ENVIRONMENTAL
PRODUCT
DECALARATION

HEMP WOOL INSULATION PANEL

PROFIB™ MAT

A pioneer in the manufacturing of plant-based insulation products in Canada, Nature fibres presents the environmental product declaration (EPD) of its hemp and polyester fibre insulation panel: Profib™ Mat.

This EPD presents the results of the life cycle assessment (LCA) of the insulation panel, encompassing the raw material supply manufacturing, transport, installation, use, and end of life stages (i.e., cradle to grave).

The EPD and LCA were prepared by CT Consultant according to EN 15804, ISO 14025 and ISO 21930, and verified by Vertima.

For further information about Nature fibres, visit
www.naturefibres.com

Period of validity: March 2021 – March 2026

ASTM INTERNATIONAL

1 | GENERAL INFORMATION

Program operator	**ASTM International** 100 Barr Harbor Drive West Conshohocken, PA 19428 United States of America www.astm.org
Declaration holder	**Nature fibres** 385 Industriel Boulevard Val-des-Sources, Quebec Canada J1T 4T7 (819) 716-0141 www.naturefibres.com info@naturefibres.com
Declared product	Profib™ Mat insulation panel
Functional unit	1 m^2 of installed hemp/polyester fibre insulation panel with a thickness that gives an average thermal resistance RSI = 1 $m^2 \cdot K/W$.
Declaration number	EPD-197
Date of issue	March 2021
Period of validity	March 2021 – March 2026
EPD type	Product-specific
EPD scope	Cradle to grave
Reference period	2019
Region covered	North America
LCA Software	OpenLCA version 1.10.3 [1]
Life cycle inventory database	ecoinvent version 3.4 [2]
Life cycle impact assessment method	TRACI version 2.1 [3]
Product Category Rules (PCR)	UL Environment. Building Related Products and Services. Part B: Building Envelope Thermal Insulation EPD requirements, v2.0, April 2018 [4]
PCR review	Thomas Gloria, Chairman of the peer review panel.

2 | PREPARATION AND VERIFICATION

- This EPD and the LCA were prepared by:

  CT CONSULTANT
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- This EPD and the LCA were verified by:

  This verification was carried out in accordance with ISO 14025:2006 [5], ISO 14044:2006 [6], and the reference PCR.

  ☐ INTERNAL ☒ EXTERNAL

  Vertima
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- The PCR "UL Environment, Building Related Products and Services, Part A v3.1, May 2018" [7] based on ISO 21930:2017 [8] and EN 15804:2013 [9] serves as the core PCR, with additional considerations for the USGBC/UL Environment Part A Enhancement (2017).

3 | NOTES ON EPD COMPARISON

For products from the same category but from different programs environmental declarations may not be comparable. When EPDs are used to compare the environmental performance of different building envelope thermal insulation products, it is essential to take into account the products' use and their impacts on the building. Therefore, EPDs cannot be used for comparison purposes when the building's energy consumption is not considered [4]. Furthermore, in order to allow comparability, all the life cycle stages of a thermal insulation product must have been considered. The same standards and the same reference PCR must be used, and the product installation scenarios must be equivalent [4]. It should also be noted that the use of different LCA softwares and databases may affect the reliability of the EPD comparison.

4 | PRODUCT AND COMPANY DESCRIPTION

4.1. Company description

A pioneer in the manufacturing of plant-based insulation products in Canada, Nature fibres produces the Profib™ Mat insulation panel, an insulation product made of hemp fibres and polyester fibres. In addition to producing insulation panels for buildings, Nature fibres manufactures other hemp products, such as insulation wool for cold-preserving during the transport of food and pharmaceutical products. The manufacturing plant is located at 385 Industriel Boulevard in Val-des-Sources (formerly Asbestos), Quebec, Canada.

4.2. Product description and applications

The Profib™ Mat hemp wool insulation panel is a semi-rigid panel used for thermal insulation in residential and commercial buildings. It can be used to insulate ceilings, walls and floors. The insulation panel is easily installed by inserting it manually so as to fill the volume between two sections of the frame. The Profib™ Mat insulation panel is produced using an innovative industrial process that gives it high mechanical resistance and stability that prevents subsidence in the long term. Thanks to its high hemp fibre content, the insulation panel has the ability to regulate hygrometry (absorption and release of excess ambient humidity), limiting the negative effects caused by condensation. Non-allergenic, the panel does not emit volatile organic compounds (VOCs) ans is resistant to animals (rodents) and parasites (mites and termites).

4.3. Reference product

The insulation panel is available in either standard or custom sizes. For all sizes, the material composition, density and manufacturing steps remain the same. Therefore, this EPD applies to all sizes of Profib™ Mat insulation panels.

Photo 1. Installed Profib™ Mat insulation panel

4.4. Material composition

Table 1. Material composition of the Profib™ Mat insulation panel

Material	Mass (% of the panel)	Production site	Distance travelled to Nature fibres' manufacturing plant
Hemp fibre	92%	Saint-Thomas, Quebec, Canada	203 km
		Bar-sur-Aube, France	5954 km
Polyester fibre	8%	Lyon, France	6143 km

Note: The insulation panel does not require a safety data sheet.

4.5. Thermal performance of the product

Table 2. Thermal performance of the Profib™ Mat insulation panel

Standard	Title	Result	Verification laboratory
ASTM C518-17 [10]	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus	0.257 m²·K/W/cm (3.7 ft²·°F hr/BTu/in)	UL Laboratories Canada Inc. Varennes, Quebec, Canada

4.6. Density and sizes of the product

Table 3. Density and sizes of the Profib™ Mat insulation panel upon delivery

Property	Value	Unit
Density	35	kg/m^3
Thickness	2.0¼; 3.5¼; 5.5¼; 7.5¼ *	in
	5.1; 8.9; 14.0; 19.0 *	cm
Width	15¼; 23¼	in
	38.7; 59.0	cm
Length	48	in
	122	cm

** The insulation panel can be made to measure with a custom thickness.*

4.7. Manufacturing

The insulation panel is made of hemp fibres and polyester fibres. The polyester is produced in Lyon, France. The hemp is cultivated in two agricultural regions: 25% of the production comes from the Saint-Thomas area in Quebec (Canada) and 75% of production comes the Bar-sur-Aube area in France. The steps included in the production of hemp fibre are shown in Figure 1. Once the hemp plant has reached maturity, the seeds (hempseeds) are harvested with a combine. The straw is mowed by a mower, baled, and then transported to a nearby defibration plant. The straw enters the defibrator which separates the fibre from the hemp shives. The hemp fibres and the polyester fibres are shipped to the Nature fibres manufacturing plant in Val-des-Sources, Quebec (Canada). During the manufacturing of the insulation panel, the hemp fibres and the polyester fibres are combined (Figure 2). The fibres are then spread out, layered, pressed and heated in a propane furnace, then cooled, cut into panels and packaged for delivery.

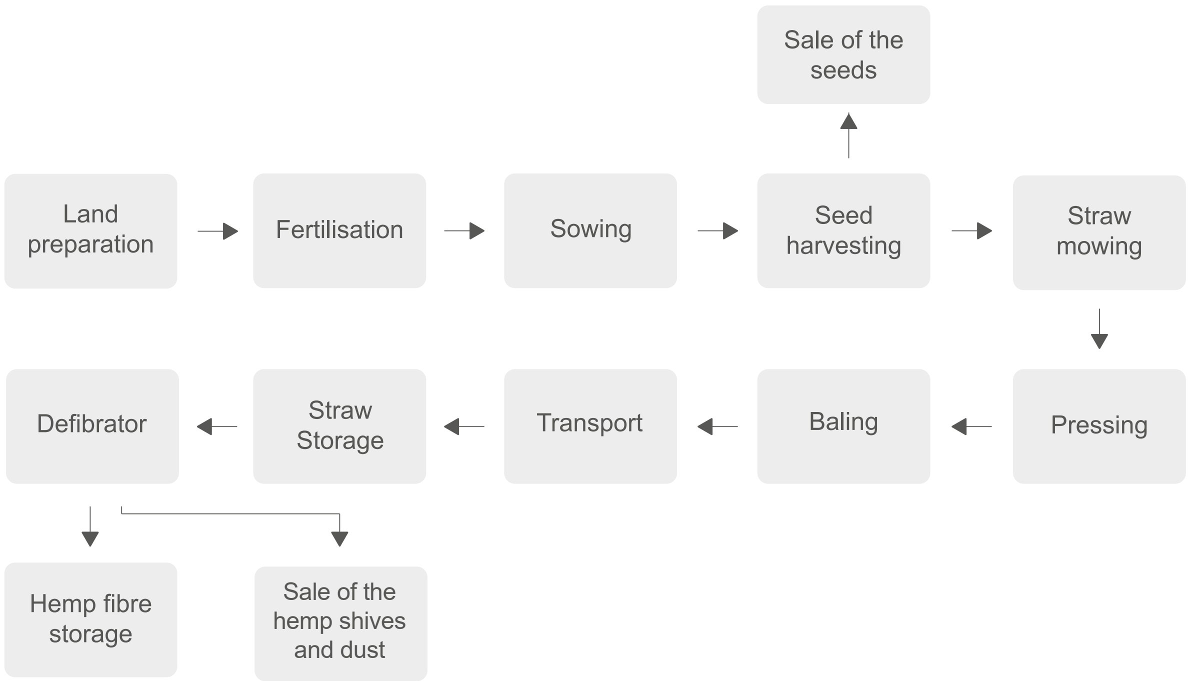


Figure 1. Steps for the production of hemp fibre (Saint-Thomas, Quebec, Canada and Bar-sur-Aube, France)

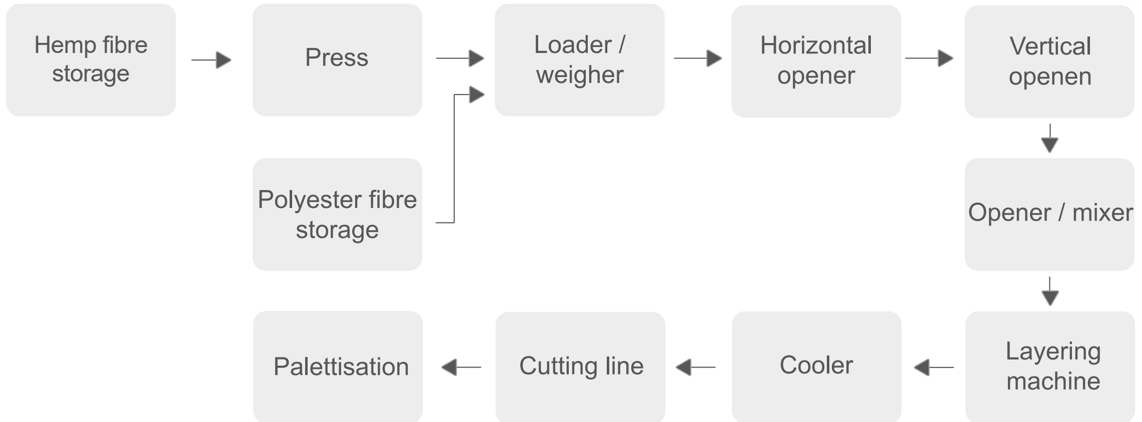


Figure 2. Steps for the production of the insulation panel at Nature fibres' manufacturing plant in Val-des-Sources, Quebec, Canada

4.8. Manufacturing losses

There are no material losses during the insulation board manufacturing. Cutting line scraps are collected, crushed, pressed and reincorporated into the manufacturing process.

4.9. Packaging

The insulation panel is delivered to the client on a wood pallet wrapped in a plastic film. Each pallet carries on average 104 kg of insulation panels.

4.10. Transport

The insulation panel is delivered to the client following a three-step scenario:

- Step 1: Transport to a retail store by truck-trailer over an estimated 250 km distance;
- Step 2: Storage in a retail store;
- Step 3: Transport to the construction site by pick-up truck over an estimated 30 km distance.

4.11. Installation

The insulation panel is installed manually between two sections of the frame. The installation does not require any energy or materials. There is no material loss during installation as the scraps are used to insulate the outline of the building openings. Following the installation, the wood pallet and the plastic packaging film are recycled or sent to a landfill site.

4.12. Use

Once installed, the insulation panel does not require any maintenance, repair or replacement. It does not release any emissions to the air during its service life.

4.13. Reference service life

The reference service life is considered equivalent to that of the building, set to 75 years as a default value by the PCR [4].

4.14. End of life

When the building (in which the Profib™ Mat insulation panel is installed) reaches its end of life, it is assumed that it is demolished without any sorting or recycling of materials. Therefore, the insulation panel will be incorporated into the rest of the demolition waste and sent to a landfill site.

5 | METHODOLOGY USED FOR THE LIFE CYCLE ASSESSMENT

5.1. Functional unit

The LCA results are the life cycle environmental impacts related to the mass of insulation panel required to achieve the functional unit. The latter is based on the thermal resistance of the insulation panel (ASTM C518-17), as specified in the PCR [4].

Table 4. Functional unit and key parameters

Parameter	Value	Unit
Functional unit	1 m² of insulation material with a thickness that gives an average thermal resistance RSI=1 m^2·K/W.	-
Mass	1.36	kg
Thickness to achieve the functional unit	0.039	m

5.2. System boundaries

The cradle to grave LCA includes the following life cycle stages and modules (EN 15804 et ISO 21930 [8,9]):

- Production (A1-A3)
- Construction process (A4-A5)
- Use (B1-B7)
- End of life (C1-C4)

Although technically possible, the recycling of the insulation panel at the end of life stage was not considered since no product recovery system is currently in place. Thus, module D was not included in the LCA.

Table 5. Life cycle stages and modules included in and excluded from the LCA

PRODUCTION STAGE (A1-A3)			CONSTRUCTION PROCESS STAGE (A4-A5)		USE STAGE (B1-B7)							END OF LIFE STAGE (C1-C4)				BEYOND SYSTEM BOUNDARY
Production of raw materials	Transport of raw materials	Insulation panel manufacturing	Transport to construction site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Energy use	Water use	Deconstruction	Transport to waste treatment site	Waste treatment	Disposal	Benefits associated with reuse / recycling / energy recovery
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

Legend: x: Module included in the LCA MND: Module not declared

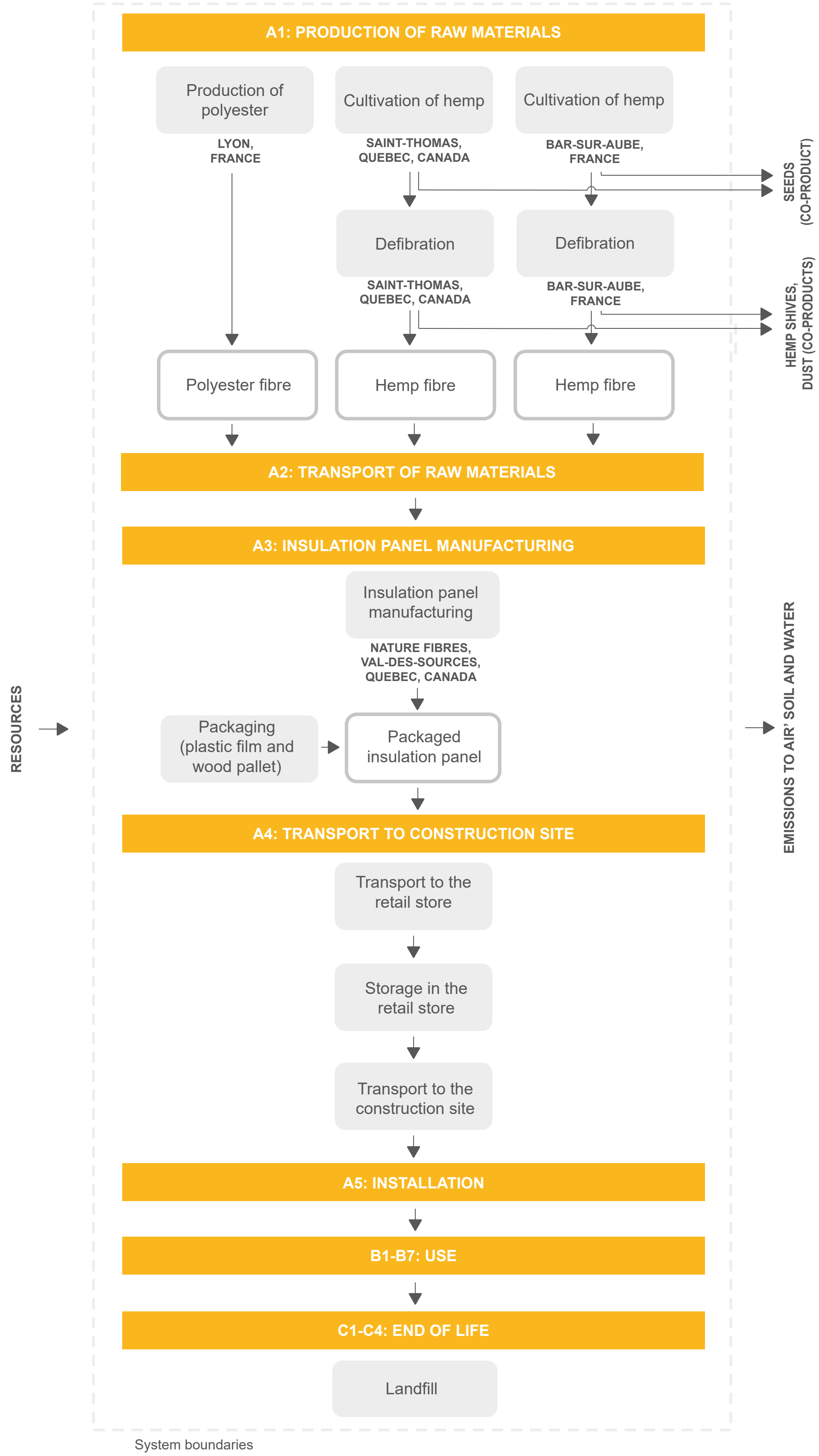


Figure 3. "Cradle to grave" life cycle stages of the Profib™ Mat insulation panel

5.3. Assumptions

Carrying out an LCA entails making assumptions when data is incomplete or missing. Within the framework of this LCA, the following assumptions were developed:

- Hemp fibre production: The farming processes, the hemp cultivar and the agricultural yield of Saint-Thomas and Bar-sur-Aube are equivalent.
- Storage: 78% of warehouses are heated with electricity and 22% are heated with natural gas [11].
- Packaging end of life: There is no reuse of the wood pallet.
- Insulation panel landfill: The methane capture rate at the landfill site is 68.7%, this methane is completely burned in a flare [12].

5.4. Cut-off criteria

As defined in ISO 21930 [8], all input and output processes whose mass and/or energy flow account for more than 1% of the total mass and/or cumulative energy of the insulation panel were included. Also in line with with the standard, at least 95% of all mass and energy flows were included. No equipment or infrastructure maintenance, administrative activity, nor transport of Nature fibres employees or workers were added to the LCA model. No known mass or energy flows were deliberately excluded from this EPD.

5.5. Allocation

When a farming or manufacturing process yields several outputs (multifunctional processes), its environmental impact must be allocated to the different outputs (product and co-products). During the insulation panel's life cycle, the hemp cultivation and defibration processes produce several outputs. In accordance with the PCR [4], mass allocation was used for these two processes, i.e., the environmental impact of each of these processes was allocated according to the mass of each output.

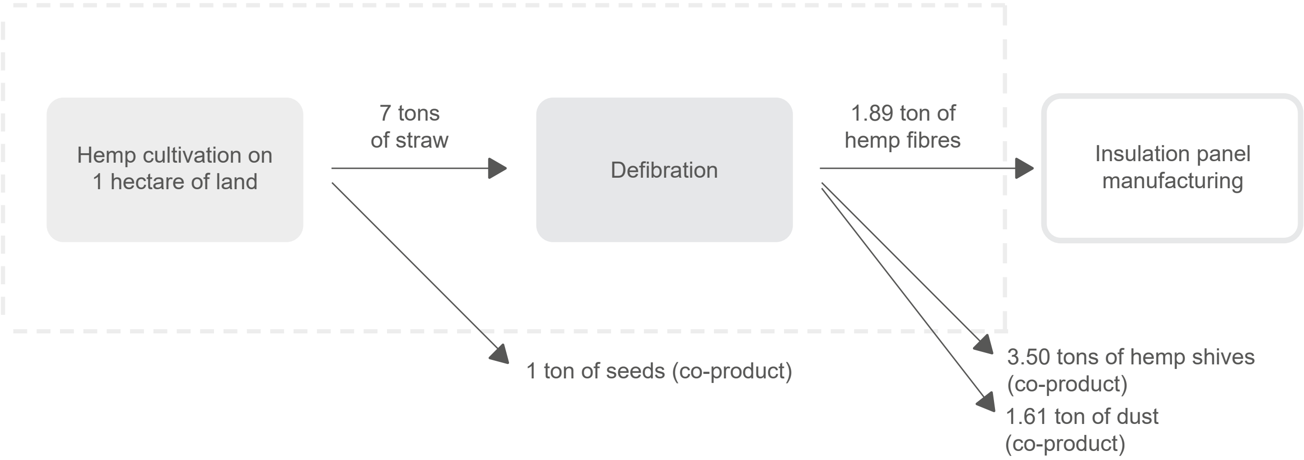


Figure 4. Multifunctional processes subject to mass allocation

5.6. Reference period

The inventory data is representative of the 2019 production year.

5.7. Date sources and quality

Table 6. Inventory data sources of the insulation panel

Data type	Source
Primary data	Primary data was provided by Nature fibres for the period from 1 January to 31 December 2019 and included: • measured data concerning hemp cultivation and the manufacturing of the insulation panel; • data based on realistic assumptions regarding transport of raw materials, transport to the construction site, installation and use of the insulation panel.
Secondary data	Secondary data was obtained from the following sources: • the ecoinvent version 3.4 "cut-off" [2] database; • scientific reports; • reference guides.

Table 7. Data quality assessment

Criterion	Evaluation
Geographical representativeness	The primary data represents the life cycle stages of the insulation panel in Quebec and France. The secondary data was selected in such a way that their geographical context is as representative as possible. In the case of processes taking place in Quebec (Canada), data representative of the Quebec context was prioritized, otherwise, data representative of the global market was used. Regarding the processes related to hemp cultivation and the manufacturing of polyester in France, the best available data was used following this order of priority: Europe / Switzerland / World. The data is considered to have high geographical representativeness.
Temporal representativeness	The primary data is representative of 2019. The secondary data comes from recent reports and reference guides, i.e., published less than 10 years ago. Life cycle inventory data is taken from the ecoinvent version 3.4 (2017) database. This version is based on version 3.0 which has been released annually since 2013. It should be noted that some version 3.0 data comes from earlier versions (1991-2012). The data is considered satisfactory in terms of temporal representativeness.
Technological representativeness	The primary data is representative of the technologies used during the insulation panel's life cycle. The secondary data was selected in order to represent these technologies as accurately as possible. This included the machinery used for hemp cultivation, the energy mix, transport, and methane drainage resulting from the deterioration of the insulation panel in the landfill. The secondary data is deemed to have a high technological representativeness.
Completeness	All processes whose mass and energy flow are above the cut-off threshold (1%) were included in the LCA in accordance with the PCR. No known flow was deliberately excluded.

6 | SCENARIOS USED BEYOND THE MANUFACTURING STAGE

6.1. Transport to the construction site (A4)

Table 8. Scenario for the transport of the insulation panel from the manufacturing plant to the construction site

Parameter	Unit	Value / Specification
1. Transport from the manufacturing plant to the retail store		
Fuel type	-	Diesel
Liters of fuel	L/100 km	31
Vehicle type	-	Truck-trailer with a load capacity of 32 tons or more
Transport distance	km	250
Capacity utilization	%	50
Density of product	kg/m^3	35
2. Transport from the retail store to the construction site		
Fuel type	-	Gasoline
Liters of fuel	L/100 km	10
Vehicle type	-	Pick-up truck
Transport distance	km	30
Capacity utilization	%	100
Density of product	kg/m^3	35

Table 9. Scenario for the loading and unloading of the insulation panel during transport from the manufacturing plant to the construction site

Parameter	Unit	Value / Specification
Machine type	-	Forklift
Fuel type	-	Propane
Number of loading and unloadings	-	3

Table 10. Scenario for the storage of the insulation panel in the retail store

Parameter	Unit	Value / Specification
Storage duration	days	20
Electric heating	kWh	0.157
Natural gas heating	kWh	0.045

6.2. Installation (A5)

Table 11. Building insulation panel installation scenario

Parameter	Unit	Value / Specification
Electricity consumption	kWh	-
Ancillary materials	kg	-
Water consumption	m^3	-
Other resources	-	-
Product loss	-	-
Packaging waste	kg	0.289
Emissions to air, soil and water	kg	-
Volatile organic compound content	mg/m^3	-

Table 12. End of life packaging scenario

Parameter	Unit	Value / Specification
Wood pallets		
Recycling rate [7]	%	20
Landfill rate [7]	%	80
Biogenic carbon contained in the wood pallet (removal)	kg CO_2	0.64
Plastic film		
Recycling rate [7]	%	78
Landfill rate [7]	%	22
Transport to the landfill site / recycling plant		
Transport distance	km	50
Vehicle type	-	Truck-trailer with a load capacity of 32 tons or more

6.3. Use (B1-B7)

It is considered that there are no emissions of substances or use of resources during the use stage of the insulation panel. In addition, no maintenance, repair or replacement processes were included.

6.4. Reference service life

Table 13. Reference service life of the insulation panel

Parameter	Unit	Value / Specification
Reference service life	years	75
Declared product properties	-	Building envelope thermal insulation
Design application parameters	-	Install per Nature fibres' instructions
An assumed quality of work, when installed in accordance with the manufacturer's instructions	-	The insulation panel meets the specified R-value
Outdoor environment	-	Not applicable (interior use only)
Indoor environment	-	The insulation panel is encapsulated in the building envelope to prevent exposure to water
Use conditions	-	Not applicable (the insulation panel does not require any resources)
Maintenance	-	No maintenance required

6.5. End of life (C1-C4)

Table 14. Scenario for the end of life of the insulation panel

<table>
<tr><th colspan="2">Parameter</th><th>Unit</th><th>Value / Specification</th></tr>
<tr><td colspan="2">Description of the end of life scenario</td><td>-</td><td>Considering that the building is demolished without any sorting or recycling of materials when it reaches its end of life, the insulation panel is assumed to be incorporated into the rest of the demolition waste and sent to a landfill site.</td></tr>
<tr><td colspan="2">Transport distance</td><td>km</td><td>50</td></tr>
<tr><td colspan="2">Vehicle type</td><td>-</td><td>Truck-trailer with a load capacity of 32 tons or more</td></tr>
<tr><td rowspan="2">Collection process</td><td>Collected separately</td><td>kg</td><td>-</td></tr>
<tr><td>Collected with mixed construction waste</td><td>kg</td><td>1.36</td></tr>
<tr><td rowspan="4">Recovery</td><td>Reuse</td><td>kg</td><td>-</td></tr>
<tr><td>Recycling</td><td>kg</td><td>-</td></tr>
<tr><td>Incineration</td><td>kg</td><td>-</td></tr>
<tr><td>Incineration with energy recovery</td><td>kg</td><td>-</td></tr>
<tr><td>Landfill</td><td>Product destined for landfill</td><td>kg</td><td>1.36</td></tr>
<tr><td colspan="2">Biogenic carbon emissions (excluding packaging)</td><td>kg CO_2</td><td>0.238</td></tr>
</table>

7 | LIFE CYCLE IMPACT ASSESSMENT RESULTS

The results of the life cycle impact assessment are reported for 1 m² of insulation panel giving an average thermal resistance of RSI = 1 m².K/W. The results were calculated for six impact categories using the TRACI 2.1 impact assessment method [3], and are reported for each declared life cycle module [8].

Table 15. Life cycle impact assessment results calculated with TRACI 2.1

INDICATOR		UNIT	TOTAL	PRODUCTION STAGE (A1-A3)			CONSTRUCTION STAGE (A4-A5)		USE STAGE (B1-B7)	END OF LIFE STAGE (C1-C4)			
				A1	A2	A3	A4	A5	B1 - B7	C1	C2	C3	C4
Global warming potential	Fossil carbon	kg CO_2 eq	2.28E+0	8.85E-1	1.51E-1	7.00E-1	5.05E-1	7.12E-3	0.00E+0	0.00E+0	1.14E-2	0.00E+0	2.41E-2
	Biogenic carbon[1]	kg CO_2 eq	-1.60E+0	-1.90E+0	0.00E+0	-6.33E-1	0.00E+0	3.01E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	6.35E-1
	Total[2]	kg CO_2 eq	6.84E-1	-1.02E+0	1.51E-1	6.71E-2	5.05E-1	3.08E-1	0.00E+0	0.00E+0	1.14E-2	0.00E+0	6.59E-1
Acidification potential		kg SO_2 eq	1.30E-2	7.66E-3	1.75E-3	1.77E-3	1.64E-3	3.96E-5	0.00E+0	0.00E+0	5.18E-5	0.00E+0	1.20E-4
Eutrophication potential		kg N eq	1.94E-2	5.59E-3	2.10E-4	6.80E-4	7.70E-4	1.66E-3	0.00E+0	0.00E+0	1.27E-5	0.00E+0	1.05E-2
Smog formation potential		kg O_3 eq	1.42E-1	5.56E-2	2.97E-2	2.47E-2	2.69E-2	8.50E-4	0.00E+0	0.00E+0	1.22E-3	0.00E+0	2.63E-3
Ozone depletion potential		kg CFC-11 eq	3.85E-7	9.75E-8	3.57E-8	1.35E-7	1.07E-7	1.63E-9	0.00E+0	0.00E+0	2.74E-9	0.00E+0	4.86E-9
Abiotic depletion potential (fossil resources)		MJ (LHV)	4.31E+0	1.55E+0	3.19E-1	1.35E+0	1.01E+0	1.63E-2	0.00E+0	0.00E+0	2.46E-2	0.00E+0	4.80E-2

[1] Since TRACI 2.1 considers biogenic CO_2 as equal to 0, the removals of biogenic carbon and emissions of biogenic CO_2 and methane were modeled separately according to assumptions specific to this study. In order to avoid double counting, the impact factor for biogenic methane in TRACI 2.1 was set to 0.

[2] The global warming potential impact category results are presented in three categories: 1) fossil carbon; 2) biogenic carbon (emissions and removals); 3) total (fossil and biogenic carbon).

It should be noted that the life cycle impact assessment results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. 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 should not use additional measures for comparative purposes.

8 | LIFE CYCLE INVENTORY RESULTS

The life cycle inventory results relate to: 1) resource use; 2) waste and output flows; 3) removals and emissions of biogenic carbon.

8.1. Resource use inventory indicators

Table 16. Life cycle inventory results for resource use

INDICATOR	UNIT	TOTAL	PRODUCTION STAGE (A1-A3)			CONSTRUCTION PROCESS STAGE (A4-A5)		USE STAGE (B1-B7)	END OF LIFE STAGE (C1-C4)			
			A1	A2	A3	A4	A5	B1 - B7	C1	C2	C3	C4
Renewable primary energy used as energy carrier (fuel)[1]	MJ (LHV)	1.01E+1	7.96E-1	3.78E-2	8.46E+0	7.88E-1	4.31E-3	0.00E+0	0.00E+0	2.06E-3	0.00E+0	1.09E-2
Renewable primary resources with energy content used as material[1]	MJ (LHV)	2.32E+1	1.85E+1	0.00E+0	4.63E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Total use of renewable primary resources with energy content[1]	MJ (LHV)	3.33E+1	1.93E+1	3.78E-2	1.31E+1	7.88E-1	4.31E-3	0.00E+0	0.00E+0	2.06E-3	0.00E+0	1.09E-2
Non-renewable primary resources used as an energy carrier (fuel)[1]	MJ (LHV)	2.97E+1	1.01E+1	2.30E+0	9.35E+0	7.28E+0	1.26E-1	0.00E+0	0.00E+0	1.73E-1	0.00E+0	3.53E-1
Non-renewable primary resources with energy content used as material[1]	MJ (LHV)	3.04E+0	2.81E+0	0.00E+0	2.33E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Total use of non-renewable primary resources with energy content[1]	MJ (LHV)	3.28E+1	1.29E+1	2.30E+0	9.59E+0	7.28E+0	1.26E-1	0.00E+0	0.00E+0	1.73E-1	0.00E+0	3.53E-1
Renewable secondary fuels	MJ (LHV)	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Non-renewable secondary fuels	MJ (LHV)	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Secondary materials	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Recovered energy	MJ (LHV)	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Use of net freshwater resources[2]	m^3	7.43E-3	4.12E-3	3.77E-4	1.21E-3	1.25E-3	7.68E-5	0.00E+0	0.00E+0	2.99E-5	0.00E+0	3.76E-4

[1] *The results of these indicators were calculated with the CED LHV method [13] according to the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14].*

[2] *The results of this indicator were calculated based on the output flows specified in the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017" [14].*

8.2. Waste categories and output flows inventory indicators

Table 17. Life cycle inventory results for waste categories and output flows

INDICATOR	UNIT	TOTAL	PRODUCTION STAGE (A1-A3)			CONSTRUCTION PROCESS STAGE (A4-A5)		USE STAGE (B1-B7)	END OF LIFE STAGE (C1-C4)			
			A1	A2	A3	A4	A5	B1 - B7	C1	C2	C3	C4
Hazardous waste disposed[1]	kg	2.07E-2	1.67E-2	2.04E-3	2.05E-4	9.66E-4	2.22E-4	0.00E+0	0.00E+0	1.40E-4	0.00E+0	4.20E-4
Non-hazardous waste disposed[1]	kg	2.62E+0	8.00E-1	1.79E-1	1.45E-2	1.05E-1	2.37E-1	0.00E+0	0.00E+0	1.36E-2	0.00E+0	1.27E+0
High-level radioactive waste[1]	m^3	5.15E-10	3.58E-10	4.25E-11	4.23E-11	6.08E-11	3.57E-12	0.00E+0	0.00E+0	1.68E-12	0.00E+0	5.58E-12
Intermediate- and low-level radioactive waste[1]	m^3	3.63E-8	8.10E-9	1.20E-8	7.57E-10	1.25E-8	5.46E-10	0.00E+0	0.00E+0	9.18E-10	0.00E+0	1.50E-9
Components for re-use[2]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for recycling[2]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Materials for energy recovery[2]	kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Exported energy[2]	MJ (LHV)	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0

[1] The results of these indicators were calculated using a waste classification based on Annex K of the national supplement to the NF EN 15804+A1 standard [15] and the Resource Conservation and Recovery Act (RCRA), Subtitle 3 [16] classification.

[2] The insulation panel is not reused, recycled or used for energy recovery. The results of these indicators are therefore equal to zero.

8.3. Biogenic carbon emissions and removals inventory indicators

The ISO 21930 standard and the PCR UL Part A v3.1 require that the removals and emissions of biogenic carbon dioxide (CO_2) be presented separately when included in the calculation of the global warming potential impact category [7,8].

Table 18. Life cycle inventory results for biogenic carbon emissions and removals

INDICATOR	UNIT	TOTAL	PRODUCTION STAGE (A1-A3)			CONSTRUCTION PROCESS STAGE (A4-A5)		USE STAGE (B1-B7)	END OF LIFE STAGE (C1-C4)			
			A1	A2	A3	A4	A5	B1 - B7	C1	C2	C3	C4
Biogenic carbon removal from product[1]	kg CO_2	-1.90E+0	-1.90E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Biogenic carbon emission from product[1 2]	kg CO_2	2.38E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.38E+0
Biogenic carbon removal from packaging[1]	kg CO_2	-5.11E-1	-5.93E-3	0.00E+0	-6.33E-1	0.00E+0	1.28E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Biogenic carbon emission from packaging[1 2]	kg CO_2	6.48E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	6.48E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Calcination carbon emissions	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Carbonatation carbon removal	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Carbon emissions from combustion of waste from non-renewable sources used in production processes	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Carbon emissions from combustion of waste from renewable sources used in production processes	kg CO_2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0

[1] The results of these indicators were calculated according to the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017 " [14].

[2] For these inventory indicators, only carbon dioxide emissions are included. Methane emissions are excluded in accordance with the PCR UL Part A v3.1 [7].

9| LIFE CYCLE ASSESSMENT INTERPRETATION

9.1. Global warming impact indicators

Biogenic carbon flow

Biogenic carbon, i.e., carbon from biomass, is comprised of input flows (removals) and output flows (emissions). The input biogenic carbon flows include carbon absorbed by the hemp fibre and the wood pallet. The output biogenic carbon flows are those related to the end of life emissions from the hemp fibre and pallet wood. The total input biogenic carbon flows are higher than the output flows (negative net balance), which means that biogenic carbon is sequestered over the life cycle of the insulation panel. This biogenic carbon sequestration helps reduce the global warming potential of the insulation panel.

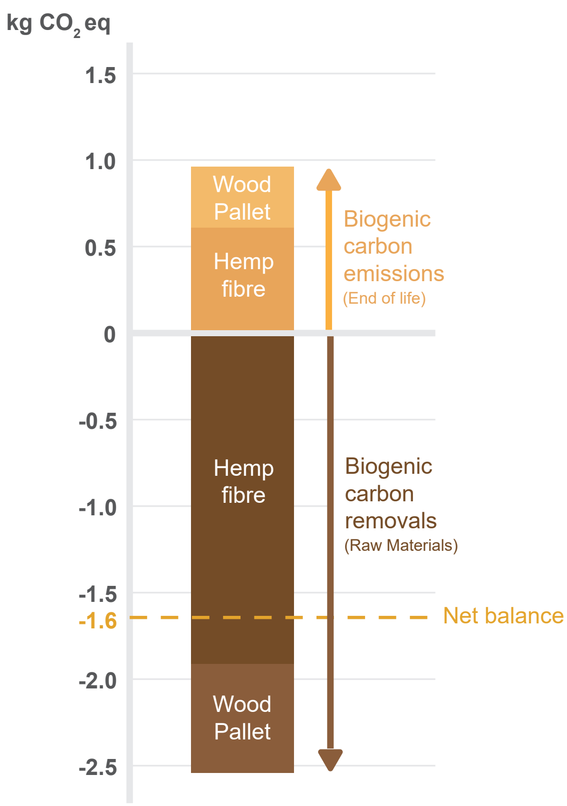
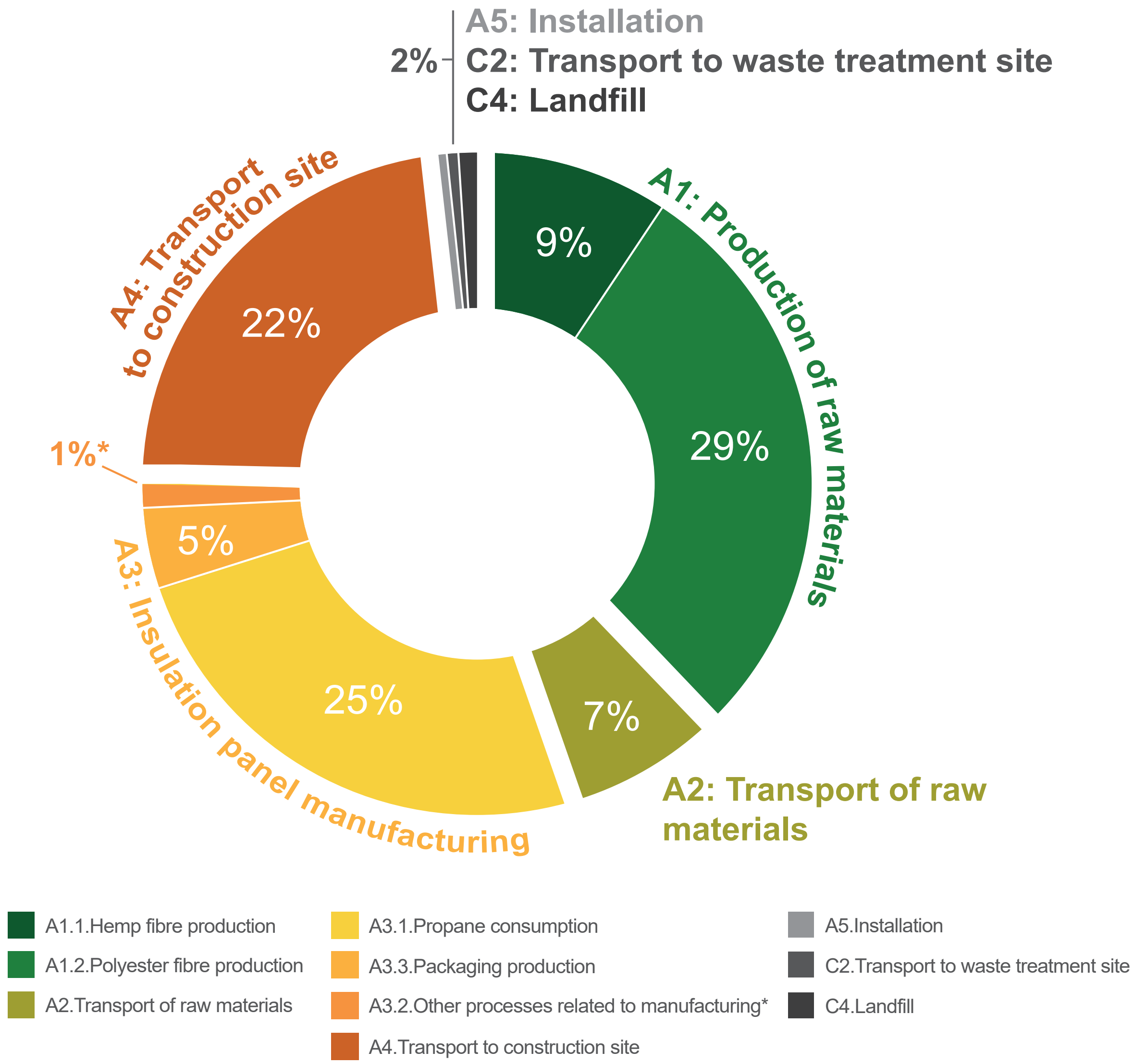


Figure 5. Biogenic carbon flow contribution over the life cycle of the insulation panel

[1] The output flows include biogenic carbon dioxide and methane, expressed in kg CO_2 eq.

Fossil carbon emissions

Fossil carbon emissions are emissions related to fossil fuels (gasoline, diesel, propane, natural gas). The life cycle module which contributes the most to fossil carbon emissions is A1 Production of raw materials (38%), followed by A3 Insulation panel manufacturing (31%) and lastly A4 Transport to construction site (22%). These three modules represent 92% of the total fossil carbon emissions. Regarding production of raw materials, the main contributor is A1.2 Polyester fibre production (29%). As for the manufacturing of the insulation panel, the biggest contributor is A3.1 Propane consumption (25%).

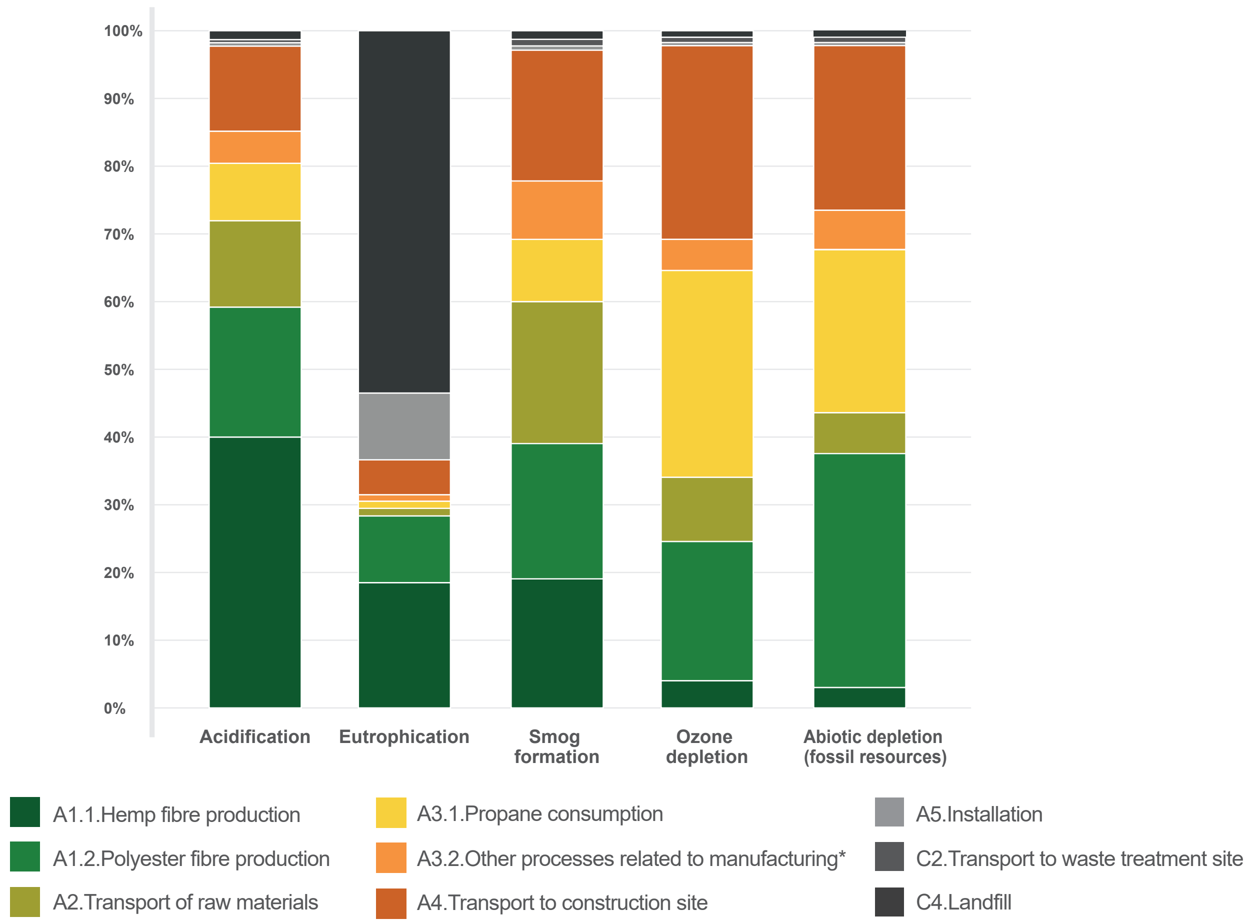


** "Other processes related to manufacturing" includes: transport of propane, electricity consumption at the manufacturing plant, materials used to build the manufacturing plant and the manufacturing processes and end of life of the polyester fibre's packaging film.*

Figure 6. Contribution of the different life cycle modules and processes to fossil carbon emissions

9.2. Acidification, eutrophication, smog formation, ozone depletion and abiotic depletion impact indicators

The three modules that contribute the most to **acidification** are A1 Production of raw materials (59%), A4 Transport to construction site (13%) and A2 Transport of raw materials (13%). The major contributing processes are A1.1 Hemp fibre production (40%) and A1.2 Polyester fibre production (29%). Regarding the **eutrophication** impact category, the modules C4 Landfill (54%) and A1 Production of raw materials (29%) are the biggest contributors. As for the **smog formation** indicator, A1 Production of raw materials (39%), A2 Transport of raw materials (21%) and A4 Transport to construction site (19%) are the main contributors. The **ozone depletion** indicator is mainly affected by modules A3 Insulation panel manufacturing (35%), A4 Transport to construction site (28%) and A1 Production of raw materials (25%). Regarding the manufacturing of the insulation panel, the process A3.1 Propane consumption contributes significantly to this indicator (31%), because the propane extraction generates hydrocarbon and combustion gas emissions. As for **abiotic depletion**, the main contributors are modules A1 Production of raw materials (36%), A3 Insulation panel manufacturing (31%) and A4 Transport to construction site (23%). The process included in the raw materials production which contributes the most to the depletion of abiotic resources is A1.2 Polyester fibre production (31%).

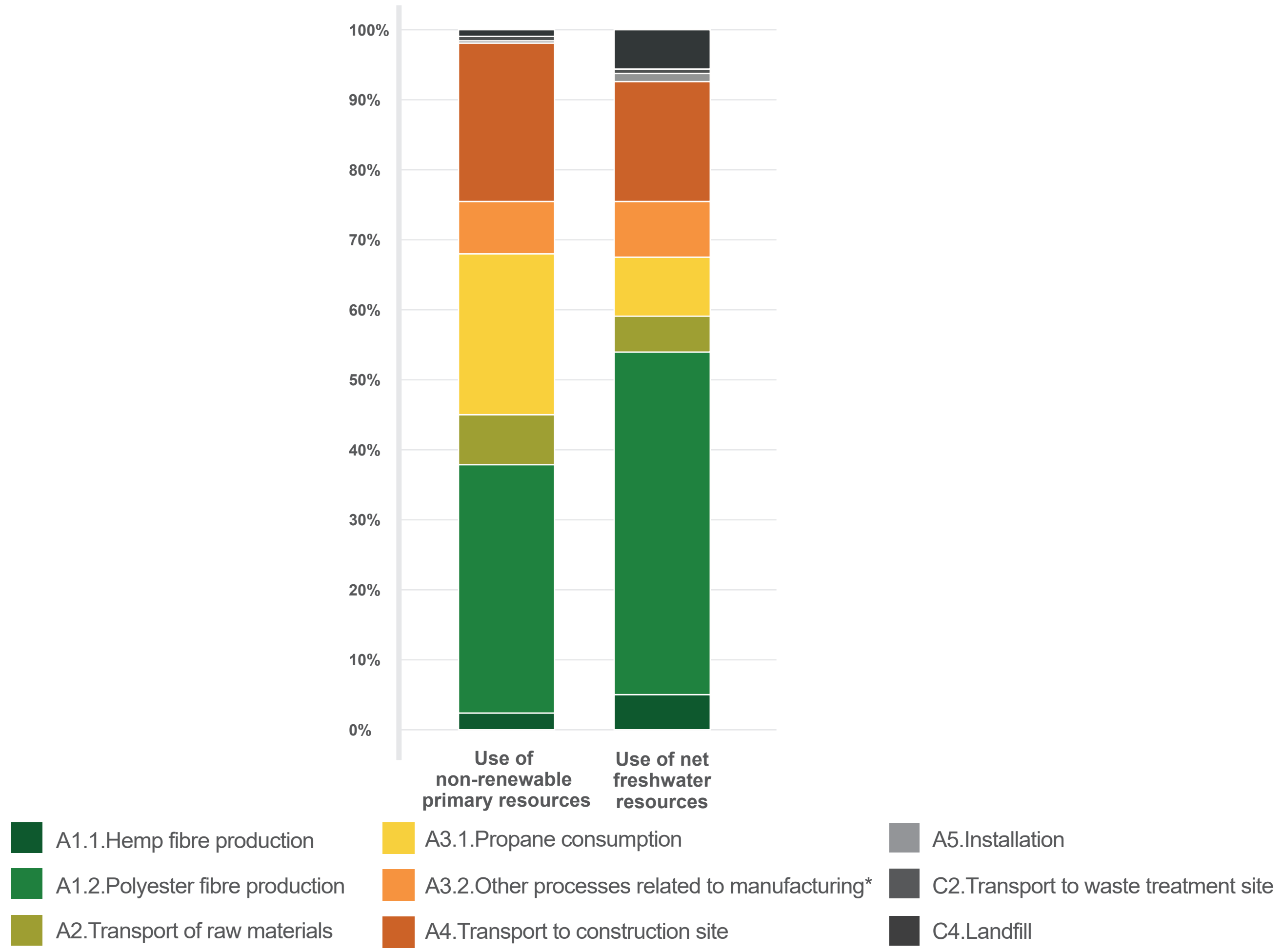


** "Other processes related to manufacturing" includes: transport of propane, electricity consumption at the manufacturing plant, insulation panel packaging production, materials used to build the manufacturing plant and the manufacturing processes and end of life of the polyester fibre's packaging film.*

Figure 7. Contribution of the different life cycle modules and processes to different impact categories

9.3. Use of non-renewable primary resources and use of freshwater resources inventory indicators

The indicator regarding the **use of non-renewable primary resources** is mainly dominated by modules A1 Production of raw materials (38%), A3 Insulation panel manufacturing (29%), and A4 Transport to construction site (22%) . The process A1.2 Polyester fibre production is the biggest contributor to this indicator (34%). As for the **use of fresh water resources** indicator, the process which contributes the most is A1.2 Polyester fibre production (47%).



** "Other processes related to manufacturing" includes: transport of propane, electricity consumption at the manufacturing plant, insulation panel packaging production, materials used to build the manufacturing plant and the manufacturing processes and end of life of the polyester fibre's packaging film.*

Figure 8. Contribution of the different life cycle modules and processes to non-renewable primary resources use and freshwater resources use

10 | ADDITIONAL ENVIRONMENTAL INFORMATION

10.1. Regulated hazardous substances

The insulation panel contains only hemp and polyester fibres, two substances that are not on Canada's list of toxic substances [17]. Thus, no regulated hazardous substances are related to the production of the insulation panel.

10.2. Environment and health during manufacturing and installation

The manufacturing of the insulation panel does not have any effect on the health of the factory workers and does not alter the quality of the immediate environment. The insulation panel installation has no effect on the health of the installers. Furthermore, the insulation panel does not emit any substance that could affect the health of the building occupants once installed.

10.3. Energy savings during building operation

The use of building envelope thermal insulation reduces energy consumption (heating and air conditioning) during building operation. Because the aim of this EPD is limited to presenting the environmental impacts generated by the insulation panel, energy savings-related environmental impacts reduction were not included. Performing an energy simulation of a specific building insulated with the Profib^{TM} Mat panel would enable an assessment of the energy savings and would serve as a basis for the calculation of the avoided impacts.

10.4. Unexpected adverse events

There are no unexpected adverse effects resulting from the combustion or mechanical alteration of the insulation panel.

10.5. Land use change for hemp cultivation

The agricultural land used for the production of hemp in Quebec and France was previously used for the cultivation of another crop (wheat, hay, soybean, etc.). Therefore, no greenhouse gas emissions related to land use change were accounted for in the LCA.

11 | IMPACT AND INVENTORY INDICATORS DEFINITIONS

Table 19. Definitions and units of the EPD's impact indicators [3,7]

Indicator Category	Definition	Unit
Global warming potential	This indicator measures the impact of an increase in global average temperature caused by greenhouse gas emissions on the world's climate. The main greenhouse gases are CO_2, CH_4, and N_2O.	kg CO_2 eq
Acidification potential	This indicator measures the impact of an increase in the concentration of hydrogen ions (H^+) in soil or water environments caused by emissions of acidifying substances (for example, sulfuric acid).	kg SO_2 eq
Eutrophication potential	This indicator measures the consequences of an enrichment of water by nutrients (nitrates and phosphates), thus increasing the growth of algae deteriorating the aquatic ecosystem.	kg N eq
Smog formation potential	This indicator measures the formation of smog (ground-level ozone (O_3)), which is a pollutant that impacts the respiratory system. Smog is produced by the exposure of nitrogen oxides (NOx) and volatile organic compounds (VOCs) to solar radiation.	kg O_3 eq
Ozone depletion potential	This indicator measures the impact of the depletion of the ozone layer, which is a gas that protects living organisms from solar radiation. Ozone depletion is mainly caused by chlorofluorocarbon (CFC) and halon emissions.	kg CFC-11 eq
Abiotic depletion potential (fossil resources)	This indicator measures the depletion of abiotic (fossil) energy resources and represents the excess energy required to extract these resources in the future.	MJ (LHV)

Table 20. Definitions and units of the EPD's inventory indicators [7]

Indicator Category	Definition	Unit
Renewable primary energy used as energy carrier/material	Use of renewable primary energy as a source of energy (hydroelectric, solar, wind) or as a material (wood, hemp).	MJ (LHV)
Non-renewable primary energy used as energy carrier/material	Use of non-renewable primary energy (peat, oil, gas, coal) as a source of energy or as a material (plastics).	MJ (LHV)
Hazardous, non-hazardous and radioactive disposed waste	Generation of hazardous (solvents, engine oil, acids), non-hazardous (concrete, plastic, glass) or radioactive (radioactive fuels, products contaminated by radioactive substances) disposed waste.	kg, m^3
Use of fresh water resources	Use of freshwater, excluding non-consumed water (water used to power turbines, or as coolant and recirculated) and water losses caused by natural phenomena (evaporation of rainwater).	m^3
Removals and emissions of biogenic carbon	Product and/or packaging biogenic carbon input (biomass removals) and output (emissions) flows.	kg CO_2

12 | ACRONYMS AND EMPIRICAL FORMULAS

- **CFC -** Chlorofluorocarbons
- **CFC-11 -** Trichlorofluoromethane
- **CH_4 -** Methane
- **CO_2 -** Carbon dioxide
- **EPD -** Environmental product declaration
- **eq. -** Equivalent
- **FU -** Functional unit
- **LCA -** Life cycle assessment
- **LHV -** Lower heating value
- **N -** Nitrogen
- **NOx -** Nitrogen oxides
- **O_3 -** Ozone
- **PCR -** Product category rules
- **SO_2 -** Sulfur dioxide
- **VOCs -** Volatile organic compounds

13 | GLOSSARY

- **Biogenic carbon:** carbon derived from biomass produced by living organisms through natural processes, excluding carbon which is fossilized or derived from fossil resources [8].
- **Biomass:** material of biological origin including organic material (both living and dead) above or below ground (trees, crops, animals) and biological waste (manure). Biomass excludes material embedded in geological formations, fossilized material and peat [8].
- **Co-product:** any of one or more products from the same process which is not the object of the assessment [8].
- **Cut-off criteria:** criteria for excluding inputs and outputs based on their contribution (%) to the total mass and energy. If this contribution is lower than a certain threshold (cut-off), these flows can be ignored [8].
- **Environmental impact:** any negative or beneficial modification of the environment, resulting wholly or in part from environmental aspects [23], that is to say elements of the activities, products or services of an organization that can interact with the environment [18].
- **Environmental product declaration (EPD ou Type III declaration):** environmental declaration providing quantified environmental data using predetermined parameters based on the ISO 14040 and ISO 14044 standards [8].
- **Fibre:** long cell or set of cells from the bark of the hemp stalk obtained after treatment and whose structure is comprised largely of cellulose [20].
- **Functional unit (UF):** quantified performance of a product system intended to be used as a reference unit in a life cycle assessment [18].
- **Hemp shives:** all the woody tissues resulting from primary processing, comprising mainly the hemp stalk pith [20].
- **Layering machine:** textile manufacturing equipment used to "layer" the insulating panel, i.e., to spread and structure the fibres without weaving them [21].
- **Life cycle assessment (LCA):** compilation and evaluation of the inputs and outputs (inventory), as well as the assessment of potential environmental impacts of a product during its life cycle [18].
- **Product category rules (PCR):** set of specific rules, requirements and guidelines for the development of EPDs [8]. The PCR referenced in this EPD refers to the PCR “UL PCR Part B: Building Envelope Thermal Insulation EPD requirements”.
- **Seed:** part of the fruit containing the germ of a new plant similar to the one that produced it [19].
- **Straw:** natural plant fibres derived from the stalks [22].

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