CY2024 Rolled Aluminum Sheet Product Life Cycle Assessment Summary

Introduction

Tri-Arrows Aluminum, Inc. (TAA) is a leading supplier of rolled aluminum sheet in the North American beverage can sheet and automotive sheet markets. Aluminum sheet is manufactured in Russellville, KY at Logan Aluminum (herein referred to as the "Russellville Mill"), a joint venture production facility between TAA and Novelis Corporation. This memo provides the results of a life cycle assessment (LCA) of rolled aluminum sheet produced at the Russellville Mill in CY2024. As the Russellville Mill is a joint venture between TAA and Novelis Corporation, this LCA provides results for product produced at the Russellville mill for TAA only. An equity share strategy was used to determine TAA's portion of environmental impacts from the mill and associated operations.

At the Russellville Mill, TAA manufactures rolled aluminum sheet from a mixture of scrap aluminum and primary aluminum (prime) via melting, casting, hot rolling, cold rolling, and finishing operations. Prime and scrap aluminum is melted to a liquid state at the melting operations, while casting cools the liquid into cast ingots. The aluminum ingots are rolled in a series of both hot and cold rolling units that convert the ingots into slabs and then into rolled aluminum coils. The raw coils are then finished to customer specifications through additional steps which can include leveling (unrolling and re-rolling the coils to level the metal surface), slitting (trimming the edges of the coils), annealing, and coating. The final product is then packaged and transported off site via ship, rail or truck for distribution.

This LCA was commissioned in 2025 by TAA, and performed by Trinity Consultants, Inc. (Trinity). The LCA was conducted in conformance with the requirements outlined in Product Category Rules (PCR) for aluminum products. Specifically, the PCRs consulted included:

- PCR for Building-Related Products and Services in North America, Part A: Life Cycle Assessment Calculation Rules and Report Requirements, UL Environment, Version 4 (PCR Part A);
- PCR Guidance for Building-Related Products and Services in North America, Part B Requirements on the EPD for Products of Aluminium and Aluminium alloys, UL Environment, Version 1.1 (PCR Part B).

While these PCRs refer to building-related products, other aluminum manufacturers including The Aluminum Association have utilized these PCRs in support of Environmental Product Declarations (EPD) for aluminum sheet that cover non-building related industries similar to TAA including beverage can sheet and automotive sheet markets[1]. Therefore, TAA is choosing to use these PCRs for this LCA of its rolled aluminum sheet product focusing on the beverage can sheet and automotive sheet markets.

These PCRs are consistent with and conform with the mandatory requirements of the following standards:

- ISO 14040:2006/Amd 1:2020, Environmental management – Life cycle assessment – Principles and framework

[1] https://www.aluminum.org/sites/default/files/2022-10/103.1_EPD_AA_Sheet.pdf

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- ISO 14044:2006/Amd 1:2017/Amd 2:2020, Environmental management – Life cycle assessment – Requirements and guidelines
- ISO 21930:2017, Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services
- ISO 14025:2011, Environmental labeling and declarations – Type III environmental declarations – Principles and procedures

Goal and Scope

Goal

TAA's goal of this LCA was to assess the "cradle-to-gate" environmental impacts associated with the subject product. This LCA may be used to develop and publish an Environmental Product Declaration (EPD) for aluminum products manufactured by TAA at the Russellville Mill in the future.

Declared Unit

The product discussed in this LCA memo is rolled aluminum sheet product manufactured by TAA at the Russellville Mill located at 6920 Lewisburg Rd, Russellville, KY 42276 in CY2024. This LCA Report is specific to TAA's operational share of the Russellville Mill.

The declared unit, and reference flow, for the product system is one metric ton of rolled aluminum sheet product (herein referred to as "the product"). Impacts are normalized to the production tonnage of rolled aluminum sheet product.

System Boundary

The scope of the LCA is cradle-to-gate, including raw material extraction and processing, transportation, and product manufacture. The analysis represents aluminum production from TAA's Russellville Mill for the reference year 2024. Per ISO 21930, the system boundary applied in this study includes:

- Module A1: raw material supply to the Russellville Mill;
- Module A2: transport to Russellville Mill; and
- Module A3: manufacture of the rolled aluminum sheet product at the Russellville Mill including ancillary service operations and packaging for dispatch to customers at the exit gate.

Modules A4 – A5, B1 – B7, C1 – C4, and D have not been included, due to the inability to predict how the material will be used following manufacture.

Methodology, Estimates, and Assumptions

Methodology

This LCA was conducted using the LCA for Experts software (formerly known as GaBi)[2] utilizing the datasets available in the 2024 Professional Database.

[2] https://sphera.com/product-sustainability-software/

Cut-off Criteria

According to the PCR, processes contributing greater than 1% of the total environmental impact indicator for each impact are included in the inventory. In cases where no matching life cycle inventories were available to represent a flow, proxy data were applied based on conservative assumptions regarding environmental impacts. The mass input of any omitted stream is less than 1% of the total mass input streams for their respective unit processes and the cumulative mass input of all of the omitted streams is less than 5% of the total mass input streams. No other known flows are deliberately excluded from this LCA. Therefore, no data gaps were allowed which were expected to significantly affect the outcome of the indicator results.

Allocation

Per ISO 21930 and the PCR, this is an attributional LCA and as such, no allocation using system expansion was performed. Allocation of background data (energy and materials) taken from the Managed LCA Content (formerly known as GaBi databases) is documented online at https://sphera.com/life-cycle-assessment-lca-database/.

Approximately ~1% of TAA's cast ingot is sold as-is to external customers (herein referred to as "external cast ingot"). The remaining cast ingot continues to the rolling mill and subsequent operations to be turned into rolled aluminum sheet. The external cast ingot and rolled aluminum sheet product are considered co-products of the product system resulting from a joint co-production process. As a conservative assumption, no allocation was performed to allocate the environmental burden upstream of the rolling mill between the external cast ingot and rolled aluminum sheet. All environmental burdens are allocated to the rolled aluminum sheet.

Electricity Power Mix

The Tennessee Valley Authority (TVA) provides electricity to the Russellville Mill. The most recent 2023 data for TVA was used since utility specific information was available. This local utility provider-specific grid mix most accurately represents the actual electricity grid mix sent to the facility. This electricity grid mix is shown in Table 1.

Table 1. TVA Electricity Grid Mix

Generation/Fuel Source	Percentage of Total Electricity Production
Natural Gas	27.86%
Coal	15.33%
Diesel	0.00%
Hydroelectric	9.37%
Nuclear	43.22%
Wind	1.42%
Solar	0.31%
Biomass	0.05%
Oil	0.11%
Other (Unknown)	2.33%
Total	**100.00%**

a. "Other (Unknown)" was modeled as the average eastern US electricity grid mix in LCAfE.
b. Acquired from Edison Electric Institute (EEI): https://www.eei.org/

Life Cycle Impact Assessment Results

The environmental impact category indicators outlined below are reported using characterization factors based on the U.S. EPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts – TRACI 2.1 – with the exception of GWP 100, which uses the IPCC 2013 (AR5) methodology, and ADP_{fossil}, which uses CML-baseline v4.7 August 2016, per the PCR Part A Section 4.7.

North American Life Cycle Impact Assessment impacts were calculated using LCA for Experts. Those impact categories are required by PCR Part A and Part B, which are consistent and conform with ISO 21930, ISO 14025, ISO 14044, and ISO 14040.

Table 2. North American Life Cycle Impact Assessment Results (per metric ton of product)

Parameter	Description	A1	A2	A3	Total	Unit
GWP 100	Global Warming Potential, excluding biogenic carbon and land-use	1.20E+03	6.29E+01	7.55E+02	2.02E+03	kg CO_2 eq
ODP	Ozone Depletion Potential	2.46E-09	7.86E-13	1.65E-09	4.11E-09	Kg CFC 11 eq
AP	Acidification Potential	5.31E+00	4.92E-01	6.09E+00	1.19E+01	kg SO_2 eq
EP	Eutrophication Potential	1.36E-01	3.29E-02	8.63E-02	2.55E-01	kg N eq
SFP	Smog Formation Potential	5.28E+01	1.36E+01	2.75E+01	9.40E+01	Kg O_3 eq
ADP_{FOSSIL}	Abiotic Resource Depletion Potential of non-renewable (fossil) energy resources	1.29E+04	7.97E+02	1.43E+04	2.80E+04	MJ, LHV

Table 3. Resource Use (per metric ton of product)[a]

Parameter	Description	A1	A2	A3	Total	Unit
RPR_E	Renewable primary resources used as energy carrier (fuel)	6.22E+03	4.82E+01	5.84E+02	6.85E+03	MJ
RPR_M	Renewable primary sources with energy content used as material	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MJ
$NRPR_E$	Non-renewable primary resources used as an energy carrier (fuel)	1.32E+04	8.29E+02	1.76E+04	3.16E+04	MJ
$NRPR_M$	Non-renewable primary resources with energy content used as material	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MJ
SM	Secondary materials	9.65E+02	0.00E+00	0.00E+00	9.65E+02	kg
RSF	Renewable secondary fuels	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MJ
NRSF	Non-renewable secondary fuels	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MJ
RE	Recovered energy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MJ
FW	Use of fresh water resources	2.05E+01	1.11E-01	3.97E+00	2.46E+01	m^3

a. Lower calorific values (LHV) of fuels are used for energy parameters.

Table 4. Output Flows and Waste Categories (per metric ton of product)

Parameter	Description	A1	A2	A3	Total	Unit
HWD	Hazardous waste disposed	0.00E+00	0.00E+00	1.44E+00	1.44E+00	kg
NHWD	Non-hazardous waste disposed	0.00E+00	0.00E+00	2.02E+01	2.02E+01	kg
HLRW	High-level radioactive waste, conditioned, to final repository	1.32E-04	1.35E-05	1.38E-03	1.53E-03	kg
ILLRW	Intermediate and low-level radioactive waste, conditioned, to final repository	1.10E-01	1.13E-02	1.16E+00	1.28E+00	kg
CRU	Components for re-use	0.00E+00	0.00E+00	0.00E+00	0.00E+00	kg
MR	Materials for recycling	0.00E+00	0.00E+00	1.43E+02	1.43E+02	kg
MER	Materials for energy recovery	0.00E+00	0.00E+00	0.00E+00	0.00E+00	kg
EE	Recovered energy exported from the product system	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MJ

Conclusions

Overall, Module A1, i.e. Raw Material Extraction and Processing, is the key contributor to most potential environmental impacts, including global warming potential, ozone depletion potential, eutrophication potential, and smog formation potential. Module A3, i.e. manufacturing, is the most significant category for acidification potential and abiotic resource depletion potential of fossil energy resources. Module A2, i.e. transport to the facility, is not the most significant contributor in any impact category.

The major contributors to GWP are displayed in Figure 1 below. Based on Figure 1 below, the largest contributor to the product's GWP is primary aluminum ingot, which makes up 48% of the total GWP.

Figure 1. GWP Contributors