# Environmental Product Declaration

In accordance with ISO 14025 and EN 15804 for:

## Primary Aluminium Products

from

## Press Metal Bintulu Sdn Bhd

PRESS METAL®

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|---|---|
| Programme: | The International EPD® System, www.environdec.com |
| Programme operator: | EPD International AB |
| EPD registration number: | S-P-04686 |
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ECO PLATFORM EPD VERIFIED

# Programme information

| | |
|---|---|
| **Programme:** | **The International EPD® System**<br><br>EPD registered through the fully aligned regional hub:<br>**EPD Southeast Asia**<br>www.epd-southeastasia.com |
| **Programme Operator:** | **EPD International AB**<br>Box 210 60, SE-100 31 Stockholm, Sweden<br>www.environdec.com<br>info@environdec.com<br><br>**EPD Southeast Asia**<br>Kencana Tower Level M, Business Park Kebon Jeruk<br>Jl. Raya Meruya Ilir<br>No. 89, Jakarta Barat 11620, Indonesia<br>https://www.epd-southeastasia.com/ |

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|---|
| Product category rules (PCR): PCR 2012:01 v2.33 Construction products and construction services with reference to EN 15804:2012+A1:2013 and UN CPC codes: 41532 Bars, rods, and profiles, of aluminium; 41533, wire of aluminium |
| PCR review was conducted by: *The Technical Committee of the International EPD® System. Contact via info@environdec.com* |
| Independent third-party verification of the declaration and data, according to ISO 14025:2006:<br><br>☐ EPD process certification ☒ EPD verification |
| Third party verifier:<br>*Vladimír Kočí, PhD*<br>*Šárecká 5,*<br>*16000 Prague 6*<br>*Czech Republic*<br>*www.lcastudio.cz*<br><br>*Approved by the International EPD System*<br><br>This EPD is prepared by denkstatt Bulgaria Ltd.<br>www.denkstatt.bg |
| Procedure for follow-up of data during EPD validity involves third-party verifier:<br><br>☐ Yes ☒ No |

The EPD owner has the sole ownership, liability, and responsibility for the EPD. EPDs within the same product category but from different programmes may not be comparable.

# Company information

Owner of the EPD : Press Metal Bintulu Sdn Bhd
Address : Lot 36, Block 1, Samalaju Industrial Park, Kemena Land District, 97000 Bintulu, Sarawak, Malaysia
Contact Person : Ivan Gan Chee Seng
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Description of the organisation:

Press Metal Bintulu Sdn Bhd ("PMBTU") was established in 2010 and its smelting plants are located at the Samalaju Industrial Park in the state of Sarawak. With the recent completion of the new Phase 3 smelter, an additional 320,000 tonnes of annual smelting capacity has been added, making PMBTU's total annual smelting capacity 960,000 metric tonnes.

PMBTU is an 80%-owned subsidiary of Press Metal Aluminium Holdings Berhad ("PMAHB"), and the remaining 20% is owned by Bunga Raya Aluminium Sdn Bhd, which is a wholly-owned subsidiary of Sumitomo Corporation ("SC"). The midstream smelting segment is PMAHB's core business and is undertaken by PMBTU and Press Metal Sarawak Sdn Bhd ("PMS"), which is likewise 80% owned. PMS, which was founded in 2007 and is located in Mukah, Sarawak, is Malaysia's first aluminium smelting facility, with a smelting capacity of 120,000 metric tonnes per annum.

With an aggregate smelting capacity of 1,080,000 metric tonnes per annum from PMBTU and PMS, PMAHB is the largest aluminium smelter in Southeast Asia. All its smelting plants are strategically located in the Sarawak Corridor of Renewable Energy ("SCORE"), which is an economic region and development corridor covering central Sarawak, where electricity is predominantly generated by hydropower plants.

PMAHB's midstream smelting segment, which is undertaken by PMBTU and PMS, is PMAHB's core business. The smelting products include primary products such as London Metal Exchange ("LME") certified primary aluminium ingots ("P1020"), as well as value-added products such as Primary Foundry Alloy ("PFA") aluminium ingots, aluminium billets, and aluminium wire rods.

PMAHB aspires to grow sustainably by strengthening operational efficiency, sustainability performance and leadership to future proof the success of its business. We address the Environmental, Social and Governance ("ESG") aspects of our operations by monitoring and managing the Group's impact on the environment, society and economy throughout our value chain.

Name and location of production site:

Press Metal Bintulu Sdn Bhd, is located in Samalaju Industrial Park, Bintulu, Sarawak, Malaysia. Samalaju Industrial Park is one of the SCORE key areas managed by the Regional Corridor Development Authority ("RECODA").

# Product information

This EPD declares the environmental footprint of four similar aluminium-based products: P1020 Aluminium Ingot, Primary Foundry Alloy ("PFA") Aluminium Ingot, Aluminium Billet / Alloy, And Aluminium Rods EC Grades / Alloy. PMBTU is certified with ISO 9001:2015 (Quality Management Systems) and ISO 14001:2015 (Environmental Management Systems).

Geographical scope: Applicable for all four products: Global

The products are manufactured in PMBTU, Samalaju Industrial Park, Sarawak, Malaysia and exported to clients located in all continents.

Further details are provided below:

Product name: P1020 Aluminium Ingot

Product identification: High Grade Aluminium Ingot

Product description: P1020 Aluminium Ingot is used in various sectors as primary materials for the production of aluminium products such as aluminium billets, aluminium slabs, and aluminium rolls. P1020 Aluminium Ingot is registered with LME under High-Grade Primary Aluminium Contract.

The P1020 Aluminium Ingot is made up of more than 99.7% of aluminium.

Product name: Primary Foundry Alloy ("PFA") Aluminium Ingot

Product identification: Primary Foundry Alloy ("PFA") Aluminium Ingot

Product description: PFA Aluminium Ingot is mostly utilised as material to produce car wheels and auto parts in the automotive industry. PFA Aluminium Ingot is produced under stringent conditions to cater to the specific requirement of the customer.

PFA Aluminium Ingot is mainly made of over 90% of aluminium. PFA Aluminium Ingot also contains other materials such as iron, silicon, copper, zinc, magnesium, titanium, manganese, and strontium. The composition of these materials varies depending on the requirement of the customer.

Product name: Aluminium Billet / Alloy

Product identification: Billets

Product description: Aluminium Billet / Alloy is mostly used as raw material for the extrusion industry. The Aluminium Billet / Alloy is manufactured using the air slip technology in various sizes ranging from 4 inches to 10 inches in diameter and are fully homogenized.

The Aluminium Billet / Alloy is mainly made of over 98.9% of aluminium. The Aluminium Billet / Alloy also contains other materials such as chromium, copper, iron, magnesium, manganese, silicon, titanium, and zinc.

Product name: Aluminium Rods EC Grades / Alloy

Product identification: Aluminium rods, wire rods

Product description: Aluminium Rods EC Grades / Alloy is an aluminium electrical conductor grade wire rod with a minimum of 99.0% purity. Aluminium Rods EC Grades / Alloy is manufactured according to ASTM Standards catering to the wire and cable industry. Aluminium is considered a preferred alternative material due to its lightweight characteristics, corrosion resistance, and high electrical conductivity.

Aluminium Rods EC Grades / Alloy is mainly made of over 99.0% of aluminium. Aluminium Rods EC Grades / Alloy is widely used in the production of overhead power transmission and distribution cables.

# Life Cycle Assessment ("LCA") information

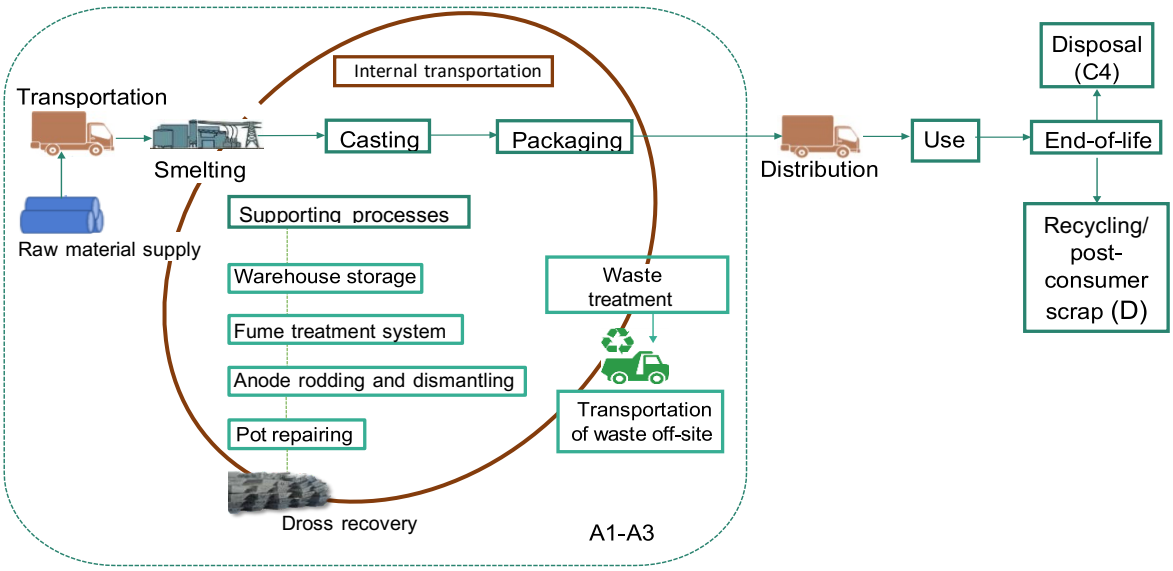
Functional unit / declared unit: The declared unit is the production of 1 kg of either P1020 Aluminium Ingot, PFA Aluminium Ingot, Aluminium Billet / Alloy, or Aluminium Rods EC Grades / Alloy .

Reference service life: Product Reference Service Life depends on the product application. Aluminium itself has an infinite lifetime.

Time representativeness: All primary data (data on raw materials, transportation, energy, waste, water) in this EPD is representative for the year 2020 production by PMBTU.

Database(s) and LCA software used: The most recent version of Ecoinvent database (V3.7.1) was used as a source of background data.

System diagram: The following system diagram provides information on the production stages of all four products and their end-of-life. In contrast to ingots and wire rods, billets pass an aging step. The environmental burden associated with the recycling potential of waste streams due to use in the next product systems is not reported.




*System diagram*

Description of system boundaries: This EPD is "cradle-to-gate with options". The system boundary covers A1-A3 product stages referred to as "Raw material supply", "Transportation" and "Manufacturing",C4 as "Disposal" and D as " Reuse-Recovery-Recycling Potential".

Upstream processes (A1: Raw Material Supply): This module includes the extraction and processing of raw materials. Alumina is the main raw material, sourced from overseas mainly from Australia and Indonesia.

Core processes (A2: Transportation and A3: Manufacturing): Transportation includes the delivery of raw materials to the plant, internal transport to the production facilities and transportation of waste to the relevant treatment facilities off-site. Manufacturing covers activities related to the production (e.g., smelting, casting, aging), packaging, waste treatment, supporting processes (e.g., warehouse storage,

fume treatment system, anode rodding and dismantling, pot repairing, dross recovery, etc.).

Downstream processes (C4: Disposal): According to the European Aluminium Association ("EAA") as much as 90% of the aluminium for the automotive industry is being recycled, while the rest 10% are being disposed of / landfilled. This module includes the assessment of the environmental impacts associated with the disposal.

Beyond system boundaries (Module D: Reuse-Recovery-Recycling Potential): Benefits of avoided burden related to the recycling of products at the end-of-life are reported in Module D.

Excluded life cycle stages: The life cycle stages A4-5, B1-7 and C1-3 are excluded from this LCA study, as the specific product applications are strongly market dependent.

# More information

Goal and scope: This EPD evaluates the environmental impacts of 1 kg of aluminium products as specified above from cradle-to-gate with options, as being intended for Business-to-Business communication with clients and relevant stakeholders within several sectors.

Estimates and assumptions: The following assumptions have been made:

- Only the burdens and benefits of the aluminium products at disposal (C4) and recycling potential (D) are reported. These figures are based on data published by the EAA and International Aluminium Institute ("IAI") for recyclability (90%) and metal loss (2%) in the automotive industry.
- Due to the lack of datasets for certain flows (soda ash, magnesium fluoride, aluminium boron, strontium, copper, iron, etc.) proxy emission factors are used instead.
- Quantities of spent pot lining and aluminium dross, kept at the warehouse, are assumed to be transported. Allocation is done based on the mass balance of transported quantities.
- An average transportation distance of 75 km is used for locally sourced raw materials such as silicon.
- Hazardous waste is classified into two categories (general hazardous waste and waste oils).
- The total amount of water used for cooling is classified as tap water. The respective emission factors for these datasets are applied.

Cut-off rules: For this LCA study, a 5% cut-off rule applies. However, flows that might have significant environmental impacts are accounted for despite the cut-off rule. Capital goods, such as buildings, machinery, vehicles, infrastructure are not included in the scope of the study. Some inputs with less of 1% contribution are also included since data on quantity are easily available.

Background data and quality: This study is mainly based on specific data collected from the production site in Samalaju Industrial Park, Bintulu, Sarawak. Data collected is representative of one and the same technology for year 2020. The calculations are based on data for all inputs and outputs following the above- mentioned cut-off criteria. Regionally specific datasets were used to model the electricity consumption,alumina and prebaked anode. The processes of transport, datasets were chosen according to their technological and geographical representation.

Allocations: The production facilities manufacture four types of products. Firstly, the production system was divided into sub-processes (smelting, casting and storage & support processes) when collecting the input and output data. Secondly, allocation is done based on the inherent physical properties of the main four products such as production volume / mass.

# Content declaration

The aluminium products are manufactured in accordance with the following technical specifications:

***P1020 Aluminium Ingot***

| Materials / chemical substances | % |
|---|---|
| Primary aluminium (Al) | >99.7 |
| Alloying elements | 0 |

| Technical specifications* | Value |
|---|---|
| Melting / freezing point, °C | 660 |
| Boiling / condensation point, °C | 2,460 |
| Relative density | 2.7 |

***PFA Aluminium Ingot***

| Materials / chemical substances | % |
|---|---|
| Primary aluminium (Al) | >90 |
| Iron (Fe) | <0.12 |
| Silicon (Si) | 6.5 - 7.5 |
| Copper (Cu) | <0.01 |
| Zinc (Zn) | <0.01 |
| Magnesium (Mg) | 0.25 - 0.45 |
| Titanium (Ti) | 0.03 - 0.20 |
| Manganese (Mn) | <0.03 |
| Strontium (Sr) | 0.01 - 0.04 |

| Technical specifications* | Value |
|---|---|
| Melting / freezing point, °C | 660 |
| Boiling / condensation point, °C | 2,460 |
| Relative density | 2.7 |

***Aluminium Billet / Alloy***

| Materials / chemical substances | % |
|---|---|
| Primary aluminium (Al) | >98.9 |
| Chromium (Cr) | <0.1 |
| Copper (Cu) | <0.25 |
| Iron (Fe) | <0.25 |
| Magnesium (Mg) | <0.95 |

| Materials / chemical substances | % |
|---|---|
| Manganese (Mn) | <0.59 |
| Silicon (Si) | <1.05 |
| Titanium (Ti) | <0.01 |
| Zinc (Zn) | <0.15 |

| Technical specifications* | Value |
|---|---|
| Melting / freezing point, °C | 660 |
| Boiling / condensation point, °C | 2,460 |
| Relative density | 2.7 |

***Aluminium Rods EC Grades / Alloy***

| Materials / chemical substances | % |
|---|---|
| Primary aluminium (Al) | >99.0 |
| Alloying elements | 0 |

| Technical specifications* | Value |
|---|---|
| Melting / freezing point, °C | 660 |
| Boiling / condensation point, °C | 2,460 |
| Relative density | 2.7 |

Environmental / Hazardous properties

No substances included in the Candidate List of Substances of Very High Concern for authorisation under the REACH Regulations are present in the company's profiles, either above the threshold for registration with the European Chemicals Agency or above 0.1% (wt / wt).

The final products are not expected to produce significant adverse health effects when the recommended instruction for use is followed. No specific fire or explosion hazard of the solid form metal is reported. However, fines and / or particles from processing may be readily ignitable. Fine particles and molten aluminium are highly reactive with water, oxidizers, acids and alkalis, halogenated compounds, and certain metal oxides. Toxic gases (aluminium oxides and fume) may be evolved when heated.

## Packaging

PET straps, fumigated wooden batten and wooden pallets are used for packaging. All packaging materials are recyclable / reusable. The impacts of packaging materials are included in the manufacturing stage. The disposal of the packaging is excluded from the assessment as being insignificant to other waste streams.

## Recycled materials

Provenience of recycled materials (pre-consumer or post-consumer) in the product: No recycled materials are used in the production of any of the aluminium products subject to this EPD (excluding packaging).

*In accordance with standard testing methods

# LCA: Results

The system boundaries in tabular form for all modules are shown in the table below.

*Description of the system boundary (X = module included in the LCA; MNA = Module Not Assessed)*

| Product stage | | | Construction stage | | Use stage | | | | | | | End of life stage | | | | Resource recovery stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw Materials Supply | Transport | Manufacturing | Transport | Construction installation | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | De-construction and demolition | Transport | Waste processing | Disposal | Reuse-Recovery-Recycling potential |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
| X | X | X | MNA | MNA | MNA | MNA | MNA | MNA | MNA | MNA | MNA | MNA | MNA | MNA | X | X |

The results of the LCA with the indicators as per EPD requirement are given in the following tables, presented as impacts per 1 kg of product, split into the relevant modules (A1, A2, A3), (C4) and (D).

# Environmental performance

*Potential environmental impacts per 1 kg P1020 Aluminium Ingot*

| Parameter[1] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| GWP | kg $CO_2$-Eq | 6.12E+00 | 1.00E-01 | 1.84E+00 | 8.06E+00 | 3.94E-03 | -1.84E+01 |
| GWP-Fossil | kg $CO_2$-Eq | 5.30E+00 | 1.00E-01 | 1.84E+00 | 7.24E+00 | 3.92E-03 | -1.84E+01 |
| GWP-Biogenic | kg $CO_2$-Eq | 6.15E-01 | 2.81E-05 | 5.55E-07 | 6.15E-01 | 1.31E-05 | 1.10E-02 |
| GWP-LULUC | kg $CO_2$-Eq | 3.79E-01 | 6.54E-05 | 2.61E-07 | 3.79E-01 | 3.71E-06 | -2.65E-03 |
| ODP | kg CFC11-Eq | 5.11E-07 | 1.64E-08 | 5.22E-10 | 5.27E-07 | 3.47E-10 | -4.56E-07 |
| AP | kg $SO_2$-Eq | 3.67E-02 | 1.71E-03 | 7.97E-03 | 4.63E-02 | 2.07E-05 | -1.52E-01 |
| EP | kg $PO_4$-Eq | 1.04E-02 | 2.01E-04 | 6.23E-06 | 1.06E-02 | 6.00E-06 | -4.07E-02 |
| POCP | kg $C_2H_4$-Eq | 1.65E-03 | 4.66E-05 | 3.18E-04 | 2.01E-03 | 1.41E-06 | -7.64E-03 |
| ADPe | kg Sb-Eq | 3.93E-02 | 6.45E-04 | 1.97E-05 | 3.99E-02 | 3.01E-05 | -1.15E-01 |
| ADPf | MJ | 1.23E+02 | 1.45E+00 | 4.43E-02 | 1.24E+02 | 6.27E-02 | -1.95E+02 |
| WSP | $m^3$ | 1.09E-02 | 4.57E-05 | 1.63E-06 | 1.10E-02 | 1.83E-05 | -5.60E-02 |

*Resource use per 1 kg P1020 Aluminium Ingot*

| Parameter[2] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| PERE | MJ | 5.15E+01 | 1.16E-02 | 2.27E-04 | 5.15E+01 | 3.57E-03 | -3.18E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERT | MJ | 5.15E+01 | 1.16E-02 | 2.27E-04 | 5.15E+01 | 3.57E-03 | -3.18E+00 |
| PENRE | MJ | 7.13E+01 | 1.43E+00 | 4.41E-02 | 7.28E+01 | 5.91E-02 | -1.92E+02 |
| PENRM | MJ | 0.00E+00 | 0.00E+00 | 4.60E-03 | 4.60E-03 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 7.13E+01 | 1.43E+00 | 4.87E-02 | 7.28E+01 | 5.91E-02 | -1.92E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NRSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| FW | $m^3$ | 0.00E+00 | 0.00E+00 | 1.11E-04 | 1.11E-04 | 0.00E+00 | 0.00E+00 |

*Output flows and waste categories per 1 kg P1020 Aluminium Ingot*

| Parameter[3] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| HWD | kg | 4.92E-05 | 2.11E-06 | 9.80E-08 | 5.14E-05 | 5.34E-08 | -3.81E-05 |
| NHWD | kg | 4.24E+00 | 2.72E-02 | 8.46E-05 | 4.26E+00 | 1.05E-01 | -4.42E+00 |
| RWD | kg | 1.95E-04 | 9.24E-06 | 2.86E-07 | 2.05E-04 | 2.21E-07 | -4.07E-04 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MFR | kg | 0.00E+00 | 0.00E+00 | 1.75E-02 | 1.75E-02 | 0.00E+00 | 9.00E-01 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Potential environmental impacts per 1 kg PFA Aluminium Ingot*

| Parameter[1] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| GWP[1] | kg $CO_2$-Eq | 6.81E+00 | 9.81E-02 | 1.79E+00 | 8.69E+00 | 3.94E-03 | -1.84E+01 |
| GWP-Fossil | kg $CO_2$-Eq | 6.03E+00 | 9.82E-02 | 1.79E+00 | 7.92E+00 | 3.92E-03 | -1.84E+01 |
| GWP-Biogenic | kg $CO_2$-Eq | 5.96E-01 | 2.77E-05 | 1.20E-05 | 5.96E-01 | 1.31E-05 | 1.10E-02 |
| GWP-LULUC | kg $CO_2$-Eq | 3.57E-01 | 6.27E-05 | 5.83E-06 | 3.57E-01 | 3.71E-06 | -2.65E-03 |
| ODP | kg CFC11-Eq | 5.42E-07 | 1.61E-08 | 1.25E-08 | 5.71E-07 | 3.47E-10 | -4.56E-07 |
| AP | kg $SO_2$-Eq | 3.92E-02 | 1.63E-03 | 7.97E-03 | 4.88E-02 | 2.07E-05 | -1.52E-01 |
| EP | kg $PO_4$-Eq | 1.13E-02 | 1.93E-04 | 1.24E-04 | 1.16E-02 | 6.00E-06 | -4.07E-02 |
| POCP | kg $C_2H_4$-Eq | 1.83E-03 | 4.44E-05 | 3.09E-04 | 2.19E-03 | 1.41E-06 | -7.64E-03 |
| ADPe | kg Sb-Eq | 4.42E-02 | 6.34E-04 | 4.77E-04 | 4.53E-02 | 3.01E-05 | -1.15E-01 |
| ADPf | MJ | 1.32E+02 | 1.42E+00 | 1.07E+00 | 1.34E+02 | 6.27E-02 | -1.95E+02 |
| WSP | $m^3$ | 1.47E-02 | 4.60E-05 | 1.87E-05 | 1.48E-02 | 1.83E-05 | -5.60E-02 |

*Resource use per 1 kg PFA Aluminium Ingot*

| Parameter[2] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| PERE | MJ | 5.07E+01 | 1.16E-02 | 5.20E-03 | 5.07E+01 | 3.57E-03 | -3.18E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERT | MJ | 5.07E+01 | 1.16E-02 | 5.20E-03 | 5.07E+01 | 3.57E-03 | -3.18E+00 |
| PENRE | MJ | 8.11E+01 | 1.41E+00 | 1.07E+00 | 8.36E+01 | 5.91E-02 | -1.92E+02 |
| PENRM | MJ | 0.00E+00 | 0.00E+00 | 4.60E-03 | 4.60E-03 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 8.11E+01 | 1.41E+00 | 1.07E+00 | 8.36E+01 | 5.91E-02 | -1.92E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NRSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| FW | $m^3$ | 0.00E+00 | 0.00E+00 | 1.11E-04 | 1.11E-04 | 0.00E+00 | 0.00E+00 |

*Output flows and waste categories per 1 kg PFA Aluminium Ingot*

| Parameter[3] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| HWD | kg | 5.19E-05 | 2.13E-06 | 2.68E-06 | 5.67E-05 | 5.34E-08 | -3.81E-05 |
| NHWD | kg | 4.03E+00 | 2.87E-02 | 1.27E-03 | 4.06E+00 | 1.05E-01 | -4.42E+00 |
| RWD | kg | 2.27E-04 | 9.08E-06 | 7.00E-06 | 2.43E-04 | 2.21E-07 | -4.07E-04 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MFR | kg | 0.00E+00 | 0.00E+00 | 1.75E-02 | 1.75E-02 | 0.00E+00 | 9.00E-01 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Potential environmental impacts per 1 kg Aluminium Billet / Alloy*

| Parameter[1] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| GWP | kg $CO_2$-Eq | 6.10E+00 | 9.90E-02 | 1.83E+00 | 8.03E+00 | 3.94E-03 | -1.84E+01 |
| GWP-Fossil | kg $CO_2$-Eq | 5.30E+00 | 9.90E-02 | 1.83E+00 | 7.23E+00 | 3.92E-03 | -1.84E+01 |
| GWP-Biogenic | kg $CO_2$-Eq | 6.01E-01 | 2.78E-05 | 8.81E-06 | 6.01E-01 | 1.31E-05 | 1.10E-02 |
| GWP-LULUC | kg $CO_2$-Eq | 3.68E-01 | 6.41E-05 | 4.27E-06 | 3.68E-01 | 3.71E-06 | -2.65E-03 |
| ODP | kg CFC11-Eq | 5.10E-07 | 1.62E-08 | 9.17E-09 | 5.35E-07 | 3.47E-10 | -4.56E-07 |
| AP | kg $SO_2$-Eq | 3.61E-02 | 1.67E-03 | 8.09E-03 | 4.58E-02 | 2.07E-05 | -1.52E-01 |
| EP | kg $PO_4$-Eq | 1.02E-02 | 1.97E-04 | 8.95E-05 | 1.05E-02 | 6.00E-06 | -4.07E-02 |
| POCP | kg $C_2H_4$-Eq | 1.64E-03 | 4.56E-05 | 3.16E-04 | 2.00E-03 | 1.41E-06 | -7.64E-03 |
| ADPe | kg Sb-Eq | 3.95E-02 | 6.38E-04 | 3.49E-04 | 4.05E-02 | 3.01E-05 | -1.15E-01 |
| ADPf | MJ | 1.22E+02 | 1.43E+00 | 7.87E-01 | 1.24E+02 | 6.27E-02 | -1.95E+02 |
| WSP | $m^3$ | 1.18E-02 | 4.55E-05 | 1.39E-05 | 1.19E-02 | 1.83E-05 | -5.60E-02 |

*Resource use per 1 kg Aluminium Billet / Alloy*

| Parameter[2] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| PERE | MJ | 5.01E+01 | 1.15E-02 | 3.80E-03 | 5.02E+01 | 3.57E-03 | -3.18E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 2.52E-01 | 2.52E-01 | 0.00E+00 | 0.00E+00 |
| PERT | MJ | 5.01E+01 | 1.15E-02 | 2.56E-01 | 5.04E+01 | 3.57E-03 | -3.18E+00 |
| PENRE | MJ | 7.19E+01 | 1.42E+00 | 7.83E-01 | 7.41E+01 | 5.91E-02 | -1.92E+02 |
| PENRM | MJ | 0.00E+00 | 0.00E+00 | 4.60E-03 | 4.60E-03 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 7.19E+01 | 1.42E+00 | 7.88E-01 | 7.41E+01 | 5.91E-02 | -1.92E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NRSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| FW | $m^3$ | 0.00E+00 | 0.00E+00 | 1.11E-04 | 1.11E-04 | 0.00E+00 | 0.00E+00 |

*Output flows and waste categories per 1 kg Aluminium Billet / Alloy*

| Parameter[3] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| HWD | kg | 4.99E-05 | 2.11E-06 | 1.95E-06 | 5.40E-05 | 5.34E-08 | -3.81E-05 |
| NHWD | kg | 4.12E+00 | 2.76E-02 | 9.39E-04 | 4.15E+00 | 1.05E-01 | -4.42E+00 |
| RWD | kg | 1.95E-04 | 9.14E-06 | 5.13E-06 | 2.10E-04 | 2.21E-07 | -4.07E-04 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MFR | kg | 0.00E+00 | 0.00E+00 | 1.75E-02 | 1.75E-02 | 0.00E+00 | 9.00E-01 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

*Potential environmental impacts per 1 kg Aluminium Rods EC Grades / Alloy*

| Parameter[1] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| GWP[1] | kg $CO_2$-Eq | 6.20E+00 | 1.01E-01 | 1.88E+00 | 8.19E+00 | 3.94E-03 | -1.84E+01 |
| GWP-Fossil | kg $CO_2$-Eq | 5.37E+00 | 1.01E-01 | 1.88E+00 | 7.36E+00 | 3.92E-03 | -1.84E+01 |
| GWP-Biogenic | kg $CO_2$-Eq | 6.22E-01 | 2.84E-05 | 4.97E-06 | 6.22E-01 | 1.31E-05 | 1.10E-02 |
| GWP-LULUC | kg $CO_2$-Eq | 3.83E-01 | 6.62E-05 | 2.41E-06 | 3.83E-01 | 3.71E-06 | -2.65E-03 |
| ODP | kg CFC11-Eq | 5.14E-07 | 1.66E-08 | 5.16E-09 | 5.36E-07 | 3.47E-10 | -4.56E-07 |
| AP | kg $SO_2$-Eq | 3.71E-02 | 1.73E-03 | 8.25E-03 | 4.71E-02 | 2.07E-05 | -1.52E-01 |
| EP | kg $PO_4$-Eq | 1.05E-02 | 2.03E-04 | 5.04E-05 | 1.08E-02 | 6.00E-06 | -4.07E-02 |
| POCP | kg $C_2H_4$-Eq | 1.66E-03 | 4.71E-05 | 3.26E-04 | 2.04E-03 | 1.41E-06 | -7.64E-03 |
| ADPe | kg Sb-Eq | 3.97E-02 | 6.52E-04 | 1.97E-04 | 4.05E-02 | 3.01E-05 | -1.15E-01 |
| ADPf | MJ | 1.24E+02 | 1.46E+00 | 4.43E-01 | 1.26E+02 | 6.27E-02 | -1.95E+02 |
| WSP | $m^3$ | 1.16E-02 | 4.62E-05 | 8.23E-06 | 1.17E-02 | 1.83E-05 | -5.60E-02 |

*Resource use per 1 kg Aluminium Rods EC Grades / Alloy*

| Parameter[2] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| PERE | MJ | 5.21E+01 | 1.17E-02 | 2.14E-03 | 5.21E+01 | 3.57E-03 | -3.18E+00 |
| PERM | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| PERT | MJ | 5.21E+01 | 1.17E-02 | 2.14E-03 | 5.21E+01 | 3.57E-03 | -3.18E+00 |
| PENRE | MJ | 7.20E+01 | 1.45E+00 | 4.41E-01 | 7.39E+01 | 5.91E-02 | -1.92E+02 |
| PENRM | MJ | 0.00E+00 | 0.00E+00 | 4.60E-03 | 4.60E-03 | 0.00E+00 | 0.00E+00 |
| PENRT | MJ | 7.20E+01 | 1.45E+00 | 4.45E-01 | 7.39E+01 | 5.91E-02 | -1.92E+02 |
| SM | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NRSF | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| FW | $m^3$ | 0.00E+00 | 0.00E+00 | 1.11E-04 | 1.11E-04 | 0.00E+00 | 0.00E+00 |

*Output flows and waste categories per 1 kg Aluminium Rods EC Grades / Alloy*

| Parameter[3] | Unit | A1 | A2 | A3 | A1-A3 | C4 | D |
|---|---|---|---|---|---|---|---|
| HWD | kg | 5.20E-05 | 2.13E-06 | 1.09E-06 | 5.52E-05 | 5.34E-08 | -3.81E-05 |
| NHWD | kg | 4.29E+00 | 2.75E-02 | 5.43E-04 | 4.31E+00 | 1.05E-01 | -4.42E+00 |
| RWD | kg | 1.96E-04 | 9.34E-06 | 2.88E-06 | 2.09E-04 | 2.21E-07 | -4.07E-04 |
| CRU | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| MFR | kg | 0.00E+00 | 0.00E+00 | 1.75E-02 | 1.75E-02 | 0.00E+00 | 9.00E-01 |
| MER | kg | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| EE | MJ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

[1] GWP: Global warming potential; ODP: Ozone depletion potential; AP: Acidification potential; EP: Eutrophication potential; POCP: Formation potential of tropospheric ozone photochemical oxidants; ADPE: Abiotic depletion potential for non-fossil resources; ADPF: Abiotic depletion potential for fossil resources, WSP: Water scarcity potential

[2] PERE: Use of renewable primary energy excluding resources used as raw materials; PERM: Use of renewable primary energy resources used as raw materials; PERT: Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials); PENRE: Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM: Use of non-renewable primary energy resources used as raw materials; PENRT: Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials); SM: Use of secondary material - material recovered from previous use or from waste which substitutes primary materials; RSF: Use of renewable secondary fuels - secondary fuel: fuel recovered from previous use or from waste which substitutes primary fuels; NRSF: Use of non-renewable secondary fuels; FW: Use of net fresh water

[3] HWD: Hazardous waste disposed; NHWD: Non-hazardous waste disposed; RWD: Radioactive waste disposed CRU: Components for re-use; MFR: Materials for recycling; MER: Materials for energy recovery; EE: Exported energy, electricity and thermal

## Dominance analysis

| Share of environmental impacts average for all four products | | | | | | | |
|---|---|---|---|---|---|---|---|
| Impact category | GWP | ODP | AP | EP | POCP | ADPe | ADPf |
| Unit | kg $CO_2$-Eq | kg CFC11-Eq | kg $SO_2$-Eq | kg $PO_4$-Eq | kg $C_2H_4$-Eq | kg Sb-Eq | MJ |
| Energy | 22.1% | 6.4% | 8.0% | 12.8% | 12.1% | 16.5% | 48.1% |
| Materials | 54.9% | 90.5% | 71.8% | 85.3% | 70.5% | 81.9% | 50.7% |
| Transportation | 1.2% | 3.0% | 3.6% | 1.8% | 2.2% | 1.5% | 1.1% |
| Waste | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Water | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Disposal (C4) | 0.0% | 0.1% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% |
| Direct process emissions | 21.8% | 0.0% | 16.6% | 0.0% | 15.1% | 0.0% | 0.0% |

The tables clearly show that the dominant life-cycle stages appeared to be the raw materials supply (54-91%) and energy use (6-48%), responsible together for approximately 77-99% of the total impact in main impact categories. As well, 15-22% can be attributed to direct process emissionsfrom the smelting process (only applicable to some of the impact categories like POCP, AP, GWP). Extraction of enriched alumina has a strong influence on the results (approximately 50%) followed by the energy, mainly electricity, used during smelting. Other inputs such as some of the alloying elements PET straps, diesel for furnace operations contribute moderately to the environmental impacts.

Water use, waste management, transportation and disposal have relatively low contributions to the overall environmental impact, being responsible for less than 4% of the impact for all impact categories.The only assigned burdens to the recycled waste streams originate from transportation activities. The burdens from recycling are not considered in the assessment as they are allocated to the next system. As described above, for some minor flows the burden of transportation is already included in the category of raw material supply.

# References


| | |
|---|---|
| International EPD® System | General Programme Instructions of the International EPD® System. Version 3.0. |
| PCR 2012 | Product Category Rules Construction Products and Construction Services 2012:01 Version 2.33, 2020, International EPD System |
| CML 2001 | Method "Centrum voor Milieukunde", Leiden, NL |
| Ecoinvent | Ecoinvent Database, Swiss Centre for Life Cycle Inventories, Data Version 3.7.1 |
| EN 14020 | ISO 14020:2001, Environmental labels and declarations — General principles |
| EN 14025 | ISO 14025:2010, Environmental labels and declarations — Type III environmental declarations — Principles and procedures |
| EN 14044 | ISO 14044:2006, Environmental management — Life cycle assessment — Requirements and guidelines |
| EN 15804 | EN 15804:2012-04: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products |
| (ILCD) Handbook | (ILCD) Handbook European Commission, Joint Research Centre, Institute for Environment and Sustainability. (2010). International Reference Life Cycle Data System (ILCD) Handbook |

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