Environmental Product Declaration

Aluminium Rod – Lapointe

prysmian

ALASTA
Advanced Aluminum Technologies

Environmental Product Declaration

CSA Group Registered Based on ISO 14025 and Other Requirements
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3529-5312
November 2023-November 2028

The development of this **product-specific Type III** environmental product declaration (EPD) for **aluminium rod manufactured at Prysmian's Lapointe** (Québec) **facility**, was commissioned by **Prysmian**, a world leader in aluminium wire and cable products. This EPD was developed by **Groupe AGÉCO** in compliance with CAN/CSA-ISO 14025, EN 15804 and ISO 21930 and was verified by Tom P. Gloria, Ph.D., from Industrial Ecology Consultants.

This EPD includes a life cycle assessment (LCA). The LCA is a cradle-to-gate modules A1-A3, C1-C4 and module D. LCA and EPD was performed by **Groupe AGÉCO**.

For more information about Prysmian, please go to www.prysmian.com

Issue date: November 29, 2023

Minor Amendment: June 20, 2024

This environmental product declaration (EPD) is in accordance with CAN/CSA-ISO 14025, ISO 21930:2017, EN 15804 and the product category rule (PCR) noted below. Environmental declarations from different programs (ISO 14025) may not be comparable. Any EPD comparison must be performed in conformance with ISO 21930 guidelines. Care should be taken when comparing results since differences in certain assumptions, data quality and datasets are unavoidable, even when using the same PCR.

Comparison of the environmental performance of aluminium cast products using EPD information shall be based on the product's use and impacts at the construction works level, and therefore EPDs may not be used for comparability purposes when not considering the construction works energy use phase as instructed under the selected PCR.

Full conformance with the PCR for aluminium products allows EPD comparability only when all stages of a life cycle have been considered when they comply with all referenced standards, use the same sub-category PCR, and use equivalent scenarios. However, variations and deviations are possible. Example of variations: different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.

This EPD reports environmental impacts based on established life cycle impact assessment methods. The reported environmental impacts are estimates, and their level of accuracy may differ for a product line and reported impact. LCAs do not generally address site-specific environmental issues related to resource extraction or toxic effects of products on human health. Unreported environmental impacts include (but are not limited to) factors attributable to human health, land use change and habitat destruction. Regulations address some of these issues. EPDs do not report product environmental performance against any benchmark. Also, the EPD and PCR process is informational only and does not warranty performance.

General information

Program operator	**CSA Group** | 178 Rexdale Blvd, Toronto, ON, Canada M9W 1R3 | www.csagroup.ca
EPD recipient organization	**Prysmian |** 2040, rue de Neuville, Jonquière, QC, G7S 3G6 | www.prysmian.com
EPD registration number	#3529-5312
Declared product	Aluminium rod
Reference PCR	– Product Category Rules for Building-Related Products and Services. Part A: Calculation Rules for the LCA and Requirements on the Project Report according to EN 15804+A2:2019 (version 1.3; IBU, 2021) – PCR Part B: Requirements on the EPD for Products of aluminium and aluminium alloys, Version v6 (IBU, 2023)
Date of issue (approval)	November 29, 2023
Period of validity	November 29, 2023 – November 27, 2028 (5 years)

The PCR review was conducted by:	Tom Gloria (Industrial Ecology Consultants) – chair of the Review Panel
This EPD and related data were independently verified by an external verifier, Tom P. Gloria, according to CAN/CSA-ISO 14025:2006 and ISO 21930:2017.	__ Internal x **External** Thomas Gloria Tom P. Gloria, Ph.D. Industrial Ecology Consultants 35 Bracebridge Rd., Newton, MA 02459-1728, USA www.industrial-ecology.com
This life cycle assessment was conducted in accordance with ISO 14044:2006 and the reference PCR by:	Groupe AGÉCO www.groupeageco.ca | ageco@groupeageco.ca

Summary Sheet
Environmental Product Declaration

Aluminium Rod

This is a summary of the environmental product declaration (EPD) specific type III describing the environmental performance of aluminium rods manufactured at Prysmian's Lapointe plant in Canada.

EPD commissioner and owner	Period of validity	Program operator and registration number	LCA and EPD consultants
Prysmian	November 29, 2023 – November 27, 2028	CSA Group #3529-5312	Groupe AGÉCO

Product Category Rules

- Product Category Rules for Building-Related Products and Services. Part A: Calculation Rules for the LCA and Requirements on the Project Report according to EN 15804+A2:2019 (version 1.3; IBU, 2021)
- PCR Part B: Requirements on the EPD for Products of aluminium and aluminium alloys (v6, IBU, 2023)

Product description
Aluminium rod destined to be transformed and used mainly in cables, wire and strip.

Declared unit
1 metric ton (equal to 1,000 kg) of aluminium shaped into rod

Material content (% average of total product mass)
Aluminium: 97.68%
Metal alloys: 2.32%

Life cycle stages included:
Cradle-to-gate (A1-A3) with modules C1-C4 and module D.

What is a Life Cycle Assessment (LCA)?
LCA is a science-based and internationally recognized tool to evaluate the relative potential environmental impacts of products and services throughout their life cycle, beginning with raw material extraction and including all aspects of transportation, production, use, and end-of-life treatment. The method is defined by the International Organization for Standardization (ISO) 14040 and 14044 standards. For EPD development, Product Category Rules (PCR) give additional guidelines on how to conduct the LCA of the product.

Why an Environmental Product Declaration (EPD)?
Prysmian is seeking to communicate the environmental performance of its aluminium products to clients and to position their products through a rigorous and recognized communication tool, the EPD. By selecting products with an EPD, building projects can earn credits towards the Leadership in Energy and Environmental Design (LEED) rating system certification. In LEED v4 and v4.1, points are awarded in the Materials and Resources category.

This EPD summary provides an overview of the full ISO 14025 compliant EPD registered with CSA Group.

Environmental impacts

The environmental impacts of 1 metric ton of aluminium rod from cradle-to-gate (A1-A3) with modules C1-C4 are summarized below for the main environmental indicators (based on life cycle impact assessment methods AR6 with and without uptake, EF Method 3.0, and TRACI 2.1). Refer to the full EPD for more detailed results, including results on resource use, generated waste, and output flows.

Method	Indicators		Units	A1-A3	C1	C2	C3	C4
AR6, with uptake (IPCC, 2021)	**GWP-total**	**Global warming potential total**	kg CO_2 eq.	4.37E+03	0	8.43E+00	2.82E+02	3.83E+00
	GWP-fossil	**Global warming potential fossil fuels**	kg CO_2 eq.	4.13E+03	0	8.43E+00	2.79E+02	3.79E+00
	GWP-biogenic	**Global warming potential biogenic**	kg CO_2 eq.	2.31E+01	0	5.50E-02	1.02E+01	2.18E-01
	GWP-CO_2 uptake	**Global warming potential CO_2 uptake**	kg CO_2 eq.	1.43E+02	0	5.08E-02	8.17E+00	1.85E-01
	GWP-luluc	**Global warming potential land use and land use change**	kg CO_2 eq.	2.26E+02	0	3.67E-03	3.78E-01	4.80E-03
EF Method 3.0 adapted to EN15804+A2/AC	**Climate Change-total**	**Global warming potential total**	kg CO_2 eq.	4.44E+03	0	8.51E+00	2.84E+02	3.92E+00
	Climate Change-fossil	**Global warming potential fossil fuels**	kg CO_2 eq	4.18E+03	0	8.50E+00	2.82E+02	3.90E+00
	Climate Change-biogenic	**Global warming potential biogenic**	kg CO_2 eq	2.81E+01	0	5.07E-03	2.51E+00	3.75E-02
	Climate Change-luluc	**Global warming potential land use and land use change**	kg CO_2 eq	2.26E+02	0	3.56E-03	3.71E-01	4.36E-03
	ODP	**Ozone depletion potential**	kg CFC-11 equivalent	4.41E-04	0	1.83E-06	1.41E-05	4.26E-07
	AP	**Acidification potential**	mol H+ equivalent	4.06E+01	0	2.50E-02	1.25E+00	2.59E-02
	EP-fw	**Eutrophication potential - freshwater**	kg P equivalent	9.01E-01	0	6.43E-04	6.92E-02	1.15E-03
	EP-m	**Eutrophication potential - marine**	kg N equivalent	3.44E+00	0	5.10E-03	2.26E-01	6.41E-03
	EP-t	**Eutrophication potential - terrestrial**	mol N equivalent	3.75E+01	0	5.56E-02	2.49E+00	6.90E-02
	POCP	**Potential formation of tropospheric ozone**	kg NMVOC equivalent	1.32E+01	0	2.09E-02	7.06E-01	2.05E-02
	ADP-minerals &metals	**Abiotic depletion (non-fossil resources)**	kg Sb equivalent	2.28E-02	0	2.95E-05	1.11E-02	8.64E-06
	ADP-fossil	**Abiotic depletion (fossil resources)**	MJ, net calorific value	4.15E+04	0	1.26E+02	1.89E+03	5.55E+01

Method	Indicators		Units	A1-A3	C1	C2	C3	C4
	WDP	**Water deprivation potential**	m^3 world eq. deprived	4.39E+03	0	4.40E-01	2.84E+01	1.45E+00
	PM	**Potential incidence of disease due to PM emissions**	disease incidence	7.52E-04	0	6.77E-07	2.07E-05	3.88E-07
	IRP	**Potential human exposure efficiency relative**	kBq U235 equivalent	4.18E+02	0	5.77E-01	9.79E+00	3.24E-01
	ETP-fw	**Potential comparative Toxic Unit for ecosystems**	CTUe	8.35E+04	0	1.09E+02	7.49E+03	6.20E+04
	HTP-c	**Potential comparative Toxic Unit for humans**	CTUh	1.61E-05	0	3.20E-09	1.90E-07	3.63E-09
	HTP-nc	**Potential comparative Toxic Unit for humans**	CTUh	1.55E-04	0	1.02E-07	7.59E-06	9.57E-08
	SQP	**Potential soil quality index**	dimensionless	3.40E+04	0	8.64E+01	1.95E+03	7.10E+01
TRACI 2.1	**ODP**	**Ozone depletion potential**	kg CFC-11 eq.	4.67E-04	0	1.94E-06	1.52E-05	4.57E-07
	AP	**Acidification potential**	kg SO_2 eq.	3.27E+01	0	2.12E-02	1.05E+00	2.85E-02
	EP	**Eutrophication potential**	kg N eq.	8.67E+00	0	8.10E-03	6.65E-01	1.03E-02
	SP	**Smog formation potential**	kg O_3 eq.	2.11E+02	0	3.15E-01	1.36E+01	3.91E-01
	FF	**Fossil fuel depletion**	MJ surplus	4.92E+03	0	1.77E+01	1.97E+02	5.41E+00

Relative contribution of each life cycle stage

The A1-A3 modules are the main contributors to all the potential impacts evaluated. Within these modules, hot aluminium production and alloying elements production are responsible for most of the impacts.

Additional environmental information

When collected, aluminium can be recycled indefinitely without loss of physical nor chemical properties. One recycling cycle is considered in module D, based on a 90% recycling rate.

1. Description of Prysmian

Prysmian is the world leader in the energy and telecom cable industry. With almost 150 years of experience, more than 30,000 employees in over 50 countries and 108 plants, the company is strongly positioned in high-tech markets and offers the widest possible range of products, services, technologies and know-how.

The Lapointe plant featured in this EPD is located in Jonquière, Québec, Canada. The plant has a capacity of approximately 70529 metric tons and serves as the cast house and starting point for all aluminum rod and strip produced under Prysmian’s ALASTA brand name.

At the core of Prysmian's business model lies a commitment to sustainability. Prysmian seeks to achieve an efficient, effective and sustainable supply of energy and information while integrating sustainable practices throughout the value chain - including initiatives like this environmental Life Cycle Assessment (LCA) of aluminum rods produced at Lapointe. The company leads global thought in the industry and action on critical climate issues by adopting a science-based approach and adhering to EPA standards to achieve net-zero emission targets for Scope 1 and 2 by 2035 and Scope 3 by 2050.

This EPD enables Prysmian to earn credits towards a LEED® (Leadership in Energy and Environmental Design) v4 or v4.1 certification (i.e., Material and Resource credits). It also helps Prysmian respond to requests for data and information on environmental performance.

2. Product description

2.1. Product identification and specification

Aluminium rod is classified under UN CPC Code 41532 (Bars, rods and profiles, of aluminium) and NAICS 331314 (Secondary Smelting and Alloying of Aluminium). It is considered a semi-finished product, ready to be transformed into aluminium final usage. It is manufactured at Prysmian’s Lapointe facility.

Figure 2-1: Rolled aluminium rods

2.2. Application

Aluminum rod produced at Lapointe is mostly used to create aluminum strip, wire and cable. Intended applications are cables and conductors, mechanical applications (such as welding wire, nails, armored cable) and electrical applications (such as DeOx, transformer strip). Those products can also be used in building and construction, transportation and consumer durables.

2.3. Technical data

Technical data is available upon request to Prysmian.

2.4. Delivery status

Rod is manufactured in various diameter, from 9.5 to 22 mm, and is coiled to allow easy transportation. The coils typically weigh approximately 3,050 kg.

2.5. Material composition (base and ancillary)

The exact composition of each rod is specific to the clients' needs. Table 2-1 shows an annual average composition of the aluminium rod produced at Prysmian's Lapointe facility.

The rod's composition does not include substances listed in the "Candidate List of Substances of Very High Concern for Authorisation" nor in the "Resource Conservation and Recovery Act."

Table 2-1: Materials and alloys in an aluminium rod

Materials	Weight (% by mass)
Aluminium	**97.68**
Alloy additives (average 2022)	**2.32**
Chromium	*0.02*
Copper	*0.05*
Iron	*0.08*
Manganese	*0.07*
Magnesium	*1.60*
Silicon	*0.24*
Aluminium-Titanium	*0.19*
Others (Boron, Strontium)	*0.07*

2.6. Manufacture

Aluminium rod requires hot (or liquid) aluminium as a main material input. Aluminium is produced from alumina oxide through the Hall-Héroult process. It involves the dissolution of alumina in a solvent (molten cryolite) and then the electrolysis of it. Alumina oxide comes from bauxite ore. Bauxite ore is mined in tropical or subtropical areas. Bauxite ore is either shipped to alumina plants or refined on site. Then it is refined, with the Bayer process, to produce aluminium oxide (alumina). It takes approximately 2.4 metric tons of bauxite ore to produce one (1) metric ton of alumina, and it takes approximately 1.9 metric tons of alumina to produce one (1) metric ton of liquid aluminium. Liquid aluminium is then cast into different shapes, such as ingots.

Liquid metal, cold aluminium ingots as well as scrap (pre-consumed aluminium) are sent to Lapointe. The cold and scrap aluminum are remelted and added to hot metal with alloying elements to achieve the desired alloy composition. Liquid metal is then cooled by a stream of fresh water and takes the shape of the rod. After passing through the casting wheel and the rod mill, the rod is coiled and ready to be shipped.

2.7. Environment and health during manufacturing

Air: Hazardous air emissions released from Lapointe plant comply with regulatory thresholds.

Water/Soil: Pollutants in wastewater discharge comply with regulatory thresholds.

Noise: Due to adequate acoustical absorption and mitigation devices, measurements of sound levels have shown all values inside and outside the production plant comply with regulatory thresholds.

2.8. Product processing/installation

Further processing and installation stage are outside the scope of this EPD.

2.9. Packaging

Packaging of aluminium rods depends on client's needs. It is within the scope of this EPD, but impacts are considered negligible.

2.10. Condition of use

The use phase is outside the scope of this EPD.

2.11. Environment and health during use

The environmental and health effects during use are outside the scope of this EPD.

2.12. Reference service life

Service lives of aluminium rods vary based on the application. Aluminium is known to have a typically long service life due to its high corrosion resistance. This EPD does not cover the product use stage and, therefore, makes no specific claims regarding typical service lives.

2.13. Extraordinary effects

Fire: Aluminium products comply with all national and local regulations with respect to fire hazards and control.

Water: No evidence suggests water runoff or exposure under normal and intended operation will violate general water quality standards.

Mechanical destruction: Not relevant for aluminium rods.

2.14. Re-use phase

Aluminium products are 100% recyclable. Recycling collection rates vary based on industry sectors and locations. Data from clients' locations and industry sectors shows a 90% estimated recycling rate.

2.15. Disposal

Disposal of final aluminium products depends on geographical location and sector. It is assumed that aluminium, if not recycled, will be sent to a landfill. This assumption is based on reports from US EPA (2020a; 2020b), Pickin et al. (2020) and EPSU (2017).

2.16. Further information

The life cycle assessment was conducted by Groupe AGÉCO using ecoinvent 3.8 database.

3. LCA Calculation Rules

3.1. Declared unit

As per the PCR, the declared unit (i.e., the reference unit on which the quantities of material inputs, energy inputs, emissions and waste are based for the modelling of the life cycle of aluminium rod) is defined as follows:

1 metric ton (equal to 1,000 kg) of aluminium rod

3.2. System boundary

The production modules included in this ***cradle-to-gate with modules C1-C4 and module D*** EPD are shown in Table 3.11. In this LCA, module D is beyond the system boundaries and is reported separately.

Table 3.11: Life cycle stages considered according to ISO 21930

Production stage			Construction stage		Use stage							End-of-life stage				Optional
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction, demolition	Transport	Waste processing	Disposal of waste	Potential net benefits from reuse, recycling and/or energy recovery beyond the system boundary
X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	X	X	X	X	X Reported separately
Legend: *x* - Considered in the cradle-to-gate LCA *ND* - Module not declared																

3.3. Estimates and assumptions

The impacts associated with the external treatment of dross and chips, generated during manufacturing, sent to external recycling and reused in the process, are allocated to the aluminium rod.

The main estimates included in this LCA were related to the end-of-life stage, based on the locations of main clients and geographical data about use and end of life of aluminium products in those regions.

Prysmian's Lapointe facility in the Saguenay-Lac-Saint-Jean region is 100% supplied by hydroelectricity produced by reservoir dams managed by a third-party supplier. The ecoinvent dataset "Electricity, high voltage {CA-QC}| electricity production, hydro, reservoir, non-alpine region | Cut-off, U" has been adapted to be more representative of biogenic emissions from Québec reservoirs, particularly in the Saguenay-Lac-Saint-Jean region.

3.4. Cut-off criteria

As per the PCR, no known flows are deliberately excluded from this assessment. No single flow representing more than 1% of the total inflows was excluded and the total excluded input flows did not exceed a maximum of 5% of energy usage and mass. Based on Groupe AGÉCO's experience or the relatively low contribution of the life cycle stages to which they pertain, the following processes were excluded:

- Research and development activities
- Any secondary packaging (e.g. pallets)
- Business travel

In practice, all inputs and outputs for which data are available have been included in the calculation. Data gaps have been filled by conservative assumptions with average or generic data.

3.5. Data sources

Table 3.5 presents the main sources of data used for this EPD. Producer-specific data were collected from Lapointe for operations occurring between January 2022 and December 2022 (less than three years old). Generic data collected for the raw material supply processes, transportation, and manufacturing of aluminium were representative of the 2022 context and used technologies. IAI data from LCI global surveys are published every five years. The latest report was published in 2021 based on data from 2019.

The geographical boundaries represent current equipment and processes associated with aluminium rod manufactured at Prysmian's Lapointe plant. Since the data were collected for the year 2022, they are considered temporally representative (i.e., less than three years old).

Table 3.52: Data sources for the LCA of aluminium rod

Module	Main processes	Data sources
A1	Raw material extraction and processing	ecoinvent 3.8 & IAI
A2	Transportation to plant	Calculations based on supplier's country locations
A3	Manufacture	Primary data & ecoinvent 3.8
C1	Deconstruction, demolition	Calculations based on client's country locations and industry sectors & ecoinvent 3.8
C2	Transport	
C3	Waste processing	
C4	Disposal	
D	Potential net benefits from reuse, recycling, and/or energy recovery	

The LCA model was developed with the SimaPro 9.3 software using ecoinvent 3.8 database, which was released in 2021. Since most of the data within ecoinvent is of European origin and represents European industrial conditions and processes, several data were adapted to enhance representativeness of the products and contexts being examined. Ecoinvent is one of the most complete and internationally recognized LCA databases.

3.6. Data quality

The overall data quality ratings show that the data used were good. This data quality assessment confirms the sufficient reliability, representativeness (technological, geographical and time-related), completeness and consistency of the information and data used for this study.

3.7. Allocation

When a process in the life cycle of aluminium rod generated co-products or is directly connected to another system (i.e., the life cycle of another product), the following allocation methods were applied to distribute the impacts between the co-products or linked systems.

Allocation of multi-output processes

As prioritized in the PCR used in this study, allocation for multi-output processes was done on a mass basis. Economic value allocation was not used.

Allocation for end-of-life processes

A recycled content approach (i.e., cut-off approach) was applied when a product is recycled. The impacts associated with the recycling process are thus attributed to the products using these materials. As stated in the PCR, there are no credits allowed for displacement nor system boundary expansion or consequential analysis. Instead, potential credits are displayed separately.

Ecoinvent processes with allocation

Many of the processes in the ecoinvent database also provide multiple functions, and allocation is required to provide inventory data per function (or per process). This study accepts the allocation method used by ecoinvent for those processes. The ecoinvent system model used was “Allocation, cut-off by classification.” It should be noted that the allocation methods used in ecoinvent for background processes (i.e., processes representing the complete supply chain of a good or service used in the life cycle of aluminium) may be inconsistent with the approach used to model the foreground system (i.e., to model the manufacturing of aluminium exterior cladding with data collected in the literature and from manufacturers). While this allocation is appropriate for foreground processes, continuing this methodology into the background datasets would add complexity without substantially improving the quality of the study.

4. LCA Results

Impact assessment classifies and combines the flows of materials, energy, and emissions into and out of each product system by the type of impact their use or release has on the environment. These flows, which interact with the environment, are then evaluated for their potential effects on different environmental issues presented in the result tables. The method used to evaluate environmental impacts is EF 3.0 (EPLCA, 2019). In addition, the method TRACI 2.1 (EPA, 2012) and the method with global warming potential updated with the values from the Sixth Assessment Report (AR6; IPCC, 2021) have been evaluated.

Table 4-1 presents the disclaimers relative to the environmental impact indicators.

Table 4-1: Disclaimers to the declaration of core and additional environmental impact indicators

Indicators	Disclaimer
Global warming potential (GWP)	none
Depletion potential of the stratospheric ozone layer (ODP)	none
Potential incidence of disease due to PM emissions (PM)	none
Acidification potential, Accumulated Exceedance (AP)	none
Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
Formation potential of tropospheric ozone (POCP)	none
Potential Human exposure efficiency relative to U235 (IRP)	1
Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
Abiotic depletion potential for fossil resources (ADP-fossil)	2
Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
Potential Comparative Toxic Unit for humans (HTP-c)	2
Potential Comparative Toxic Unit for humans (HTP-nc)	2
Potential Soil quality index (SQP)	2
Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.	
Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.	

4.1. LCA Results for modules A1-3 and modules C1-4

Table 4-2: Results for environmental indicators

Method	Indicators		Units	A1-A3	C1	C2	C3	C4
AR6, with uptake (IPCC, 2021)	GWP-total	Global warming potential total	kg CO_2 eq.	4.37E+03	0	8.43E+00	2.82E+02	3.83E+00
	GWP-fossil	Global warming potential fossil fuels	kg CO_2 eq.	4.13E+03	0	8.43E+00	2.79E+02	3.79E+00
	GWP-biogenic	Global warming potential biogenic	kg CO_2 eq.	1.65E+02	0	5.50E-02	1.02E+01	2.18E-01
	GWP-CO_2 uptake	Global warming potential CO_2 uptake	kg CO_2 eq.	-1.43E+02	0	-5.08E-02	-8.17E+00	-1.85E-01
	GWP-luluc	Global warming potential land use and land use change	kg CO_2 eq.	2.26E+02	0	3.67E-03	3.78E-01	4.80E-03
EF Method 3.0 adapted to EN15804+ A2/AC	Climate Change-total	Global warming potential total	kg CO_2 eq.	4.44E+03	0	8.51E+00	2.84E+02	3.92E+00
	Climate Change-fossil	Global warming potential fossil fuels	kg CO_2 eq	4.18E+03	0	8.50E+00	2.82E+02	3.90E+00
	Climate Change-biogenic	Global warming potential biogenic	kg CO_2 eq	2.81E+01	0	5.07E-03	2.51E+00	3.75E-02
	Climate Change-luluc	Global warming potential land use and land use change	kg CO_2 eq	2.26E+02	0	3.56E-03	3.71E-01	4.36E-03
	ODP	Ozone depletion potential	kg CFC-11 equivalent	4.41E-04	0	1.83E-06	1.41E-05	4.26E-07
	AP	Acidification potential	mol H+ equivalent	4.06E+01	0	2.50E-02	1.25E+00	2.59E-02
	EP-fw	Eutrophication potential - freshwater	kg P equivalent	9.01E-01	0	6.43E-04	6.92E-02	1.15E-03
	EP-m	Eutrophication potential - marine	kg N equivalent	3.44E+00	0	5.10E-03	2.26E-01	6.41E-03
	EP-t	Eutrophication potential - terrestrial	mol N equivalent	3.75E+01	0	5.56E-02	2.49E+00	6.90E-02
	POCP	Potential formation of tropospheric ozone	kg NMVOC equivalent	1.32E+01	0	2.09E-02	7.06E-01	2.05E-02
	ADP-minerals &metals	Abiotic depletion (non-fossil resources)	kg Sb equivalent	2.28E-02	0	2.95E-05	1.11E-02	8.64E-06
	ADP-fossil	Abiotic depletion (fossil resources)	MJ, net calorific value	4.15E+04	0	1.26E+02	1.89E+03	5.55E+01
	WDP	Water deprivation potential	m^3 world eq. deprived	4.39E+03	0	4.40E-01	2.84E+01	1.45E+00

Method	Indicators		Units	A1-A3	C1	C2	C3	C4
	PM	Potential incidence of disease due to PM emissions	disease incidence	7.52E-04	0	6.77E-07	2.07E-05	3.88E-07
	IRP	Potential human exposure efficiency relative	kBq U235 equivalent	4.18E+02	0	5.77E-01	9.79E+00	3.24E-01
	ETP-fw	Potential comparative Toxic Unit for ecosystems	CTUe	8.35E+04	0	1.09E+02	7.49E+03	6.20E+04
	HTP-c	Potential comparative Toxic Unit for humans	CTUh	1.61E-05	0	3.20E-09	1.90E-07	3.63E-09
	HTP-nc	Potential comparative Toxic Unit for humans	CTUh	1.55E-04	0	1.02E-07	7.59E-06	9.57E-08
	SQP	Potential soil quality index	dimensionless	-3.40E+04	0	8.64E+01	1.95E+03	7.10E+01
TRACI 2.1	ODP	Ozone depletion potential	kg CFC-11 eq.	4.67E-04	0	1.94E-06	1.52E-05	4.57E-07
	AP	Acidification potential	kg SO_2 eq.	3.27E+01	0	2.12E-02	1.05E+00	2.85E-02
	EP	Eutrophication potential	kg N eq.	8.67E+00	0	8.10E-03	6.65E-01	1.03E-02
	SP	Smog formation potential	kg O_3 eq.	2.11E+02	0	3.15E-01	1.36E+01	3.91E-01
	FF	Fossil fuel depletion	MJ surplus	4.92E+03	0	1.77E+01	1.97E+02	5.41E+00

Table 4-3: Results for resource use

Method	Indicators		Units	A1-A3	C1	C2	C3	C4
Cumulative Energy Demand 2.0	PERE	Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ	7.42E+04	0	1.47E+00	2.02E+02	3.59E+00
	PERM	Use of renewable primary energy resources used as raw materials	MJ	0	0	0	0	0
	PERT	Total use of renewable primary energy resources	MJ	7.42E+04	0	1.47E+00	2.02E+02	3.59E+00
	PENRE	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ	4.45E+04	0	1.33E+02	2.03E+03	5.91E+01
	PENRM	Use of non-renewable primary energy resources used as raw materials	MJ	0	0	0	0	0
	PENRT	Total use of non-renewable primary energy resources	MJ	4.45E+04	0	1.33E+02	2.03E+03	5.91E+01

Method	Indicators		Units	A1-A3	C1	C2	C3	C4
	SM	Use of secondary material	kg	5.34E+01	0	0	0	0
From invent-tory	RSF	Use of renewable secondary fuels	MJ	0	0	0	0	0
	NRSF	Use of non-renewable secondary fuels	MJ	0	0	0	0	0
	FW	Use of net fresh water	m3	3.04E-01	0	0	0	0

Table 4-4: Results for outputs flows and waste categories

Method	Indicators		Units	A1-A3
From invent-tory	HWD	Hazardous waste disposed	kg	4.25E-03
	NHWD	Non-hazardous waste disposed	kg	1.35E-04
	HLRW	High-level radioactive waste, conditioned, to final repository	kg	0
	ILLRW	Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	0
	CRU	Components for re-use	kg	0
	MFR	Materials for recycling	kg	2.33E-02
	MER	Materials for energy recovery	kg	0
	EEE	Exported electrical energy	MJ	0
	EET	Exported thermal energy	MJ	0

4.2. LCA Results for module D

Table 4-5: Results for environmental indicators for module D

Method	Indicators		Units	D (total)	D (Burden)	D (Potential credit)
AR6, with uptake (IPCC, 2021)	GWP-total	Global warming potential total	kg CO_2 eq.	-3.43E+03	7.27E+02	-4.15E+03
	GWP-fossil	Global warming potential fossil fuels	kg CO_2 eq.	-3.21E+03	7.14E+02	-3.92E+03
	GWP-biogenic	Global warming potential biogenic	kg CO_2 eq.	-1.01E+02	5.53E+01	-1.56E+02
	GWP-CO_2 uptake	Global warming potential CO_2 uptake	kg CO_2 eq.	9.26E+01	-4.31E+01	1.36E+02
	GWP-luluc	Global warming potential land use and land use change	kg CO_2 eq.	-2.14E+02	9.42E-01	-2.14E+02
EF Method 3.0 adapted to EN15804+ A2/AC	Climate Change-total	Global warming potential total	kg CO_2 eq.	-3.48E+03	7.34E+02	-4.22E+03
	Climate Change-fossil	Global warming potential fossil fuels	kg CO_2 eq.	-3.25E+03	7.26E+02	-3.98E+03
	Climate Change-biogenic	Global warming potential biogenic	kg CO_2 eq.	-1.22E+01	1.44E+01	-2.67E+01

Method	Indicators		Units	D (total)	D (Burden)	D (Potential credit)
	Climate Change-luluc	Global warming potential land use and land use change	kg CO_2 eq.	-2.14E+02	8.82E-01	-2.14E+02
	ODP	Ozone depletion potential	kg CFC-11 equivalent	-3.75E-04	4.45E-05	-4.19E-04
	AP	Acidification potential	mol H+ equivalent	-2.88E+01	9.78E+00	-3.86E+01
	EP-fw	Eutrophication potential - freshwater	kg P equivalent	-1.46E-01	7.10E-01	-8.56E-01
	EP-m	Eutrophication potential - marine	kg N equivalent	-2.41E+00	8.56E-01	-3.27E+00
	EP-t	Eutrophication potential - terrestrial	mol N equivalent	-2.54E+01	1.02E+01	-3.57E+01
	POCP	Potential formation of tropospheric ozone	kg NMVOC equivalent	-9.52E+00	2.99E+00	-1.25E+01
	ADP-minerals &metals	Abiotic depletion (non-fossil resources)	kg Sb equivalent	1.56E-01	1.78E-01	-2.17E-02
	ADP-fossil	Abiotic depletion (fossil resources)	MJ, net calorific value	-3.18E+04	7.64E+03	-3.94E+04
	WDP	Water deprivation potential	m^3 world eq. deprived	-3.62E+03	5.47E+02	-4.17E+03
	PM	Potential incidence of disease due to PM emissions	disease incidence	-6.62E-04	5.24E-05	-7.14E-04
	IRP	Potential human exposure efficiency relative	kBq U235 equivalent	-3.51E+02	4.55E+01	-3.97E+02
	ETP-fw	Potential comparative Toxic Unit for ecosystems	CTUe	-1.12E+04	6.81E+04	-7.93E+04
	HTP-c	Potential comparative Toxic Unit for humans	CTUh	-1.36E-05	1.76E-06	-1.53E-05
	HTP-nc	Potential comparative Toxic Unit for humans	CTUh	-4.41E-05	1.03E-04	-1.47E-04
	SQP	Potential soil quality index	dimensionless	3.95E+04	7.27E+03	3.23E+04
TRACI 2.1	ODP	Ozone depletion potential	kg CFC-11 eq.	-3.95E-04	4.86E-05	-4.44E-04
	AP	Acidification potential	kg SO_2 eq.	-2.33E+01	7.82E+00	-3.11E+01
	EP	Eutrophication potential	kg N eq.	-2.75E+00	5.49E+00	-8.23E+00
	SP	Smog formation potential	kg O_3 eq.	-1.50E+02	5.04E+01	-2.01E+02
	FF	Fossil fuel depletion	MJ surplus	-3.93E+03	7.39E+02	-4.67E+03

5. LCA interpretation

Impact categories

Figure 5-1 shows the contribution of each sub-modules to each environmental indicator. The module A1, referring to the **supply of primary aluminium** (hot and cold) **is the main contributor** to most of the indicators. For aluminium produced in Québec, the main contributors to the environmental impacts of liquid aluminium are direct anode consumption and emissions of perfluorocarbons due to anode effect during electrolysis, transportation of bauxite and alumina and the production of alumina. With the cut-off approach, the supply of secondary aluminium (from external scrap) comes with no environmental burden. The contribution of hot metal production is significant (>60%) for all indicators with the exception of two indicators (PM and ADP).

Alloying elements is the second contributor for most of the indicators. For PM and ADP-minerals and metals, the contribution of the alloying elements represents more than 20% of the impacts. Magnesium is the alloying element presenting the most impacts, which are mostly due to the Pidgeon manufacturing process carried out in China.

Within the ancillary materials used in manufacturing (A3 module), contributing between 1 and up to 27% (for WDP), the consumption or **argon** is responsible of more than 99% of the impacts of the sub-module.

Energy consumption is the second main contributor to Ozone Depletion Potential and Fossil Use indicator due to **natural gas** consumption (> 99% of the impact of the sub-module). SQP and GWP-CO_2 uptake indicators are not displayed in the graph as the only negative results, the contribution of A1-A3 modules can be seen in section 4.1.

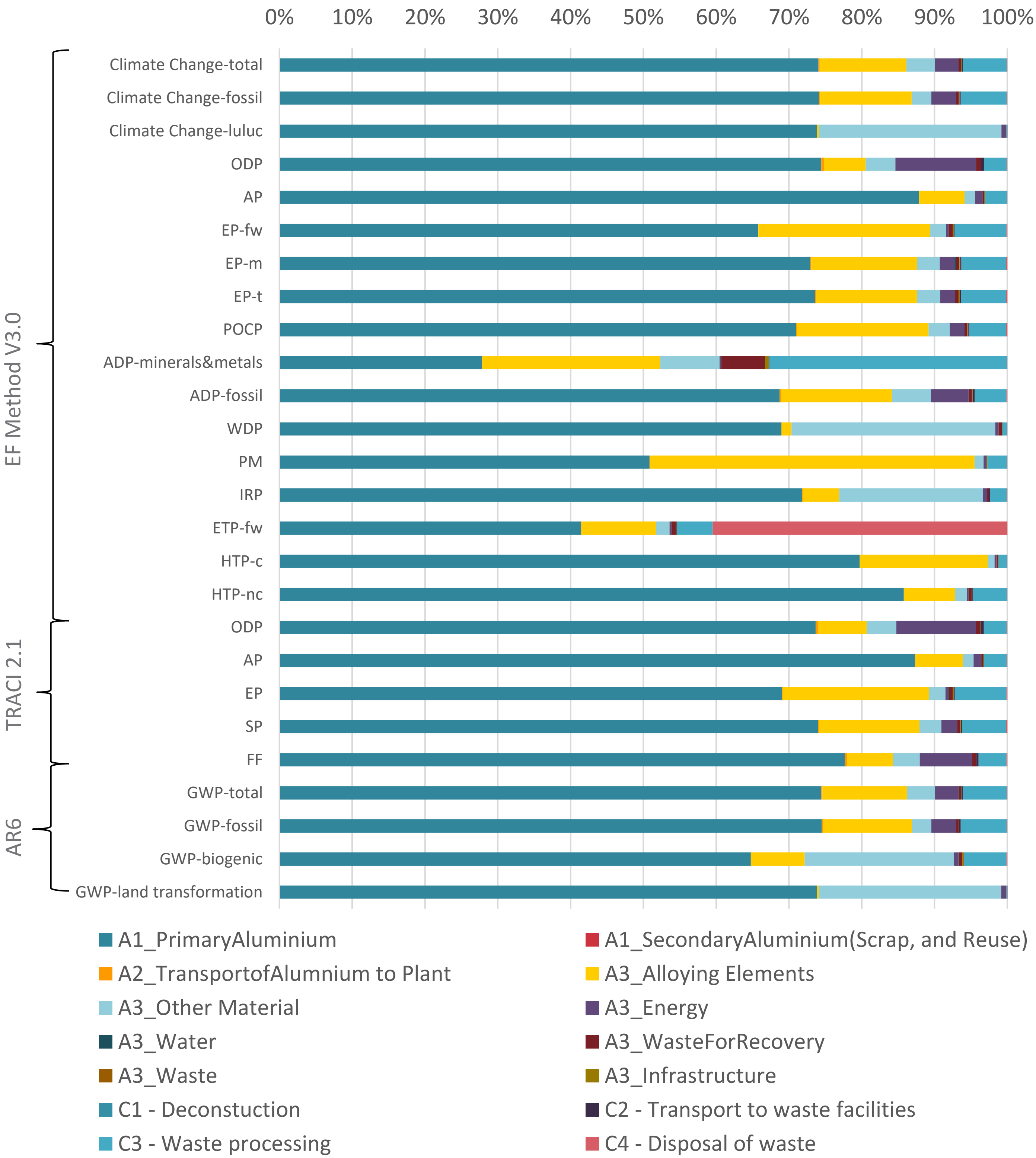

Figure 5-1: Relative contribution of rod life cycle stages to environmental indicators

Resource use

The production of the hot metal represents more than 65% of both renewable and non-renewable primary energy use (see Figure below). Primary renewable energy comes from hydroelectricity, and non-renewable energy comes from fossil fuels used in alumina production, bauxite transportation and ancillary materials supply.

The use of secondary material corresponds to the scrap inputs, as no other secondary material is used. Freshwater consumption is due to the evaporation of cooling water during the casting stage.

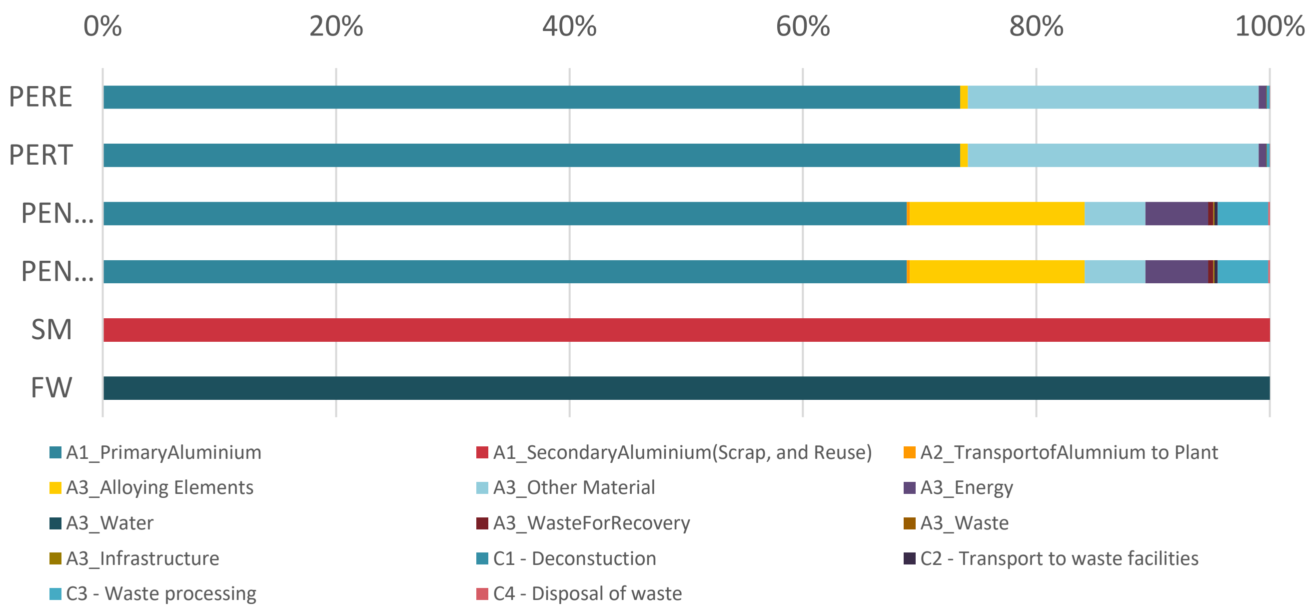

Figure 5-2: Relative contribution of aluminium production stages to resource use categories

Outputs flows and waste

Waste categories were evaluated for the foreground processes only. The disposal of both non-hazardous and hazardous waste was reported. There is no radioactive waste generated by the foreground processes. The disposal of non-hazardous waste reported, as well as the disposal of a small amount of hazardous waste defined by local laws.

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