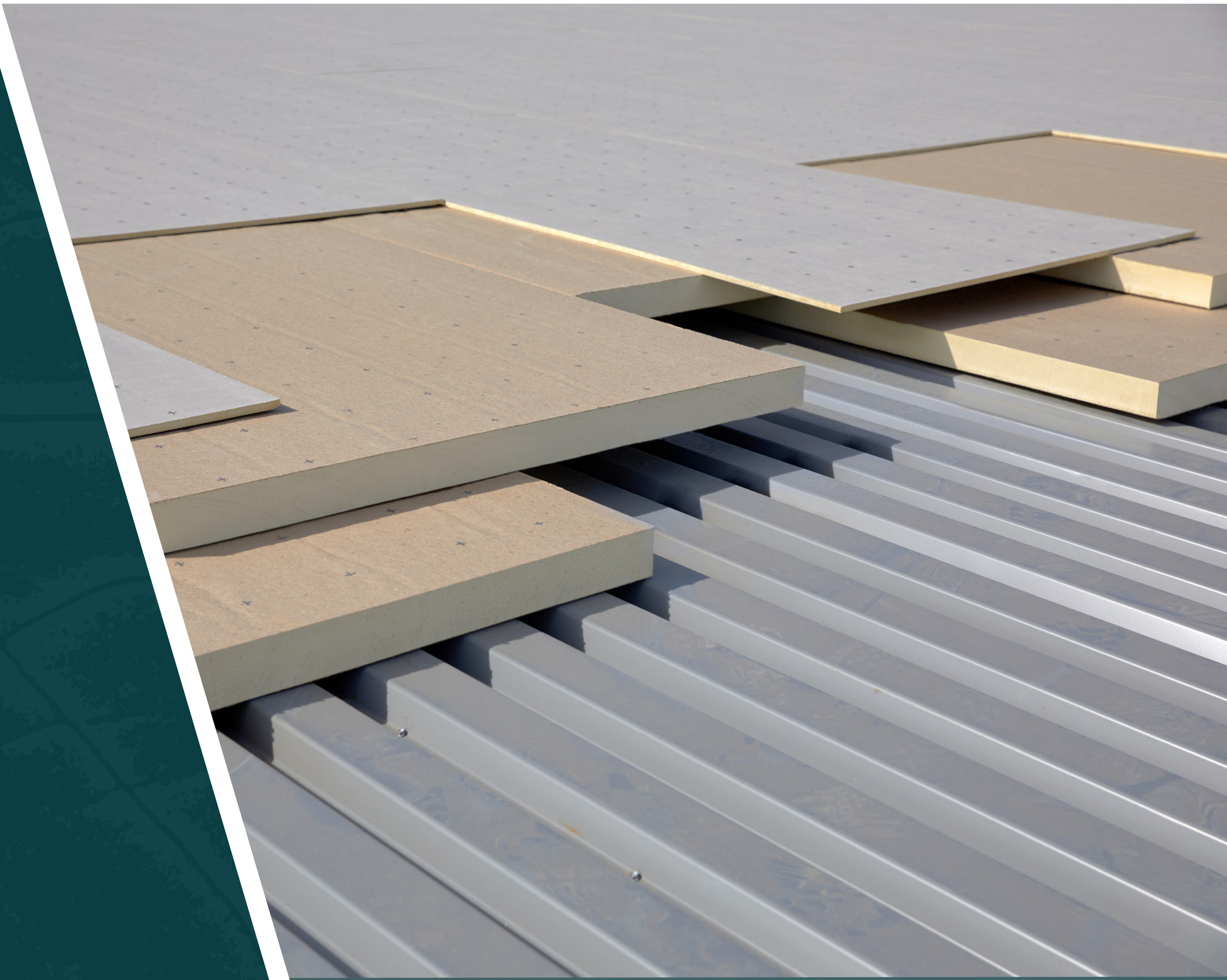
Polyiso High-Density Roof Cover Boards



POLYISOCYANURATE INSULATION MANUFACTURERS ASSOCIATION

ENVIRONMENTAL PRODUCT DECLARATION

ISO 14025:2006 and ISO 21930:2017

Certified Environmental Product Declaration
www.nsf.org

The Polyisocyanurate Insulation Manufacturers Association (PIMA) is pleased to present this Environmental Product Declaration (EPD) for Polyiso High-Density Roof Cover Boards. This EPD was developed in compliance with ISO 14025 and ISO 21930 and has been verified by NSF.

The LCA and the EPD were prepared by Vertima Inc. The EPD includes cradle-to-gate with options life cycle assessment (LCA) results.

For more information about PIMA, visit www.polyiso.org.

For any explanatory material regarding this EPD, please contact the program operator.

1. GENERAL INFORMATION

PCR GENERAL INFORMATION			
Reference PCR	PCR Part B: Roof Cover Protection Board EPD Requirements (UL 10010-36), v.1.0 and its core PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL 10010-36), v.4.0 UL Environment November 2021 to November 2026 (validity period of PCR Part B) March 28, 2022 to March 28, 2027 (validity period of PCR Part A)		
The PCR review was conducted by:	*Jack Geibig (Chair)* *Ecoform, LLC* *jgeibig@ecoform.com*	*Angela Fisher, LCA CP* *Aspire Sustainability* *angela@aspiresustainability.com*	*Mike Ennis* *Ennis Associates* *m.ennis@mac.com*

EPD GENERAL INFORMATION		
Program Operator	NSF 789 N. Dixboro Road Ann Arbor, Michigan 48105 USA www.nsf.org	
General Program Instructions	NSF International, NSF Certification Policies for Environmental Product Declarations (EPD), 2022	
Declared Products	**Polyiso High-Density Roof Cover Boards with Coated Glass Facer (CGF)**	
EPD Registration Number EPD11187	**EPD Date of Issue** February 28, 2026	**EPD Period of Validity** February 28, 2026 to February 28, 2031
EPD Recipient Organization	Polyisocyanurate Insulation Manufacturers Association 3101 Wilson Boulevard, Suite 500 Arlington, Virginia 22201 USA	PIMA POLYISOCYANURATE INSULATION MANUFACTURERS ASSOCIATION

EPD Type/Scope and Functional Unit Industry-average cradle-to-gate with options EPD with functional unit of 1 m² of installed roof cover board, including 7% installation waste.	**Year of Reported Manufacturer Primary Data** 2023

Geographical Scope	**LCA Software**	**LCI Databases**	**LCIA Methodology**
North America	OpenLCA v.2.03	Ecoinvent 3.9.1	TRACI 2.2, IPCC AR5, CML 4.8

This LCA and EPD were prepared by:	Vertima Inc. www.vertima.ca
This EPD and LCA were independently verified in accordance with ISO 14025:2006, ISO 14040:2006, ISO 14044:2006 and ISO 21930:2107, as well as the UL Environment PCR "Part B: Roof Cover Protection Board EPD Requirements (UL 10010-36), v.1.0," and PCR "Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL 10010), v.4.0," which serves as the core PCR. ☐ Internal ☒ External	Jack Geibig Ecoform, LLC

The owner of the declaration shall be liable for the underlying information and evidence; NSF or its affiliates, shall not be liable with respect to manufacturer information, life cycle assessment data, and evidence.

2. PARTICIPATING MEMBERS

Primary data from all of PIMA's 2023 polyiso manufacturer members, regardless of their size, were used for the underlying life cycle assessment. According to industry estimates, PIMA members account for more than 90 percent of the polyiso produced and installed in North America based on the number of manufacturing plants. Results in this declaration represent the combined weighted average production for the following companies.

Amrize
26 Century Blvd., Suite 205
Nashville, TN 37214
www.amrize.com

Atlas Roofing Corporation
2100 Riveredge Parkway, Suite 600
Atlanta, GA 30328
www.atlasrwi.com

Carlisle Construction Materials
1285 Riner Highway
Carlisle, PA 17013
www.carlisleconstructionmaterials.com

GAF
1 Campus Drive
Parsippany, NJ 07054
www.gaf.com

IKO Industries Ltd.
40 Hansen Road South
Brampton, ON L6W 3H4
www.iko.com

Johns Manville
717 17th Street
Denver, CO 80202
www.jm.com

Sika Corporation
2075 Midway Road, Suite 100
Lewisville, TX 75056
www.rmax.com

SOPREMA
1688, Jean-Berchmans-Michaud
Drummondville, QC J2C 8E9
www.soprema.ca

3. PRODUCT BRANDS

PIMA manufacturer members provide primary data for products marketed by the following companies.

Carlisle SynTec
1285 Ritner Highway
Carlisle, PA 17013
www.carlislesyntec.com

Duro-Last
525 Morley Drive
Saginaw, MI 48601
www.duro-last.com

Elevate
26 Century Blvd., Suite 205
Nashville, TN 37214
www.elevatecommercialbp.com

GenFlex
26 Century Blvd., Suite 205
Nashville, TN 37214
www.genflex.com

Hunter Panels
15 Franklin Street
Portland, ME 04101
www.hunterpanels.com

Mule-Hide Products Co., Inc.
1195 Prince Hall Drive
Beloit, WI 53511
www.mulehide.com

Sika Roofing & Waterproofing
100 Dan Road
Canton, MA 02021
www.usa.sika.com/roofing

Siplast
14911 Quorum Drive, Suite 600
Dallas, TX 75254
www.siplast.com

Versico Roofing Systems
1285 Ritner Highway
Carlisle, PA 17013
www.versico.com

WeatherBond Roofing
P.O. Box 251
Plainfield, PA 17081
www.weatherbondroofing.com

LIMITATIONS

Environmental declarations within the same product category but from different programs may not be comparable. [1]

Comparison of the environmental performance of products using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase as instructed under this PCR. Full conformance with the PCR for building envelope thermal insulation products or roof cover protection boards allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category Part B PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible (e.g. Different LCA software and background LCI datasets that may lead to differences in calculated and reported results upstream or downstream of the life cycle stages declared).[2], [3]

The results of this study are representative of the 2023 North American polyiso industry. Furthermore, they are for HD cover boards with specific facer types.

4. PRODUCT SYSTEM DESCRIPTION

For more than 30 years, the Polyisocyanurate Insulation Manufacturers Association (PIMA) has served as the voice of the North American rigid polyiso industry, and as a proactive advocate for safe, cost-effective, sustainable, and energy-efficient high-performance building construction. PIMA is one of the foremost industry advocates for building energy-efficiency practices and policies.

PIMA membership includes manufacturers of polyiso insulation products, raw material suppliers to the industry, and businesses that provide third-party testing services to manufacturers. PIMA members produce the majority of polyiso used in commercial roof and wall applications, and residential, institutional and industrial construction throughout the United States and Canada. PIMA represents the rigid polyiso industry in the development of product technical standards, certification programs, and energy efficiency advocacy.

As a leading advocate for building energy efficiency, PIMA has received many environmental awards, including the U.S. Environmental Protection Agency's Climate Protection Award in 2007 for the Association's leadership in promoting energy efficiency and climate protection. The U.S. EPA also awarded PIMA the Stratospheric Ozone Protection Award in 2002 for leadership in the CFC phase-out in polyiso insulation and in recognition of exceptional contributions to global environmental protection.

4.1. PRODUCT DESCRIPTION

Polyisocyanurate (polyiso) is a cellular closed-cell rigid foam plastic insulation. Polyiso HD roof cover boards[1] consist of a foam core between two facers (top and bottom) as shown in Figure 1. The foam core is comprised of a thermoset polymer that hardens by curing from a viscous liquid prepolymer. The rigid foam is produced through the reaction of methylene diphenyl diisocyanate (MDI) with polyester polyol. Other additives such as catalyst, surfactant, flame retardant, and blowing agent (pentane or pentane blends) are part of the formulation. Pentane is a hydrocarbon with negligible ozone depletion potential (ODP) [7] and low global warming potential (GWP).[8] For nearly 20 years, the polyiso industry has only utilized pentane or pentane blends in product formulations. Upon mixing of the components, the viscous pre-polymer is laid between the facers, and a chemical reaction cross-links polymer chains creating a rigid, durable and closed-cell structure. The facers are coated glass facers (CGF). Typical HD roof cover boards typically are 80 psi.

Features and Benefits

The versatile, durable and sustainable polyiso insulation boards offer the following benefits:

- Excellent impact resistance from foot traffic, storms and hail
- Long-term durability
- Superior water resistance
- Lightweight for installation efficiencies
- Easy to cut (no special tools required) and virtually dust free
- Resistance to mold growth

Figure 1: Polyiso HD roof cover board with coated glass facer (CGF).

[1] CSI and CSA MasterFormat® Reference: 07 22 16 Roof board insulation.

4.2. PRODUCT APPLICATION

Polyiso HD roof cover boards may be used in commercial, light commercial, residential, and industrial roof construction projects on new buildings and on existing buildings during reroofing, and provide added rigidity, strength and impact resistance. These products are versatile and compatible with single-ply roof membrane systems (i.e., TPO, PVC and EPDM) and modified bitumen (self-adhered and cold-applied) roof membrane systems. The polyiso HD roof cover boards are also compatible with various insulation types. These products are installed in roof systems between the insulation (below) and roof membrane (above) and may be mechanically attached or adhered. A typical roof system that includes a polyiso HD roof cover board is illustrated in Figure 2. Many factors and design considerations impact the selection of a roof system, and additional components, such as an air barrier, vapor retarder and thermal barrier, may be required in specific applications.

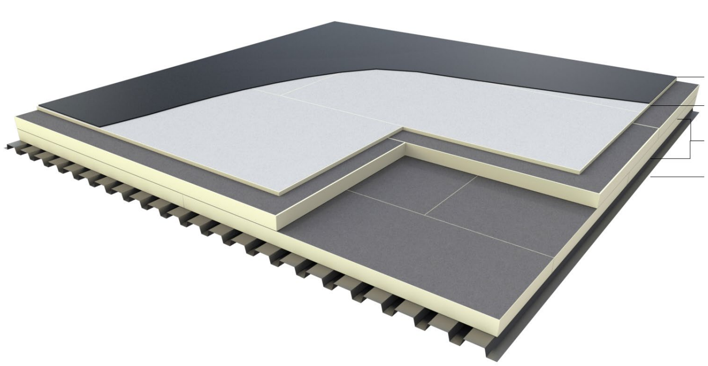


Figure 2: Typical roof assembly with polyiso HD roof cover board installed between the insulation and the roof membrane.

4.3. MATERIAL COMPOSITION

Polyiso HD roof cover boards are comprised of a foam core and two facers on the top and bottom surfaces. The foam core consists of the average weighted formulation by mass listed in Table 1. More than half of the foam formulation consists of MDI which reacts with polyester polyol containing other chemicals including blowing agent, flame retardant, surfactant, catalyst and water. The product contains no other additives, nor ancillary materials known to remain in the product. The chemical reaction forms a rigid cellular foam structure following a curing process. The most common type of facer for polyiso HD roof cover boards is CGF.

Table 1: Weighted average polyiso HD roof cover board material composition and foam formulation.

Component		Formulation (% by mass) Facer: CGF 80 psi / 550 kPa
Facer		52.5%
Foam		47.5%
Foam composition	MDI	61.8%
	Polyester Polyol	29.8%
	Blowing Agent (Pentane)	2.4%
	Flame Retardant (TCPP)	3.9%
	Surfactant	0.5%
	Catalyst	1.4%
	Water	0.1%

4.4. TECHNICAL DATA

Polyiso HD roof cover boards are manufactured to meet the requirements of industry consensus product specifications and standards in the United States and Canada. Note: Compliance with model building codes does not always ensure compliance with state or local building codes, which may be amended versions of these model codes. Always check with local building code officials to confirm compliance. Typical physical properties for polyiso HD roof cover boards are listed in Table 2.

- ASTM C1289 – Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation.
- CAN/ULC-704.1 – Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced.

Table 2: Typical physical properties of polyiso HD roof cover boards and corresponding requirements listed in ASTM C1289 and CAN/ULC-704.1 standards.

Physical Property	Standard Designation	ASTM C1289 (Type II, Class 4)	CAN/ULC-704.1 (Type 4, 5 and 6)
Thermal Resistance, Min		12.7 mm (0.5-inch): RSI 0.35 K m^2/W (R-value 2.0F ft^2 h/Btu) Thermal resistance determined per ASTM C518 after 180-day conditioning	12.5 mm (0.5-inch): RSI 0.4 K m^2/W (R-value 2.0F ft^2 h/Btu) Long-term thermal resistance determined per Annex B of CAN/ULC-704.1,
Compressive Strength, Min	ASTM D162	Grade 1: 80 psi (550 kPa) Grade 2: 110 psi (760 kPa) Grade 3: 140 psi (965 kPa)	Type 4: 80 psi (550 kPa) Type 5: 110 psi (760 kPa) Type 6: 140 psi (965 kPa)
Flexural Strength, Min	ASTM C203	400 psi (2750 kPa) For 12 mm (1/2 inch) product	400 psi (2750 kPa)
Tensile Strength, Min		2000 psf (95 kPa) determined per ASTM C209	2000 psf (95 kPa) determined per ASTM D1623
Dimensional Stability, % Linear Change, Thickness, Max	ASTM D2126	-40°F (-40°C) / ambient RH: 4.0 158°F (70°C) / 97% RH: 4.5 200°F (93°C) / ambient RH: 4.0	Not applicable
Dimensional Stability, % Linear Change, Length and Width, Max	ASTM D2126	-40°F (-40°C) / ambient RH: 1.0 158°F (70°C) / 97% RH: 1.0 200°F (93°C) / ambient RH: 1.0	-20°F (-29°C) / ambient RH: 2.0 158°F (70°C) / 97% RH: 2.0 176°F (80°C) / ambient RH: 2.0
Water Absorption, % by Volume, Max		4.0 determined per ASTM C1763 – Procedure B	3.5 determined per ASTM D2842 – Procedure B
Water Vapor Permeance	ASTM E96/E96M Desiccant Method	≤1.5 perm (≤85.8 ng/Pa·s·m^2)	Class 1: ≤0.26 perm (≤15 ng/Pa·s·m^2) Class 2: >0.26, ≤1.57 perm (>15, ≤90 ng/Pa·s·m^2) Class 3: > 1.57 perm (>90 ng/Pa·s·m^2)

Thermal Performance: The use of continuous insulation is required in model building codes as a prescriptive measure of increasing energy efficiency of building envelope components including exterior roofing. The thermal resistance (R-value) or long-term thermal resistance (LTTR) is a measure of insulation's resistance to heat transfer for a given material thickness. The R-value of polyiso insulation board is determined on full thickness boards using a test method described in ASTM C518 "Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus." LTTR is determined using test methods described in CAN/ULC-S770 "Standard Test Method for Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulating Foams," or ASTM C1303/1303M "Standard Test Method for Predicting Long-Term Thermal Resistance of Closed Cell Foam Insulation."

4.5. MANUFACTURING

An overview of the manufacturing process for polyiso insulation is illustrated in Figure 3 and is described below.

Manufacturing Process Detail:

- *Raw Material Unloading and Storage - Raw materials are delivered to the manufacturing plant via bulk shipment methods including rail cars and large totes. After unloading, certain materials are transferred and stored on-site in large tanks or totes.*
- *Facer Unwind - Rolls of facer material are loaded on the front end of the lamination line. Two rolls of material are unwound and fed toward the laminator. The material will become the top and bottom of the finished product.*
- *Compounding - Raw materials are compounded and heated to form the polyol or B-side component of the product formulation. The isocyanate or A-side of the product formulation is heated and transferred through a separate line.*
- *Mixing Head and Pour Table - The A-side and B-side components are mixed with the blowing agent at the mixing head. At the pour table, the mixture is applied through the mixing head applicator and laid onto one layer of the facer material. The chemical reaction begins at this point in the process, and the second layer of the facer material is brought into contact with the foam mixture as it enters the laminator.*
- *Laminator - The chemical reaction transforms the liquid mixture into the rigid foam core as the product moves through the laminator. The laminator is used to control the thickness of the finished product as well as other characteristic such as cell formation, curing, and facer adhesion. The laminator can also be adjusted to form any tapered characteristics for finished polyiso boards.*
- *Trim and Cutting - The product is manufactured in a continuous process and must be trimmed and cut after exiting the laminator. A cross-cut saw and gang saw are used to cut the material down to either 4' or 8' finished lengths.*
- *Robot Stacker - A conveyor system moves the polyiso boards through the trimming and cutting process to the robot stacker. An initial quality check is performed as the boards are stacked in bundles.*
- *Packaging - The stacked bundles are transferred to a hooding machine where each bundle is individually wrapped with a plastic film. The factory packaging secures the product for warehouse storage and transport.*

- *Foot Station and Warehousing* - The product identification labels are applied to each bundle. A forklift transfers the bundles from the end of the line to warehouse storage. Polyiso boards complete the curing process while stored in the warehouse.
- *Quality Assurance and Control* - Product samples are selected and subjected to various quality assurance and quality control (QA/QC) testing. The QA/QC is performed against applicable standards and internal controls for physical properties including initial R-value, compressive strength, and dimensional stability.
- *Loading and Shipping* - After QA/QC testing and storage in the warehouse, the bundles are transferred to the loading dock. Bundles are loaded onto flatbed trucks and secured for transport to jobsites or distribution locations.

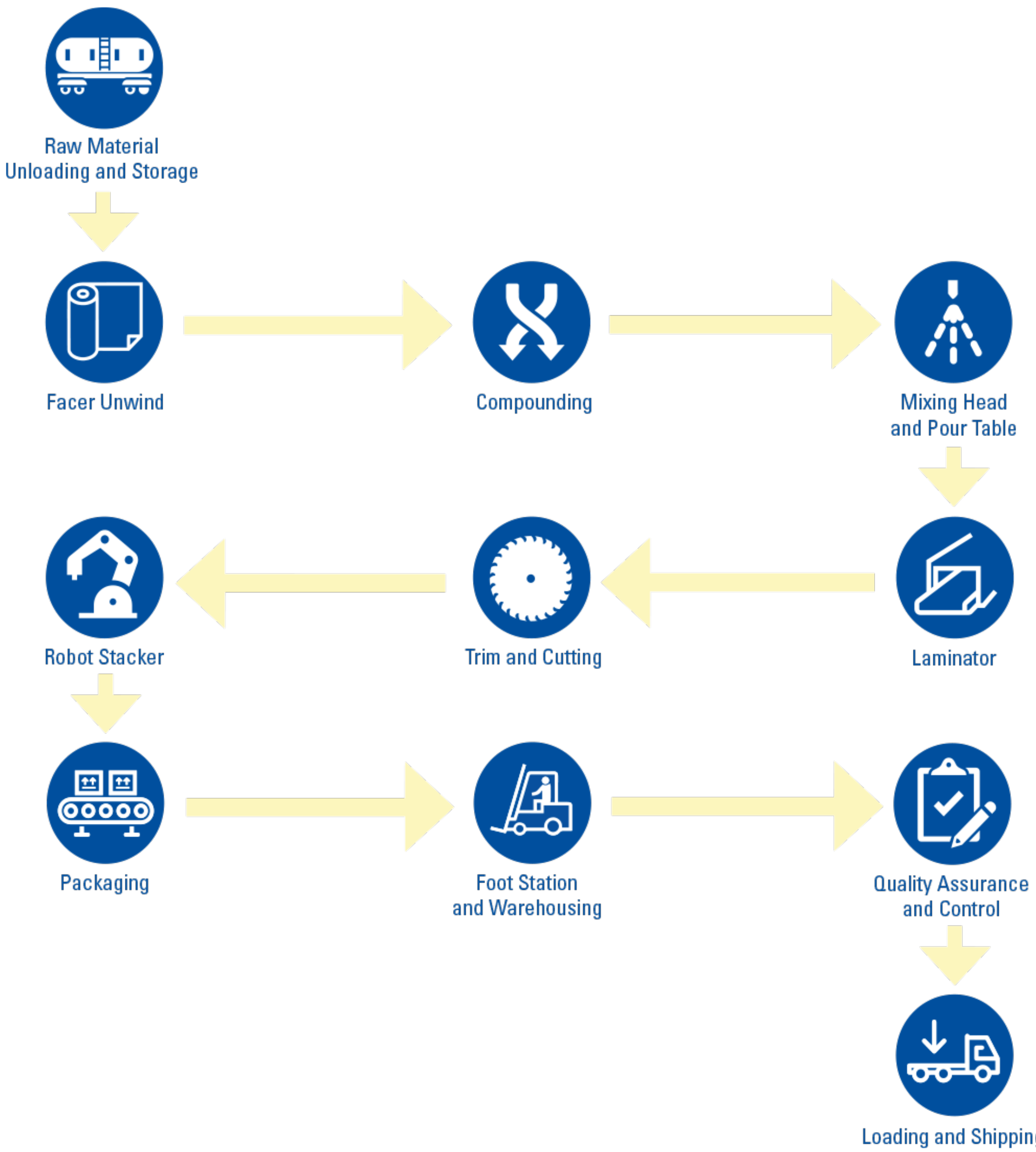


Figure 3: Illustration of the polyiso insulation manufacturing process.

4.6. PROPERTIES OF PRODUCT AS DELIVERED

The manufactured polyiso HD roof cover boards are typically shipped and delivered to jobsites stacked in bundles protected by a plastic wrap, plastic bag or both. The boards are typically 1.2 m by 2.4 m (4 feet by 8 feet) or 1.2 m by 1.2 m (4 feet by 4 feet) and 12.7-mm thick (0.5-inch thick). Typically, the bundles consist of 42 to 96 boards.

4.7. PACKAGING

Bundles of polyiso HD roof cover boards are wrapped and/or bagged in plastic prior to shipment from the manufacturing facility. Packaging used to wrap/shroud bundles is made from extruded low-density polyethylene (LDPE) film.

Table 3: Amount of packaging materials for polyiso HD roof cover boards per product reference service life (RSL)*.

Material	HD roof cover boards- CGF 80 psi	Unit
Polyethylene	4.18E-02	kg/m^2

*: RSL is the lifetime of the product (RSL = 40 years for roof products.)

4.8. TRANSPORTATION

The polyiso HD roof cover boards are transported in wrapped bundles from the manufacturing facilities to product distributor sites or directly to project jobsites by a diesel-powered truck with a flatbed trailer. The average transport distance from the production facility is 643 km (400 miles). Additional transportation details are reported in Table 8 in the life cycle assessment scenario section of the EPD.

4.9. PRODUCT INSTALLATION

Upon delivery to the jobsite, the bundles of polyiso HD roof cover boards are unloaded from the truck to the rooftop using a crane or all-terrain forklift, all packaging is removed, and the individual boards are placed on top of insulation by a roofing crew. The HD boards are secured to the insulation using mechanical fasteners or adhesives, prior to the installation of the roofing membrane. The waste scrap from installation is collected and transported to a local landfill for disposal. Disposal of installation waste scrap to a local landfill was modeled as 7% product loss as prescribed by the PCR.[2] Additional installation details are reported in Table 9 in the life cycle assessment scenario section of the EPD.

4.10. USE CONDITIONS

The use phase follows the installation of HD roof cover boards. In a roofing system, the insulation is located on top of a roof deck and below the roof membrane. If HD roof cover board is part of the system, it is located on top of insulation and below the roof membrane. The roof membrane, when installed properly and adequately maintained, protects the insulation and the HD cover board from environmental elements (i.e., rainwater) and weather during its use. The HD roof cover board offers additional protection (i.e., impact resistance) for the insulation below it. Therefore, it is expected that polyiso roof insulation and HD roof cover boards will not sustain damage that affects its performance and function and does not require maintenance.

4.11. PRODUCT REFERENCE SERVICE LIFE AND BUILDING ESTIMATED SERVICE LIFE

As defined in the governing PCR, the Building Estimated Service Life (ESL) is 75 years. The necessary steps for providing weather protection are specified by manufacturer installation instructions and are mandated by model building codes. The roof membrane's useful life span is influenced by many variables including roof system design, quality of the installation, type and durability of the membrane, roof system component configuration and maintenance as well as weather conditions and events. Assuming that variables are sufficiently addressed through the membrane and the roof system design and installation, the insulation will serve its functional purpose for the 75-year life span of the building. However, the real-world reroofing scenarios, building owner tendencies, and the expected service life of roof membranes all indicate that reroofing activity will take place during the 75-year building ESL.

Reroofing activity may initially occur at 15-30 years after the installation of the original system and driven by recurring roof leaks that cannot be remedied by patch repairs of the membrane. When reroofing is required, options are available to address the need for a new roof membrane without the need to replace the insulation. The model building codes describe a "Roof Recover" as an acceptable reroofing practice, which occurs when a new roof covering is installed on top of the existing roof system without disturbing or removing the existing roof covering or the insulation below. Roof Recover, as defined by industry practices, involves visual examination and appropriate testing to ensure that all roof components, including insulation, have not sustained damage or deterioration. This approach allows the insulation to be reused instead of being disposed of into a landfill. The Roof Recover approach is a common practice in the roofing industry: it is permitted by model building codes and allows the service life of a roof system to be extended (without the need to replace the insulation). However, while the Roof Recover approach is a common practice, it is often not captured in reroofing studies available in the public domain, which typically contemplate a full roof replacement. Pertinent to this declaration, PIMA recognizes a 20-year life span for the original installation of the membrane followed by a Roof Recover, which extends the life of the original roof system to 40 years. This practice, and the PCR, establishes a 40-year product RSL for polyiso roof insulation boards and HD roof cover boards. In the United States the model building codes allow a roof to be recovered only once. Where two roof membranes are installed on an existing roof, a reroofing process referred to as a "Roof Replacement" is required. This process involves the removal of all roof components down to the roof deck. Depending on the condition of the insulation or cover board, these materials can be reused on site, resold on secondary markets or landfilled. Typically, roof demolition is preferred to alleviate the labor required to separate materials for reuse. This study conservatively assumes all insulation is disposed in the landfill during a Roof Replacement. Therefore, the polyiso roof insulation boards' cradle-to-grave assessment incorporates all life cycle stage environmental impacts connected with the original building construction, a Roof Recover operation at 20 years, as well as the building's Roof Replacement operation at 40 years. This translates to 0.9 replacement cycles during the 75-year building ESL (75-year ESL/40-year RSL -1= 0.9 replacement cycles). In Canada, the National Model Building Codes do not provide guidance or limitations for recovers of existing roofs. Even though the age of roofs may surpass 40 years, the same roof replacement cycle of 40 years is assumed in this study for buildings in Canada.

4.12. RE-USE PHASE

If the product is still in good condition and has not passed its reference service life, it may be reused. No re-use is considered in this EPD.

4.13. DISPOSAL

At the end of the building's service life, the polyiso HD roof cover boards are assumed to be disposed of in a landfill and no recycling is considered. The boards are transported 161 km (100 miles) to landfill sites by truck for disposal. Additional disposal details are reported in the Transport to waste disposal (module C2) and Disposal of waste (module C4) tables presented in the scenario section.

[Photo courtesy of PIMA]

5. LCA CALCULATION RULES

5.1. REFERENCE FLOW AND FUNCTIONAL UNIT

The selected functional unit (FU) for this study is: **1 m^2** of installed roof cover board, including **7% installation waste**. A building service life of **75 years** is considered and a product **thickness of 12.7 mm (1/2 inch)**. The product thickness selected represents by far the predominant product thickness available on the market.

Table 4 below summarizes the reference flows associated with the functional unit. HD cover boards represent RSI value as per test method described in ASTM C518. Reference flows are shown per product reference service life (RSL) and per building estimated service life (ESL). The product weight per product RSL represents: 1 m^2 of polyiso HD roof cover board without installation loss or replacement. The product weight per building ESL, on the other hand, represents: 1 m^2 of polyiso HD roof cover board with installation loss and replacement.

For polyiso HD roof cover boards, there is a 7% loss at installation and a replacement factor. The reference mass per ESL is calculated as follows:

$$ESL\ product\ weight\ (kg) = \frac{RSL\ product\ weight\ (kg)}{\left(100\% - Installation\ loss\ (\%)\right)} * (1 + Replacement)$$

For 80 psi polyiso HD roof cover board, this gives:

$$ESL\ product\ weight\ (kg) = \frac{1.818\ kg}{(100\% - 7\%)} * (1 + 0.9) = 3.714\ kg$$

Table 4: Reference flows of studied products per reference service life (RSL) and per building estimated service life (ESL) in metric units and imperial units.

Reference flows		HD - CGF 80 psi	Unit	HD - CGF 80 psi	Unit
RSL	**Product weight**	1.818	kg/m^2	0.372	lb/ft^2
	Facer weight	0.955	kg/m^2	0.196	lb/ft^2
	Foam weight	0.863	kg/m^2	0.177	lb/ft^2
	Thickness	12.7	mm	0.500	inch
	RSI / R-value	0.44	m^2·K/W	2.50	ft^2 °F·h/BTU
ESL	**Product weight**	3.714	kg/m^2	0.761	lb/ft2
	Installation loss	7.0%	%	7.0%	%
	Replacement (ESL/RSL-1)	0.900		0.900	

5.2. PRODUCTION AVERAGE

All polyiso product manufacturer PIMA members participated in this industry-wide EPD. A vertical mass-weighted average was calculated based on the LCA results obtained from 39 facilities, whichever their size, representing eight polyiso manufacturers, which provided their production data for the full 2023 calendar year. All facilities are located in North America.

5.3. ESTIMATES AND ASSUMPTIONS

The table below presents the datasets selected to represent the polyiso foam raw materials.

Table 5: Datasets selected to represent polyiso insulation raw materials.

Material	Data source	Data Reference Year
MDI	American Chemistry Council (ACC), 2022, cradle-to-gate LCI study: LCIA results (mass and elemental alloc.)	2015 - 2017
Polyester Polyol	Primary data	2023
Blowing agent	Ecoinvent dataset 3.9.1: pentane production | pentane | Cutoff, U - RoW	2001 - 2022
Flame retardant	TCPP GABi database: Tris(2-chloroisopropyl)phosphate (TCPP) - US	2018
Surfactant	Ecoinvent 3.9.1 datasets (for 1 kg of surfactant) 0.4 kg polydimethylsiloxane production | polydimethylsiloxane | Cutoff, U – GLO 0.6 kg polyol production | polyol | Cutoff, U - RoW	2015 - 2022
Catalyst	Ecoinvent 3.9.1 datasets (for 1 kg of catalyst) 0.5 kg ethanolamine production | triethanolamine | Cutoff, U - RoW 0.29 kg potassium hydroxide production | potassium hydroxide | Cutoff, U - RoW USLCI dataset*: 0.31 kg Acetic acid, at plant/kg/RNA	2000 - 2022 1998 – 2022 2002
CGF Facer	Primary data	2023

*Cut-off processes have been filled with ecoinvent data

5.4. SYSTEM BOUNDARIES

The system boundaries are **cradle-to-gate with options**, i.e., cover the production, construction and end-of-life life cycle stages as well as module B4.[2] Information modules B1, B2, B3, B5, B6, and B7 are assumed to be zero for this product category. Figure 4 presents the process flow diagram for polyiso HD roof cover boards. Neither renewable energy credits nor carbon credits are used within the scope of this project.

It should be noted that the industry also published EPDs for polyiso wall insulation boards and polyiso roof insulation boards. Those EPDs were published according to a different PCR, i.e., UL Solutions Part B PCR for Building Envelope Thermal Insulation products.[9] That PCR requires reporting of blowing agent emissions during the use of the product (module B1). To ensure consistency in EPD results of polyiso products, emissions during product use (module B1) is also reported in this EPD.

Table 6: Description of the system boundary life cycle stages and related information modules.

PRODUCTION STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Extraction and Upstream Production	Transport to Factory	Manufacturing	Transport to Site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction / Demolition	Transport to Waste Processing or Disposal	Waste Processing	Disposal of Waste
X	X	X	X	X	X*	X	X	X **	X	X	X	X	X	X	X

Key: X = included; MND = module not declared (excluded).

*: Required for wall and roof insulation board EPD. Shown as additional information for polyiso HD roof cover boards.

**: Roofing applications have a reference service life of 40 years for a 75-year building estimated service life; hence, a replacement of 0.9 is considered.

Production (modules A1 to A3)

Extraction and upstream production (module A1): This module includes the extraction and transformation of raw materials needed to produce polyiso products.

Transport to factory (module A2): This module includes the transportation of raw materials from suppliers to the manufacturing facilities.

Manufacturing (module A3): This module includes water and energy (electricity, natural gas, diesel, propane) consumption for the manufacturing processes and building requirements (lighting, heating, cooling). Ancillary materials used in the polyiso manufacturing process and their transport from the suppliers to the manufacturing facilities have been considered here, as well as packaging materials to make the products ready for shipment. Blowing agent emissions from the production process and from the polyiso board cuttings are also included in this module, as well as the transport of waste to waste treatment and the waste treatment itself. The majority of the manufacturing waste is sent to landfill.

Construction (modules A4 to A5)

Delivery and installation: These modules included the delivery of the product to the client and their installation. Product loss during the installation of HD roof cover boards is 7%.[2] Waste generated during installation, such as product loss and packaging, are considered landfilled. Transport and treatment of waste are included. It should be noted that the production (modules A1 to A3) and delivery (module A4) of lost products are included in module A5.

Use (modules B1 to B7)

Use: Module B1 includes pentane emissions during the use phase and module B4 includes replacement for roofing product applications. Modules B2, B3, B5, B6 and B7 are "null" for the purpose of the EPDs.

End-of-Life (modules C1 to C4)

End-of-life: This stage includes modules C2 and C4, transport to and treatment of waste at inert material landfill, respectively. Modules C1 and C3 modules are "null."

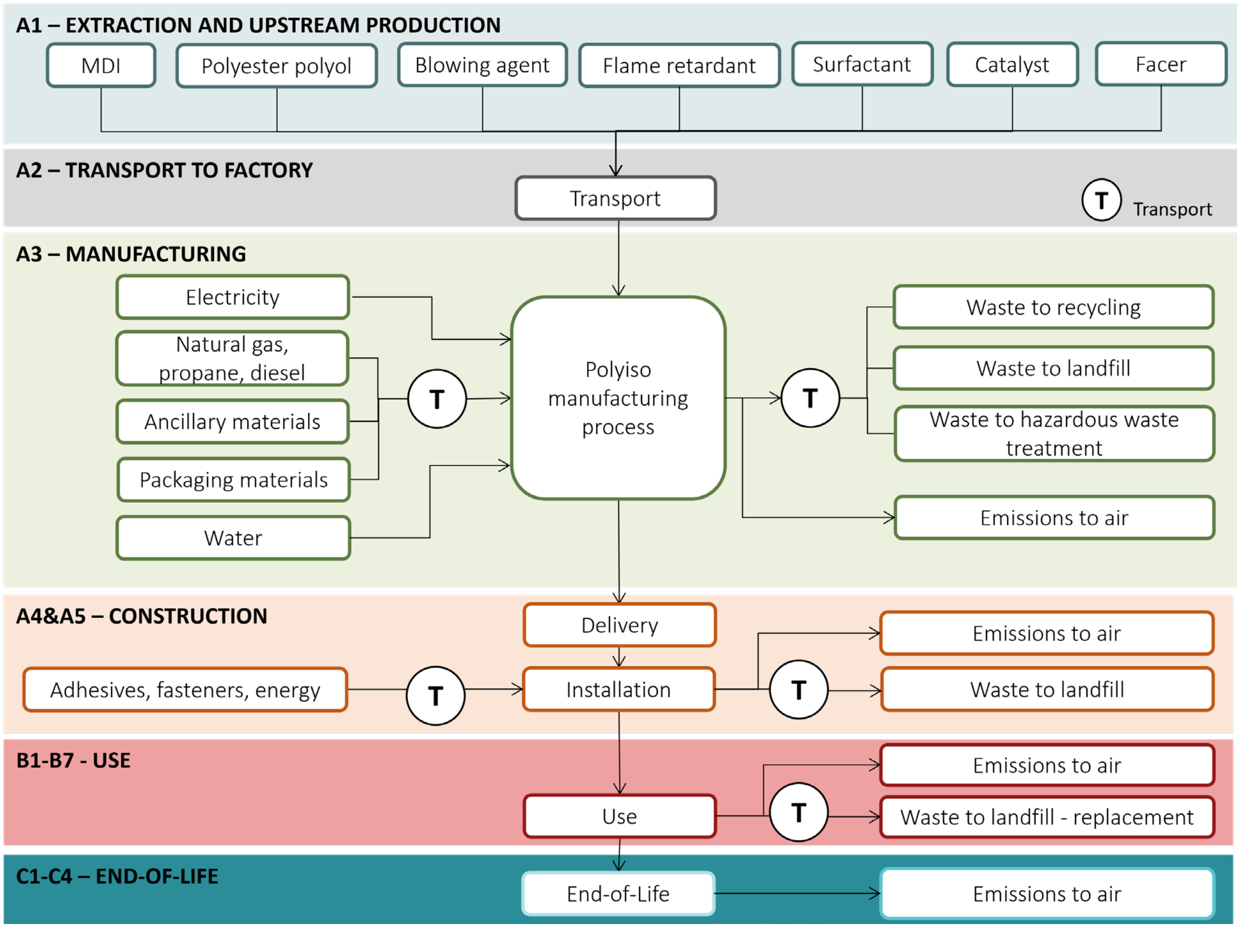


Figure 4: Cradle-to-gate with options system boundaries of polyiso product LCA.

5.5. CUT-OFF CRITERIA

According to ISO 21930:2017, cut-off rules shall not be applied in order to hide data. All data shall be included. In the case of insufficient data, the cut-off criteria shall be 1% of energy or 1% of total mass input and 1% of environmental impacts of the unit process. The total cut-off input flows per module shall be a maximum of 5% energy, mass and environmental impacts.

No known flows are deliberately excluded from this study.

For this study, no data on the construction, maintenance or dismantling of the capital assets, daily transport of employees, office work, business trips or other employee activities were included in the model. The model only takes into account the processes associated with infrastructures that are already included in the ecoinvent unit processes.

5.6. ALLOCATION

Whenever possible, allocation should be avoided by collecting data related to the process under study or by expanding the product system. When allocation cannot be avoided, according to UL Solutions Part B PCR, mass allocation should be used.[2]

Energy consumption, ancillary materials and packaging materials were provided for the entire manufacturing facilities; thus, **mass allocation** was used. Otherwise, no co-product allocation was required.

Waste processing of the material flows undergoing **recycling processes** are included up to the system boundary of the end-of-waste.[6] In other words, a **cut-off approach** was used as further processing of the recycled material is part of raw material preparation of another product system (open-loop recycling).

Blowing agent (pentane) emissions during the life cycle of the product were calculated from primary data and PCR blowing agent emission allocation factors to preserve mass balance.[9] The calculated blowing agent emission allocation factors are shown in the table below.

Table 7: Calculated pentane emission allocation factors per information module.

	A3	A5	B1	C4	Remains in material
HD Polyiso Roof Cover Boards	7.3%	7%	18.4%	67.3%	0%

The Roof Cover Protection Board PCR does not specify how to deal with pentane emissions and, furthermore, sets module B1 to zero. To harmonize the life cycle assessment information of the polyiso board products, the approach presented in the Building Envelope Thermal Insulation PCR is used for polyiso HD roof cover boards. This adds consistency between all the polyiso board product LCA analysis and the EPDs.

5.7. CALCULATION METHOD

The openLCA software v2.03 [12], an open-source software, was used to calculate the inventory and to assess potential environmental impacts associated with the inventoried emissions.

[Photo courtesy of PIMA]

5.8. DATA SOURCES AND QUALITY REQUIREMENTS

Data Source/Quality Parameter	Data Source/Quality Discussion
Source of manufacturing data (primary data)	Manufacturing data was collected from 8 manufacturers with a total of 39 manufacturing plants located in North America for the 2023 production year. This data included: total annual mass of products produced at the manufacturing plants; specific product composition; raw materials and fuels entering the product production process; transport distance of materials and fuels, electricity consumption, water consumption, emissions to the environment at the manufacturing plant; and packaging.
Source of secondary data (background data)	MDI: American Chemistry Council (ACC), 2022, cradle-to-gate LCI study: LCIA results (mass and elemental allocation) Polyester Polyol and facer: primary data Flame retardant: GaBi Catalyst: ecoinvent 3.9.1 and US LCI Pentane, surfactant, energy use, transport, waste treatment and packaging: ecoinvent 3.9.1
Geographical representativeness	Manufacturing facilities are based in North America; hence electricity consumption is based on each facility's regional grid mix and natural gas consumption from the Canadian or US high-pressure natural gas market as appropriate. Geographical correlation of the material supply and the selected datasets are largely representative of the same area. When this was not possible, datasets representing a larger geographical area were used.
Temporal representativeness	Primary data was collected from the polyiso manufacturers and their specific facilities for the full 2023 calendar year. Datasets selected were almost all from a time period ending within the last ten years.
Technological representativeness	Primary data, obtained from the participating polyiso manufacturers, is representative of the current technologies and materials used by their company.
Completeness	All relevant process steps were considered and modeled to satisfy the goal and scope. No known flows were cut off.
Consistency	The same data was collected from all facilities, the same data treatment was applied to all facilities and, as a vertical mass-weighted average was calculated based on the LCA results obtained from 39 facilities, the same model was used for all facilities; hence, the consistency of this study is high.
Reproducibility	Given access to the LCA report and the quality-checked primary data of all facilities, an independent practitioner would be able to reproduce the results as calculation rules and model details are reported in detail in the LCA report.

6. LIFE CYCLE ASSESSMENT SCENARIO

6.1. TRANSPORT TO INSTALLATION SITE (MODULE A4)

Primary data was collected from each participating manufacturer regarding product transport to installation sites or distributors (transport distance and transport mode). A marginal percentage of product was not transported by truck; however, the contribution to potential environmental impacts from this portion of transportation compared to total A4 transportation impacts is small (< 4.3%). The details are thus not reported in Table 8 for confidentiality purposes.

Table 8: Transport to building site assumptions (module A4).

Name	Manufactured boards	Unit
Fuel type	Diesel	
Vehicle type*	53' Tractor-trailer	
Transport distance**	643	km
Capacity utilization (including empty runs, mass-based)	50	%
Gross density of products transported	143.1	kg/m^3
Capacity utilization volume factor	1	

* Modelled using ecoinvent 3.9.1 dataset "transport, freight, lorry >32 metric ton, EURO6 | transport, freight, lorry >32 metric ton, EURO6 | Cutoff, U – RoW."

** From primary data, represents the mass weighted average.

6.2. INSTALLATION (MODULE A5)

UL Solutions Part B PCR is prescriptive on product losses during installation.[2] Installation assumptions (ancillary materials, electricity consumption, diesel fuel consumption) were taken from the UL Solutions Part B PCR Building Envelope Thermal Insulation to harmonize the polyiso EPDs.[9] Details are presented in Table 9. Waste product and packaging are considered non-hazardous waste sent to inert landfill by refuse truck over 161 km. The packaging waste, a low fraction of the Construction & Demolition (C&D) waste, is difficult to separate and recover; thus, packaging waste is considered all sent to landfill.[10] No biogenic carbon is considered emitted from LDPE packaging and, apart from pentane emissions, no other VOC emissions are considered emitted in A5, nor were any VOC emissions tests performed.

Table 9: Installation into the building site assumption (module A5).

Name	Manufactured boards	Unit
Ancillary materials	0.0012 Fasteners 0.0012 Adhesive	kg
Electricity consumption	0.012	kWh
Diesel fuel for onboard generators	0.37	MJ
Product loss	7%	%
Pentane emissions	0.00171	kg
Product waste at the construction site before waste processing, generated by product installation	0.137	kg
LDPE packaging waste	0.045	kg

6.3. USE (MODULE B1)

The use phase only includes pentane emissions. According to the UL Solutions Part B PCR: Building Insulation,[9] 21.5% of the pentane in the installed product is emitted during the use phase and the balance at disposal (module C4).

6.4. REPLACEMENT (MODULE B4)

Roofing products, which have a reference service life (RSL) of 40 years, have a replacement cycle of 0.9. The estimated service life (ESL) of the building is 75 years. The replacement cycle in Table 10 represents the additional quantity of product produced in the production life cycle stage (modules A1-A3) necessary to meet replacement needs throughout the building's estimated service life (ESL), their transport to the installation site, their installation, as well as the end-of-life stage of the original boards replaced.

Table 10: Replacement (module B4).

Name	Roofing application	Unit
Building's Estimated Service Live (ESL)	75	years
Reference Service Life (RSL)	40	years
Replacement cycle*	0.9	N/A

* Replacement cycle is calculated with the following equation (ESL/RSL) – 1. Result is rounded-up to the nearest tenth of the building's ESL.

6.5. END-OF-LIFE (MODULES C1-C4)

At their end-of-life, polyiso HD roof cover boards are removed and transported to a landfill.

Polyiso roof cover boards do not require waste processing. In addition, potential environmental impacts associated with deconstruction of polyiso boards are considered negligible compared to the potential environmental impacts of the deconstruction of the whole building; hence, module C1 is considered null.

Table 11: End-of-life (modules C1-C4).

Name		Manufactured boards	Unit
Transport		161	km
Collection process *	Collected with mixed construction waste	1.813	kg
Disposal **	Product for final disposal (100% landfill)	1.797	kg
Blowing agent emissions		0.016	kg

* Mass adjusted to account for mass loss due to off-gassing in module B1. Values per product reference service life (RSL).

**Mass adjusted to account for mass of pentane loss in modules B1 and C4, which is 100% of the pentane in product. Values per product reference service life (RSL).

7. LIFE CYCLE ASSESSMENT RESULTS

7.1. RESULTS TABLES

It should be noted that Life Cycle Impact Assessment (LCIA) results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

The reported six 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.

The tables below present the LCIA results according to the product functional unit using the TRACI methodology (GWP from IPCC AR5, ADF-ff from CML 4.8), as well as primary energy consumption, consumption of renewable and non-renewable materials, water consumption, and waste generation. EPA updated TRACI in 2021 to include spatially-specific eutrophication factors. All other indicators remain the same from version 2.1; hence, as an optional additional indicator, Eutrophication Potential from TRACI 2.1 is shown for information purposes. It should be noted that, except for roofing applications where replacement impacts are reported in module B4, modules B2 – B7 are reported as zero, as are modules C1 and C3 as they have no associated impacts.

TRACI 2.2 potential impact indicators
GWP: Global Warming Potential; **ADP-ff**: Abiotic Resource Depletion Potential of Non-Renewable (Fossil) Energy Resources; **AP**: Acidification Potential; **EP_f**: Eutrophication Potential – Freshwater; **EP_m**: Eutrophication Potential – Marine; **ODP**: Ozone Layer Depletion Potential; **SFP**: Smog Formation Potential.
Resource use
RPR_E: Renewable Primary Resources Used as Energy Carrier (Fuel); **RPR_M**: Renewable Primary Resources with Energy Content Used as Material; **RPR_T**: Renewable Primary Resources Total; **$NRPR_E$**: Non-Renewable Primary Resources Used as Energy Carrier (Fuel); **$NRPR_M$**: Non-Renewable Primary Resources with Energy Content Used as Material; **$NRPR_T$**: Non-Renewable Primary Resources Total; **SM**: Secondary Materials; **RSF**: Renewable Secondary Fuels; **NRSF**: Non-Renewable Secondary Fuels; **RE**: Recovered Energy; **FW**: Use of Net Fresh Water Resources.
Output flows and waste categories
HWD: Hazardous Waste Disposed; **NHWD**: Non-Hazardous Waste Disposed; **HLRW**: High-Level Radioactive Waste, Conditioned, to Final Repository; **ILLRW**: Intermediate and Low-Level Radioactive Waste, Conditioned, to Final Repository; **CRU**: Components for Re-Use; **MFR**: Materials for Recycling; **MER**: Materials for Energy Recovery; **EE**: Exported Energy.
Additional indicator – TRACI 2.1
EP: Eutrophication Potential

Table 12: Cradle-to-gate with options LCA results for 1 m^2 of installed HD roof cover board, including 7% installation waste, CGF, 80 psi, with a building service life of 75 years.

Environmental indicator		Unit	A1 (per m2)	A2 (per m2)	A3 (per m2)	A4 (per m2)	A5 (per m2)	B1* (per m2)	B4 (per m2)	C2 (per m2)	C4 (per m2)
IPCC AR5 and TRACI 2.12	GWP[(1)]	kg CO_2 eq.	4.11E+00	1.99E-01	4.70E-01	1.18E-01	4.38E-01	0.00E+00	5.22E+00	3.65E-01	9.86E-03
	GWP_{fossil}[(1)]	kg CO_2 eq.	4.08E+00	1.98E-01	4.69E-01	1.18E-01	4.35E-01	0.00E+00	5.19E+00	3.65E-01	9.86E-03
	$GWP_{biogenic}$[(1)]	kg CO_2 eq.	7.09E-03	5.91E-05	4.32E-04	3.50E-05	6.20E-04	0.00E+00	7.46E-03	3.71E-05	4.00E-06
	$GWP_{LU\&LUT}$[(1)]	kg CO_2 eq.	2.65E-02	1.19E-04	5.93E-04	6.12E-05	2.08E-03	0.00E+00	2.65E-02	4.59E-05	5.85E-06
	ADP-ff[(2)]	MJ, LHV	8.38E+01	2.77E+00	7.93E+00	1.79E+00	8.17E+00	0.00E+00	9.95E+01	4.73E+00	2.44E-01
	AP	kg SO_2 eq.	1.37E-02	1.55E-03	9.60E-04	2.89E-04	1.70E-03	0.00E+00	1.85E-02	1.82E-03	6.64E-05
	EP_f	kg P eq.	7.74E-04	1.56E-05	1.15E-04	9.48E-06	7.60E-05	0.00E+00	8.99E-04	6.41E-06	7.71E-07
	EP_m	kg N eq.	9.45E-03	1.36E-03	6.18E-04	2.20E-04	1.42E-03	0.00E+00	1.43E-02	2.22E-03	7.23E-05
	ODP	kg CFC-11 eq.	2.68E-06	3.40E-09	2.86E-09	2.17E-09	2.04E-07	0.00E+00	2.61E-06	6.02E-09	3.02E-10
	SFP	kg O_3 eq.	2.41E-01	3.46E-02	1.83E-02	6.15E-03	3.88E-02	1.12E-02	3.96E-01	6.04E-02	2.13E-02
Resource use	RPR_E[(3)]	MJ, LHV	2.80E+00	4.65E-02	5.70E-01	2.57E-02	2.86E-01	0.00E+00	3.38E+00	2.09E-02	2.36E-03
	RPR_M[(4)]	MJ, LHV	1.00E-02	0.00E+00	0.00E+00	0.00E+00	7.56E-04	0.00E+00	9.72E-03	0.00E+00	0.00E+00
	RPR_T	MJ, LHV	2.81E+00	4.65E-02	5.70E-01	2.57E-02	2.87E-01	0.00E+00	3.39E+00	2.09E-02	2.36E-03
	$NRPR_E$[(5)]	MJ, LHV	4.86E+01	2.80E+00	9.19E+00	1.80E+00	5.63E+00	0.00E+00	6.68E+01	4.72E+00	2.45E-01
	$NRPR_M$[(6)]	MJ, LHV	3.98E+01	0.00E+00	2.57E-04	0.00E+00	3.03E+00	0.00E+00	3.86E+01	0.00E+00	0.00E+00
	$NRPR_T$	MJ, LHV	8.85E+01	2.80E+00	9.19E+00	1.80E+00	8.66E+00	0.00E+00	1.05E+02	4.72E+00	2.45E-01
	SM	kg	3.13E-02	0.00E+00	0.00E+00	0.00E+00	2.36E-03	0.00E+00	3.03E-02	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
	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
	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
	FW[(7)]	m³	2.96E-02	3.80E-04	3.13E-03	2.58E-04	2.77E-03	0.00E+00	3.31E-02	2.30E-04	2.59E-04
Output flows and waste categories	HWD[(8)]	kg	2.67E+00	8.40E-02	6.05E-01	5.17E-02	2.93E-01	0.00E+00	3.37E+00	3.42E-02	4.11E-03
	NHWD[(9)]	kg	5.32E-01	1.63E-01	4.39E-02	1.52E-01	1.49E-01	0.00E+00	2.76E+00	2.30E-02	1.62E+00
	HLRW[(10)]	m^3	5.88E-09	3.52E-11	1.89E-09	2.13E-11	6.30E-10	0.00E+00	7.64E-09	1.89E-11	1.92E-12
	ILLRW[(11)]	m^3	4.57E-08	1.87E-10	5.00E-09	1.12E-10	4.03E-09	0.00E+00	4.97E-08	9.66E-11	1.03E-11
	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
	MFR	kg	4.61E-02	0.00E+00	7.42E-03	0.00E+00	4.03E-03	0.00E+00	5.18E-02	0.00E+00	0.00E+00
	MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	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
Additional indicator – TRACI 2.1											
	EP	kg N eq.	1.08E-02	2.12E-04	9.91E-04	1.03E-04	1.01E-03	0.00E+00	1.20E-02	1.90E-04	1.14E-05

*: Required for wall and roof insulation board EPD. Shown as additional information for polyiso HD roof cover boards.

Table notes

(1) GWP 100, excludes biogenic CO_2 removals and emissions associated with biobased products and packaging; 100-year time horizon GWP factors are provided by the IPCC 2013 Fifth Assessment Report (AR5). $GWP_{biogenic}$ includes biogenic methane emissions to air, while $GWP_{LU\&LUT}$ includes carbon dioxide emissions to air from land transformation and to soil or biomass stock, as well as methane emissions to air from soil or biomass stock.

(2) Abiotic Resource Depletion Potential of non-renewable (fossil) energy resources (ADP-ff, in MJ, LHV) is based on CML-baseline, v4. August 2016.

(3) $RPR_E = RPR_T - RPR_M$, where RPR_T is equal to the value for renewable energy obtained using the CED methodology (LHV).

(4) Calculated as per ACLCA ISO 21930 Guidance, 6.2 Renewable primary resources with energy content used as a material, RPR_M.

(5) $NRPR_E = NRPR_T - NRPR_M$, where $NRPR_T$ is equal to the value for non-renewable energy obtained using the CED methodology (LHV).

(6) Calculated as per ACLCA ISO 21930 Guidance, 6.4 Non-renewable primary resources with energy content used as a material, $NRPR_M$.

(7) Represents the use of net fresh water calculated from life cycle inventory results, i.e., water consumption using ReCiPe Midpoint (E) 2016.

(8) Calculated from life cycle inventory results, based on datasets classified under "treatment and disposal of hazardous waste." The manufacturer does not generate hazardous waste.

(9) Calculated from life cycle inventory results, based on waste that is neither "hazardous" nor "radioactive" and EPD values.

(10) Calculated from life cycle inventory results, based on ecoinvent waste flow "high-level radioactive waste for final repository." The manufacturer does not generate radioactive waste.

(11) Calculated from life cycle inventory results, based on ecoinvent waste flow "low-level radioactive waste for final repository." The manufacturer does not generate radioactive waste.

7.2. INTERPRETATION

This section details the contribution to the potential environmental impacts and resource use of the different information modules. As can be seen from the figure below, replacement (module B4) is the main contributor to all potential impact categories, except ozone layer depletion (ODP), as well as renewable and non-renewable resource consumption. It should be noted that module B4 is equal to the replacement factor times the sum of modules A1-A5 plus the sum of modules C1-C4 of the initial installed product; hence, extraction and upstream production (module A1) is, in fact, the main contributor to all potential impact categories, as well as renewable and non-renewable resource consumption.

Furthermore, the sensitivity analysis indicated that variations in foam density, facer density, and the quantities of MDI, polyol, and surfactants influence the potential environmental impacts across one or more impact categories. These sensitive parameters affect the quantity of raw materials used, which the contribution analysis identified as the primary drivers of environmental impacts in several categories.

Therefore, modifications to the datasets selected to represent the various polyiso raw materials—particularly facer material, MDI, polyol, and surfactants—may alter the results. Consequently, manufacturer-specific EPD results should not be compared with industry-wide EPD results unless identical modeling choices are applied. It should also be noted that, in order to benchmark a manufacturer-specific EPD against an industry-average EPD, the requirements outlined in Section 10.2 of the UL Part A PCR must be met.

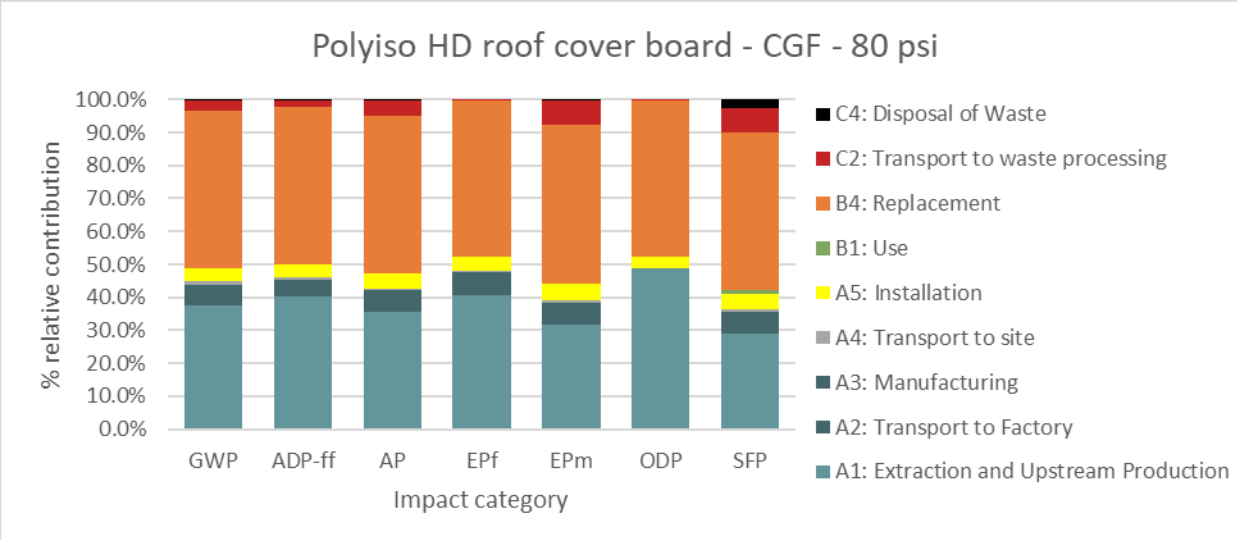


Figure 5: Contribution of life cycle information modules to the potential environmental impacts of 1m^2 of installed polyiso HD roof cover board, CGF, 80 psi, for 75 years.

7.3. MODULES A1-A3 RESULTS VARIATION

The tables below show the weighted average (WA) potential environmental impacts results for modules A1-A3 for each impact category and each product group. The tables also show the coefficient of variation (CV), a statistical measure of relative dispersion that quantifies the weighted standard deviation as a percentage of the mean, expressed by the formula CV = the weighted standard deviation divided by the weighted average. It essentially quantifies how much the data deviates from its average. Facer area density was fixed for the calculation of the coefficient of variation. A 10% facer area density would increase the results by 0.1% to 4.2% depending on the impact category (GWP = 4.0% increase).

Table 13: Weighted average (WA) cradle-ot-gate (modules A1-A3) polyiso HD roof cover boards with coated glass facer (CGF) potential environmental impact results and their coefficient of variation (CV).

Environmental indicator		Unit	HD roof cover board	
			WA (per m2)	CV (per m2)
IPCC AR5 and TRACI 2.1	GWP(1)	kg CO_2 eq.	4.78E+00	8%
	ADP-ff(2)	MJ, LHV	9.45E+01	8%
	AP	kg SO_2 eq.	1.62E-02	10%
	EP_f	kg P eq.	9.05E-04	13%
	EP_m	kg N eq.	1.14E-02	11%
	ODP	kg CFC-11 eq.	2.69E-06	27%
	SFP	kg O_3 eq.	2.94E-01	10%

8. ADDITIONAL ENVIRONMENTAL INFORMATION

8.1. CONTENT OF REGULATED HAZARDOUS SUBSTANCES

Polyiso products contain pentane or pentane blend blowing agent (2.4%).

8.2. RELEASE OF DANGEROUS SUBSTANCES FROM CONSTRUCTION PRODUCTS

Pentane and pentane blends blowing agent is considered to off-gas very slowly over years/decades during the use and the end-of-life of polyiso products. Freshly expanded or heated foam may off-gas some pentane-blowing agent, which is heavier than air and may accumulate to ignitable concentrations if stored inside a sealed container or within confined areas. Installation methods which include cutting and mechanical fastening may release the blowing agent retained in the product. Provide adequate ventilation to assure localized concentrations in release areas are maintained below the lower flammability limit. Good housekeeping and controlling of dust are necessary for safe handling of products.

Fire Performance: The fire performance of low-slope roof assemblies is evaluated using assembly tests (that include the roof deck and all materials above it) with respect to both external and internal fire exposure. The fire exposures in tests simulate the type of fire exposure a roof may encounter during its service life, including interior building fires or exterior hazards. The resistance of a roof system to external fire exposure is evaluated using ASTM E108 “Standard Test Methods for Fire Tests of Roof Coverings,” UL 790 “Standard Test Methods for Fire Tests of Roof Coverings” or the Canadian equivalent, CAN/ULC-S107 “Methods of Fire Tests of Roof Coverings.” The test methods provide a basis for comparing roof assemblies under a simulated exterior fire. Roof assemblies restricted to non-combustible decks require only the spread-of-flame test, while roof assemblies used on combustible decks are evaluated for spread of flame, intermittent flame, and the burning brand tests. Roof assemblies can achieve a Class A, B, or C classification. Class A designates the resistance to relatively severe fire-test exposure. Class B designates resistance to relatively moderate fire-test exposure. Class C designates resistance to relatively light fire-test exposure.

Fires can also originate within the building interior and roof system response to fire exposure originating from the interior of the building may be evaluated using NFPA 276 “Standard Method of Fire Test for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components,” FM Approval 4470 “Single-Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof: Assemblies for Use in Class 1 and non-combustible Roof Deck Construction,” UL 1256 “Fire Test of Roof Deck Construction,” or CAN/ULC-S126 “Standard Method of Test for Fire Spread Under Roof-Deck Assemblies.” The passing criteria is established by a limit-of-fuel contribution within a designated time period. Polyiso remains the only foam plastic roof insulation to earn FM Class 1 approval for direct-to-steel deck applications when tested in accordance with FM Approval 4470. Polyiso is also classified by UL under UL 1256 for direct-to-steel deck applications with both single-ply and asphalt-based roof coverings.

8.3. FURTHER INFORMATION

Additional information is available on the Polyisocyanurate Insulation Manufacturers Association (PIMA) website: https://www.polyiso.org/.

9. REFERENCES

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