ENVERGE

Spray Polyurethane Foam Insulation

ENVIRONMENTAL PRODUCT DECLARATION

Closed Cell Spray Foam

GENERAL INFORMATION

This cradle-to-grave Environmental Product Declaration covers a spray foam product produced at the Spring, TX and Waukesha, WI facilities. The Life Cycle Assessment (LCA) was prepared in conformity with ISO 21930, ISO 14025, ISO 14040, and ISO 14044 and PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL 10010, Version 4.0) and Part B: Building Envelope Thermal Insulation EPD Requirements (UL10010-1, Version 3.0). This EPD is intended for business-to-business (B-to-B) audiences.

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Product Category Rules for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL 10010, Version 4.0) serves as the core PCR; Part B: Building Envelope Thermal Insulation EPD Requirements (UL10010-1, Version 3.0) serves as the sub-category PCR.

- Sub-category PCR review was conducted by Thomas Gloria, Ph.D. (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants
- Independent verification of the declaration, according to ISO 21930:2017 and ISO 14025:2006.: ☐ internal ☑ external
- Third party verifier Thomas P. Gloria, Ph.D. (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants
- For additional explanatory material Manufacturer Representative: Sherrie MacWilliams (sherrie.macwilliams@amrize.com) This LCA EPD was prepared by May W. Ang LCA and EPD Project Manager • Sphera (www.sphera.com)
- EPDs are comparable only if they comply with ISO 21930 (2017), use the same sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

Limitations:

- Environmental declarations from different programs (ISO 14025) may not be comparable.
- 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 this 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 for upstream or downstream of the life cycle stages declared.

ENVERGE

PRODUCER

Enverge is a leading manufacturer in spray foam insulation (SPF) solutions, dedicated to enhancing the performance and efficiency of modern buildings. We specialize in advanced, multi-functional insulation materials designed to create superior building envelopes. Our products, including both open-cell (like EasySeal™ .5 and SucraSeal®) and closed-cell (like OnePass® and NexSeal™) foams, are engineered to address critical building science needs, such as achieving exceptional thermal performance and creating seamless air barriers.

ENVERGE

PRODUCTS

Enverge HFO-based Closed Cell Spray Foam: The Dense, Multi-Functional Powerhouse

For applications demanding maximum thermal performance, moisture resistance, and structural integrity, Enverge Closed Cell Spray Foam, featuring products like **Enverge OnePass®** and **NexSeal™**, is the premier choice. This denser foam creates a monolithic air, thermal, and vapor barrier in a single application, providing R-values ranging from R-6.5 to R-7.2 per inch. Its robust nature makes it ideal for achieving high insulation levels in limited spaces, such as exterior walls, crawl spaces, and unvented attics. Beyond its superior insulation and air-sealing capabilities, Enverge closed-cell foam also resists moisture, acts as a vapor retarder, and adds significant rigidity and structural enhancement to the building assembly, contributing to a more resilient and durable structure.

FIGURE 1

Closed Cell Spray Foam

The products covered in this EPD have the following Physical and Performance Properties

(as illustrated in tables 1 - 3 below)

All SPF products must meet numerous performance requirements to comply with building codes. The details of these requirements are described in specific tests listed in consensus standards for material performance and code compliance. Table 1 outlines the properties of Enverge Closed Cell Spray Foam: **Enverge OnePass®** and **NexSeal™**.

TABLE 1

Physical Properties

TYPICAL PROPERTIES			
Property	**Test Method**	**NexSeal**	**OnePass**
APPARENT DENSITY	ASTM D-1622	2.1 +/- 10% lbs/ft^3	2.1 +/- 10% lbs/ft^3
R-VALUE (AGED)	ASTM C-518	R 7.2 @ 1" (25.4 mm) R 28 @ 4" (10.mm)	R 7.2 @ 1" (25.4 mm) R 28 @ 4" (10.mm)
COMPRESSIVE STRENGTH	ASTM D-1621	25 nominal	25 nominal
TENSILE STRENGTH	ASTM D-1623	50 PSI	50 PSI
CLOSED CELL CONTENT	ASTM D-6226	> 90% (vol.)	> 90% (vol.)
WATER ABSORPTION (96 HRS, 2" HEAD, 70-74 °F (21-23 °C)	ASTM D-2842	0.29% by volume	0.29% by volume
WATER VAPOR PERMEANCE	ASTM E-96	≤ 1.0 PERMS @ 1.6"	≤ 1.0 PERMS @ 1.6"
FUNGI RESISTANCE	ASTM C-1338	Pass – No growth	Pass – No growth
FLAME SPREAD INDEX	ASTM E-84	< 25	< 25

TYPICAL PROPERTIES			
Property	**Test Method**	**NexSeal**	**OnePass**
SMOKE DEVELOPED INDEX	ASTM E-84	< 450	< 450
DIMENSIONAL STABILITY, -20°F	ASTM D-2126	< 5% Change	< 5% Change
DIMENSIONAL STABILITY, +200°F	ASTM D-2126	< 10% Change	< 10% Change
DIMENSIONAL STABILITY, +158°F & 100%RH	ASTM D-2126	<10% Change	<10% Change
AIR PERMEANCE	ASTM E-2178	<.02 L(s•m^2) @ 75 PA	<.02 L(s•m^2) @ 75 PA
GLOBAL WARMING POTENTIAL		1	1

*Calculated from 3.5" thick sample.

These values are typical. However, values will vary and should not be considered part of the product specifications. It is imperative that the trained applicator read and understand this technical data sheet and SDS to process the material correctly and understand environmental and equipment limitations.

TECHNICAL REQUIREMENT

Spray foam insulation products must be installed in compliance with building codes. Nearly all jurisdictions have adopted a version of the following building codes:

- International Code Council (ICC) - International Residential Code (IRC) – For 1 and 2 family dwellings
- International Code Council (ICC) - International Building Code (IBC) – For multifamily dwellings, as well as commercial, institutional and industrial buildings.
- International Code Council (ICC) - International Energy Conservation Code (IECC) – Providing envelope energy efficiency requirements for all buildings.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1- Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.2- Energy-Efficient Design of Low-Rise Residential Buildings

To meet code requirements, closed cell products must meet minimum performance requirements, demonstrated by laboratory testing using approved test methods. These tests are performed by third-party laboratories and test data typically submitted to a certification agency for evaluation of the results and the creation of an independent code compliance report for the product. Certification agencies also perform regular quality control testing from random samples taken from the manufacturer's facilities.

There are two guides that are followed by these certification bodies to collect and evaluate data to generate code compliance reports:

- ICC 1100 Standard for Spray-applied Polyurethane Foam Plastic Insulation (2021)
- IAPMO/ANSI ES1000 Building Code Compliance Spray-Applied Polyurethane Foam (2020)

TABLE 2

Testing Requirements per ICC 1100 and IAPMO ES1000 Standards

TESTING REQUIREMENTS PER ICC 1100 AND IAPMO ES1000 STANDARDS			
Property	**Measurement**	**Test Method**	**Requirement**
Thermal Resistance	R-value at thickness or thermal resistance	ASTM C177-19 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus, ASTM C518-21 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, OR ASTM C1363-24 Standard Test Method for Thermal Performance of Building Materials and Envelope	Report

TESTING REQUIREMENTS PER ICC 1100 AND IAPMO ES1000 STANDARDS			
Property	**Measurement**	**Test Method**	**Requirement**
		Assemblies by Means of a Hot Box Apparatus	
Air Permeance	Thickness where foam is air impermeable	ASTM E283/E283M-19 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen OR ASTM E2178-21a Standard Test Method for Determining Air Leakage Rate and Calculation of Air Permeance of Building Materials	Report minimum thickness where air impermeable
Water Vapor Permeance	Thickness where foam meets Class I, II or III vapor retarder performance	ASTM E96/E96M-24 Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials (Method A)	Report thickness at vapor retarder class I, II or III.
Density	Mass density of foam	ASTM D1622-20 Standard Test Method for Apparent Density of Rigid Cellular Plastics	Report
Surface Burning Characteristics	Flame Spread Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	75 or less
Surface Burning Characteristics	Smoke Developed Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	450 or less for insulation, unlimited for roofing
Thermal Barrier Testing	Pass fire test with prescriptive thermal barrier for thickness over 4"	NFPA 286, FM 4880, UL 1040 or UL1715	Pass 15 minute criteria
Alternate Thermal Barrier Assembly	Pass fire test with specific covering or coating	NFPA 286, FM 4880, UL 1040 or UL1715	Pass 15 minute criteria
Ignition Barrier Testing	Pass fire test with or without covering or coating	Various special test methods	See standard for details

In addition to these standards, there are also ASTM material standards for closed cell products:

- ASTM C1029 Standard Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation

TABLE 3

Testing Requirements per ASTM C1029 Material Standards

Property	Measurement	Test Method	ASTM C1029 Requirement
Thermal Resistance	R-value at thickness or thermal resistance	ASTM C177-19 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus, ASTM C518-21 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, OR ASTM C1363-24 Standard Test Method for Thermal Performance of Building Materials and Envelope	R-value at thickness or thermal resistance

Property	Measurement	Test Method	ASTM C1029 Requirement
		Assemblies by Means of a Hot Box Apparatus	
Water Vapor Permeability	perm-inches	ASTM E96/E96M-24 Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials (Method A)	3.0 perm-inches
Density	Apparent density of foam	ASTM D1622-20 Standard Test Method for Apparent Density of Rigid Cellular Plastics	Report
Surface Burning Characteristics	Flame Spread Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	Report (75 limit in building codes)
Surface Burning Characteristics	Smoke Developed Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	Report (no limit in building codes)
Closed-cell Content	Percentage of closed cells	ASTM D6226-21 Standard Test Method for Open Cell Content of Rigid Cellular Plastics	90% or greater
Compressive Strength	psi	ASTM D1621-16(2023) Standard Test Method for Compressive Properties of Rigid Cellular Plastics	Minimum determined by Type per ASTM C1029: Type I - 15 psi Type II - 25 psi Type III - 40 psi Type IV - 60 psi
Tensile Strength	psi	ASTM D1623-17(2023) Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics	Minimum determined by Type per ASTM C1029: Type I - 20 psi Type II - 32 psi Type III - 42 psi Type IV - 56 psi
Response to Thermal/Humid Aging	dimensional stability percent	ASTM D2126-20 Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging	Maximum determined by Type per ASTM C1029: Type I - 12% Type II - 9% Type III - 6% Type IV - 5&
Water Absorption	Percentage by volume	ASTM D2842-19 Standard Test Method for Water Absorption of Rigid Cellular Plastics	5% maximum

MATERIAL COMPOSITION

The side-A is made from a blend of polymeric methylene diphenyl diisocyanate (MDI). The side-B is a mixture of polyester and polyether polyols, flame retardants, blowing agents, catalysts, and other additives that, when mixed with side-A, creates foam that can be applied for insulation. Due to company confidentiality, the industry average side-B formulation is displayed in 4.

While some of the ingredients may be classified as hazardous, per the Resource Conservation and Recovery Act (RCRA), Subtitle C, the product as installed and ultimately disposed of is not classified as a hazardous substance, as hazardous ingredients are rendered chemically inert after installation.

There are no toxic materials or hazardous wastes directly associated with either the manufacturing of these components or the installation of the spray foam systems.

TABLE 4

Industry Closed cell, HFO Side-B Formulations

CHEMICAL (% COMPOSITION)		INDUSTRY CLOSED CELL, HFO
Polyol	Polyester	41
	Polyether	25
	Mannich	4
Fire Retardant	TCPP	13
Blowing Agent	HFO-1233zd or HFO-1336mzzZ	9
	Reactive ($H2O$)	3
Catalyst	Catalyst, amine	2
	Catalyst, aggregated	2
Surfactant	Silicone	1

APPLICATION

SPF products are commonly used in residential, light commercial, commercial, institutional, and certain industrial applications. Closed cell products are commonly applied to the storages or interior side of the building envelope as an insulation and air-sealing material.

FUNCTIONAL UNIT

The functional unit (FU) as required by the PCR (Section 3.1 in Part B of the PCR) is:

One square meter (1 m^2) of installed insulation material with a thickness that gives an average thermal resistance R_{SI} = 1 $m^2 \cdot K/W$ (R = 5.68 $hr \cdot ft^2 \cdot °F/Btu$) and with a building service life of 75 years (packaging included).

As requested by the PCR, the Functional Unit of this LCA is expressed in Table 5.

TABLE 5

Functional Unit Properties

FUNCTIONAL UNIT (FU)	VALUE	SI UNIT	VALUE	IMPERIAL UNIT
1m² of insulation material with a thickness that gives an average thermal resistance R_{SI}=1 m^2K/W				
Mass	0.67	kg	1.49	lbs
Thickness to achieve FU	0.02	m	0.79	inch

** 1.49 lbs in the mass of insulating foam that fulfills the required RSI value, which excludes the mass of packaging*

LIFE CYCLE ASSESSMENT

SYSTEM BOUNDARY

This EPD is a cradle-to-grave EPD, covering A1-C4 stages of the life cycle.

TABLE 6

Life Cycle Product Stages

PRODUCTION STAGE (MANDATORY)			CONSTRUCTION STAGE		USE STAGE					END-OF-LIFE STAGE			
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction / Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4
X	X	X	X	X	X	X	X	X	X	X	X	X	X

***NOTE**: MND = module not declared; X = module included.*

CUT-OFF

Items excluded from system boundary include:

- production, manufacture and construction of manufacturing capital goods and infrastructure;
- production and manufacture of production equipment, delivery vehicles, and laboratory equipment;
- personnel-related activities (travel, furniture, and office supplies); and
- energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

DATA SOURCES

The LCA model was created using the LCA for Experts (LCA FE) v10.9 software system for life cycle engineering, developed by Sphera (Sphera, 2024). Background life cycle inventory data for raw materials and processes were obtained from the Sphera Managed LCA content (MLC) 2024.2 database. Primary manufacturing data was provided by Amrize.

DATA QUALITY

A variety of tests and checks were performed by the LCA practitioner throughout the project to ensure high quality of the completed LCA. Checks included an extensive internal review of the project-specific LCA models developed as well as the background data used. A full data quality assessment is documented in the background report.

Temporal coverage

The data are intended to represent the production during the 2023 calendar year. As such, primary data was provided for 12 consecutive months during the 2023 calendar year. Background data for upstream and downstream processes are obtained from the Sphera MLC databases 2024.2 and are representative of the years 2017-2023.

Geographical coverage

This background LCA represents Amrize's production in the US. Primary data are representative of the Spring, TX and Waukesha, WI facilities. Regionally specific datasets were used to represent each manufacturing location's energy consumption. Proxy datasets were used as needed for raw material inputs to address lack of data for a specific material or for a specific geographical region. These proxy datasets were chosen for their technological representativeness of the actual materials.

Technological coverage

Data on material composition were developed using specific side-B formulation. Manufacturing data were collected directly from Amrize. Waste, emissions, and energy use are calculated from reported annual production during the reference year.

PERIOD UNDER REVIEW

Primary data collected represent production during the 2023 calendar year. This analysis is intended to represent production in 2023.

ALLOCATION

Primary data collected represent production during the 2023 calendar year. This analysis is intended to represent production in 2023. Multi-output allocation follows the requirements of ISO 14044, section 4.3.4.2 (ISO, 2006a; ISO, 2006b). When allocation becomes necessary during the data collection phase, the allocation rule most suitable for the respective process step was applied. Energy and waste outputs were allocated based mass allocation.

The background MDI dataset used in the LCA study, which was developed by the European diisocyanates and polyols producers' association known as ISOPA is based on a combination of mass and elemental allocation approach (European Diisocyanate and Polyol Producers Association (ISOPA), 2021). This also aligns with the 2022 LCA study conducted by the American Chemistry Council. (American Chemistry Council, 2022) and the SPFA industry EPDs (SPFA, 2024).

The cut-off allocation approach is adopted in the case of any post-consumer and post-industrial recycled content, which is assumed to enter the system burden-free. Only environmental impacts from the point of recovery and forward (e.g., inbound transports, grinding, processing, etc.) are considered.

MANUFACTURING

The manufacturing process is depicted in the flow diagram presented in Figure 2. The manufacturing process of Enverge Spray Foam includes packaging, manufacturing waste and associated releases to the air, soil, group and surface water.

Spray Foam is applied in the field via a two-part system. The A-side (MDI) is a purchased component that is shipped in tandem with the B-side as a final product. The B-side (includes all or in part: polyols, surfactants, fire retardants, solvents, blowing agents, catalysts, cell openers) is manufactured by raw materials that originate from chemicals stored in onsite bulk storage tanks and packaged chemicals that are transferred from standalone containers to a mixing vessel at the manufacturing location. The B-side manufactured polyol will generate a HFO Formulations for closed cell.

Once the B-side raw materials have been combined in the vessel and mixed appropriately, it is packaged into the desired container size. The manual filled containers will be sealed suitably, labelled and secured on pallets with its A-side purchased component. The A-side MDI and B-side manufactured polyol will be transferred to a warehouse area for storage as a complete finished product. Eventually this product will be loaded on trucks for shipment.

The finished product is packaged in unpressurized containers of varying types, most commonly in 55-gallon (208 L) steel drums and are loaded onto pallets. In this study, it is assumed that the empty chemical containers are properly cleaned and taken to a drum recycler.

Disposal of packaging materials is modeled in accordance with the assumptions outlined in Part A of the PCR (UL Environment, 2022). Plastic based packaging is disposed in landfill (68%), incineration (17%), and recycled (15%). Metal based packaging is disposed in landfill (34%), incineration (9%), and recycled (57%). Paper based packaging is disposed in landfill (20%), incineration (5%), and recycled (75%).

After manufacturing (A1-A3) processes, the installation phase covers both transport to site (A4) and Installation (A5). Table 7 and 8 provide more information about modules A4 and A5. The tables report results per functional unit.

Final products are distributed via container truck, which are fueled by diesel. These final products are either directly to customers, or first to warehouse, prior to being sent to customers. Table 7 details distribution assumptions for finished product. After being transported to the site, the packs are unloaded from the truck to the rooftop using a diesel crane. Then, the boards are installed manually through a mechanical attachment procedure involving fasteners and fastening plates and necessary equipment to support the procedure. Finally, the waste scrap from installation is collected and transported to a local landfill for disposal.

For SPF with physical blowing agents, this study assumes 10% of the installed blowing agent is released to surrounding air during the installation phase. Discarded foam from installation also experiences blowing agent release while in landfill. Disposal of packaging materials is modeled in accordance to the assumptions outlined in Part A of the PCR (UL Environment, 2022). All ancillary installation materials are assumed to be sent to landfill.

FIGURE 2

Process Flow Diagram of Spray Foam Manufacturing

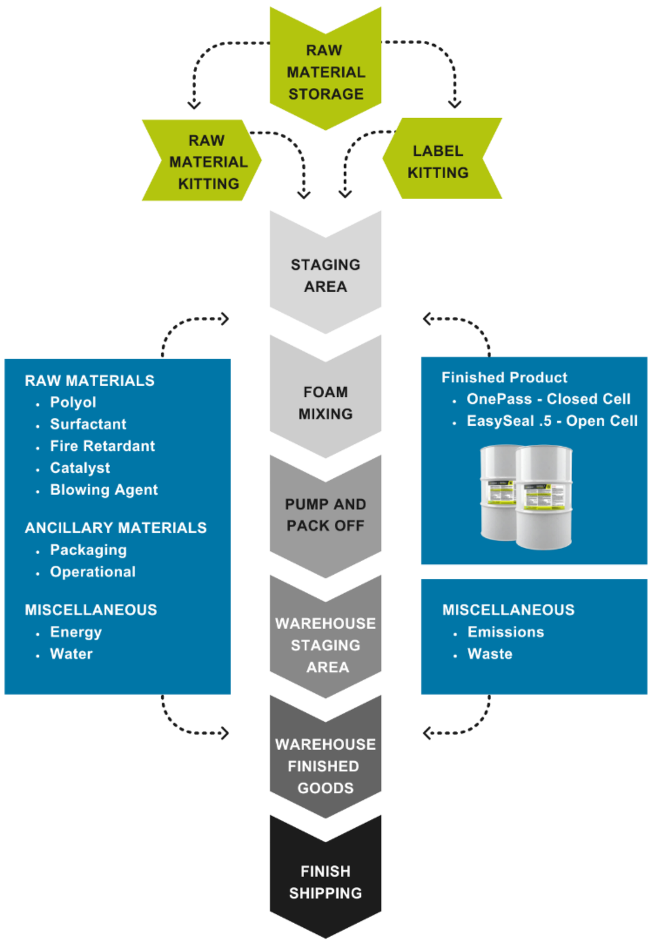


TABLE 7

Transport to the building site (A4) per Functional Unit

Name	Value		Unit
Fuel type	Diesel		
Liters of fuel	0.0011	0.0015	/l100km
Vehicle type	Truck-heavy/bulk	Truck-TL/dry van	
Transport distance	821	684	km
Capacity utilization (including empty runs, mass based	100	100	%
Gross density of products transported	33.6		kg/m^3

TABLE 8

Installation into the building (A5) per Functional Unit

Name	Value	Unit
Ancillary materials	0.021	kg
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	-	m^3
Other resources	N/A	kg
Electricity consumption	0.04	kWh
Other energy carriers	2.67	MJ
Product loss per functional unit	0.025	kg
Waste materials at the construction site before waste processing, generated by product installation	0.0032	kg
Output materials resulting from on-site waste processing (specified by route; e.g. for recycling, energy recovery and/or disposal)	-	kg
Biogenic carbon contained in packaging	0.0006	kg CO_2
Direct emissions to ambient air, soil and water	0.0034	kg
VOC content	-	µg/m^3

B1 – B5 USE STAGE

As this study only looks at the life cycle of spray foam insulation, and not the building, the use phase only contains emissions of any chemicals off-gassed from the foam. This study assumes 24% of the original chemical blowing agent is off-gassed over a 75-year lifetime (Honeywell International).

Table 9 provides information about the product's reference service life per functional unit.

TABLE 9

Reference Service Life

Name	Value	Unit
Direct emissions to ambient air, soil and water	0.0083	kg

C1 – C4 END-OF-LIFE STAGE

When the building is decommissioned, it is assumed that only manual labor is involved to remove the foam. Waste is assumed to be transported 30 miles (48 km) to the disposal site. The spray foam is assumed to be landfilled at end-of-life, as is typical for construction and demolition waste in the US. This study assumes 16% of the original physical blowing agent is emitted at this stage in the life cycle. It is further assumed the spray foam is inert in the landfill and 50% of the blowing agent remains in the product after disposal. (Kjeldsen & Jensen, 2001).

Table 10 provides more information about modules C1 to C4 (end of life). The table reports results per functional unit.

TABLE 10

End of life (C1-C4)

Name		Value	Unit
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)		Landfill	
Collection process (specified by type)	Collected with mixed construction waste	0.67	kg
Recovery (specified by type)	Landfill	0.67	kg
Disposal (specified by type)	Product or material for final deposition	0.67	kg
Removals of biogenic carbon (excluding packaging)		-	kg CO_2

LIFE CYCLE ASSESSMENT RESULTS

This declaration is cradle-to-grave and all information modules are declared. As discussed in the Life Cycle Assessment Scope and Boundaries Section, Modules B2, B3, B4, B5, B6, B7, C1 and C3 do not contribute to impacts and are declared as zero. Optional Module D – Benefits and Loads Beyond the System Boundary – is not included in this LCA study. Only relevant stages are presented with results, to make it easier to follow.

TABLE 11

Closed Cell Spray Form, per Functional Unit.

IMPACT ASSESSMENT UNIT	PRODUCTION (A1-A3)	TRANSPORT (A4)	INSTALLATION (A5)	USE (B1)	EOL (C1-C4)	TOTAL
Global warming potential (GWP)[1] (kg CO_2 eq)						
	2.34E+00	6.63E-02	2.86E-01	4.14E-03	1.84E-02	2.71E+00
Depletion potential of the stratospheric ozone layer (ODP) (kg CFC-11 eq)						
	1.59E-08	1.69E-16	4.10E-12	0.00E+00	7.01E-16	1.59E-08
Eutrophication potential (EP) (kg N eq)						
	3.97E-04	2.51E-05	1.07E-04	0.00E+00	3.67E-06	5.33E-04
Acidification potential of soil and water sources (AP) (kg SO2 eq)						
	4.04E-03	2.72E-04	1.23E-03	0.00E+00	8.01E-05	5.62E-03
Formation potential of tropospheric ozone (POCP) (kg O_3 eq)						
	7.20E-02	6.25E-03	4.19E-02	2.31E-03	2.99E-03	1.26E-01
Resource Use						
Abiotic depletion potential for fossil resources (ADPfossil) (MJ, NCV)						
	5.17E+01	8.70E-01	4.31E+00	0.00E+00	2.28E-01	5.71E+01
Renewable primary energy resources as energy (fuel), (RPRE[2])* (MJ, NCV)						
	3.63E+00	3.80E-02	2.65E-01	0.00E+00	2.80E-02	3.96E+00
Renewable primary resources as material, (RPRM[2])* (MJ, NCV)						
	8.79E-03	0.00E+00	3.22E-03	0.00E+00	0.00E+00	1.20E-02
Non-renewable primary resources as energy (fuel), (NRPRE[2])* (MJ, NCV)						
	3.79E+01	8.76E-01	3.94E+00	0.00E+00	2.35E-01	4.29E+01
Non-renewable primary resources as material, (NRPRM[2])* (MJ, NCV)						
	1.59E+01	0.00E+00	5.34E-01	0.00E+00	0.00E+00	1.64E+01
Consumption of fresh water, (FW[2]) (m3)						
	2.12E-02	1.28E-04	8.51E-04	0.00E+00	3.06E-05	2.22E-02
Secondary Material, Fuel and Recovered Energy						
Secondary Materials, (SM[2]) * (kg)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

1 GWP 100; 100-year time horizon GWP factors are provided by the IPCC 2013 Fifth Assessment Report (AR5). CO2 from biogenic secondary fuels used in kiln are climate-neutral (CO2 sink = CO2 emissions), ISO 21930, 7.2.7.

2 Calculated per ACLCA ISO 21930 Guidance.

Renewable secondary fuels, (RSF[2])* (MJ, NCV)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels (NRSF[2])* (MJ, NCV)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy, (RE[2]) *(MJ, NCV)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste & Output Flows						
Hazardous waste disposed, (HW[2]) * (kg)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste disposed, (NHWD[2]) * (kg)						
	4.95E-03	0.00E+00	4.83E-02	0.00E+00	6.74E-01	7.27E-01
High-level radioactive waste, (HLRW[2]) * (kg)						
	8.46E-07	2.69E-09	6.82E-08	0.00E+00	2.67E-09	9.20E-07
Intermediate and low-level radioactive waste, (ILLRW[2])* (kg)						
	7.49E-04	2.27E-06	5.71E-05	0.00E+00	2.38E-06	8.10E-04
Components for reuse, (CRU[2]) * (kg)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling, (MR[2]) * (kg)						
	1.53E-03	0.00E+00	3.30E-02	0.00E+00	0.00E+00	3.46E-02
Materials for energy recovery, (MER[2]) * (kg)						
	6.93E-09	0.00E+00	5.27E-03	0.00E+00	0.00E+00	5.27E-03
Recovered energy exported from the product system, (EE[2]) * (MJ, NCV)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon Emissions and Removal						
Biogenic Carbon Removal from Product, (BCRP) * (kg CO_2)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Biogenic Carbon Emission from Product, (BCEP) * (kg CO_2)						
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Biogenic Carbon Removal from Packaging, (BCRK) * (kg CO_2)						
	6.01E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E-04
Biogenic Carbon Emission from Packaging, (BCEK) * (kg CO_2)						
	0.00E+00	0.00E+00	6.01E-04	0.00E+00	0.00E+00	6.01E-04

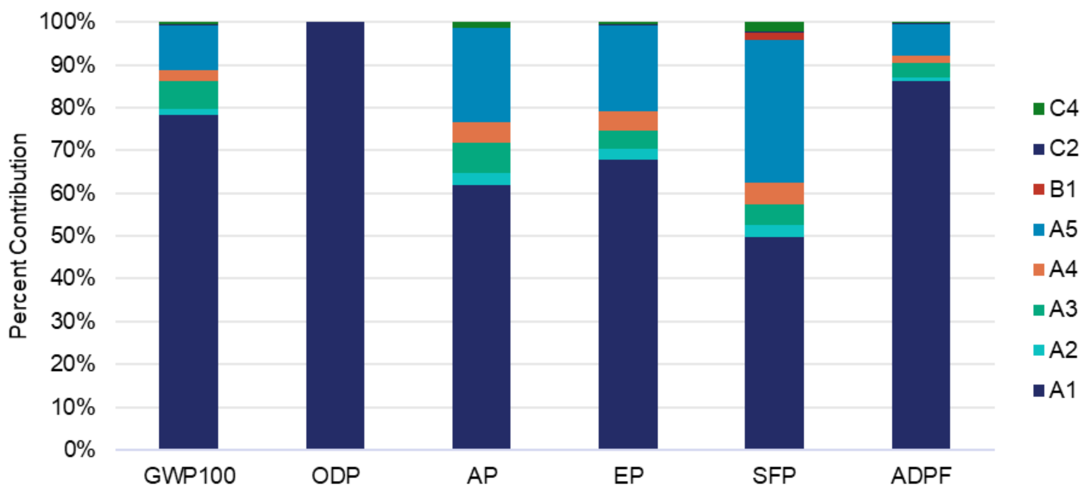
LCA INTERPRETATION

Figure 4 presents the results for the environmental performance of 1 m^2 of installed product with a thickness that provides a thermal resistance of 1 $m^2 \cdot K/W$ (5.68 $hr \cdot ft^2 \cdot °F/Btu$).

It is clear from the figure that raw materials (A1) have the largest contribution to the environmental footprint, followed by installation (A5) and manufacturing (A3). Transportation modules (A2, A4, and C2) have a cumulative contribution of 0% to 5% across the impact categories. Use (B1) and end-of-life (C4) have negligible impact (< 2.3%) overall.

FIGURE 4

Contribution Analysis by Module of Closed Cell Product per Functional Unit



ADDITIONAL ENVIRONMENTAL INFORMATION

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