ENVIRONMENTAL PRODUCT DECLARATION

WOOD NOISE BARRIER

PILEBYG CLASSIC™



Ramo is pleased to present this Environmental Product Declaration (EPD) for the Pilebyg Classic™ wood noise barrier. This EPD was developed by CT Consultant in compliance with CAN/CSA-ISO 14025:2006, and has been verified by Marie Bellemare Consulting.

This EPD includes life cycle assessment (LCA) results for the raw materials supply and manufacturing stages (i.e., cradle to gate).

For more information about Ramo, visit https://ramo.eco/

Environmental Product Declaration

CSA Group Registered Based on ISO 14025 and Other Requirements
For more information visit csaregistries.ca/epd

6090-7473
February 2024-February 2029

1| GENERAL INFORMATION

This environmental product declaration (EPD) is in accordance with CAN/CSA-ISO 14025:2006 [1] and the PCRs noted below. EPDs from different programs may not be comparable (ISO 14025:2006). Comparison of the environmental performance using EPDs must consider all relevant information modules over the full life cycle of the products within the building. The PCRs allow comparison of EPDs only when the same functional requirements between products are ensured and the requirements of section 5.5 of ISO 21930:2017 are met. It should be noted that the use of different LCA software and life cycle inventory databases may lead to different results and affect the quality of the comparison.

Programme operator	**CSA Group** 178 Rexdale Boulevard Toronto, Ontario, Canada M9W 1R3 www.csagroup.org
General program instructions	CSA Group (2013) CSA Group Environmental Product Declaration (EPD) Program: Program Requirements. CSA Group. https://www.csaregistries.ca/GHG_VR_Listing/EPD_ProcessPage#
EPD registration number	6090-7473
EPD recipient organization	**Ramo** 517, rang du Ruisseau-des-Anges S Saint-Roch-de-l'Achigan, Quebec, Canada J0K 3H0 https://ramo.eco/
Product	Pilebyg Classic™ wood noise barrier
Declared unit	1 m^3 wood noise barrier
Market of applicability	North America
EPD type	Product-specific
Dataset variability	Not applicable
EPD scope	Cradle to gate
Reference period	2022
LCI database and version number	Ecoinvent version 3.9.1 “cut-off” [2]
LCIA methodology and version number	TRACI 2.1 [3]
LCA software	openLCA v2.02 (2023) [4]
Date of issue	February 16, 2024
Period of validity	February 16, 2024 to February 14, 2029
Reference product category rules (PCR)	PCR Part A: UL Environment. Building Related Products and Services. Life cycle assessment calculation rules and report requirements. v4.0. March 2022 - March 2027. UL 10010. PCR Part B: UL Environment. Building Related Products and Services. Structural and Architectural Wood Products EPD requirements. v1.1. May 2020 - October 2024. UL 10010-09.
The PCR review was conducted by:	Thomas Gloria, PhD Industrial Ecology 35 Bracebridge Road, Newton, Massachusetts, United States of America (USA) (617) 533-4929 / t.gloria@industrial-ecology.com
This declaration was independently verified in accordance with ISO 14025:2006. The UL Environment “Part A: Life cycle assessment calculation rules and report requirements”, v4.0 (March 2022), in conformance with ISO 21930:2017, serves as the core PCR, with additional considerations from the USGBC/UL Environment Part A Enhancement (2017).	☐ INTERNAL ☒ EXTERNAL  Marie Bellemare, Marie Bellemare Consulting

2| DESCRIPTION OF ORGANIZATION

Ramo is a Canadian company specialized in plant technologies to solve environmental problems. Ramo is the largest producer of fast-growing willows in North America and has unique expertise in willow cultivation, phytotechnologies and manufacturing low-carbon footprint noise barriers. At its Quebec facility, Ramo's green screens manufacturing division produces the Pilebyg Classic™, a wood noise barrier made up of two woven willow stem facades and a rock wool acoustic core. This product is manufactured under exclusive licence from the Danish company Pilebyg. The company also manufactures the HF1, a wood noise barrier under exclusive licence from the German company Heinrich Fahlenkamp. Ramo's manufacturing plant is located at 517, rang du Ruisseau-des-Anges S in Saint-Roch-de-l'Achigan, Quebec, Canada.

3| PRODUCT DESCRIPTION

3.1. Product description and applications

The Pilebyg Classic™ wood noise barrier is an effective, durable and maintenance-free solution for reducing transport or industrial noise pollution (Figure 1). Inspired by traditional Scandinavian fencing made from woven willow stems, the design of this product has been refined to offer a modern design and durability by applying the principles of constructive protection. The noise barrier is made up of two willow stem facades and a rock wool acoustic core that makes the product absorbent on both sides. The willow stem facades are woven vertically without fasteners into a frame made of vertical larch posts and horizontal galvanized steel tubes. At the construction site, the noise barrier is easily installed using steel or wooden posts. To ensure that the noise barrier is harmoniously integrated to the surrounding landscape, vines are planted at the base of the wall which will cover the infrastructure within a few years.

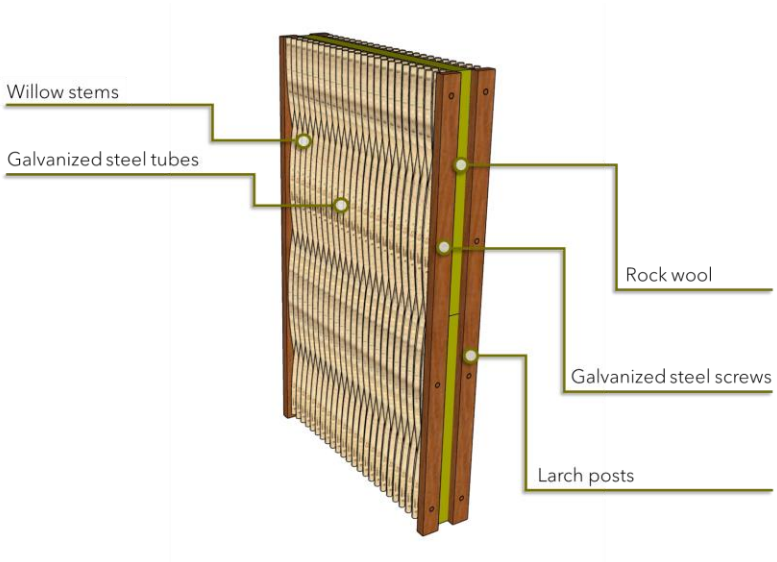


Figure 1. Pilebyg Classic™ wood noise barrier

3.2. Product covered by the EPD

This EPD covers the Pilebyg Classic™ wood noise barrier.

3.3. Technical specifications of the noise barrier

Table 1. Technical specifications of the noise barrier

Property	Standard	Result
Sound Transmission Class (STC)	ASTM E90 and ASTM E413	25
Noise reduction coefficient (NRC)	ASTM C423	0.80

The evaluation reports are available on request from Ramo (https://ramo.eco/).

According to an independent laboratory, the willow stems used in the facades of the wood noise barriers have a good performance after a decade of exposure to the elements. Willow stems are also highly resistant to de-icing salts such as calcium chloride [5].

3.4. Material composition of the noise barrier

The Pilebyg Classic™ wood noise barrier consists of a rock wool acoustic core and two facades. The facades are made of willow stems woven into a frame made up of larch posts, galvanized steel tubes and galvanized steel screws (Table 2).

Table 2. Composition of the noise barrier

Material	Mass (% of the noise barrier)	Production site	Distance travelled to Ramo's manufacturing plant
Willow stems	45.4%	Canada	< 1 km
Rock wool	37.0%	Canada	622 km
Larch wood posts	10.9%	Canada	364 km
Galvanized steel tubes	6.7%	Asia	22,348 km
Galvanized steel screws	< 1%	Global market	858 km

Note: The noise barrier does not have a safety data sheet.

3.5. Willow stem production and noise barrier manufacturing

To produce the willow stems, cuttings are planted in an agricultural field and the stems are harvested mechanically every 3 to 4 years over a 20-year life cycle[1] (Figure 2).

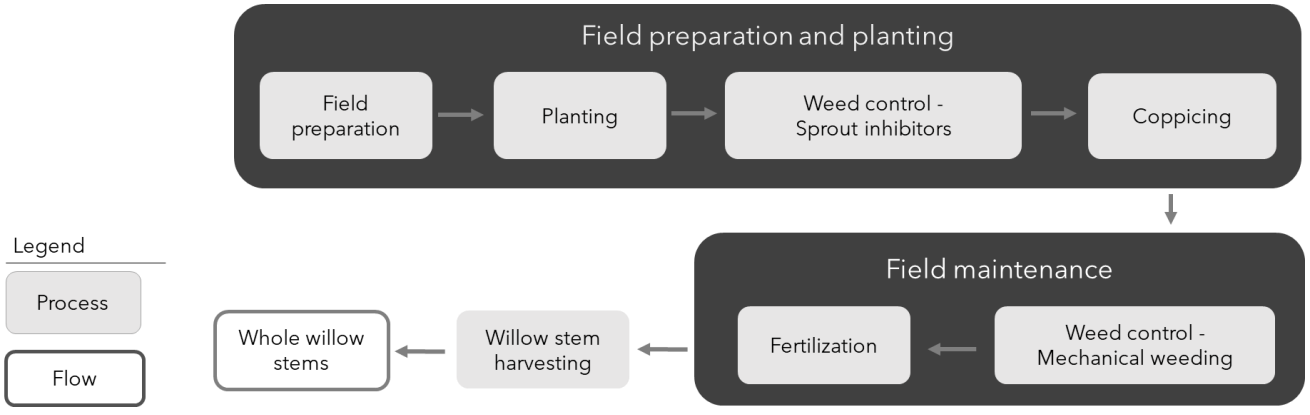
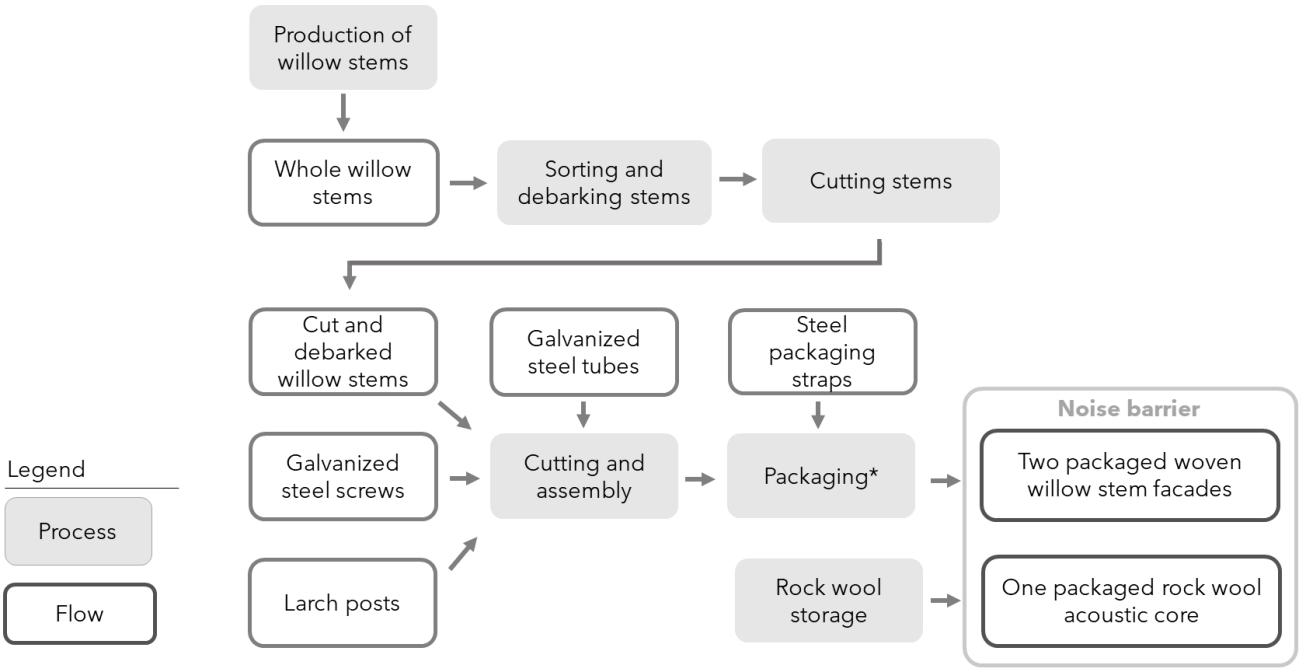


Figure 2. Willow stem production stages (Saint-Roch-de-l'Achigan, Quebec, Canada)

[1] The willow plantations have a life cycle of at least 20 years.

Both facades are manufactured at Ramo's plant: the willow stems are sorted and debarked using specialized electrical equipment (Figure 3). The residues from sorting and debarking are recovered and turned into mulch (co-product) which is sold on the horticultural market. The willow stems are then air-dried and cut using an electric saw. The residues from stem cutting are recovered and recycled by a local company. The larch posts are cut and drilled using electric hand tools. The residues from cutting the larch posts are used to make spacers. The galvanized steel tubes are drilled using an electric drill press. Using electrical equipment, the frame is then assembled with galvanized steel screws and the willow stems are woven into the frame. Galvanized steel screws waste (1% of the mass) and steel packaging straps waste (1% of the mass) are sent to recycling. Rock wool for the acoustic core is shipped as received from the supplier.



* To model the packaging, only the steel straps are included (larch spacers are excluded as they fall below the cut-off criteria).

Figure 3. Manufacturing stages of the Pilebyg Classic™ wood noise barrier (Saint-Roch-de-l'Achigan, Quebec, Canada)

3.6. Packaging

Prior to shipment, the facades are packaged in bundles of 11 and fastened with steel straps to larch spacers (made from residues of the larch posts). The stone wool is shipped as received from the supplier on a pallet with plastic film wrapping.

3.7. Properties of the noise barrier as produced

The noise barrier as produced at the manufacturing plant has the properties shown in Table 3.

Table 3. Properties of the noise barrier as produced

Parameter		Value	Unit
Mass		179.58	kg
Dimensions of the wood noise barrier as produced	Thickness	0.317	m
		1.040	ft
	Width	1.524	m
		5	ft
	Height	3.048	m
		10	ft

4| SCOPE OF EPD

4.1. Declared unit

The declared unit, i.e., the quantity of construction product used as a reference unit for the presentation of environmental information, is 1 m^3 of the Pilebyg Classic™ wood noise barrier as defined in PCR Part B [6]. The key parameters of the noise barrier which meets the declared unit are shown in Table 4.

Table 4. Key parameters linked to the declared unit

Parameter		Value	Unit
Declared unit		1	m^3
Mass		179.58	kg
Dimensions to reach the declared unit	Thickness	0.317	m
	Width	1	m
	Height	3.15	m
Density of the components	Willow stem	250	kg/m^3
	Larch post	560	kg/m^3
	Rock wool	176	kg/m^3
	Galvanized steel tube	7,800	kg/m^3
	Galvanized steel screw	7,800	kg/m^3
Moisture content of the components	Willow stem	15% (average)	-
	Larch post	15% (average)	-
Conversion factor to 1 m^2 noise barrier		0.317	-

4.2 System boundaries

The cradle-to-gate LCA includes the production stage of the noise barrier comprising the life cycle modules A1, A2 and A3 (EN 15804:2013 and ISO 21930:2017 [7][8]). Thus, the other life cycle modules as identified by these standards are excluded from the system.

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

PRODUCTION STAGE (A1 - A3)			CONSTRUCTION STAGE (A4 - A5)		USE STAGE (B1 - B7)							END-OF-LIFE STAGE (C1 - C4)				BEYOND SYSTEM BOUNDARIES (D)
Production of raw materials	Transport of raw materials	Wood noise barrier 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	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME

Legend: X: Life cycle module included in the LCA ME: Life cycle module excluded from the LCA

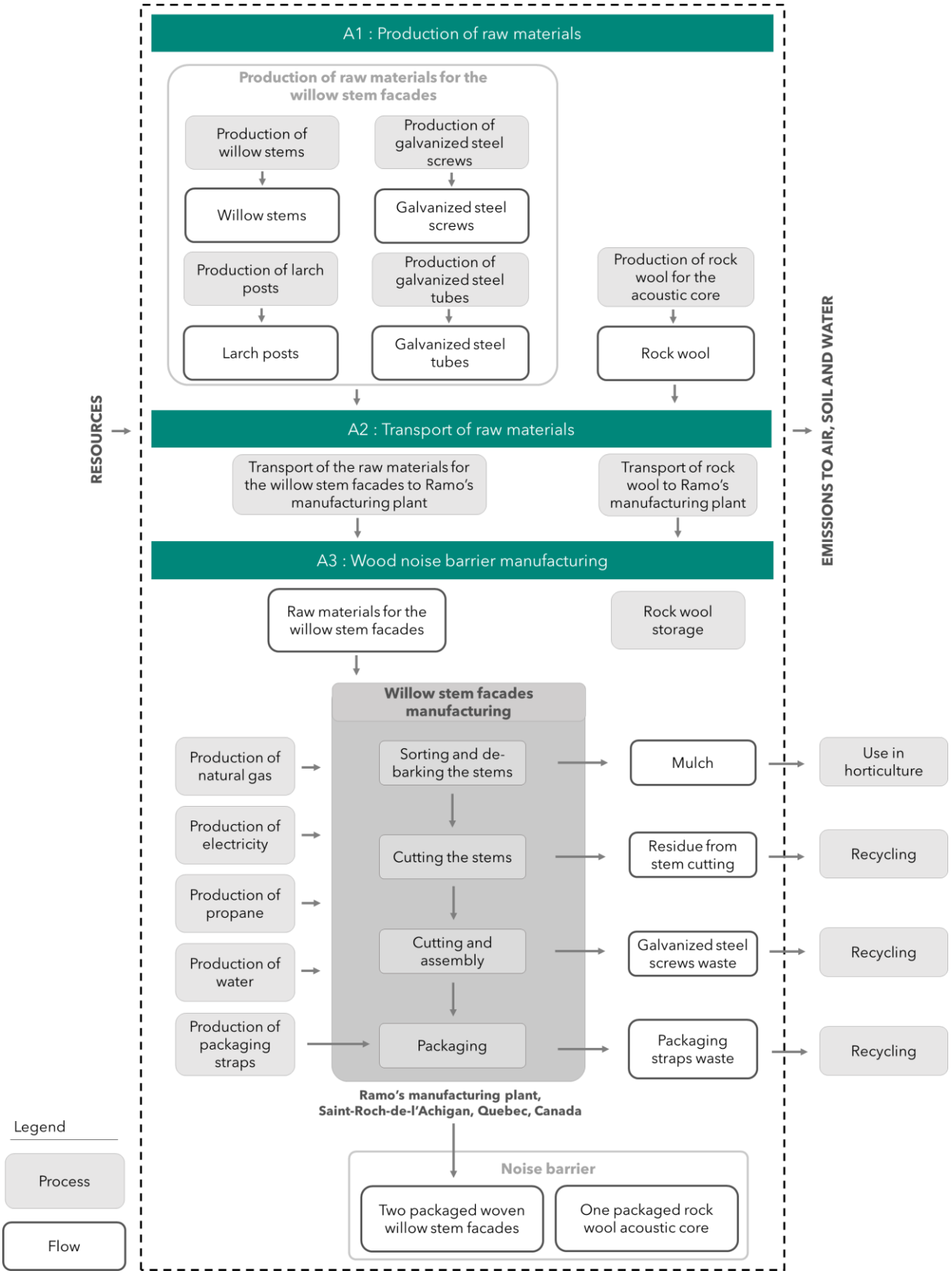


Figure 4. System boundaries - Pilebyg Classic™ wood noise barrier

4.3. Assumptions

Carrying out an LCA involves making assumptions when data is incomplete or missing. The following assumptions were applied with respect to the present LCA:

- **Fuel consumption of agricultural equipment (A1).** Fuel consumption is estimated on the basis of specific fuel consumption (litres/hour) and productivity (ha/hour) for each piece of agricultural equipment (chisel, rotary tiller, sprinkler, step planter, shredder, mower, fertilizer spreader and weeding equipment) required for willow cultivation.
- **Environmental emissions linked to land spreading (A1).** Environmental emissions linked to the spreading of synthetic fertilizers, organic fertilizers and pesticides are determined using the CERES modelling tool on the basis of the most representative data in the Quebec context [9].
- **Galvanization of the steel tubes (A1).** The galvanization of the steel tubes and screws is modelled using the Ecoinvent data "zinc coat, pieces", which assumes a zinc coating thickness of 65 micrometres on all the surfaces exposed to galvanization.
- **Transport to the recycling site (A3).** The distance travelled by the screws and packaging straps waste from Ramo's manufacturing plant to the recycling site is estimated to be 50 km.

4.4 Cut-off criteria

As defined in ISO 21930:2017 [8] all input and output flows whose mass and/or energy accounts for more than 1% of the total cumulative mass and/or energy were included. Also in line with the standard, at least 95% of all mass and energy flows were included. The maintenance of equipment and infrastructure, administrative activities and transport of employees were not included in the LCA model. No known mass or energy flows were deliberately excluded.

4.5. Allocation

When a process in the life cycle of a product generates several outputs (multifunctional processes) or is linked to another system (life cycle of a product outside of the boundaries of the system under study), the environmental impact of the process must be allocated to the different products, co-products and systems. The allocation methods considered in the present study are:

- **Allocation for multifunctional processes.** During the process of sorting and debarking the willow stems, two outputs are generated: the debarked willow stem and mulch. The mulch is a co-product sold on the horticultural market. The impacts of the electricity and water consumption associated with the sorting and debarking process are divided between the debarked willow stem and the mulch (outside the system). Since no physical relationship could be established between the flows of electricity and water and the outputs, and that the difference in economic value between the two outputs is greater than 25%, the distribution of impacts was carried out using an economic allocation as specified in PCR Part A [10]. The distribution of the economic value, and therefore the impacts, of the two outputs is 93% for the debarked willow stem and 7% for the mulch (Figure 5).

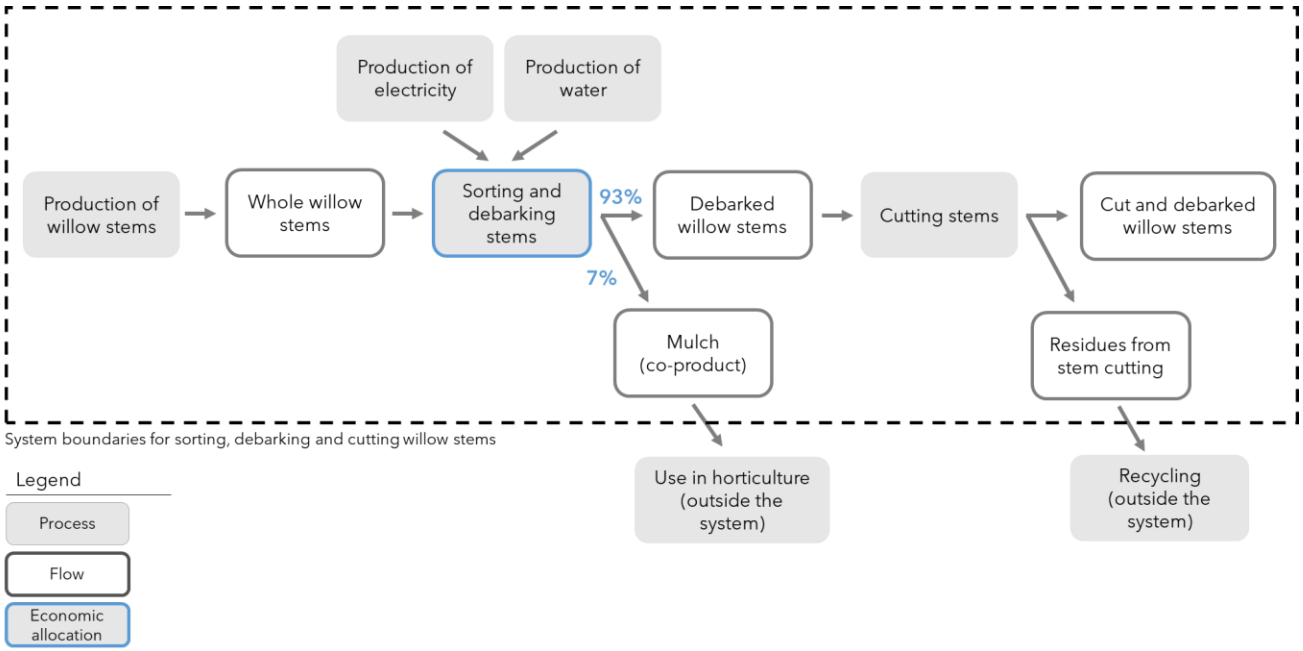


Figure 5. Allocation for the (multifunctional) willow stem sorting and debarking process

- **Allocation for end-of-life processes.** The cut-off approach was chosen in compliance with ISO 21930 [8]. This approach specifies that the impacts associated with secondary materials entering the system are to be attributed to the system that generated them, and that the benefits associated with the recycling of materials leaving the system are not included. In this study, the paper mill sludge and chicken manure used for the cultivation of willow stems have zero impact and no environmental benefits associated with the materials sent for recycling (residues from stem cutting, galvanized steel screws waste, packaging straps waste) were included.
- **Allocation approach in Ecoinvent data.** The Ecoinvent data used is "Allocation, cut-off by classification" which attributes the impacts of secondary materials entering the system to those that generated them and excludes the benefits associated with recycling materials. This is in line with the cut-off approach specified in ISO 21930:2017.

4.6. Reference period

The inventory data is representative of the production year 2022 (from 1 January 2022 to 31 December 2022).

4.7. Data sources and quality

Table 6. Life cycle inventory data sources for the noise barrier

Data type	Source
Primary data	Primary data was provided by Ramo for the period from 1 January 2022 to 31 December 2022. The primary data includes measured data regarding willow cultivation (stem production), raw material quantities, noise barrier manufacturing and packaging.
Secondary data	Secondary data is obtained from the following sources: • Ecoinvent database version 3.9.1 "cut-off [2]; • EPD • scientific reports • reference guide • emission modelling tools [9][11]

Table 7. Data quality assessment

Criterion	Evaluation
Geographical representation	The primary data concerning the willow stem production, willow stem transport and noise barrier manufacturing stages represents Ramo's specific context. Secondary data was selected to be as representative as possible of Ramo's noise barrier manufacturing context. Priority was given to secondary data representative of the Quebec context, otherwise data representative of the global market was used. The main inventory data by geographical context are: • Quebec context: production of willow stems, environmental emissions linked to the spreading of fertilizers and pesticides, production of larch posts, electricity grid mix, production of natural gas and production of water. • North American context: stone wool production • Global context: production of steel components and their galvanization, production of packaging material, production of propane, transport by truck and boat, production of diesel, production of petrol, production of synthetic fertilizers, production of pesticides. The geographical representativeness of the primary and secondary data is considered satisfactory.
Temporal representativeness	The primary data is representative of the reference period (1 January to 31 December 2022). The secondary data comes mainly from the Ecoinvent version 3.9.1 (2022) database, which is based on version 3.0 (released annually since 2013). It should be noted that some version 3.0 data comes from earlier versions (1991-2012). The other secondary data comes from recent reference guides, i.e., published less than 10 years ago, with the exception of the CERES environmental emissions modelling tool which was released 11 years ago (2013) [12]. The primary and secondary data is deemed satisfactory in terms of temporal representativeness.

Criterion	Evaluation
Technological representativeness	The primary data regarding the production of willow stems and the manufacturing of noise barriers are based on data measured by Ramo. The secondary data was selected in order to represent as accurately as possible the production of willow stems, the production of other raw materials and the manufacturing of noise barriers by Ramo. Rockwool North America's EPD was chosen to model the rock wool acoustic core in order to achieve high technological (and geographical) representativeness [12]. The primary and secondary data are considered to have a satisfactory technological representativeness.
Completeness	All flows whose mass and energy flow are above the cut-off threshold (1%) were included in the LCA in accordance with the PCR Part B [6]. No known flow was deliberately excluded from the LCA. The study is considered to have a satisfactory level of completeness.

5| ENVIRONMENTAL IMPACTS

5.1 Environmental life cycle impacts

The environmental life cycle impacts are reported for 1 m^3 of noise barrier (declared unit) and also for 1 m^2 for reference purposes. They are presented for six impact categories of the TRACI 2.1 assessment method [3] for the three selected life cycle modules (A1, A2 and A3) [8].

Table 8. Environmental life cycle impacts of the noise barrier [13]

IMPACT CATEGORY	UNIT AND INDICATOR	1 M^3 OF NOISE BARRIER (DECLARED UNIT)				1 M^2 OF NOISE BARRIER			
		TOTAL	LIFE CYCLE MODULE			TOTAL	LIFE CYCLE MODULE		
			A1	A2	A3		A1	A2	A3
Global warming potential	kg CO_2 eq	1.58E+2	1.22E+2	9.76E+0	2.65E+1	5.02E+1	3.87E+1	3.09E+0	8.39E+0
Acidification of soil and water sources potential	kg SO_2 eq	1.14E+0	1.02E+0	9.45E-2	2.22E-2	3.61E-1	3.24E-1	3.00E-2	7.05E-3
Eutrophication potential	kg N eq	5.26E-1	5.19E-1	5.21E-3	2.09E-3	1.67E-1	1.65E-1	1.65E-3	6.63E-4
Smog formation potential	kg O_3 eq	1.06E+1	8.16E+0	1.94E+0	5.30E-1	3.37E+0	2.59E+0	6.16E-1	1.68E-1
Ozone depletion potential	kg CFC-11 eq	1.80E-6	1.40E-6	1.71E-7	2.30E-7	5.70E-7	4.42E-7	5.43E-8	7.30E-8
Abiotic depletion potential (fossil resources)	MJ (LHV)	2.20E+2	1.40E+2	1.94E+1	6.10E+1	6.98E+1	4.44E+1	6.15E+0	1.93E+1

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, EPD users should not use additional measures for comparative purposes.

The term "potential" means that the impact scores do not represent actual measured impacts, but are the results of theoretical modelling using an impact assessment method such as TRACI 2.1. To lighten the text, the term "potential" will not be used in the rest of the EPD.

5.2 Life cycle inventory categories

5.2.1 Resource use

Table 9. Resource use inventory categories [13]

INVENTORY CATEGORY	UNIT	1 M³ OF NOISE BARRIER (DECLARED UNIT)				1 M² OF NOISE BARRIER			
		TOTAL	LIFE CYCLE MODULE			TOTAL	LIFE CYCLE MODULE		
			A1	A2	A3		A1	A2	A3
Renewable primary energy used as energy carrier (fuel)[1]	MJ (LHV)	7.50E+2	6.34E+2	1.60E+0	1.14E+2	2.38E+2	2.01E+2	5.06E-1	3.63E+1
Renewable primary resources with energy content used as material[1]	MJ (LHV)	3.23E+2	3.23E+2	0.00E+0	0.00E+0	1.02E+2	1.02E+2	0.00E+0	0.00E+0
Total use of renewable primary resources with energy content[1]	MJ (LHV)	1.07E+3	9.57E+2	1.60E+0	1.14E+2	3.40E+2	3.03E+2	5.06E-1	3.63E+1
Non-renewable primary resources used as an energy carrier (fuel)[1]	MJ (LHV)	1.79E+3	1.27E+3	1.37E+2	3.83E+2	5.66E+2	4.01E+2	4.33E+1	1.21E+2
Non-renewable primary resources with energy content used as material[1]	MJ (LHV)	1.31E+2	1.31E+2	0.00E+0	0.00E+0	4.14E+1	4.14E+1	0.00E+0	0.00E+0
Total use of non-renewable primary resources with energy content[1]	MJ (LHV)	1.92E+3	1.40E+3	1.37E+2	3.83E+2	6.08E+2	4.43E+2	4.33E+1	1.21E+2
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
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
Secondary materials[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
Recovered energy[3]	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
Use of net freshwater resources[4]	m³	2.28E+0	1.34E+0	1.63E-2	9.27E-1	7.23E-1	4.24E-1	5.17E-3	2.94E-1

[1] The results of these inventory categories were calculated using the CED LHV method [14] *following the "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017"* [15].

[2] The noise barrier contains no secondary source materials, this inventory category is therefore zero.

[3] The noise barrier is not used for energy recovery, this inventory category is therefore zero.

[4] The results of this inventory category were determined by using the "water consumption" category from the ReCiPe 2016 Midpoint (H) impact assessment method. [14].

5.2.2 Waste and output flows

Table 10. Waste and output flows inventory categories [13]

INVENTORY CATEGORY	UNIT	1 M³ OF NOISE BARRIER (DECLARED UNIT)				1 M² OF NOISE BARRIER			
		TOTAL	LIFE CYCLE MODULE			TOTAL	LIFE CYCLE MODULE		
			A1	A2	A3		A1	A2	A3
Hazardous waste disposed[1]	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
Non-hazardous waste disposed[1]	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
High-level radioactive waste[2]	m³	5.93E-8	3.44E-8	1.42E-9	2.35E-8	1.88E-8	1.09E-8	4.49E-10	7.45E-9
Intermediate- and low-level radioactive waste[2]	m³	1.64E-7	1.34E-7	7.35E-9	2.30E-8	5.21E-8	4.25E-8	2.33E-9	7.29E-9
Components for reuse[3]	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
Materials for recycling[1]	kg	6.09E-1	0.00E+0	0.00E+0	6.09E-1	1.93E-1	0.00E+0	0.00E+0	1.93E-1
Materials for energy recovery[3]	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
Exported energy[3]	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

[1] The results of these inventory categories were calculated according to the "ACLCA Guidance to calculating non-LCIA inventory metrics in accordance with ISO 21930:2017" [15] *by using the foreground data provided by the manufacturer.*

[2] The results of these inventory categories were calculated according to the "ACLCA Guidance to calculating non-LCIA inventory metrics in accordance with ISO 21930:2017" [15] *by using the inventory data. It is important to note that the foreground data of this LCA does not include radioactive waste, i.e., the noise barrier manufacturing process does not directly generate radioactive waste. According to ISO 21930:2017* [8]*, radioactive waste, when generated for electricity production, consists mainly of spent fuel from reactors (high-level radioactive waste) and routine maintenance and operation of the facilities (low- and medium-level radioactive waste).*

[3] No material flows are recovered or reused, these inventory categories are therefore zero.

5.3 Interpretation of life cycle impacts

The life cycle impacts are interpreted using a contribution analysis and a summary of the methodological limitations of an LCA of a wood-based product. The aim of the contribution analysis is to determine the share of impacts associated with the different life cycle modules and sub-modules (Figure 6).

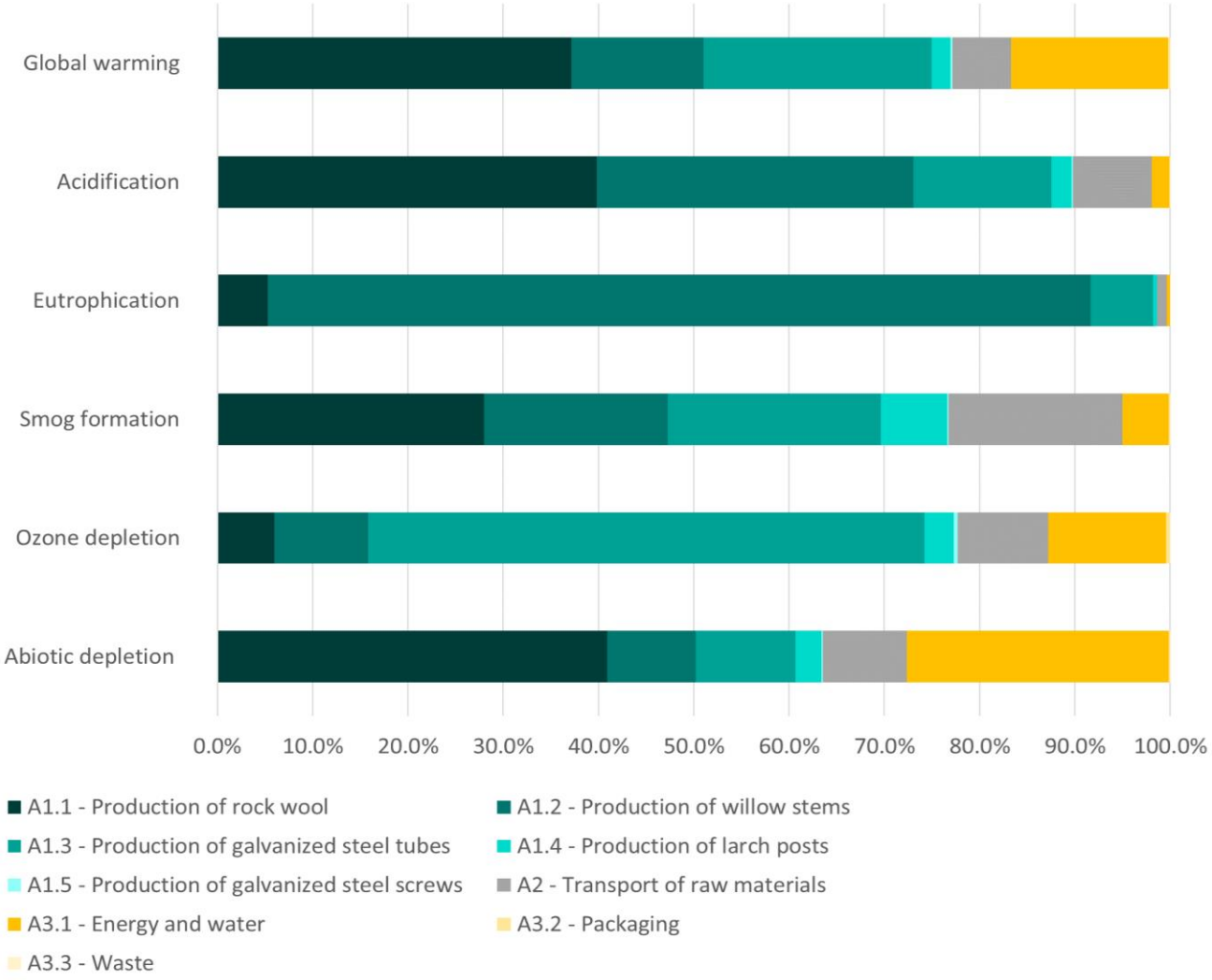


Figure 6. Share of impacts associated with life cycle modules and sub-modules in the different impact categories

Regarding the contribution of the life cycle modules (A1, A2 and A3) to the total impact scores, it appears that the impacts for all the different categories are dominated by the life cycle module A1 - Production of raw materials (in turquoise), which accounts for 63.5 to 98.6% of the total impacts. As for A3 - Wood noise barrier manufacturing, this life cycle module represents 0,4 to 27,7% of the total impacts for the six impact categories. The life cycle module A2 - Transport of raw materials represents between 1.0 and 18.3% of the total impacts for the various categories.

In terms of sub-modules (activities), A1.1 - Production of rock wool is the largest contributor to the *Global warming, Acidification*, *Smog formation* and *Abiotic depletion* impact categories, representing 28.0 to 40.9% of the total impacts. This is explained by the fact that the rock wool represents a large portion of the mass of raw materials (37.0% of the mass of the noise barrier) and has a greater specific impact than the other raw materials. For the *Ozone depletion* impact category, the sub-module A1.3 - Production of galvanized steel tubes is the

highest contributor, representing 58.4% of the total impacts. As for the *Eutrophication* impact category, the sub-module A1.2 - Production of willow stems is the largest contributor (86.4% of total impacts). The impacts of this sub-module are mainly due to the spreading of fertilizers.

The main methodological limitations associated with the LCA of a wood-based product are the following (PCR Part B):

- While this EPD does not address impacts related to forest management, these potential impacts may be addressed through regulatory and normative frameworks (ASTM 7612-15 and ISO 21930:2017 section 7.2.11). These regulatory and normative frameworks, combined with this EPD, may provide a more complete picture of the environmental and social performance of wood products.
- While this EPD does not address all forest management activities that influence forest carbon stocks, wildlife habitat, endangered species and soil and water quality, these potential impacts may be addressed through regulatory frameworks and/or on the basis of forest certification systems. These frameworks and certification systems, combined with this EPD, will give a more complete picture of the environmental and social performance of wood products.
- EPDs can complement but cannot replace assessment tools and certifications designed to address environmental impacts and/or set performance thresholds, e.g. Type 1 certifications and health assessments and declarations.
- Life cycle inventory data related to the cutting of trees in forests (extraction of raw materials) remain generic data that represent average forestry operations and not forestry operations in a specific location. Thus, the impacts can differ greatly between average and specific forestry operations.
- EPDs are based on average manufacturing plant data and not on data specific to the manufacturing of a single product. For the purpose of this EPD, variability was taken into account by means of a sensitivity analysis included in the LCA report.

6| ADDITIONAL ENVIRONMENTAL INFORMATION

6.1. Biogenic carbon

The noise barrier is made of materials that contain biogenic carbon, i.e., carbon derived from biomass (willow and larch). In accordance with ISO 21930:2017, the capture and emissions of biogenic carbon are presented separately from the impact on *Global Warming* as the LCA is cradle to gate. This calculation was made using the "Business-to-Business Carbon Sequestration Tool" developed by FPInnovations [11]. The net balance of the biogenic carbon capture and biogenic carbon emissions is presented for 1 m^3 of noise barrier (Table 11).

Table 11. Net biogenic carbon balance for 1 m^3 of Pilebyg Classic™ wood noise barrier

Parameter of the FPInnovations "Business-to-Business Carbon Sequestration Tool"	Unit	Biobased products in 1 m^3 of noise barrier		Total
		Willow	Larch	
General parameters				
Dry mass	kg	69.28	16.68	**85.96**
Carbon content	%	50%	47.21%	**-**
Type of wood	-	Hardwood	Softwood	**-**
Carbon capture				
Carbon captured in the product at the factory gate	kg CO_2 eq	-127.01	-28.87	**-155.89**
Biogenic carbon emissions at end of life				
CO_2 emissions of recycled wood (counted as 100% of emitted CO_2)	kg CO_2	11.90	2.21	**14.11**
CO_2 emissions from the combustion of wood waste	kg CO_2	11.90	2.21	**14.11**
CO_2 emissions from aerobic landfill sites	kg CO_2	8.92	1.57	**10.50**
CO_2 emissions from fugitive landfill gas	kg CO_2	6.06	1.03	**7.09**
CO_2 emissions from the combustion of landfill gas	kg CO_2	4.98	0.85	**5.83**
Total CO_2 emissions	kg CO_2	43.75	7.88	**51.64**
Methane emissions at end of life				
CH_4 emissions from fugitive emissions from landfill sites[1]	kg CH_4	1.80	0.31	**2.11**
Net biogenic carbon balance				
Net biogenic carbon balance	kg CO_2 eq	-32.80	-12.39	**-45.19**

[1] According to the "Business-to-Business Carbon Sequestration Tool", the global warming potential of CH_4 is 28 kg CO_2 eq /kg CH_4.

6.2. Regulated hazardous substances

The Pilebyg Classic™ noise barrier contains rock wool, willow stems, larch posts and galvanized steel, which are not on Canada's list of hazardous substances [16]. Thus, there are no regulated hazardous substances associated with the production of the Pilebyg Classic™ noise barrier.

6.3. Health and environmental quality during manufacturing

The Pilebyg Classic™ noise barrier does not have any adverse effect on the health of the workers during manufacturing and does not emit any substances that could affect health or the environment. The use of a dust extraction system is recommended for certain manufacturing processes that emit wood dust.

6.4. Delayed emissions and unexpected adverse events

No delayed emissions are expected from the Pilebyg Classic™ noise barrier. There are no unexpected adverse effects from the combustion, water damage or mechanical alteration of the product.

6.5. Willow cultivation

The willow used in the Pilebyg Classic™ noise barrier is a renewable biobased resource. A plantation of fast-growing willow is harvested every 3 to 4 years over its 20-year lifespan. The use of willow generates multiple co-benefits, such as the reclamation of degraded sites and marginal land, the use of fertilizing waste and carbon sequestration with fast-growing trees.

6.6. Additional information

Additional information can be found at: https://ramo.eco/

7| IMPACT AND INVENTORY CATEGORIES DEFINITIONS

Table 12. Impact categories used in the LCA, definitions, units and indicators [3]

Impact category	Definition	Unit and indicator
Global warming potential	This impact category 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 of soil and water sources potential	This category 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 impact category measures the consequences of an enrichment of water by nutrients (nitrates and phosphates), thus increasing the growth of algae that deteriorate the aquatic ecosystem.	kg N eq
Smog formation potential	This impact category 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 (NO_x) and volatile organic compounds (VOCs) to solar radiation.	kg O_3 eq
Ozone depletion potential	This category measures the impact of the depletion of the ozone layer, which 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 impact category measures the depletion of abiotic (fossil) energy resources and represents the excess energy required to extract these resources in the future.	MJ (LHV)

Table 13. Inventory categories used in the study, definitions and units [10]

Inventory 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, paper).	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 freshwater resources	Freshwater that is consumed, i.e., by evaporation (cooling towers), evapotranspiration, freshwater embedded in the product or drainage of water into the ocean.	m^3
Removals and emissions of biogenic carbon	Biogenic carbon input (removal during biomass formation) and output (emissions) related to the product and packaging.	kg CO_2

8| ABBREVIATIONS, ACRONYMS AND CHEMICAL FORMULAE

- CFC Chlorofluorocarbon
- CFC-11 Trichlorofluoromethane
- CH_4 Methane
- CO_2 Carbon dioxide
- DU Declared unit
- EPD Environmental product declaration
- eq Equivalent
- LCA Life cycle assessment
- LHV Lower heating value
- N Nitrogen
- NO_x Nitrogen oxides
- O_3 Ozone
- PCR Product category rules
- SO_2 Sulphur dioxide
- VOCs Volatile organic compounds

9| 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].
- **Declared unit (DU):** Quantity of construction product used as a reference unit for presenting environmental information by life cycle module. The term “declared unit” is used instead of “functional unit” when the performance of the product in use is not known [6].
- **Ecoinvent:** Life cycle inventory database for materials, chemicals, power generation systems, transport and waste treatment processes [2].
- **Environmental impact:** any negative or beneficial modification of the environment, resulting wholly or in part from environmental aspects [17], 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):** environmental declaration providing quantified environmental data using predetermined parameters based on the ISO 14040:2006 and ISO 14044:2006 standards [18] [19][8].
- **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 refer to "UL PCR Part B: Structural and Architectural Wood Products EPD Requirements" and "UL PCR Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report."
- **Reference flow:** Quantity of process outputs in a given product system required to fulfil the function as expressed by the declared unit [18].

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ramo
517, rang du Ruisseau-
des- Anges S
Saint-Roch-de-l'Achigan,
Quebec
Canada J0K 3H0
1 844 588-0013
https://ramo.eco/