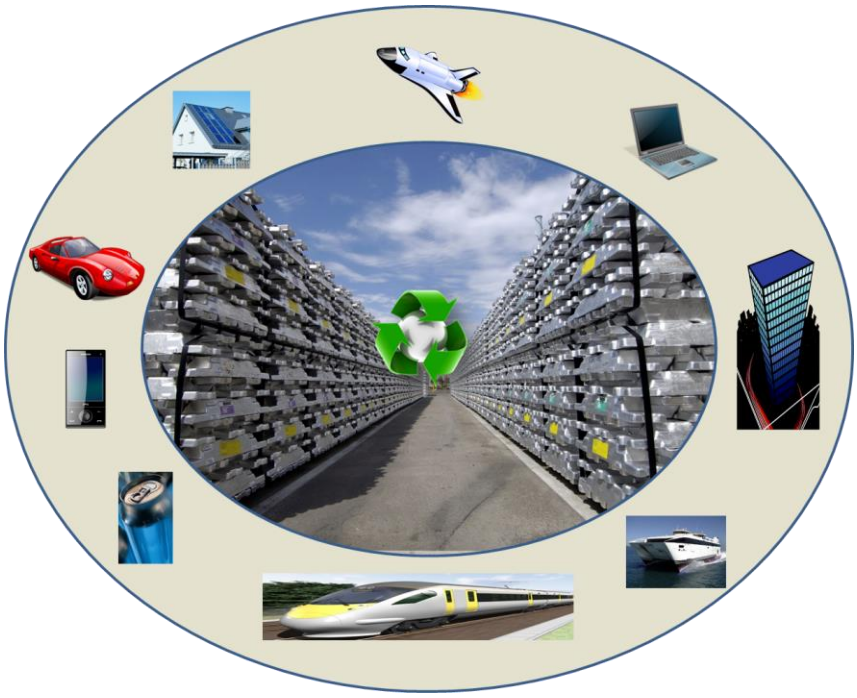
ENVIRONMENTAL PRODUCT DECLARATION

PRIMARY ALUMINUM INGOT

INDUSTRY-AVERAGE PRIMARY ALUMINUM INGOT
MANUFACTURED IN NORTH AMERICA



The Aluminum Association

The Aluminum Association and the aluminum industry are committed to responsible environmental stewardship. Aluminum is one of the most sustainable materials in use today:

- Strong and lightweight: Aluminum's favorable strength-to-weight ratio means it can be substituted for heavier materials, driving energy efficiency.
- Infinitely recyclable: Aluminum can be recycled over and over again without losing any of its fundamental properties.
- Efficiency Improvements: Through voluntary industry efforts, the North American aluminum industry has reduced the carbon footprint of primary aluminum production by 37 percent since 1995.
- Corrosion-resistant: Durable aluminum lasts longer than many competing materials, limiting the need for replacement.
- Highly recycled: Aluminum is one of the most recycled materials on the market today. And producing recycled aluminum takes just 8 percent of the energy needed to make primary aluminum.

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

ENVIRONMENTAL PRODUCT DECLARATION

The Aluminum Association

Primary Aluminum Ingot
Products of Aluminum and Aluminum Alloys

According to ISO 14025 and EN 15804

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	The Aluminum Association
DECLARATION NUMBER	4786092064.104.1
DECLARED PRODUCT	Primary Aluminum Ingot
REFERENCE PCR	Products of Aluminum and Aluminum Alloys (IBU, July 2012)
DATE OF ISSUE	October 16, 2014
PERIOD OF VALIDITY	5 years
EXTENSION PERIOD	August 16, 2022
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	The Independent Expert Committee
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas Gloria, Industrial Ecology Consultants

This EPD conforms with EN 15804

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Product

Product Description

This EPD covers the production of primary aluminum ingot for further processing into aluminum semi-fabrications and products. The results represent an average across all primary aluminum ingot manufactured in North America (United States and Canada) and includes various alloy compositions. Averages are obtainted through aggregating production-weighted data from the participating companies.

Applications

Primary aluminum ingots are used to create aluminum semi-fabricated products, such as rolled coils, casted components, or extrusions for further aluminum product manufacturing.

Technical Data

Name	Value	Unit
Density	2.66-2.84	$(kg/m^3) \times 10^3$
Melting point (Typical)	475-655	°C
Electrical conductivity (Typical) at 20°C/at 68˚F	Equal Volume:16-36	MS/m (0.58*%IACS)
Thermal conductivity (Typical) at 25˚c/at 77˚F	109-234	W/(m.K)
Average Coefficient of thermal expansion (Typical) 20˚ to 100˚c /68° to 212°F	19.4-24.1	per ˚C
Modulus of elasticity (Typical)	69-74	$MPa * 10^3$
Chemical composition	Varying alloy by alloy, most case Al > 90	% by mass

Applicable Standards

Aluminum ingots do not need to comply with any particular standard. Chemical composition of most high-purity alloys follow the *International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys* (AA 2009).

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Delivery Status

The output of primary ingot production are aluminum ingots, primarily from bauxite ore, suitable for rolling, extruding, or shape casting. The dimensions of the ingot vary based on the semi-fabrication requirements.

Base and Ancillary Materials

Bauxite ore is the primary raw material source for aluminum production. This ore consists primarily of the minerals gibbsite $Al(OH)_3$, boehmite, and diaspore AlOOH, together with minor fractions of iron oxides, clay minerals, and small amount of TiO_2.

The bauxite ore must first be refined into alumina (aluminum oxide) before it can be electrolyzed into aluminum ingot. According to a recent survey by the International Aluminium Institute (IAI), the production of one metric ton of alumina requires approximately 2.9 metric tons of bauxite (taking into account the purity of bauxite and losses during processing and transportation) (IAI 2013). Raw materials for alumina production include bauxite, caustic soda, and sodium carbonate.

In addition to the alumina, carbon anodes are used in the electrolysis process to produce primary aluminum ingot. Anodes are made from petroleum coke and coal pitch, and are consumed in the process of separating the alumina into aluminum and oxygen gas. The final composition of the aluminum ingot varies by alloy, but is typcially greater than 90% aluminum by mass.

Manufacture

The manufacturing of primary aluminum ingot includes the component processes of bauxite mining, alumina refining, electrolysis (including anode production and smelting), and primary ingot casting. The intial raw material is bauxite ore and the final product is primary aluminum ingot with intermediate products of alumina (aluminum oxide) and molten aluminum (liquid) metal.

Nearly all primary aluminum ingot in North America is made from imported bauxite. The ore for this declaration is modeled as being imported from Jamaica, Guinea, and Brazil, which sum to 99.4% of the bauxite imports to North America in 2010 (USGS 2011). Additionally, some alumina is imported directly by the North American aluminum industry. This is modeled based upon data directly collected and aggregated by the International Aluminium Institute.

There are two generic types of electrolysis technologies for aluminum: Prebake and Söderberg. The two technologies differ in the type of anodes they consume. As a consequence of advanced design and better computer control of the Prebake technology, the efficiency and emission levels have been significantly improved. Approximately 95% of the production in North America in 2010 was from Prebake technology and 5% was from Söderberg technology.

Molten metal from electrolysis is siphoned from the pots and sent to a resident cast house for further alloying, heat treatment, fluxing, and filtering as necessary for the final product. The metal is then cast into ingots in a variety of methods: open molds (typically for remelt ingot), through direct chill molds for various fabrication shapes, electromagnetic molds for some sheet ingots, and through continuous casters for aluminum coils.

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Environment and Health during Manufacturing

Air: Hazardous air emission releases 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 that all values inside and outside the production plant comply with regulatory thresholds.

Product Processing and Installation

Further processing of primary aluminum ingot depends on the final application of the product and is outside the scope of this EPD.

Packaging

Product delivery packaging includes wood, steel, paper board, and sometimes plastic wraps. Packaging is included in the scope of this EPD.

Condition of Use

No special conditions of use are relevant for this product under the scope of this EPD.

Environment and Health During Use

The environmental and health effects during use are dependent on the ultimate use of the primary aluminum ingot and are outside the scope of this EPD. The following general statements are relevant for all aluminum products:

- Aluminum products are often made from both primary and recycled ingots
- There is no relevant chemical composition difference between primary and secondary ingots if both are governed by the same alloy designation and chemical composition limit standards
- The service life of the final product depends on its application, but is typically long due to aluminum's excellent corrosion resistance
- For that same reason, maintenance needs during use are usually low.

Reference Service Life

Service lifes for primary aluminum products vary based on their application. This EPD does not cover the product use phase and therefore makes no specific claim as to a typical reference service life.

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Extraordinary Effects

Fire: Aluminum products comply with ASTM E 136-11.

Water: There is no evidence to suggest water runoff or exposure under normal and intended operation will violate general water quality standards.

Mechanical destruction: Not relevant for aluminum.

Recycling

The recycling of the primary aluminum ingot is not covered by this declaration due to its application as an input to downstream fabrication (e.g., extrusion, shape-casting, rolling). However, most aluminum products are highly recycled at the end of their service life, particularly for those used in the transportation, infrastructure, and building & construction markets. Industry case studies found that the recovery rate of the metals in the automotive and construction sectors is 95% (IAI 2013). Once recovered, the scrap metals enter a well established and easily accessed trading and processing system and end up being used to produce new metals for the same or a different application.

Post-industrial scrap is highly utilized within the aluminum industry. Most process and new scrap materials that occur in the manufacture and processing of primary aluminum ingot are fed back into the production process.

Disposal

The disposal of products made from primary aluminum ingot is not covered by this declaration.

Further Information

For further information on aluminum and aluminum products, please visit the Aluminum Association website: www.aluminum.org.

The life cycle assessment was conducted by PE INTERNATIONAL using GaBi data.

PE INTERNATIONAL
SUSTAINABILITY PERFORMANCE

Life Cycle Assessment

Declared Unit

The declared unit is the production of one metric ton of primary aluminum ingot. The results can be converted to one kilogram by dividing by 1,000.

System Boundary

This is a “cradle-to-gate” EPD. The following processes are considered in the product stages A1–A3 of the primary aluminum ingot production:

- The provision of resources, additives and energy
- Transport of resources and additives to the production site
- Production process of primary ingot, including energy, production of additives, disposal of production residues, consideration of related emissions, and recycling of production scrap and dross (“closed loop”).

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)																
PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport	Construction-installation process	Use	Maintenance	Repair	Replacement[1]	Refurbishment[1]	Operational energy use	Operational water use	De-construction 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	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Estimates and Assumptions

The LCA required only limited use of estimates and assumptions. Averages and best-estimates were used to fill in minor data gaps, such as the source of ingots for some facilities. Other estimates and assumptions are discussed in detail in the LCA background report.

Cut-off Criteria

Input: All material flows that enter the system and are over 1% of the product mass or contribute more than 1% to the primary energy consumption are included.

Output: All material flows that exit the system and whose environmental impact makes up more than 1% of the total impact in an impact category considered are included.

Background Data

In order to model the life cycle for the production of the primary aluminum ingot, the GaBi 6 software system developed by PE INTERNATIONAL was used. All relevant background data necessary for the production of primary aluminum ingot were taken from the GaBi 2012 databases or were made available by the Aluminum Association through industry survey results. Companies participating in the project, either with AA or AIA, are provided in the *Participating Companies* section.

Data Quality

The data is considered of high quality. Inventory data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source) and representativeness (geographical, temporal, and technological). To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background life cycle inventories from the GaBi 2012 database were used.

The LCI data sets from the GaBi database are widely distributed and used with the GaBi 6 Software. The datasets have been used in LCA models worldwide in industrial and scientific applications in internal as well as in many critically reviewed and published studies. In the process of providing these datasets, they are cross-checked with other databases and values from industry and science.

Period under Review

Primary data for bauxite mining, alumina refining, and primary aluminum production was collected by the International Aluminum Institute (IAI) and provided to the Aluminum Association (AA). Primary data collected from the participating companies and from their operational activities is representative for the year of 2010. Additional data necessary to model raw material production, energy generation, etc. were adopted from the GaBi 2012 database with typical reference years between 2006 and 2010.

Allocation

Allocation is not used within the model. Recycling of co-products (e.g., salt cake, dross) is included within the model. Note that allocation is used on select background data from the GaBi database (e.g., caustic acid).

Comparability

A comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to EN 15804 and the building context, respectively the product-specific characteristics of performance are taken into account.

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Life Cycle Assessment: Results

Results given per one metric ton of primary aluminum ingot.

CML 2001 (Nov 2010)

		Product Stage
Parameter	**Unit**	**A1-A3**
GWP	kg CO_2 eq	8.94E+03
ODP	kg CFC-11 eq	4.35E-07
AP	kg SO_2 eq	6.11E+01
EP	kg PO_4^3 eq	2.60E+00
POCP	kg C_2H_4 eq	3.11E+00
ADPE	kg Sb eq	4.94E-03
ADPF	MJ	8.83E+04

TRACI 2.1

		Product Stage
Parameter	**Unit**	**A1-A3**
GWP	kg CO_2 eq	8.94E+03
ODP	kg CFC-11 eq	4.63E-07
AP Air	kg SO_2 eq	5.64E+01
AP Water	kg SO_2 eq	4.58E-03
EP Air	kg N eq	8.35E-01
EP Water	kg N eq	1.35E-01
SFP	kg O_3 eq	4.46E+02
FF	MJ	6.23E+03

		Product Stage
Parameter	**Unit**	**A1-A3**
PERE	[MJ]	4.98E+04
PERM	[MJ]	0.00E+00
PERT	[MJ]	4.98E+04
PENRE	[MJ]	8.83E+04
PENRM	[MJ]	0.00E+00
PENRT	[MJ]	8.83E+04
SM	[kg]	0.00E+00
RSF	[MJ]	0.00E+00
NRSF	[MJ]	0.00E+00
FW	[m^3]	2.18E+05

		Product Stage
Parameter	**Unit**	**A1-A3**
HWD	[kg]	2.69E+03
NHWD	[kg]	3.86E+01
RWD	[kg]	3.63E+00
CRU	[kg]	0.00E+00
MFR	[kg]	4.70E+00
MER	[kg]	0.00E+00
EEE	[MJ]	0.00E+00
EET	[MJ]	0.00E+00

Glossary

Environmental Impacts

GWP	Global warming potential
ODP	Depletion potential of the stratospheric ozone layer
AP	Acidification potential
EP	Eutrophication potential
POCP	Photochemical oxidant creation potential
SFP	Smog formation potential
ADPE	Abiotic depletion potential for non-fossil resources
ADPF	Abiotic depletion potential for fossil resources
FF	Fossil fuel consumption

Resource Use

PERE	Renewable primary energy as energy carrier
PERM	Renewable primary energy resources as material utilization
PERT	Total use of renewable primary energy resources
PENRE	Non-renewable primary energy as energy carrier
PENRM	Non-renewable primary energy as material utilization
PENRT	Total use of non-renewable primary energy resources
SM	Use of secondary material
RSF	Use of renewable secondary fuels
NRSF	Use of non-renewable secondary fuels
FW	Use of net fresh water

Output Flows and Waste Categories

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
EEE	Exported electrical energy
EET	Exported thermal energy

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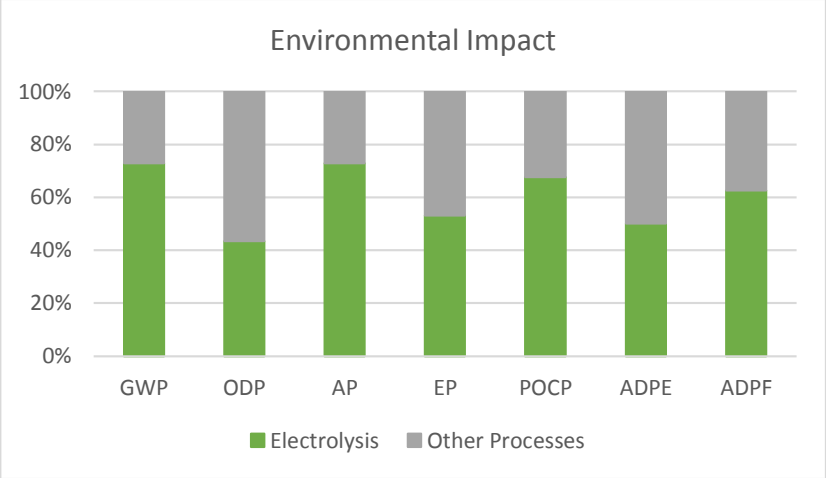
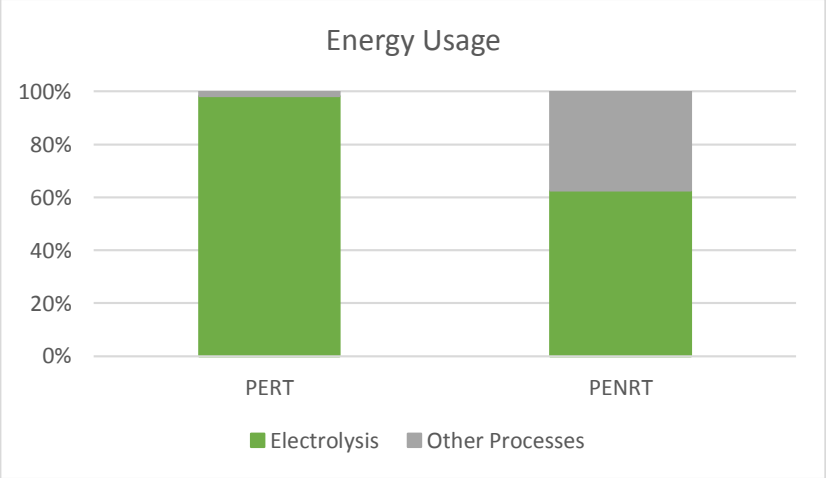
Life Cycle Assessment: Interpretation

The results represent the cradle-to-gate impacts of the production of one metric ton of primary aluminum ingot. A key result is that the environmental impacts of primary aluminum ingot production are largely driven by the electricity consumption during the electrolysis of alumina. Therefore, there is a strong push in the aluminum industry to maximize aluminum recycling rates and close material loops.





Participating Companies

Company	Data Category	Note
Alcoa Inc.	Bauxite, Alumina, Primary Aluminum, Recycled Aluminum, Hot and Cold Rolling, Extrusion	Include Kawneer and Traco
Aleris International Inc.	Recycled Aluminum, Hot and Cold Rolling	
Alexandria Extrusion Company	Extrusion	
Century Aluminum Company	Primary Aluminum	
Constellium	Hot and Cold Rolling	At the time of data survey, it was owned by Rio Tinto Alcan
Grupo Cuprum	Recycled Aluminum, Extrusion	
Hydro Aluminum North America	Bauxite, Alumina, Recycled Aluminum, Extrusion	
Jupiter Aluminum Corporation	Recycled Aluminum, Hot and Cold Rolling	
Kaiser Aluminum	Recycled Aluminum, Hot and Cold Rolling, Extrusion	
KB Alloy	Recycled Aluminum	
Logan Aluminum	Recycled Aluminum, Hot and Cold Rolling	
Metal Exchange Corporation	Recycled Aluminum, Extrusion	
Minalex Corporation	Extrusion	
Nichols Aluminum	Recycled Aluminum, Hot and Cold Rolling	
Noranda Aluminum Inc.	Alumina, Primary Aluminum	
Novelis Inc.	Recycled Aluminum, Hot and Cold Rolling	
Ormet Corporation	Alumina, Primary Aluminum	
Peerless of America	Extrusion	
Penn Aluminum International LLC	Extrusion	
Rio Tinto Alcan	Bauxite, Alumina, Primary Aluminum	
Sapa Extrusions Inc.	Recycled Aluminum, Extrusion	
Scepter Inc.	Recycled Aluminum	
Sherwin Alumina	Alumina	
Smelter Service Corporation	Recycled Aluminum	
Tri-Arrows Aluminum Inc.	Recycled Aluminum, Hot and Cold Rolling	

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