SATIVA BUILDING SYSTEMS

Environmental Product Declaration

Environmental Product Declaration for the Z Panel produced by Sativa Building Systems at their facility in Wittenberg, Wisconsin

ADMINISTRATIVE INFORMATION

International Certified Environmental Product Declaration

Declared Product:	This Environmental Product Declaration (EPD) covers thermal insulation products produced by Sativa Building Systems. Declared Unit: 1 m2 of insulation material with thickness that gives an average thermal resistance RSI=1
Declaration Owner:	Sativa Building Systems
	W17509 Birch Lane
	Wittenberg, Wisconsin
	https://sativabuildingsystems.com
Program Operator:	Labeling Sustainability
	11670 W Sunset Blvd.
	Los Angeles, CA 90049
	www.labelingsustainability.com
Product Category Rule:	ISO 21930:2017 Sustainability in buildings and civil engineering works Core rules for environmental product declarations of construction products and services.
	Sub PCR: Part B: Building Envelope Thermal Insulation EPD Requirements, Valid Until April 2028, UL Environmental
	Review conducted by Thomas Gloria, PhD.
Independent LCA Reviewer and EPD Verifier:	This declaration was independently verified in accordance with ISO 14025:2006.
	Independent verification of the declaration, according to ISO 14025:2006
	Internal □; External □ X
	Third Party Verifier
	Geoffrey Guest, Certified 3rd Party Verifier under the Labeling Sustainability Program (www.labelingsustainability.com), CSA Group (www.csaregistries.ca),
Date of Issue:	11 September 2023
Period of Validity:	5 years; valid until 11 September 2028
EPD Number:	d28bfcf1-0e69-429f-8611-c41224fbd6e6

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COMPANY DESCRIPTION

Sativa Building Systems is raising standards with safe and sustainable building products. The flagship product is the Z Panel. The Z Panel is a utility-patented, sustainable, hemp-based block panel used to construct walls of buildings. Our products improve the comfort and quality of life of building occupants by being breathable, non-toxic, mold resistant, pest resistant, rot resistant, and fire resistant.

STUDY GOAL

The intended application of this life cycle assessment (LCA) is to comply with the procedures for creating a Type III environmental product declaration (EPD) and publish the EPD for public review on the website, www.labelingsustainability.com. This level of study is in accordance with EPD Product Category Rule (PCR) for Thermal Insulation published by; International Standards Organization (ISO) 14025:2006 Environmental labels and declarations, Type III environmental declarations-Principles and procedures; ISO 14044:2006 Environmental management, Life cycle assessment- Requirements and guidelines; and ISO 14040:2006 Environmental management, Life cycle assessment-Principles and framework. The performance of this study and its subsequent publishing is in alignment with the business-to-business (B2B) communication requirements for the environmental assessment of building products. The study does not intend to support comparative assertions and is intended to be disclosed to the public.

This project report was commissioned to differentiate Sativa Building Systems from their competition for the following reasons: generate an advantage for the organization; offer customers information to help them make informed product decisions; improve the environmental performance of Sativa Building Systems by continuously measuring, controlling and reducing the environmental impacts of their products; help project facilitators working on Leadership in Energy and Environmental Design (LEED) projects achieve their credit goal; and to strengthen Sativa Building System's license to operate in the community. The intended audience for this LCA report is Sativa Building System's employees, their suppliers, project specifiers of their products, architects, and engineers. The EPD report is also available for policy makers, government officials interested in sustainability, academic professors, and LCA professionals. This LCA report does not include product comparisons from other facilities.

DESCRIPTION OF PRODUCT AND SCOPE

The Z Panel is a hempcrete (hemp, lime, and water) block panel for constructing the walls of residential and commercial buildings. It works with code-approved load bearing, making installation fast and easy.

Z Panels are fully non-toxic, they are resistant to mold, pests, rot, and fire also Z Panels maximize the use of sustainable materials.

Since the RSI (thermal resistance) of a material significantly varies depending on its type and thickness. A higher RSI value indicates greater insulating property of the material. As specified by the PCR; the functional unit, mass, and thickness to achieve the functional unit shall be indicated in the EPD by using appropriate table.

Table 1: **Parameters for functional unit.**

Name	Value	Unit
Functional Unit	1 m^2 of insulation material with a thickness that gives an average thermal resistance of 1 RSI.	m^2-K/W
Mass	22.09	kg
Thickness to achieve functional unit	0.072	m

The structure of the lignin molecule is inherently complex and likely always variable. Sativa only uses the woody part of the stem of the hemp plant, not the fiber, and not the whole stem. This part is called shiv or hurd. The measured biogenic value for carbon sequestration of shiv/hurd is 2.1 kg CO2 per 1 kg of shiv. Therefore, the biogenic carbon content is calculated as proportion of carbon content multiplied by the product density i.e. 32.2%

The product contains sustainably managed biomass containing materials in the declared product derived from both softwood lumber and hemp fibers. In total, 4.02kg of carbon or 14.748 kg bio-CO2eq is stored in the product on a per functional unit basis.

Table 2: **Biogenic carbon stored in the declared product.**

Entity	Value	Unit
Bio-carbon in lumber framing	0.395	kg carbon
Bio-carbon in hemp shiv	2.1	kg carbon
Total bio-carbon in product	2.495	kg carbon
Total bio-CO2e in product	14.748	kg bio-CO2eq

Product	Total bio-CO2e per FU (kg bio-CO2eq)	GWP (kg CO2eq) per declared unit	Calculation method*	Partial Carbon Footprint of Products*
Z Panel	14.74807	18.1	= 18.1 – 14.748	**3.352**

Additionally, the curing of Lime Hemp Concrete (LHC) such as the Z Panel, is achieved through carbonation of lime binder. Through laboratory testing using XRD analysis, it was found that the carbonation process consumes .993 kg of CO2 per kg of lime binder. Each functional unit requires 4.535 kg of lime binder equating to an additional 4.505 kg of CO2 consumed within the production process.

Product	Partial Carbon Footprint of Products*	Carbonation (kg COeq consumed) per declared unit	Calculation method*	Carbon Footprint of Products*
Z Panel	3.352	4.505	= 3.352-4.505	**-1.153**

*The Quantification of the carbon footprint of a product is the sum of GHG emissions and GHG removals, expressed as CO2 equivalents (kg CO2 eq/FU of Z Panel)

This LCA assumes the impacts from products manufactured in accordance with the standards outlined in this report. This LCA is a cradle-to-grave study.

THERMAL INSULATION DESIGN SUMMARY

The following tables provide a list of the calcium carbonate sand products considered in this EPD along with key performance parameters.

All Declared Products

Table 3: **Declared products with All declared products considered in this environmental product declaration**

Prod #	Unique name/ID	Short description	Product type	Unit	Density, dry kg/Unit	bio-carbon content, kg C/FU dry basis	productGroup	Height (cm)	Length (cm)	Width (cm)
1	Z-Panel	Safe & Sustainable Hempcrete (hemp, lime, and water) Block Panels.	Thermal Insulation	m2	22.66	4.02	z-panel	60.96	40.64	30.48

THERMAL INSULATION DESIGN COMPOSITION

The following figures provide mass breakdown (kg per functional unit) of the material composition of each thermal insulation design considered.

All Declared Products:

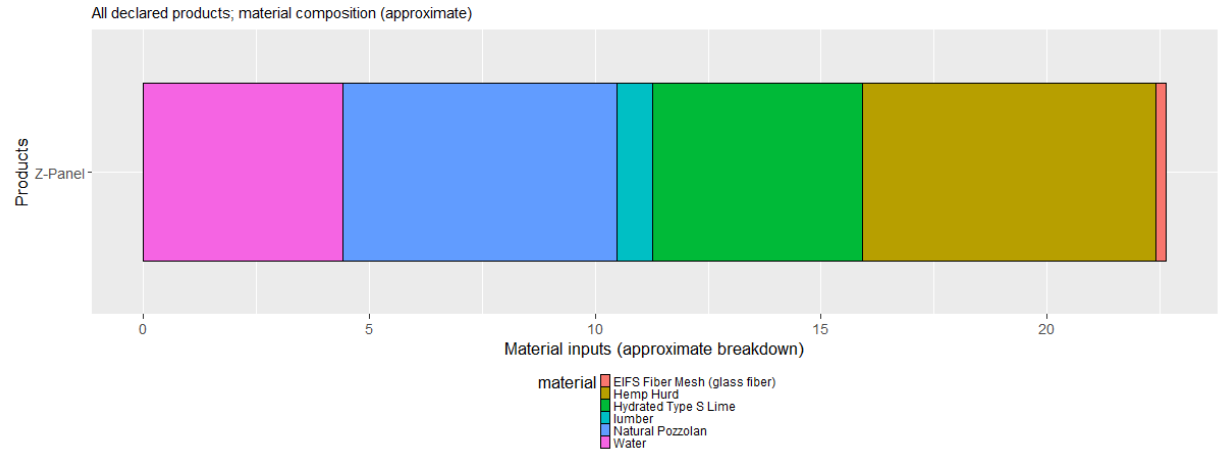

Figure 1: **Material composition - All declared products per 1 m2 of insulation material with a thickness that gives an average thermal resistance RSI = 1**

A1 RAW MATERIAL RECYCLED CONTENT AND MATERIAL LOSSES

The following table provides a list of the raw material inputs (module A1) across all products considered, their recyclability content and assumed material losses.

Table 4: **Module A1 raw material inputs, the recyclability content and assumed material losses (dry basis)**

product.name	mix.category	primary.content	post.industrial.content	post.consumer.content	material.losses
Hydrated Type S Lime	lime, hydrated, packed	100%	0%	0%	2%
Natural Pozzolan	clay	100%	0%	0%	2%
Hemp Hurd	cellulose fiber	100%	0%	0%	2%
Water	tap water	100%	0%	0%	2%
Lumber	sawnwood, softwood, dried (u=10%), planed	100%	0%	0%	2%
EIFS Fiber Mesh (glass fiber)	glass fiber	100%	0%	0%	2%

SYSTEM BOUNDARIES

The following figure depicts the cradle-to-gate system boundary considered in this study:

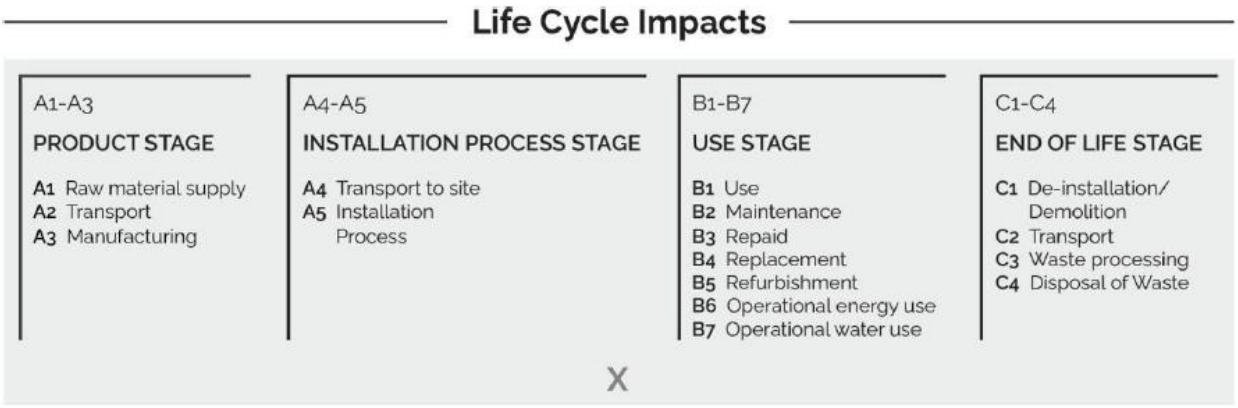

Figure 2: **General life cycle phases for consideration in a construction works system.**

This is a Cradle-to-grave life cycle assessment and the following life cycle stages are included in the study:

- A1: Raw material supply (upstream processes) - Extraction, handling, and processing of the materials used in manufacturing the declared products in this LCA.
- A2: Transportation - Transportation of A1 materials from the supplier to the "gate" of the manufacturing facility (i.e. A3).
- A3: Manufacturing (core processes)- The energy and other utility inputs used to store, move, and manufacturer the declared products and to operate the facility.
- A4: Product plant gate-to-site of use logistics
- A5: Product at-site installation requirements
- B: Product use phase requirements and direct emissions (if applicable)
- C: Product end-of-life requirements

As according to the PCR, the following figure illustrates the general activities and input requirements for producing thermal insulation products and is not necessarily exhaustive.

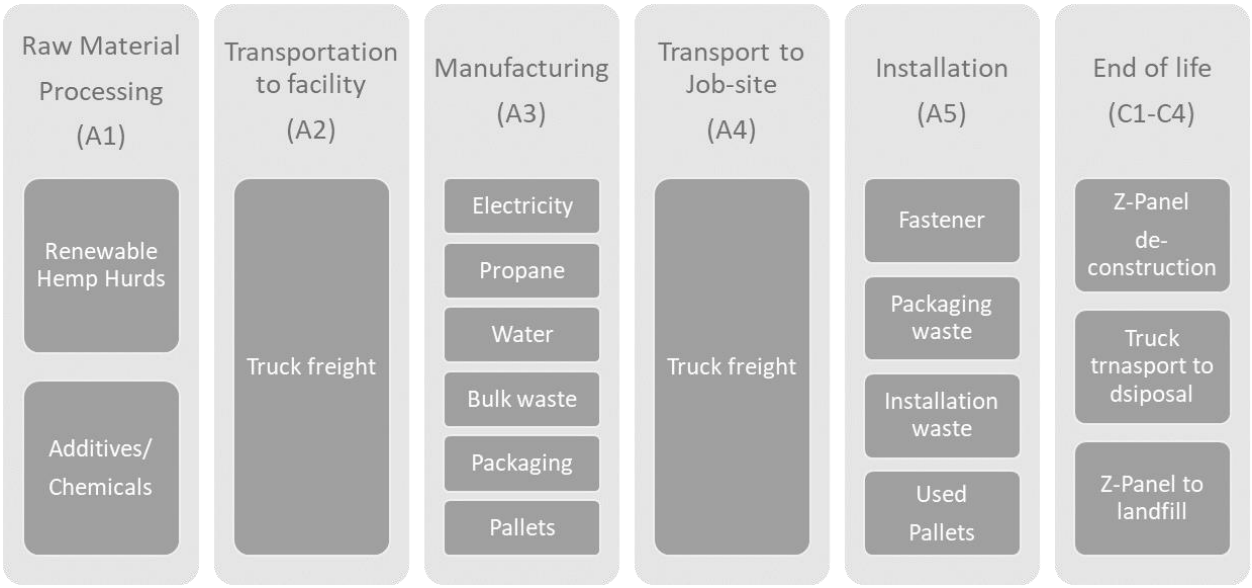

Figure 3: **General system inputs considered in the product system and categorized by modules in scope**

In addition, as according to the relevant PCR, the following requirements are excluded from this study:

- Production, manufacture and construction of A3 building/capital goods and infrastructure;
- Production and manufacture of steel production equipment, steel delivery vehicles, earth-moving equipment, and laboratory equipment;
- Personnel-related activities (travel, furniture, office supplies);
- Energy use related to company management and sales activities.

For this LCA the manufacturing plant, owned and operated by Sativa Building Systems, is located at their Z Panels facility in Wisconsin. All operating data is formulated using the actual data from Sativa Building Systems's plant at the above location, including water, energy consumption and waste generation. All inputs for this system boundary are calculated for the plant.

This life cycle inventory was organized in a spreadsheet and was then input into an RStudio environment where pre-calculated LCIA results for relevant products/activies stemming from the ecoinvent ecoinvent v3.8 database and a local EPD database in combination with primary data from Sativa Building Systems were utilized. Explanations of the contribution of each data source to this study are outlined in the section 'Data Sources and Quality'. Further LCI details for each declared product are provided in the sections 'Detailed LCI tables' and 'Transport tables' of the detailed LCA report. A parameter uncertainty analysis was also performed where key statistical results (e.g. min/mean/max etc.) are provided in the detailed LCA report.

No known flows are deliberately excluded from this EPD.

CUT-OFF CRITERIA

ISO 14044:2006 and the focus PCR requires the LCA model to contain a minimum of 95% of the total inflows (mass and energy) to the upstream and core modules be included in this study. The cut-off criteria were applied to all other processes unless otherwise noted above as follows. A 1% cut-off is considered for all renewable and non-renewable primary energy consumption and the total mass of inputs within a unit process where the total of the neglected inputs does not exceed 5%.

DATA SOURCES AND DATA QUALITY ASSESSMENT

No recovered on-site energy occurs at this facility.

Table 5: **Reused or recycled components/materials at the A3 facility site**

Component/material for re-use/recycling	Value	Units	Re-used/recycled on-site or off-site
Pallets	1031.40	kg	Off-site
Plastic film	34.56	kg	Off-site
Packaging strip	20,448	kg	Off-site

The following statements explain how the above facility requirements/generation were derived:

Raw material transport: Sativa building systems provided all the raw material data for the reference year 2022. Raw material transportation is based on the actual distance from the manufacturer. The transportation was reported using Sativa Building primary data that consisted of the actual distance, mode of transport, and location in the city, state, and the country. There is only one mode of transportation for raw material supply i.e. truck freight.

Electricity: Primary electricity consumption was calculated by using the electricity bills for the Sativa building system. Its fiscal year starts in July; twelve consecutive months were used, from July 2022 through June 2023. Sativa's utility providers' monthly usage was in kilowatt-hours (kWh), so no conversions were performed.

Process/space heating: The Sativa building systems does not have any other process or space heating.

Fuel required for machinery: On-site machinery for moving materials uses propane and was recorded in this study under Module A3. The conversion factor was used for gallons to MJ to represent the burning of the propane i.e., 1 gallon of propane= 100.758 MJ of energy.

Waste generation: All waste for A3 was calculated using primary information from Sativa bills. Packaging waste is mainly incorporated in A3 which includes plastic film, strips and pallets. Transportation defaults were used because the driver's route and ultimate final destination are unknown. Therefore, the exact mileage could not be confirmed by the waste hauler. Transportation for waste in the end-of-life modules also uses default distances set by the PCR.

Recovered energy: No on-site energy is recovered on site.

Recycled/reused material/components: According to the Advancing Sustainable Materials Management: 2018 Fact Sheet (US EPA), only 4% of the total plastic packaging is recycled in the USA. Similarly, 4.47% of Plastic waste from pallets were assumed to be recycled off-site at the end of their service life. The PCR also states the transportation distance to the disposal point is 11 km plus the default value in the WARRM Model which is 20 miles (32 km). A total value of 43 km was used per the PCR.

Module A1 material losses: Default material losses, 2% were used unless otherwise specified in the PCR.

Direct A3 emissions accounting: Direct emissions were modeled with best available ecoinvent processes (see LCI list).

A4 Product transport requirements: Sativa building systems reported the average customer distance based on direct calculations of distance and amount of purchased z-panel from purchased orders. Sativa building product arrives at the job site by freight trucks with an average distance of 322 kilometers.

A5 Product Installation: In accordance with the requirements of ISO 21930:2017, the impact from the activities normally considered in Module A1-A3 (production stage) and in Module A4 (transport to site)

for the mass of product wasted during application are included in the Module A5 and not Modules A1 to A4. Additionally, waste processing of the packaging system shall also be accounted in module A5.

The Z Panels have recesses on the top and bottom edges, allowing them to interlock with each other and the bottom plate. Embedded 2×4 wood strip is used on interior for securing to studs and then screw or nailed through 2x4 wood strip into the studs. The NEW! embedded vertical wood strip on the exterior of the Z Panel is intended for attaching siding or cladding material.

B product use phase: The Service life of the product is assumed to be 75-years therefore, there is only one product application is need for 75-years building service life. There is no energy used during the use phase of this product. During the service life, z-panel requires just regular cleaning/dusting or inspect the attachment points for any loose screws or nails. Tighten or replace them as necessary to maintain a secure installation.

C product end-of-life: At the end of the Service Life of the building, it is assumed that only manual labor is involved to remove the Insulation (z-panel). To align with the PCR, the removed Z-Panels (waste) is assumed to be transported 48 km to the disposal site i.e. landfilling as there is no infrastructure.

The following tables depict a list of assumed life cycle inventory utilized in the LCA modeling to generate the impact results across the life cycle modules in scope. An assessment of the quality of each LCI activities utilized from various sources is also provided.

Table 6: **LCI inputs assumed for module A1 (i.e., raw material supply)**

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
Water	tap water production, conventional treatment/tap water/RoW/kg	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3
Hydrated Type S Lime	lime production, hydrated, packed/lime, hydrated, packed/RoW/kg	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3
Natural Pozzolan	clay pit operation/clay/RoW/kg	ecoinvent v3.8	Wisconsin	v3.8 in 2021	1	3	1	3	3
Hemp Hurd	cellulose fibre production/cellulose fibre/RoW/kg	ecoinvent v3.8	Minnesota, Wisconsin	v3.8 in 2021	1	3	2	3	3
Lumber	sawnwood production, softwood, dried (u=10%), planed/sawnwood, softwood, dried (u=10%), planed/RoW/m3	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3

EIFS Fiber Mesh (glass fiber)	glass fibre production/glass fibre/RoW/kg	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3

Table 7: **LCI inputs assumed for module A2 (i.e. transport of A1 inputs)**

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
Bulk Waste-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
EIFS Fiber Mesh (glass fiber)-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Hemp Hurd-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Hydrated Type S Lime-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Natural Pozzolan-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3
Packaging strip- freight	market for transport, freight, lorry 16-32 metric ton,	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3

transport via Truck	EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm								
Plastic film-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	RoW	v3.8 in 2021	2	3	1	3	3

Table 8: **LCI inputs assumed for module A3**

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
Bulk Waste	process-specific burdens, residual material landfill/process-specific burdens, residual material landfill/RoW/kg	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3
Electricity	market for electricity, medium voltage/electricity, medium voltage/US-MRO/kWh	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3
Packaging strip	steel production, converter, low-alloyed/steel, low-alloyed/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	1	3	1	3	3
Pallets	EUR-flat pallet production/EUR-flat pallet/RoW/unit	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3
Plastic film	packaging film production, low density polyethylene/packaging film, low density polyethylene/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	1	3	3
Propane	propane, burned in building machine/propane, burned in building machine/GLO/MJ	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	2	3	3

Water (A3)	tap water production, conventional treatment/tap water/RoW/kg	ecoinvent v3.8	Wisconsin	v3.8 in 2021	2	3	2	3	3

Table 9: **LCI inputs assumed across modules A4 to C4 (i.e. from plant gate-to-grave if applicable)**

Input	LCI.activity	Data.source	Geo	Year	Technology	Time	Geography	Reliability	Completeness
C4. End of life	process-specific burdens, inert material landfill/process-specific burdens, inert material landfill/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	1	3	3
C4. End of life- freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	2	3	1	3	3
A5. Fastener	steel production, converter, low-alloyed/steel, low-alloyed/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	1	3	3
A5. Fastener-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	2	3	1	3	32
A5. Packaging strip to recycling	treatment of scrap steel, inert material landfill/scrap steel/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	1	3	3
A5. Packaging strip to recycling-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	2	3	1	3	3
A5. Pallets to landfill	treatment of waste wood, untreated, sanitary landfill/waste wood, untreated/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	2	3	3

A5. Pallets to landfill-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	2	3	1	3	3
A5. Pallets to recycling	waste sorting at collection center	See A3 inputs	Multiple Regions	See A3 inputs	2	A3	1	A3	A3
A5. Pallets to recycling-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	2	3	1	3	3
A4. Product to Site	Product-to-site transport requirements	See A4 transport requirements	Wisconsin	2022-07-01 to 2023-06-30	NA	NA	NA	NA	NA
A4. Product to Site-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021					
A5. Waste plastic to landfill	treatment of waste plastic, mixture, sanitary landfill/waste plastic, mixture/RoW/kg	ecoinvent v3.8	Multiple Regions	v3.8 in 2021	2	3	1	3	3
A5. Waste plastic to landfill-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	1	3	1	3	3
A5. Waste plastic to recycling	waste sorting at collection center	See A3 inputs	Multiple Regions	See A3 inputs	2	A3	1	A3	A3
A5. Waste plastic to recycling-freight transport via Truck	market for transport, freight, lorry 16-32 metric ton, EURO6/transport, freight, lorry 16-32 metric ton, EURO6/RoW/tkm	ecoinvent v3.8	see corrsp. product input above	v3.8 in 2021	2	3	1	3	3

DATA QUALITY ASSESSMENT

Data quality/variability requirements, as specified in the PCR, are applied. This section describes the achieved data quality relative to the ISO 14044:2006 requirements. Data quality is judged based on its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied within a study serving as a data source) and representativeness (geographical, temporal, and technological).

Precision: Through measurement and calculation, the manufacturers collected and provided primary data on their annual production. For accuracy, the LCA practitioner and 3rd Party Verifier validated the plant gate-to-gate data.

Completeness: All relevant specific processes, including inputs (raw materials, energy and ancillary materials) and outputs (emissions and production volume) were considered and modeled to represent the specified and declared products. The majority of relevant background materials and processes were taken from ecoinvent v3.8 LCI datasets where relatively recent region-specific electricity inputs were utilized. The most relevant EPDs requiring key A1 inputs were also utilized where readily available.

Consistency: To ensure consistency, the same modeling structure across the respective product systems was utilized for all inputs, which consisted of raw material inputs and ancillary material, energy flows, water resource inputs, product and co-products outputs, returned and recovered Calcium carbonate sand materials, emissions to air, water and soil, and waste recycling and treatment. The same background LCI datasets from the ecoinvent v3.8 database were used across all product systems. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the plant and selected process level to maintain a high level of consistency.

Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in a machine readable project file for all foreground and background processes, and in Labeling Sustainability's proprietary Calcium carbonate sand LCA calculator* for all production facility and product-specific calculations. A considerable level of transparency is provided throughout the detailed LCA report as the specifications and material quantity make-up for the declared products are presented and key primary and secondary LCI data sources are summarized. The provision of more detailed publicly accessible data to allow full external reproducibility was not possible due to reasons of confidentiality.

*Labeling Sustainability has developed a proprietary tool that allows the calculation of PCR-compliant LCA results for Calcium carbonate sand product designs. The tool auto-calculates results by scaling base-unit technosphere inputs (i.e., 1 kg sand, 1 kWh electricity, etc.) to replicate the reference flow conversions that take place in any typical LCA software like openLCA or SimaPro. The tool was tested against several LCAs performed in openLCA and the tool generated identical results to those realized in openLCA across every impact category and inventory metric (where comparisons could be readily made).

Representativeness: The representativeness of the data is summarized as follows.

- Time related coverage of the manufacturing processes primary collected data from 2022-07-01 to 2023-06-30.
- Upstream (background) LCI data was either the PCR specified default (if applicable) or more appropriate LCI datasets as found in the country-adjusted ecoinvent v3.8 database.
- Geographical coverage for inputs required by the A3 facility(ies) is representative of its region of focus; other upstream and background processes are based on US, North American, or global average data and adjusted to regional electricity mixes when relevant.
- Technological coverage is typical or average and specific to the participating facilities for all primary data.

ENVIRONMENTAL INDICATORS AND INVENTORY METRICS

Per the PCR, this EPD supports the life cycle impact assessment indicators and inventory metrics as listed in the tables below. As specified in the PCR, the most recent US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), impact categories were utilized as they provide a North American context for the mandatory category indicators to be included in the EPD. Additionally, the PCR requires a set of inventory metrics to be reported with the LCIA indicators (see tables below).

Table 10: **Life cycle impact categories and life cycle inventory metrics**

ID	LCIA.indicators	Abbreviations	Units
1	environmental impact: acidification	AP	moles of H+-Eq
2	environmental impact: eutrophication	EP	kg N
3	environmental impact: global warming	GWP	kg CO2-Eq
4	environmental impact: ozone depletion	ODP	kg CFC-11-Eq
5	environmental impact: photochemical oxidation	PCOP	kg NOx-Eq
6	material resources: metals/minerals: abiotic depletion potential (ADP): elements (ultimate reserves)	ADPe	kg Sb-Eq
7	energy resources: non-renewable: abiotic depletion potential (ADP): fossil fuels	ADPf	MJ, net calorific value
Inventory metrics			
8	Total primary energy	TPE	MJ-Eq
9	Renewable energy	RE	MJ-Eq
10	Non-renewable energy	NRE	MJ-Eq
11	Non-Renewable Resources	NRR	kg
12	Renewable Resources	RR	m^3
13	Water depletion: WDP	WDP	m^3
14	Land filling: bulk waste	LFW	kg waste
15	Land filling: hazardous waste	LFHW	kg waste

A summary description of each of the impact categories and inventory metrics is provided in the following table:

Table 11: **Definitions of life cycle impact categories and life cycle inventory metrics**

Midpoint impact categories

Global Warming Potential (GWP) (units: kg CO2-eq)	Global Warming Potential or climate change can be defined as the change in global temperature caused by the greenhouse effect that the release of greenhouse gases by human activity creates. The Environmental Profiles characterization model is based on factors developed by the United Nations Intergovernmental Panel on Climate Change (IPCC). Factors are expressed as Global Warming Potential over the time horizon of different years, being the most common 100 years (GWP100), measured in the reference unit, kg CO2 equivalent.
Ozone Depletion Potential (ODP) (kg CFC-11-eq)	Ozone-depleting gases cause damage to stratospheric ozone or the ozone layer. CFCs, halons and HCFCs are the major causes of ozone depletion. The characterization model has been developed by the World Meteorological Organization (WMO) and defines the ozone depletion potential of different gases relative to the reference substance chlorofluorocarbon-11 (CFC-11), expressed in kg CFC-11 equivalent.
Acidification Potential (AP) (kg SO2-eq)	Acidic gases such as Sulphur dioxide (SO2) react with water in the atmosphere to form acid rain, a process known as acid deposition. Acidification potential is expressed using the reference unit, kg SO2 equivalent. The model does not take account of regional differences in terms of which areas are more or less susceptible to acidification. It accounts only for acidification caused by SO2 and NOx. This includes acidification due to fertilizer use, according to the method developed by the Intergovernmental Panel on Climate Change (IPCC). CML has based the characterization factor on the RAINS model developed by the University of Amsterdam.
Eutrophication Potential (EP) (PO4 3- -eq)	Eutrophication is the build-up of a concentration of chemical nutrients in an ecosystem which leads to abnormal productivity. This causes excessive plant growth like algae in rivers which causes severe reductions in water quality and animal populations. This category is based on the work of Heijungs, and is expressed using the reference unit, kg PO4 3- equivalents. Direct and indirect impacts of fertilizers are included in the method. The direct impacts are from production of the fertilizers and the indirect ones are calculated using the IPCC method to estimate emissions to water causing eutrophication.
Photochemical Ozone Creation/Smog Potential (POCP) (kg O3-eq)	Ozone is protective in the stratosphere, but on the ground-level, it is toxic to humans in high concentration. Photochemical ozone, also called ground-level ozone, is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. The impact category depends largely on the amounts of carbon monoxide (CO), Sulphur dioxide (SO2), nitrogen oxide (NO), ammonium and NMVOC (non-methane volatile organic compounds). Photochemical ozone creation potential (also known as summer smog) for emission of substances to air is calculated with the United Nations Economic Commission for 22 Europe (UNECE) trajectory model (including fate) and expressed using the reference unit, kg ethylene (C2H4) equivalent.
Abiotic Depletion Potential (ADPel and ADPff) (kg Sb-eq)	The main concern of this category is the health of humans and the ecosystem and how it is affected by the extraction of minerals and fossil fuels, which are inputs into the system. For each extraction of minerals and fossil fuels, the abiotic depletion factor is determined. This indicator is on a global scale and is based on the concentration reserves and rate of deaccumulation. The results are presented in units of the reference element strontium (i.e. Sb). For the purposes of this EPD, this impact category is split between mineral elements (i.e. ADPel) and fossil fuels (i.e. ADPff).

Inventory metrics	
Depletion of non-renewable material resources (NRM) (kg)	This indicator covers the cumulative life cycle consumption of non-renewable resources that are extracted from the ground but not including energy resources like coal, oil and natural gas. This indicator includes the consumption of metallic ores, aggregates, and other minerals. The units of measure are in terms of kilograms material extracted and utilized/wasted in the life cycle system considered.
Use of renewable material resources (RM) (kg)	This indicator covers the cumulative life cycle consumption of renewable resources that are extracted from nature like sustainably harvested biomass. The units of measure are in terms of kilograms material extracted and utilized/wasted in the life cycle system considered.
Depletion of non-renewable energy resources (NRE) (MJ HHV)	This indicator considers the cumulative life cycle consumption of non-renewable energy resources like oil, natural gas, and coal. The units of measure are in terms of Mega-Joules of energy resource extracted and utilized/wasted in the life cycle system considered.
Use of renewable primary energy (RE) (MJ HHV)	This indicator considers the cumulative life cycle extraction of renewable energy resources from nature like solar and wind energy as well as biomass for energy purposes. The units of measure are in terms of Mega-Joules of energy resource extracted and utilized/wasted in the life cycle system considered.
Total primary energy consumption (PEC) (MJ HHV)	This indicator is the summation of non-renewable and renewable energy extracted from nature, where the units of measure are in terms of Mega-Joules of energy resource extracted/utilized/wasted in the life cycle system considered.
Water Depletion Potential (WDP) (m^3)	This indicator considers the cumulative life cycle consumption of water required to produce the declared functional unit of a given product. The units of measure are in cubic meters of water consumed.

It should be noted that emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in any of the following categories.

- Renewable primary energy resources as energy (fuel);
- Renewable primary resources as material;
- Non-renewable primary resources as energy (fuel);
- Non-renewable primary resources as material;
- Secondary Materials;
- Renewable secondary fuels;
- Non-renewable secondary fuels;
- Recovered energy;
- Abiotic depletion potential for non-fossil mineral resources.
- Land use related impacts, for example on biodiversity and/or soil fertility;
- Toxicological aspects;
- Emissions from land use change [GWP 100 (land-use change)];
- Hazardous waste disposed;
- Non-hazardous waste disposed;
- High-level radioactive waste;
- Intermediate and low-level radioactive waste;

- Components for reuse;
- Materials for recycling;
- Materials for energy recovery;
- Recovered energy exported from the product system.

TOTAL IMPACT SUMMARY

In assessing the environmental impact of producing 1 m^2 of Z Panel, with a thickness providing an average thermal resistance RSI = 1, specific key contributors or "hotspots" have been identified. These crucial data points offer insight into where environmental mitigation strategies might be most effectively employed. The following percentage contributions are in terms of the impact category GWP.

1. Raw Material Extraction and Processing: Hydrated Type S Lime: This component is the most significant contributor, accounting for 25.6% of the environmental impact. Being a primary ingredient, strategies could be targeted towards sustainable sourcing or exploring less impactful alternatives. Hemp Hurd: A notable 7.62% is attributed to Hemp Hurd, with an additional 3.52% due to its freight transport. Efforts might be made to streamline its transportation and assess sustainable farming practices.

2. Manufacturing Phase: Propane Usage: A substantial 22.8% impact is from propane, likely used as a fuel source during manufacturing. Transitioning to cleaner energy sources or improving fuel efficiency could help reduce this footprint. Plastic Film: At 11%, the use of plastic film in the production process also stands out. Investigating recyclable or biodegradable alternatives might be beneficial. Electricity Consumption: Making up 7.9% of the total impact, using electricity, primarily if sourced from fossil fuels, is significant. Transitioning to renewable energy sources or implementing energy-efficient measures could mitigate this.

3. Transportation and Distribution: Product to Site: Freight transport via truck is responsible for 7.24% of the impact, emphasizing the potential benefits of more efficient transport methods or a transition to eco-friendly vehicles. Hemp Hurd Transportation: As noted above, the transportation of Hemp Hurd adds 3.52% to the impact.

4. Other Materials: EIFS Fiber Mesh: Contributing 3.56%, the use of glass fiber mesh in the insulation material suggests room for exploring eco-friendly alternatives or optimizing the production process of the mesh itself.

In conclusion, transportation, coupled with specific raw material processing, emerges as a central theme across the environmental impact spectrum. The significant contribution of propane in the manufacturing phase also underscores the need to review energy sources in production. Strategies should be geared towards sustainable sourcing, energy efficiency, and environmentally friendly transport options.

The following table reports the total LCA results for each product produced at the given thermal insulation facility on a per 1 m2 of insulation material with a thickness that gives an average thermal resistance RSI = 1 basis.

All Declared Products:

Table 12: **Total life cycle (across modules in scope) impact results for All declared products, assuming the geometric mean point values on a per 1 m2 of insulation material with a thickness that gives an average thermal resistance RSI = 1 basis**

a) Midpoint Impact Categories:

Indicator/LCI Metric	AP	EP	GWP	ODP	PCOP	ADPe	ADPf
Unit	**moles of H+-Eq**	**kg N**	**kg CO2-Eq**	**kg CFC-11-Eq**	**kg NOx-Eq**	**kg Sb-Eq**	**MJ, net calorific value**
Z-Panel	3.18	0.00358	18.1	1.49e-06	0.0392	0.000711	226

b) Inventory Metrics:

Indicator/LCI Metric	TPE	RE	NRE	NRR	RR	WDP	LFW	LFHW
Unit	**MJ-Eq**	**MJ-Eq**	**MJ-Eq**	**kg**	**m³**	**m³**	**kg waste**	**kg waste**
Z-Panel	295	55.2	235	7.26	0.00455	0.0598	27.7	0.00032

ADDITIONAL ENVIRONMENTAL INFO

No regulated substances of very high concern are utilized on site.

REFERENCES

ISO Standards:

- ISO 6707-1: 2014 Buildings and Civil Engineering Works - Vocabulary - Part 1: General Terms
- ISO 14021:1999 Environmental Labels and Declarations - Self-declared Environmental Claims (Type II Environmental Labeling)
- ISO 14025:2006 Environmental Labels and Declarations - Type III Environmental Declarations - Principles and Procedures
- ISO 14040:2006 Environmental Management - Life Cycle Assessment - Principles and Framework
- ISO 14044:2006 Environmental Management - Life Cycle Assessment - Requirements and Guidelines

- ISO 14067:2018 Greenhouse Gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification
- ISO 14050:2009 Environmental Management - Vocabulary
- ISO 21930:2017 Sustainability in Building Construction - Environmental Declaration of Building Products

EN Standards:

- EN 16757 Sustainability of construction works - Environmental product declarations – Product Category Rules for concrete and concrete elements.
- EN 15804 Sustainability of construction works - Environmental product declarations -Core rules for the product category of construction products.

Other References:

- USGBC LEED v4 for Building Design and Construction, 11 Jan 2019 available at https://www.usgbc.org/resources/pcr-committee-process-resources-part-b
- USGBC PCR Committee Process & Resources: Part B, USGBC, 7 July 2017 available at https://www.usgbc.org/resources/pcr-committee-process-resources-part-b.
- US EPA (2020) Advancing Sustainable Materials Management: 2018 Fact Sheet, https://www.epa.gov/sites/production/files/2021-01/documents/2018_ff_fact_sheet_dec_2020_fnl_508.pdf