greenfiber

SANCTUARY® by Greenfiber®
Blow-In or Spray-Applied Insulation

SANCTUARY cellulose insulation can be easily installed in attics, walls, floors, and ceilings to significantly improve the comfort, safety and well-being of any home. The first all-in-one fiber insulation that can be blown-in, spray-applied or dense-packed, and it's suitable for all climates and conditions. Capable of reducing sound power by 60% and heating and cooling costs by up to 25%, it's made from recycled plant fibers which locks in carbon for the life of the home.

Performance dashboard

Features & functionality

Fills tiny joins, crevices or gaps, creating a dense barrier capable of muffling sound and reducing air infiltration.

Extremely versatile and easy to use.

Exceptional acoustical properties can abate the power of sound by up to 60% when installed in walls.

Capable of reducing heating and cooling costs by up to 25%.

Carries a Class 1/A fire rating and qualifies as a fire-blocking material for advanced fire resistance.

Locks in carbon for the life of the home to reduce global warming.

Environment & materials

Improved by:

Made with 85% post-consumer recycled paper

Uses low-energy manufacturing and short-haul transportation, resulting in insulation with lower embodied carbon

Free from unhealthy substances such as asbestos and formaldehyde

Lower carbon insulation material with high amount of carbon storage reduces global warming potential

Certifications & rating systems:

ASTM C739

Declare label, Red List Free

Canadian Construction Materials Centre

Energy Star

UL Classified

Health Product Declaration (HPD)

Visit Greenfiber for more product information

Sanctuary® Blow-In or Spray-Applied Insulation

MasterFormat® 07 20 00

SANCTUARY Fact Sheet, Guide Specs

For spec help, contact us or call 800.228.0024

See LCA, interpretation & rating systems

SM Transparency Report (EPD)™

VERIFICATION	LCA
3rd-party reviewed	✓
Transparency Report (EPD)	
3rd-party verified	✓

Validity: 2022/12/09 – 2027/12/08

Decl #: AGG – 20221209 – 001

This environmental product declaration (EPD) was externally verified, according to ISO 21930:2017, UL Part A, and ISO 14025:2006, by Jack Geibig, President, Ecoform.

Ecoform, LLC
11903 Black Road,
Knoxville, TN 37932
www.ecoform.com
(865) 850-1883

SUMMARY

Reference PCR
ULE PCR Part B: Building Envelope Thermal Insulation EPD Requirements v2.0, 2018

Regions; system boundaries
North America; Cradle-to-grave

Functional unit / reference service life:
1 m^2 of installed insulation material, packaging included, with a thickness that gives an average thermal resistance of RSI=1m^2·K/W; 75 years

LCIA methodology: TRACI 2.1

LCA software; LCI database
SimaPro Developer 9.4
EcoInvent 3.8, US-EI 2.2

LCA conducted by: Sustainable Minds

Public LCA:
Life Cycle Assessment of SANCTUARY Insulation for Applegate-Greenfiber

Greenfiber
5500 77 Center Drive
Suite 100
Charlotte, NC 28217
greenfiber.com
(800) 228-0024

Contact us

LCA results & interpretation

SANCTUARY® Loose-Fill or Spray-Applied Insulation by Greenfiber®

Life cycle assessment

Scope and summary

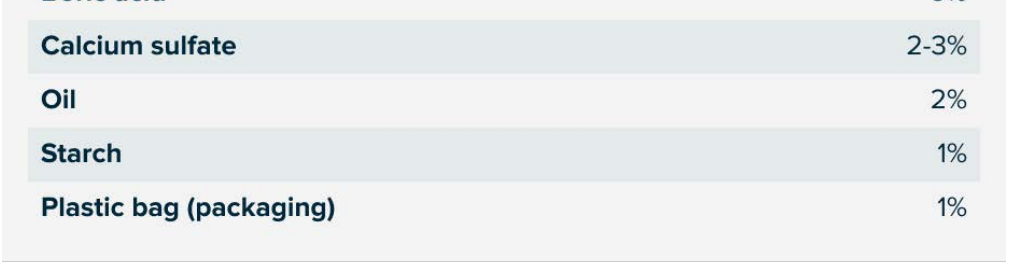
○ Cradle to gate ○ Cradle to gate with options ✔ Cradle to grave

Application
SANCTUARY is insulation primarily made of postconsumer paper and can be either blown-in or spray-applied in attics, walls, floors, and ceilings. This fiber insulation is suitable for all climates and conditions. SANCTUARY is engineered to fill tiny crevices and gaps, creating a dense, advanced barrier capable of reducing the power of sound and also heating and cooling costs. It can be easily filled over existing insulation and is designed to fill every gap, void, and hard-to-reach place without time consuming cutting and fitting.

Functional unit
Reference service life: 75 years. One square meter of installed insulation material, packaging included, with a thickness that gives an average thermal resistance of RSI=1m2·K/W over a period of 75 years.
Reference flow: 0.653 kg
Thickness: 0.0378 m
Density: 17.1 kg/m3

Manufacturing data
Reporting period: January--December, 2021
Representing six locations across the US: Mesa, AZ; Norfolk, NE; Salt Lake City, UT; Tampa, FL; Waco, TX; and Wilkes-Barre, PA. After raw materials are transported to the facilities, incoming wastepaper is shredded and placed into a fiber handling system, which is then moved to the finish mills, where the final grind is conducted and the dry fire-retardant chemicals and then a liquid fire retardant are added. That product is moved to the packaging subsystem, which hydraulically compresses the insulation into its final packaging. Each facility has a dust collection system which traps the dust from the wastepaper processing and is later sent for recycling along with production scrap.

Default installation, packaging, and disposal scenarios
At the installation site, insulation products are delivered in 25lb bags, unpackaged, and installed with a blowing machine, assumed to consume 0.003 kWh of electricity during the installation of one square meter. The disposal of packaging waste is modeled using US EPA's landfilling rate of 37.1% and recycling rate of 53.9%. No maintenance or replacement is required to achieve the product's life span. After removal, the insulation is assumed to be landfilled.

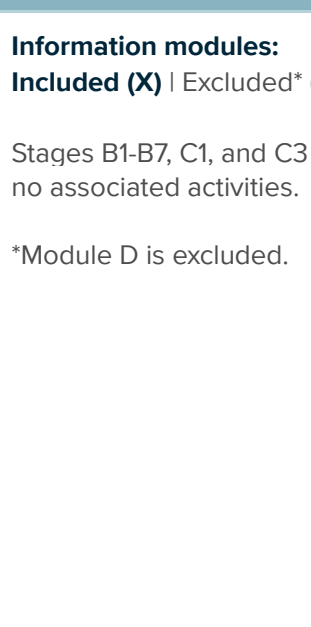


Data quality
Primary data was collected for a time period of one year, which represents typical operations of Applegate-Greenfiber facilities. Inventory data is considered to have a good precision and provide a representative depiction of the facilities. Data is also considered to be complete, as no know flows are deliberately excluded from this analysis other than those defined to be outside of the system boundary.

Material composition greater than 1% by weight

FLOW	MASS PERCENTAGE
Wastepaper	83-85%
Boric acid	9%
Calcium sulfate	2-3%
Oil	2%
Starch	1%
Plastic bag (packaging)	1%

Total impacts by life cycle stages [mPts/per func unit]



LIFE CYCLE STAGE	MPTS/FUNC. UNIT
Raw material supply and transport	1.84E-02
Manufacturing	2.70E-03
Distribution	4.27E-03
Installation and use	3.90E-05
End of life	7.67E-04

What's causing the greatest impacts

All life cycle stages
For SANCTUARY insulation, the cradle-to-gate stage (A1-A3) dominates the results for most categories. This study assessed a multitude of inventory and environmental indicators. In addition to the six major impact categories (global warming potential, ozone depletion, acidification, smog, eutrophication, and fossil fuel depletion), additional impact categories have also been included. These 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. LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Overall results are consistent with expectations for SANCTUARY's life cycle, with most of the impacts being generated during cradle-to-gate stages, as insulation is not associated with energy consumption during its installation, use, or disposal stages.

Raw materials acquisition and manufacturing
The primary finding, across the environmental indicators and for the product considered, was that cradle-to-gate impacts contribute the most impacts to most categories. This is mostly driven by the extraction of incoming raw materials (A1) and electricity consumed during manufacturing (A3). Boric acid and oil use are the raw materials that contribute to higher environmental impacts than the others. No substances required to be reported as hazardous are associated with the production of this product.

Transportation
Following the cradle-to-gate stage, the next highest impacts come from the distribution (A4) stage. The impacts associated with outbound transport are comparatively higher than that for inbound due to the further transportation distances.

Installation
Installation accounts for a small fraction of overall life cycle impacts. The only installation impacts are associated with packaging disposal and the energy used for an installation blower machine. No ancillary materials are needed for installation.

End of life
At the end of life, insulation is removed from the building and landfilled. For all products, waste was dominated by the final disposal of the product. Non-hazardous waste also accounts for waste generated during manufacturing and installation. No hazardous waste is created.

Sensitivity analysis
The electricity consumed during production drives the overall impacts in each impact category. Since the manufacturing stage is one of the major contributors to life cycle impacts, a sensitivity analysis was performed to check the robustness of the results when the energy consumed is varied by ±20%. The resulting variation in the total life cycle impacts is less than 10%, implying that the system is not sensitive to this assumed value.

Scaling factors
Scaling factors can be used to determine the impacts of each R-value of SANCTUARY Insulation based on different applications (loose and stabilized, dense pack, or spray-filled application). Loose-fill cellulose insulation is typically applied to enclosed areas, unfinished attic floors, and other hard to reach places, so the results per functional unit are presented for a loose-filled and stabilized application at RSI=1 m^2·K/W. The scaling factors are based on the mass and thickness of SANCTUARY and can be used to determine the impacts for each R-value when multiplied by the functional unit. **See the scaling factors on Page 4 >**

SANCTUARY® Cellulose Insulation is made from living trees that lock in carbon for the life of the product. Couple this with low-energy manufacturing and short-haul transportation, and it's clear why cellulose insulation is the responsible choice for homeowners and the planet. Selecting low-carbon building material options can dramatically reduce emissions while providing the same level of building performance, or higher. As insulation levels in buildings increase to meet higher energy efficiency requirements, choosing insulation products based on their embodied carbon is crucial. Since cellulose insulation is derived from trees, it sequesters carbon in the walls and ceilings of homes, a feature not seen in other types of insulation products that are commercially available.

See how we make it greener

LCA results

LIFE CYCLE STAGE	RAW MATERIAL SUPPLY AND TRANSPORT	MANUFACTURING	DISTRIBUTION	INSTALLATION	USE	END OF LIFE
Information modules: Included (X) | Excluded* (MND) Stages B1-B7, C1, and C3 though included, have no associated activities. *Module D is excluded.	A1 Raw material extraction	A3 Manufacturing operations	A4 Transport to building sites	A5 Installation	B1 Use	C1 Deconstruction
	A2 Transport to facilities				B2 Maintenance	C2 Waste transport
					B3 Repair	C3 Waste processing
					B4 Replacements	C4 Disposal
					B5 Refurbishment	
					B6 Operational energy use	
					B7 Operational water use	

SM Single Score
Learn about SM Single Score results

Impacts per functional unit: weighted average of all plants	1.84E-02 mPts	2.70E-03 mPts	4.277E-03 mPts	3.90E-05 mPts	0 mPts	7.67E-04 mPts
Materials or processes contributing >20% to total impacts in each life cycle stage	Extraction of raw materials, especially boric acid and oil.	Electricity required to operate the manufacturing process.	Truck transportation for distribution of the product.	Electricity consumed by the blower during insulation.	No activities contributing to impacts in the use stage.	Truck transportation to the disposal site, and final waste landfill.

Mesa, AZ - TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A2 RM SUPPLY & TRANSPORT	A3 MANUFACTURING	A4 DISTRIBUTION	A5 INSTALLATION	B1-B7 USE	C1-C4 END OF LIFE
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.27E-03	3.24E-04	9.28E-05	1.93E-06	0	3.55E-05
Eutrophication	kg N eq	1.44E-04	2.72E-05	1.93E-05	4.48E-07	0	5.70E-06
Global warming (embodied carbon)	kg CO_2 eq	2.04E-01	8.33E-02	5.34E-02	7.53E-04	0	1.33E-02
Ozone depletion	kg CFC-11 eq	3.34E-08	2.29E-09	1.27E-08	8.70E-11	0	3.03E-09
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	2.76E-09	1.62E-10	4.90E-11	2.66E-12	0	1.03E-11
Non-carcinogenics	CTU_h	4.93E-08	2.73E-09	7.49E-09	5.15E-11	0	1.37E-09
Respiratory effects	kg $PM_{2.5}$ eq	1.99E-04	1.96E-05	1.87E-05	1.20E-06	0	5.54E-06
Smog	kg O_3 eq	1.25E-02	2.80E-03	1.19E-03	2.40E-05	0	7.20E-04
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	4.97E-01	1.12E-01	1.13E-01	1.03E-03	0	2.79E-02
Ecotoxicity	CTU_e	73.7 %	1.0 %	21.4 %	0.1 %	0 %	3.8 %

See the additional content required by the ULE PCR Part B for building envelope thermal insulation on page 4 of the **Transparency Report PDF**.

Norfolk, NE - TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A2 RM SUPPLY & TRANSPORT	A3 MANUFACTURING	A4 DISTRIBUTION	A5 INSTALLATION	B1-B7 USE	C1-C4 END OF LIFE
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.28E-03	5.13E-04	1.18E-04	1.91E-06	0	3.52E-05
Eutrophication	kg N eq	1.41E-04	4.85E-05	2.46E-05	4.43E-07	0	5.65E-06
Global warming (embodied carbon)	kg CO_2 eq	1.90E-01	1.06E-01	6.80E-02	7.46E-04	0	1.31E-02
Ozone depletion	kg CFC-11 eq	2.96E-08	3.16E-09	1.62E-08	8.62E-11	0	3.00E-09
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	2.75E-09	2.61E-10	6.24E-11	2.64E-12	0	1.02E-11
Non-carcinogenics	CTU_h	4.76E-08	4.29E-09	9.55E-09	5.10E-11	0	1.36E-09
Respiratory effects	kg $PM_{2.5}$ eq	1.98E-04	2.94E-05	2.38E-05	1.19E-06	0	5.48E-06
Smog	kg O_3 eq	1.35E-02	4.35E-03	1.52E-03	2.38E-05	0	7.13E-04
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	4.65E-01	8.96E-02	1.44E-01	1.02E-03	0	2.77E-02
Ecotoxicity	CTU_e	67.8 %	1.5 %	26.9 %	0.1 %	0 %	3.7 %

See the additional content required by the ULE PCR Part B for building envelope thermal insulation on page 4 of the **Transparency Report PDF**.

Salt Lake City, UT - TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A2 RM SUPPLY & TRANSPORT	A3 MANUFACTURING	A4 DISTRIBUTION	A5 INSTALLATION	B1-B7 USE	C1-C4 END OF LIFE
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.15E-03	2.05E-04	1.77E-04	1.91E-06	0	3.52E-05
Eutrophication	kg N eq	1.16E-04	1.72E-05	3.70E-05	4.43E-07	0	5.65E-06
Global warming (embodied carbon)	kg CO_2 eq	1.23E-01	5.28E-02	1.02E-01	7.46E-04	0	1.31E-02
Ozone depletion	kg CFC-11 eq	1.41E-08	1.46E-09	2.43E-08	8.62E-11	0	3.00E-09
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	2.70E-09	1.05E-10	9.37E-11	2.64E-12	0	1.02E-11
Non-carcinogenics	CTU_h	4.28E-08	1.74E-09	1.43E-08	5.10E-11	0	1.36E-09
Respiratory effects	kg $PM_{2.5}$ eq	1.82E-04	1.26E-05	3.58E-05	1.19E-06	0	5.48E-06
Smog	kg O_3 eq	1.14E-02	1.79E-03	2.28E-03	2.38E-05	0	7.13E-04
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	3.26E-01	7.32E-02	2.16E-01	1.02E-03	0	2.77E-02
Ecotoxicity	CTU_e	55.4 %	0.6 %	40.2 %	0.1 %	0 %	3.7 %

See the additional content required by the ULE PCR Part B for building envelope thermal insulation on page 4 of the **Transparency Report PDF**.

Tampa, FL - TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A2 RM SUPPLY & TRANSPORT	A3 MANUFACTURING	A4 DISTRIBUTION	A5 INSTALLATION	B1-B7 USE	C1-C4 END OF LIFE
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.16E-03	2.32E-04	1.21E-04	1.93E-06	0	3.55E-05
Eutrophication	kg N eq	1.20E-04	1.75E-05	2.52E-05	4.48E-07	0	5.70E-06
Global warming (embodied carbon)	kg CO_2 eq	1.37E-01	1.16E-01	6.97E-02	7.53E-04	0	1.33E-02
Ozone depletion	kg CFC-11 eq	1.77E-08	2.36E-09	1.66E-08	8.70E-11	0	3.03E-09
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	2.72E-09	1.07E-10	6.39E-11	2.66E-12	0	1.03E-11
Non-carcinogenics	CTU_h	4.51E-08	2.07E-09	9.78E-09	5.15E-11	0	1.37E-09
Respiratory effects	kg $PM_{2.5}$ eq	1.86E-04	1.52E-05	2.44E-05	1.20E-06	0	5.54E-06
Smog	kg O_3 eq	1.13E-02	2.43E-03	1.55E-03	2.40E-05	0	7.20E-04
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	3.58E-01	2.45E-01	1.48E-01	1.03E-03	0	2.79E-02
Ecotoxicity	CTU_e	65.9 %	0.9 %	29.2 %	0.1 %	0 %	4.0 %

See the additional content required by the ULE PCR Part B for building envelope thermal insulation on page 4 of the **Transparency Report PDF**.

Waco, TX - TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A2 RM SUPPLY & TRANSPORT	A3 MANUFACTURING	A4 DISTRIBUTION	A5 INSTALLATION	B1-B7 USE	C1-C4 END OF LIFE
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.16E-03	2.94E-04	7.81E-05	1.91E-06	0	3.52E-05
Eutrophication	kg N eq	1.16E-04	2.47E-05	1.63E-05	4.43E-07	0	5.65E-06
Global warming (embodied carbon)	kg CO_2 eq	1.23E-01	8.43E-02	4.49E-02	7.46E-04	0	1.31E-02
Ozone depletion	kg CFC-11 eq	1.40E-08	3.59E-09	1.07E-08	8.62E-11	0	3.00E-09
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	2.76E-09	1.52E-10	4.12E-11	2.64E-12	0	1.02E-11
Non-carcinogenics	CTU_h	4.45E-08	2.63E-09	6.31E-09	5.10E-11	0	1.36E-09
Respiratory effects	kg $PM_{2.5}$ eq	1.86E-04	1.83E-05	1.57E-05	1.19E-06	0	5.48E-06
Smog	kg O_3 eq	1.12E-02	2.65E-03	1.00E-03	2.38E-05	0	7.13E-04
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	3.26E-01	1.27E-01	9.52E-02	1.02E-03	0	2.77E-02
Ecotoxicity	CTU_e	71.3 %	1.3 %	22.5 %	0.1 %	0 %	4.7 %

See the additional content required by the ULE PCR Part B for building envelope thermal insulation on page 4 of the **Transparency Report PDF**.

Wilkes-Barr, PA - TRACI v2.1 results per functional unit

LIFE CYCLE STAGE		A1-A2 RM SUPPLY & TRANSPORT	A3 MANUFACTURING	A4 DISTRIBUTION	A5 INSTALLATION	B1-B7 USE	C1-C4 END OF LIFE
Ecological damage							
Impact category	Unit						
Acidification	kg SO_2 eq	1.21E-03	2.24E-04	1.07E-04	1.91E-06	0	3.52E-05
Eutrophication	kg N eq	1.27E-04	1.88E-05	2.23E-05	4.43E-07	0	5.65E-06
Global warming (embodied carbon)	kg CO_2 eq	1.53E-01	5.13E-02	6.17E-02	7.46E-04	0	1.31E-02
Ozone depletion	kg CFC-11 eq	2.20E-08	2.78E-09	1.47E-08	8.62E-11	0	3.00E-09
Human health damage							
Impact category	Unit						
Carcinogenics	CTU_h	2.65E-09	1.19E-10	5.66E-11	2.64E-12	0	1.02E-11
Non-carcinogenics	CTU_h	4.87E-08	1.82E-09	8.66E-09	5.10E-11	0	1.36E-09
Respiratory effects	kg $PM_{2.5}$ eq	2.00E-04	1.36E-05	2.16E-05	1.19E-06	0	5.48E-06
Smog	kg O_3 eq	1.18E-02	1.89E-03	1.38E-03	2.38E-05	0	7.13E-04
Additional environmental information							
Impact category	Unit						
Fossil fuel depletion	MJ, LHV	3.74E-01	6.38E-02	1.31E-01	1.02E-03	0	2.77E-02
Ecotoxicity	CTU_e	69.4 %	0.8 %	25.8 %	0.1 %	0 %	3.9 %

See the additional content required by the ULE PCR Part B for building envelope thermal insulation on page 4 of the **Transparency Report PDF**.

References

LCA Background Report
Applegate-Greenfiber SANCTUARY LCA Background Report (public version), Applegate-Greenfiber 2022; SimaPro Analyst 9.4; Ecoinvent v3 and US ecoinvent (US -EI 2.2) database; TRACI 2.1.

PCRs

ISO 21930:2017 serves as the core PCR along UL Part A.

ULE PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements v3.1
February, 2018. Technical Advisory Panel members reviewed and provided feedback on content written by UL Environment and USGBC. Past and present members of the Technical Advisory Panel are listed in the PCR.

ULE PCR Part B: Building Envelope Thermal Insulation EPD Requirements v2.0
April 2018. PCR review conducted by: Thomas Gloria, PhD (Industrial Ecology Consultants); Christoph Koffler, PhD (thinkstep); and Andre Desjarlais (Oak Ridge National Laboratory).

UL Environment General Program Instructions v2.5, March 2021 (available upon request)

ISO 14025, "Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services"

Download PDF SM Transparency Report, which includes the additional EPD content required by the UL Environment PCR.

SM Transparency Reports (TR) are ISO 14025 Type III environmental declarations (EPD) that enable purchasers and users to compare the potential environmental performance of products on a life cycle basis. Environmental declarations from different programs (ISO 14025) may not be comparable. Comparison of the environmental performance of Building Envelope Thermal Insulation 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 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 differences results for upstream or downstream of the life cycle stages declared.

Rating systems

The intent is to reward project teams for selecting products from manufacturers who have verified improved life-cycle environmental performance.

LEED BD+C: New Construction | v4 - LEED v4
Building product disclosure and optimization
Environmental product declarations

○ Industry-wide (generic) EPD	½ product
✔ Product-specific Type III EPD	1 product

LEED BD+C: New Construction | v4.1 - LEED v4.1
Building product disclosure and optimization
Environmental product declarations

○ Industry-wide (generic) EPD	½ product
✔ Product-specific Type III EPD	1 product

Collaborative for High Performance Schools National Criteria
MW 7.1 – Environmental Product Declarations

✔ Third-party certified type III EPD	2 points

BREEAM New Construction 2018
Mat 02 - Environmental impacts from construction products
Environmental Product Declarations (EPD)

○ Industry average EPD	.5 points
○ Multi-product specific EPD	.75 points
✔ Product specific EPD	1 point

SM Transparency Report (EPD)™

VERIFICATION	LCA
3rd-party reviewed	✔
	Transparency Report (EPD)
3rd-party verified	✔

Validity: 2022/12/09 – 2027/12/08
Decl #: AGG – 20221209 – 001

This environmental product declaration (EPD) was externally verified, according to ISO 21930:2017, UL Part A, and ISO 14025:2006, by Jack Geibig, President, Ecoform.

Ecoform, LLC
11903 Black Road,
Knoxville, TN 37932
www.ecoform.com
(865) 850-1883

SUMMARY
Reference PCR
ULE PCR Part B: Building Envelope Thermal Insulation EPD Requirements v2.0, 2018
Regions; system boundaries
North America; Cradle-to-grave
Functional unit / reference service life:
1 m^2 of installed insulation material, packaging included, with a thickness that gives an average thermal resistance of RSI=1m²·K/W; 75 years
LCIA methodology: TRACI 2.1
LCA software; LCI database
SimaPro Developer 9.4
EcoInvent 3.8, US-EI 2.2
LCA conducted by: Sustainable Minds
Public LCA:
Life Cycle Assessment of SANCTUARY Insulation for Applegate-Greenfiber

Greenfiber
5500 77 Center Drive
Suite 100
Charlotte, NC 28217
greenfiber.com
(800) 228-0024

Contact us

How we make it greener

SANCTUARY® Loose-Fill or Spray-Applied Insulation by Greenfiber®

Collapse all

See LCA results by life cycle stage

RAW MATERIAL ACQUISITION

85% Recycled Content

SANCTUARY® Cellulose Insulation is made from up to 85% recycled paper, and cardboard—higher recycled content than almost any other commonly used building material. This plant-based, or biogenic, material locks more carbon into the paper (and out of the air) than what was emitted in harvesting and manufacturing. This opens up a new category of building materials with carbon removal and storage potential. When added to homes, cellulose insulation traps that carbon for the life of the home, effectively lowering the carbon footprint of homes.

TRANSPORTATION

Regional Transportation

The Applegate-Greenfiber® supply chain is sustainably focused, as we have a plant in each region of the country to keep the delivery of raw materials and shipping of finished product to within a 500 mile radius of each plant, lowering resulting fuel emissions.

Our SANCTUARY® Insulation is also compressively packaged to 6x, or more, nominal settled density for maximum transportation efficiency. This compressive packaging allows for fewer deliveries and more cellulose insulation on the transportation vehicle.

MANUFACTURING

Low-Energy Manufacturing

Our electric powered plants use low-energy manufacturing processes that generate zero waste, other than dust, which is confined within the production system and filtered out of the air that gets discharged into the atmosphere. We even recycle that dust, and the paper scrap from production, back into the product. Fire retardants used in our insulation are considered to be of low or no toxicity. Improvements in fire retardant processing and infusion technology have resulted in historically low fire retardant content with no loss of fire safety.

Applegate-Greenfiber's process diverts about 277,000 TONS of paper from landfills each year, equivalent to 157,000 ACRES of forest.

USE AND END OF LIFE

Protecting People and the Environment

With SANCTUARY® Insulation, the same attributes that contribute to the low global warming potential make it a great choice for homeowners who desire more sustainable, healthy homes. If you're torn between cellulose and other insulation alternatives, consider this breakdown of greenhouse gas impact, recycled content and toxic emissions. Non-irritating cellulose insulation requires no special protective clothing during installation. Our insulation products has been tested for VOC emission and have been found to be low VOC sources.

Most construction projects have large dumpsters on site full of construction waste and debris from building products that end up in the waste stream and require shipping to landfills, further impacting the environment. Our insulation is fully recovered and reused on-site when installed, leaving virtually no excess material to return to the waste stream. Special machines used in the blown-in process allow excess or over spayed material to be vacuumed up and be blown back in on site or salvaged for a future installation.

Low Carbon Footprint Homes

Research on the use of wood-intensive construction and cellulose insulation products in homes shows it is possible to lower the carbon footprint of houses, so they become "carbon sinks" capable of locking in carbon for the life of the dwelling. The carbon rich wood and cellulose wood fiber stays in the home for years effectively trapping the carbon from escaping into the environment.

SM Transparency Report (EPD)™

VERIFICATION	LCA
3rd-party reviewed	✓
Transparency Report (EPD)	
3rd-party verified	✓

Validity: 2022/12/09 – 2027/12/08

Decl #: AGG – 20221209 – 001

This environmental product declaration (EPD) was externally verified, according to ISO 21930:2017, UL Part A, and ISO 14025:2006, by Jack Geibig, President, Ecoform.

Ecoform, LLC
11903 Black Road,
Knoxville, TN 37932
www.ecoform.com
(865) 850-1883

SUMMARY

Reference PCR
ULE PCR Part B: Building Envelope Thermal Insulation EPD Requirements v2.0, 2018

Regions; system boundaries
North America; Cradle-to-grave

Functional unit / reference service life:
1 m^2 of installed insulation material, packaging included, with a thickness that gives an average thermal resistance of RSI=1m^2·K/W; 75 years

LCIA methodology: TRACI 2.1

LCA software; LCI database
SimaPro Developer 9.4
EcoInvent 3.8, US-EI 2.2

LCA conducted by: Sustainable Minds

Public LCA:
Life Cycle Assessment of SANCTUARY Insulation for Applegate-Greenfiber

Greenfiber
5500 77 Center Drive
Suite 100
Charlotte, NC 28217
greenfiber.com
(800) 228-0024

Contact us

Additional EPD content required by: ULE PCR Part B: Building Envelope Thermal Insulation EPD Requirements

SANCTUARY Insulation

Data

Background This product-specific declaration was created by collecting production data from six Applegate-Greenfiber facilities. Secondary data sources include EcoInvent 3.8 and US-EI 2.2.

Allocation The allocation methods used were examined according to the updated allocation rules in ISO 21930:2017. All facilities provided annual data for the studied product. Manufacturing inputs were allocated by mass using the amount of SANCTUARY produced compared to total production for CY2021. Based on annual production mass, the inventory (material and resources inputs and outputs) was developed for each facility for the production of a 25lb bag of SANCTUARY Insulation, which was later scaled to meet the functional unit. No further allocation was performed.

Cut-off criteria for the inclusion of mass and energy flows are 1% of renewable primary resource (energy) usage, 1% nonrenewable primary resource (energy) usage, 1% of the total mass input of that unit process, and 1% of environmental impacts. The total of neglected input flows per module does not exceed 5% of energy usage, mass, and environmental impacts. The only exceptions to these criteria are substances with hazardous and toxic properties, which must be listed even when the given process unit is under the cut-off criterion of 1% of the total mass. No known flows are deliberately excluded from this declaration; therefore, these criteria have been met. Biogenic carbon is included in reported results.

Quality Temporal and technological representativeness are considered to be high. Geographical representativeness is considered to be good. All relevant process steps for the product system were considered and modeled. The process chain is considered sufficiently complete with regards to the goal and scope of this study. The product system was checked for mass balance and completeness of the inventory. Capital equipment was excluded as required by the PCR. Otherwise, no data were knowingly omitted. For more information on data quality, see the LCA background report.

Major system boundary exclusions:

- Capital goods & infrastructure; maintenance and operation of support equipment;
- Manufacture & transport of packaging materials not associated with final product;
- Human labor and employee transport;
- Building operational energy and water use not associated with final product.

Major assumptions and limitations:

- Generic data sets used for material inputs, transport, and waste processing are considered good quality, but actual impacts from material suppliers, transport carriers, and local waste processing may vary.
- The impact assessment methodology categories do not represent all possible environmental impact categories.
- Characterization factors used within the impact assessment methodology may contain varying levels of uncertainty.
- LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Relevant technical properties

Loose-fill applications are in accordance with ASTM C739, and stabilized applications are for professional installers only using specialized equipment in accordance with ASTM C1497. Installation musty comply with ASTM C1015, as applicable, and Applegate-Greenfiber installation instructions for each application. 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. The thermal resistance (R-value) is determined by ASTM C518.

Scaling factors

The scaling factors below are based on the mass and thickness of SANCTUARY and can be used to determine the impacts for each R-value. Multiply the results per functional unit by the corresponding scaling factor for the R-value of interest in order to get results for your specific application.

Scenarios and additional technical information

PARAMETER	VALUE	UNIT
Transport to the building site [A4]		
Vehicle type	Lorry, 16-32 ton	
Fuel type	Diesel	
Liters of fuel	42	l/100 km
Distance from manufacturer to installation site	558	km (Mesa, AZ)
	711	km (Norfolk, NE)
	1,069	km (Salt Lake City, UT)
	729	km (Tampa, FL)
	470	km (Waco, TX)
	645	km (Wilkes-Barre, PA)
Capacity utilization (mass based)	76	%
Capacity utilization volume factor	>1	
Gross density of products transported	144	kg/m³ (compressed in bag)

Installation into the building [A5]

Installation scrap assumed	1	%
Electricity consumption	0.003	kWh
Product loss per functional unit (scrap)	0.00649	kg
Waste materials at the construction site before waste processing (product scrap and packaging waste)	0.0109	kg
Output materials from on-site waste processing		
Landfill	0.004	kg
Recycling	0.006	kg
Biogenic carbon contained in packaging	0	kg CO_2
VOC emissions	0	µg/m³

The final evaluation report addressing all standards required for the testing, evaluation, and approval of the declared product and its application in building assemblies for building code and other regulation compliance is available at: https://www.greenfiber.com/uploads/documents/UL-Evaluation-Report.pdf

Reference service life

Reference Service Life (RSL)	75	years
Declared product properties	Refer to 'Relevant technical properties'	
Design application parameters, indoor environment	Installation as recommended by the manufacturer, either blown-in or spray-applied in attics, walls, floors, and ceilings	
Maintenance process information	Not expected to require maintenance, repair, replacement, or refurbishment	
Use conditions	Expected to be undisturbed during use, no associated operational energy or water use	

End of life [C1-C4]

Assumptions for scenario development	Manual deconstruction, sent to landfill by truck		
Collection process	Collected separately	0	kg
	Collected with mixed construction waste	0.648	kg
Recovery	Reuse	0	kg
	Recycling	0	kg
	Landfill	0	kg
Waste transport		100	km
Final disposal (landfill)		0.648	kg
Removals of biogenic carbon (excluding packaging)		0	kg CO_2

Scaling factors table

Application	Loose-filled and stabilized application														Dense pack application			Spray-applied application	
R-value	11	13	19	22	26	30	32	38	40	44	48	49	50	60	13	21	28	13	21
Scaling factor	1.09	1.10	1.12	1.13	1.18	1.22	1.25	1.33	1.35	1.39	1.43	1.43	1.43	1.51	3.28	3.27	3.28	2.54	2.54

Mesa, AZ: LCIA results, resource use, output and waste flows, and carbon emissions & removals per functional unit

LCIA results (per m^2 installed including packaging, that gives an average thermal resistance of RSI=1m²·K/W)

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Ozone depletion	kg CFC-11 eq	6.01E-09	2.73E-08	2.29E-09	1.27E-08	8.70E-11	0	0	2.76E-09	0	2.74E-10	**5.15E-08**
Global warming	kg CO_2 eq	8.82E-02	1.16E-01	8.33E-02	5.34E-02	7.53E-04	0	0	1.17E-02	0	1.61E-03	**3.55E-01**
Smog	kg O_3 eq	1.02E-02	2.37E-03	2.80E-03	1.19E-03	2.40E-05	0	0	2.53E-04	0	4.68E-04	**1.73E-02**
Acidification	kg SO_2 eq	1.07E-03	1.94E-04	3.24E-04	9.28E-05	1.93E-06	0	0	2.00E-05	0	1.55E-05	**1.72E-03**
Eutrophication	kg N eq	1.02E-04	4.12E-05	2.72E-05	1.93E-05	4.48E-07	0	0	4.18E-06	0	1.52E-06	**1.96E-04**
Carcinogenics	CTUh	2.67E-09	9.13E-11	1.62E-10	4.90E-11	2.66E-12	0	0	9.85E-12	0	4.71E-13	**2.99E-09**
Non-carcinogenics	CTUh	3.82E-08	1.11E-08	2.73E-09	7.49E-09	5.15E-11	0	0	1.35E-09	0	1.86E-11	**6.09E-08**
Respiratory effects	kg $PM_{2.5}$ eq	1.69E-04	3.05E-05	1.96E-05	1.87E-05	1.20E-06	0	0	3.52E-06	0	2.01E-06	**2.44E-04**
Ecotoxicity	CTUe	43.4%	30.4%	1.0%	21.4%	<1%	0%	0%	3.8%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	2.54E-01	2.43E-01	1.12E-01	1.13E-01	1.03E-03	0	0	2.45E-02	0	3.41E-03	**7.51E-01**

Resource use indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	5.18E-02	1.55E-03	2.33E-01	7.20E-04	6.73E-04	0	0	1.55E-04	0	3.50E-05	**2.88E-01**
Renewable primary resources with energy content used as material	MJ, LHV	2.00E-01	5.65E-04	2.56E-02	0	2.05E-04	0	0	0	0	0	**2.27E-01**
Total use of renewable primary resources with energy content	MJ, LHV	2.52E-01	2.11E-03	2.58E-01	7.20E-04	8.78E-04	0	0	1.55E-04	0	3.50E-05	**5.14E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	1.98E+00	1.62E+00	1.26E+00	7.55E-01	1.22E-02	0	0	1.62E-01	0	2.23E-02	**5.81E+00**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.75E-04	4.85E-06	2.37E-06	0	2.40E-08	0	0	0	0	0	**1.82E-04**
Total use of non-renewable primary resources with energy content	MJ, LHV	1.98E+00	1.62E+00	1.26E+00	7.55E-01	1.22E-02	0	0	1.62E-01	0	2.23E-02	**5.81E+00**
Secondary materials	kg		0	0	0	0	0	0	0	0	0	**5.67E-01**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m³	1.79E-01	8.05E-03	4.84E-03	3.74E-03	2.98E-03	0	0	8.04E-04	0	3.92E-06	**1.99E-01**

Output flows and waste category indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.86E-03	0	8.50E-03	0	0	0	0	0	**1.04E-02**
High-level radioactive waste, conditioned, to final repository	kg	2.18E-05	5.59E-07	3.06E-06	2.60E-07	8.10E-07	0	0	5.58E-08	0	2.39E-09	**2.65E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.09E-08	2.40E-07	3.00E-08	1.12E-07	1.17E-09	0	0	2.40E-08	0	2.52E-11	**4.58E-07**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	0	0	1.78E-02	0	6.47E-03	0	0	0	0	0	**2.43E-02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**

Carbon emissions and removals

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Biogenic carbon removal from product	kg CO_2	1.04E+00	0	5.76E-02	0	0	0	0	0	0	0	**1.10E+00**
Biogenic carbon emission from product	kg CO_2	0	0	2.06E-02	0	3.69E-03	0	0	0	0	9.98E-01	**1.02E+00**
Biogenic carbon removal from packaging	kg CO_2	2.54E-04	0	0	0	0	0	0	0	0	0	**2.54E-04**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**

Norfolk, NE: LCIA results, resource use, output and waste flows, and carbon emissions & removals per functional unit

LCIA results (per m^2 installed including packaging, that gives an average thermal resistance of RSI=1m²·K/W)

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Ozone depletion	kg CFC-11 eq	6.01E-09	2.36E-08	3.16E-09	1.62E-08	8.62E-11	0	0	2.76E-09	0	2.74E-10	**5.15E-08**
Global warming	kg CO_2 eq	8.82E-02	1.01E-01	1.06E-01	6.80E-02	7.46E-04	0	0	1.17E-02	0	1.61E-03	**3.55E-01**
Smog	kg O_3 eq	1.02E-02	3.36E-03	4.35E-03	1.52E-03	2.38E-05	0	0	2.53E-04	0	4.68E-04	**1.73E-02**
Acidification	kg SO_2 eq	1.07E-03	2.10E-04	5.13E-04	1.18E-04	1.91E-06	0	0	2.00E-05	0	1.55E-05	**1.72E-03**
Eutrophication	kg N eq	1.02E-04	3.82E-05	4.58E-05	2.46E-05	4.43E-07	0	0	4.18E-06	0	1.52E-06	**1.96E-04**
Carcinogenics	CTUh	2.67E-09	8.27E-11	2.61E-10	6.24E-11	2.64E-12	0	0	9.85E-12	0	4.71E-13	**2.99E-09**
Non-carcinogenics	CTUh	3.82E-08	9.40E-09	4.29E-09	9.55E-09	5.10E-11	0	0	1.35E-09	0	1.86E-11	**6.09E-08**
Respiratory effects	kg $PM_{2.5}$ eq	1.69E-04	2.98E-05	2.94E-05	2.38E-05	1.19E-06	0	0	3.52E-06	0	2.01E-06	**2.44E-04**
Ecotoxicity	CTUe	42.8%	25.1%	1.5%	26.9%	<1%	0%	0%	3.7%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	2.54E-01	2.11E-01	8.96E-02	1.44E-01	1.02E-03	0	0	2.45E-02	0	3.41E-03	**7.51E-01**

Resource use indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	5.18E-02	2.54E-03	2.23E-01	9.17E-04	6.80E-04	0	0	1.56E-04	0	3.54E-05	**2.79E-01**
Renewable primary resources with energy content used as material	MJ, LHV	2.00E-01	6.16E-04	1.86E-02	0	2.05E-04	0	0	0	0	0	**2.20E-01**
Total use of renewable primary resources with energy content	MJ, LHV	2.52E-01	3.16E-03	2.42E-01	9.17E-04	8.85E-04	0	0	1.56E-04	0	3.54E-05	**4.99E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	1.98E+00	1.42E+00	1.46E+00	9.62E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**6.01E+00**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.87E-04	1.75E-04	6.22E-06	0	2.87E-06	0	0	0	0	0	**3.71E-04**
Total use of non-renewable primary resources with energy content	MJ, LHV	1.98E+00	1.42E+00	1.46E+00	9.62E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**6.01E+00**
Secondary materials	kg	5.83E-01	0	0	0	0	0	0	0	0	0	**5.83E-01**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m³	1.79E-01	1.27E-02	6.09E-03	4.77E-03	2.98E-03	0	0	8.04E-04	0	3.92E-06	**2.06E-01**

Output flows and waste category indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.86E-03	0	8.50E-03	0	0	0	0	0	**1.04E-02**
High-level radioactive waste, conditioned, to final repository	kg	2.20E-05	1.14E-06	3.33E-06	3.34E-07	8.10E-07	0	0	5.58E-08	0	2.39E-09	**2.77E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.14E-08	2.12E-07	3.30E-08	1.44E-07	1.17E-09	0	0	2.40E-08	0	2.52E-11	**4.65E-07**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	0	0	3.34E-02	0	6.47E-03	0	0	0	0	0	**3.98E-02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**

Carbon emissions and removals

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Biogenic carbon removal from product	kg CO_2	1.07E+00	0	5.76E-02	0	0	0	0	0	0	0	**1.13E+00**
Biogenic carbon emission from product	kg CO_2	0	0	3.85E-02	0	3.69E-03	0	0	0	0	9.98E-01	**1.04E+00**
Biogenic carbon removal from packaging	kg CO_2	2.54E-04	0	0	0	0	0	0	0	0	0	**2.54E-04**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**

Salt Lake City, UT: LCIA results, resource use, output & waste flows, & carbon emissions & removals per functional unit

LCIA results (per m^2 installed including packaging, that gives an average thermal resistance of RSI=1m²·K/W)

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Ozone depletion	kg CFC-11 eq	6.01E-09	8.06E-09	1.46E-09	2.43E-08	8.62E-11	0	0	2.73E-09	0	2.72E-10	**4.30E-08**
Global warming	kg CO_2 eq	8.82E-02	3.44E-02	5.28E-02	1.02E-01	7.46E-04	0	0	1.15E-02	0	1.59E-03	**2.91E-01**
Smog	kg O_3 eq	1.02E-02	1.24E-03	1.79E-03	2.28E-03	2.38E-05	0	0	2.50E-04	0	4.63E-04	**1.62E-02**
Acidification	kg SO_2 eq	1.07E-03	7.44E-05	2.05E-04	1.77E-04	1.91E-06	0	0	1.98E-05	0	1.54E-05	**1.57E-03**
Eutrophication	kg N eq	1.02E-04	1.32E-05	1.72E-05	3.70E-05	4.43E-07	0	0	4.14E-06	0	1.50E-06	**1.76E-04**
Carcinogenics	CTUh	2.67E-09	3.24E-11	1.05E-10	9.37E-11	2.64E-12	0	0	9.75E-12	0	4.67E-13	**2.91E-09**
Non-carcinogenics	CTUh	3.82E-08	4.65E-09	1.74E-09	1.43E-08	5.10E-11	0	0	1.34E-09	0	1.85E-11	**6.03E-08**
Respiratory effects	kg $PM_{2.5}$ eq	1.69E-04	1.31E-05	1.26E-05	3.58E-05	1.19E-06	0	0	3.49E-06	0	1.99E-06	**2.37E-04**
Ecotoxicity	CTUe	42.5%	12.9%	<1%	40.2%	<1%	0%	0%	3.7%%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	2.54E-01	7.23E-02	7.32E-02	2.16E-01	1.02E-03	0	0	2.43E-02	0	3.38E-03	**6.45E-01**

Resource use indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	5.18E-02	9.07E-04	1.46E-01	1.38E-03	6.80E-04	0	0	1.56E-04	0	3.54E-05	**2.01E-01**
Renewable primary resources with energy content used as material	MJ, LHV	2.00E-01	2.14E-04	1.60E-02	0	2.05E-04	0	0	0	0	0	**2.17E-01**
Total use of renewable primary resources with energy content	MJ, LHV	2.52E-01	1.12E-03	1.62E-01	1.38E-03	8.85E-04	0	0	1.56E-04	0	3.54E-05	**4.17E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	1.98E+00	4.85E-01	8.12E-01	1.44E+00	1.23E-02	0	0	1.64E-01	0	2.26E-02	**4.92E+00**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.75E-04	2.19E-06	2.36E-06	0	2.42E-08	0	0	0	0	0	**1.79E-04**
Total use of non-renewable primary resources with energy content	MJ, LHV	1.98E+00	4.85E-01	8.12E-01	1.44E+00	1.23E-02	0	0	1.64E-01	0	2.26E-02	**4.92E+00**
Secondary materials	kg	5.64E-01	0	0	0	0	0	0	0	0	0	**5.64E-01**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m³	1.79E-01	4.53E-03	4.23E-03	7.16E-03	2.98E-03	0	0	8.04E-04	0	3.92E-06	**1.99E-01**

Output flows and waste category indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.86E-03	0	8.50E-03	0	0	0	0	0	**1.04E-02**
High-level radioactive waste, conditioned, to final repository	kg	2.18E-05	4.04E-07	2.07E-06	4.97E-07	8.10E-07	0	0	5.58E-08	0	2.39E-09	**2.56E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.09E-08	7.16E-08	1.91E-08	2.14E-07	1.17E-09	0	0	2.40E-08	0	2.52E-11	**3.81E-07**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	0	0	1.49E-02	0	6.47E-03	0	0	0	0	0	**2.14E-02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**

Carbon emissions and removals

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Biogenic carbon removal from product	kg CO_2	1.04E+00	0	5.76E-02	0	0	0	0	0	0	0	**1.10E+00**
Biogenic carbon emission from product	kg CO_2	0	0	1.72E-02	0	3.69E-03	0	0	0	0	9.98E-01	**1.02E+00**
Biogenic carbon removal from packaging	kg CO_2	2.54E-04	0	0	0	0	0	0	0	0	0	**2.54E-04**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**

Tampa, FL: LCIA results, resource use, output and waste flows, and carbon emissions & removals per functional unit

LCIA results (per m^2 installed including packaging, that gives an average thermal resistance of RSI=1m²·K/W)

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Ozone depletion	kg CFC-11 eq	6.01E-09	1.17E-08	2.36E-09	1.66E-08	8.70E-11	0	0	2.76E-09	0	2.74E-10	**3.98E-08**
Global warming	kg CO_2 eq	8.82E-02	4.90E-02	1.16E-01	6.97E-02	7.53E-04	0	0	1.17E-02	0	1.61E-03	**3.37E-01**
Smog	kg O_3 eq	1.02E-02	1.09E-03	2.43E-03	1.55E-03	2.40E-05	0	0	2.53E-04	0	4.68E-04	**1.60E-02**
Acidification	kg SO_2 eq	1.07E-03	8.51E-05	2.32E-04	1.21E-04	1.93E-06	0	0	2.00E-05	0	1.55E-05	**1.55E-03**
Eutrophication	kg N eq	1.02E-04	1.77E-05	1.75E-05	2.52E-05	4.48E-07	0	0	4.18E-06	0	1.52E-06	**1.69E-04**
Carcinogenics	CTUh	2.67E-09	4.49E-11	1.07E-10	6.39E-11	2.66E-12	0	0	9.85E-12	0	4.71E-13	**2.90E-09**
Non-carcinogenics	CTUh	3.82E-08	6.88E-09	2.07E-09	9.78E-09	5.15E-11	0	0	1.35E-09	0	1.86E-11	**5.83E-08**
Respiratory effects	kg $PM_{2.5}$ eq	1.69E-04	1.72E-05	1.52E-05	2.44E-05	1.20E-06	0	0	3.52E-06	0	2.01E-06	**2.32E-04**
Ecotoxicity	CTUe	45.3%	20.5%	<1%	29.2%	<1%	0%	0%	4.0%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	2.54E-01	1.04E-01	2.45E-01	1.48E-01	1.03E-03	0	0	2.45E-02	0	3.41E-03	**7.79E-01**

Resource use indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	5.18E-02	6.61E-04	1.19E-02	9.40E-04	6.80E-04	0	0	1.56E-04	0	3.54E-05	**6.61E-02**
Renewable primary resources with energy content used as material	MJ, LHV	2.00E-01	2.41E-04	4.68E-02	0	2.05E-04	0	0	0	0	0	**2.48E-01**
Total use of renewable primary resources with energy content	MJ, LHV	2.52E-01	9.02E-04	5.87E-02	9.40E-04	8.85E-04	0	0	1.56E-04	0	3.54E-05	**3.14E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	1.98E+00	6.93E-01	1.98E+00	9.86E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**5.83E+00**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.75E-04	2.07E-06	2.38E-06	0	2.42E-08	0	0	0	0	0	**1.79E-04**
Total use of non-renewable primary resources with energy content	MJ, LHV	1.98E+00	6.93E-01	1.98E+00	9.86E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**5.83E+00**
Secondary materials	kg	5.83E-01	0	0	0	0	0	0	0	0	0	**5.83E-01**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m³	2.07E-01	3.44E-03	1.25E-02	4.89E-03	2.99E-03	0	0	8.04E-04	0	1.54E-04	**2.32E-01**

Output flows and waste category indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.86E-03	0	8.50E-03	0	0	0	0	0	**1.04E-02**
High-level radioactive waste, conditioned, to final repository	kg	2.18E-05	2.38E-07	4.76E-06	3.39E-07	8.10E-07	0	0	5.58E-08	0	2.39E-09	**2.80E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.09E-08	1.03E-07	4.98E-08	1.46E-07	1.17E-09	0	0	2.40E-08	0	2.52E-11	**3.74E-07**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	0	0	3.34E-02	0	6.47E-03	0	0	0	0	0	**3.98E-02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**

Carbon emissions and removals

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Biogenic carbon removal from product	kg CO_2	1.07E+00	0	5.76E-02	0	0	0	0	0	0	0	**1.13E+00**
Biogenic carbon emission from product	kg CO_2	0	0	3.85E-02	0	3.69E-03	0	0	0	0	9.98E-01	**1.04E+00**
Biogenic carbon removal from packaging	kg CO_2	2.54E-04	0	0	0	0	0	0	0	0	0	**2.54E-04**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**

Waco, TX: LCIA results, resource use, output and waste flows, and carbon emissions & removals per functional unit

LCIA results (per m^2 installed including packaging, that gives an average thermal resistance of RSI=1m²·K/W)

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Ozone depletion	kg CFC-11 eq	6.21E-09	7.81E-09	3.59E-09	1.07E-08	8.62E-11	0	0	2.73E-09	0	2.72E-10	**3.14E-08**
Global warming	kg CO_2 eq	9.01E-02	3.28E-02	8.43E-02	4.49E-02	7.46E-04	0	0	1.15E-02	0	1.59E-03	**2.66E-01**
Smog	kg O_3 eq	1.05E-02	7.31E-04	2.65E-03	1.00E-03	2.38E-05	0	0	2.50E-04	0	4.63E-04	**1.56E-02**
Acidification	kg SO_2 eq	1.10E-03	5.70E-05	2.94E-04	7.81E-05	1.91E-06	0	0	1.98E-05	0	1.54E-05	**1.57E-03**
Eutrophication	kg N eq	1.04E-04	1.19E-05	2.47E-05	1.63E-05	4.43E-07	0	0	4.14E-06	0	1.50E-06	**1.63E-04**
Carcinogenics	CTUh	2.73E-09	3.01E-11	1.52E-10	4.12E-11	2.64E-12	0	0	9.75E-12	0	4.67E-13	**2.97E-09**
Non-carcinogenics	CTUh	3.99E-08	4.60E-09	2.63E-09	6.31E-09	5.10E-11	0	0	1.34E-09	0	1.85E-11	**5.49E-08**
Respiratory effects	kg $PM_{2.5}$ eq	1.74E-04	1.15E-05	1.83E-05	1.57E-05	1.19E-06	0	0	3.49E-06	0	1.99E-06	**2.26E-04**
Ecotoxicity	CTUe	54.9%	16.4%	1.3%	22.5%	<1%	0%	0%	4.7%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	2.57E-01	6.95E-02	1.27E-01	9.52E-02	1.02E-03	0	0	2.43E-02	0	3.38E-03	**5.77E-01**

Resource use indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	5.35E-02	4.42E-04	2.54E-02	6.06E-04	6.80E-04	0	0	1.56E-04	0	3.54E-05	**8.08E-02**
Renewable primary resources with energy content used as material	MJ, LHV	2.01E-01	1.61E-04	3.45E-02	0	2.05E-04	0	0	0	0	0	**2.36E-01**
Total use of renewable primary resources with energy content	MJ, LHV	2.54E-01	6.04E-04	5.99E-02	6.06E-04	8.85E-04	0	0	1.56E-04	0	3.54E-05	**3.16E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	2.00E+00	4.64E-01	1.61E+00	6.35E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**4.91E+00**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.80E-04	1.39E-06	2.38E-06	0	2.42E-08	0	0	0	0	0	**1.84E-04**
Total use of non-renewable primary resources with energy content	MJ, LHV	2.00E+00	4.64E-01	1.61E+00	6.35E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**4.91E+00**
Secondary materials	kg	5.83E-01	0	0	0	0	0	0	0	0	0	**5.83E-01**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m³	1.85E-01	2.30E-03	4.86E-03	3.15E-03	2.98E-03	0	0	8.04E-04	0	3.92E-06	**1.99E-01**

Output flows and waste category indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.65E-03	0	8.50E-03	0	0	0	0	0	**1.01E-02**
High-level radioactive waste, conditioned, to final repository	kg	2.25E-05	1.60E-07	6.88E-06	2.19E-07	8.10E-07	0	0	5.58E-08	0	2.39E-09	**3.07E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.26E-08	6.86E-08	7.31E-08	9.41E-08	1.17E-09	0	0	2.40E-08	0	2.52E-11	**3.14E-07**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	0	0	3.31E-02	0	6.47E-03	0	0	0	0	0	**3.96E-02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**

Carbon emissions and removals

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Biogenic carbon removal from product	kg CO_2	1.07E+00	0	5.76E-02	0	0	0	0	0	0	0	**1.13E+00**
Biogenic carbon emission from product	kg CO_2	0	0	3.82E-02	0	3.69E-03	0	0	0	0	9.98E-01	**1.04E+00**
Biogenic carbon removal from packaging	kg CO_2	2.54E-04	0	0	0	0	0	0	0	0	0	**2.54E-04**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**

Wilkes-Barre, PA: LCIA results, resource use, output & waste flows, and carbon emissions & removals per functional unit

LCIA results (per m^2 installed including packaging, that gives an average thermal resistance of RSI=1m²·K/W)

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Ozone depletion	kg CFC-11 eq	6.29E-09	1.58E-08	2.78E-09	1.47E-08	8.62E-11	0	0	2.73E-09	0	2.72E-10	**4.26E-08**
Global warming	kg CO_2 eq	8.65E-02	6.61E-02	5.13E-02	6.17E-02	7.46E-04	0	0	1.15E-02	0	1.59E-03	**2.79E-01**
Smog	kg O_3 eq	1.03E-02	1.47E-03	1.89E-03	1.38E-03	2.38E-05	0	0	2.50E-04	0	4.63E-04	**1.58E-02**
Acidification	kg SO_2 eq	1.10E-03	1.15E-04	2.24E-04	1.07E-04	1.91E-06	0	0	1.98E-05	0	1.54E-05	**1.58E-03**
Eutrophication	kg N eq	1.03E-04	2.39E-05	1.88E-05	2.23E-05	4.43E-07	0	0	4.14E-06	0	1.50E-06	**1.74E-04**
Carcinogenics	CTUh	2.59E-09	6.07E-11	1.19E-10	5.66E-11	2.64E-12	0	0	9.75E-12	0	4.67E-13	**2.84E-09**
Non-carcinogenics	CTUh	3.94E-08	9.28E-09	1.82E-09	8.66E-09	5.10E-11	0	0	1.34E-09	0	1.85E-11	**6.06E-08**
Respiratory effects	kg $PM_{2.5}$ eq	1.77E-04	2.32E-05	1.36E-05	2.16E-05	1.19E-06	0	0	3.49E-06	0	1.99E-06	**2.42E-04**
Ecotoxicity	CTUe	41.7%	27.6%	<1%	25.8%	<1%	0%	0%	3.9%	0%	<1%	**100%**
Fossil fuel depletion	MJ surplus	2.34E-01	1.40E-01	6.38E-02	1.31E-01	1.02E-03	0	0	2.43E-02	0	3.38E-03	**5.97E-01**

Resource use indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	5.38E-02	8.92E-04	1.54E-02	8.32E-04	6.80E-04	0	0	1.56E-04	0	3.54E-05	**7.18E-02**
Renewable primary resources with energy content used as material	MJ, LHV	2.01E-01	3.25E-04	1.05E-02	0	2.05E-04	0	0	0	0	0	**2.12E-01**
Total use of renewable primary resources with energy content	MJ, LHV	2.55E-01	1.22E-03	2.59E-02	8.32E-04	8.85E-04	0	0	1.56E-04	0	3.54E-05	**2.84E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	1.84E+00	9.35E-01	1.04E+00	8.73E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**4.89E+00**
Non-renewable primary resources with energy content used as material	MJ, LHV	1.84E-04	2.80E-06	2.37E-06	0	2.42E-08	0	0	0	0	0	**1.89E-04**
Total use of non-renewable primary resources with energy content	MJ, LHV	1.84E+00	9.35E-01	1.04E+00	8.73E-01	1.23E-02	0	0	1.64E-01	0	2.26E-02	**4.89E+00**
Secondary materials	kg	5.74E-01	0	0	0	0	0	0	0	0	0	**5.74E-01**
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**
Use of net fresh water resources	m³	2.12E-01	4.64E-03	3.70E-02	4.33E-03	2.99E-03	0	0	8.04E-04	0	1.54E-04	**2.62E-01**

Output flows and waste category indicators

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.27E-03	0	8.50E-03	0	0	0	0	0	**9.77E-03**
High-level radioactive waste, conditioned, to final repository	kg	2.29E-05	3.22E-07	5.24E-06	3.00E-07	8.10E-07	0	0	5.58E-08	0	2.39E-09	**2.97E-05**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	5.28E-08	1.38E-07	5.44E-08	1.29E-07	1.17E-09	0	0	2.40E-08	0	2.52E-11	**4.00E-07**
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	**0**
Materials for recycling	kg	0	0	1.86E-02	0	6.47E-03	0	0	0	0	0	**2.51E-02**
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	**0**
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	**0**

Carbon emissions and removals

Parameter	Unit	A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	Total
Biogenic carbon removal from product	kg CO_2	1.05E+00	0	5.76E-02	0	0	0	0	0	0	0	**1.11E+00**
Biogenic carbon emission from product	kg CO_2	0	0	2.15E-02	0	3.73E-03	0	0	0	0	1.01E+00	**1.03E+00**
Biogenic carbon removal from packaging	kg CO_2	2.54E-04	0	0	0	0	0	0	0	0	0	**2.54E-04**
Biogenic carbon emission from packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Biogenic carbon emission from combustion of waste from renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Calcination carbon emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbonation carbon removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0**