Nikkei MC Aluminum America, Inc.
Aluminum Alloy Ingot
Life Cycle Assessment (LCA) Survey Report

Document Control

Document Owner	Nikkei MC Aluminum America, Inc.
Management Representative	GM Compliance & Quality Manager
ASI Alignment	ASI Performance Standards – Environmental Impacts & LCA
Effective Date	2025-12-01
Review Cycle	Annual or upon significant process change
Approval Authority	Executive Management

Revision History

Revision	Date	Description of Change	Author	Approver
0	2025-12-01	Initial controlled release – standardized document control and formatting	Sustainability / LCA Team	Executive Management

Nikkei MC Aluminum America, Inc.

Aluminum Alloy Ingot Life Cycle Survey Report

1 About the report

1.1 Life cycle assessment method

Life Cycle Assessment (LCA) is a standardized methodology used to evaluate resource consumption and environmental efficiency systematically and quantitatively across a product's entire life cycle. By analyzing both upstream and downstream production and consumption processes, LCA enables producers to pinpoint stages that contribute to environmental degradation.

1.2 Company Profiles

Nikkei MC Aluminum America (NMAA), a subsidiary of the Nikkei MC Aluminum Group, specializing in manufacturing recycled aluminum alloys. The company recycles aluminum by smelting scrap material in reverberatory furnaces, producing a diverse range of alloy products tailored for the die-casting and gravity-casting industries. NMAA's 5kg aluminum ingots are distributed to domestic automotive manufacturers where they are used in the production of wheels, engine components, tire molds, structural elements, battery casings, and brake systems.

1.3 Report Summary

This report examines NMAA's aluminum alloy ingots through a comprehensive Life Cycle Assessment (LCA). It investigates the full life cycle of NMAA's operations, collects relevant data, compiles an LCA inventory, and constructs product-specific LCA models. The course provides a quantitative analysis of the key resource and environmental impact factors associated with the ingots' life cycle, aiming to identify opportunities for sustainable improvements at each stage of the production process.

2 Defining Purpose and Scope

2.1 Definition of Purpose

2.1.1 Objectives of the Study

In February 2024, Nikkei MC Aluminum America (NMAA) joined the Aluminum Stewardship Initiative (ASI), becoming a member under the Production, Conversion, and

Processing categories. ASI is a non-profit organization committed to developing and certifying sustainability standards across the aluminum value chain. Its vision is to maximize aluminum's contribution to a sustainable society, with a mission focused on promoting responsible production, sourcing, and governance.

As part of ASI's framework, member companies voluntarily undergo audits aligned with ASI Performance Standards (PS), helping to foster sustainability by linking certified supply chains with responsibly manufactured aluminum products. Life Cycle Assessment (LCA) plays a critical role in these audits, offering a data-driven approach to evaluate environmental impacts throughout the product's life cycle.

Building on this background, the current project established a comprehensive life cycle model for NMAA's aluminum alloy ingots—from raw material acquisition through to product shipment. It includes data collection, LCA modeling, and evaluation of environmental performance. The resulting report, along with its findings and analytical insights, can also be used-

To obtain the results of the environmental impact indicators of the life cycle of aluminum alloy products and identify critical processes and improvement priorities in the product life cycle.

As a basis for aluminum alloy product manufacturers to compare the resources and environmental efficiency of their products under different processes and to create conditions for future selection of more environmentally friendly process technologies.

To assess the environmental impact caused by different raw material choices and to assist in the green design of aluminum alloy products.

For marketing and publicity, showing the advantages of corporate products in terms of resources and environmental efficiency, establishing an excellent enterprise and product image, and providing material support for the sales of aluminum alloy products and the procurement of auto parts manufacturers.

2.1.2 Functional Units

In this project, aluminum alloy ingots produced by NMAA are selected as representative products, with the functional unit defined as one ton of aluminum alloy ingot.

Aluminum Alloy Ingot Products

2.1.3 Data Representativeness

The LCA results in this report are representative of NMAA and its supply chain level (using actual production data). Time, geography, and technology are represented as follows:

Representativeness of Time: 2024

Geographical Representativeness: Indiana, USA

Representativeness of technology, including:

Process flow: raw material input→ melting→ purification, degassing→ resting→ aluminum ingot casting→ packing and storage

Process equipment: melting furnace, casting machine, degasser, shredder, dust collector, ingot stacking machine

Production Quantity: 56,092 tons/year

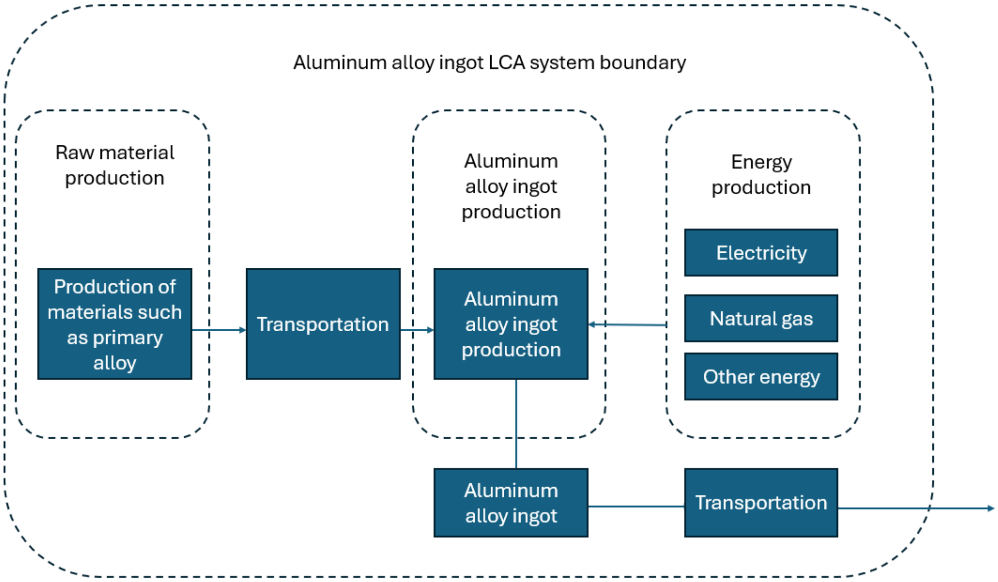
Raw materials: electrolytic aluminum, aluminum waste, industrial silicon, etc.

Energy consumption: electricity, natural gas

2.2 Defining Scope

2.2.1 System Boundaries

The system boundary defined in this report follows a "cradle to treasure chest" approach—encompassing the entire process from resource extraction to product shipment at the customer’s location. This boundary is segmented into three primary stages: raw material and energy acquisition, product manufacturing, and product transportation. The following diagram illustrates the system boundary across the aluminum alloy ingot life cycle:



2.2.2 Types of Environmental Impacts

The selection of environmental impact categories and indicators is guided by the purpose of the study, which in turn defines the scope of data collection and influences data availability. Indicator choice should reflect the environmental concerns relevant to the intended audience and application of the reports, such as the target market, customers, and stakeholders.

It is also essential to consider the environmental impacts specific to the product under evaluation. Given the characteristics of the production process examined in this study and based on the status of data collection and reporting objectives, climate change has been selected as the primary impact category. This indicator not only enables companies to identify opportunities for reducing greenhouse gas emissions and improving energy efficiency but also serves as a critical tool for advancing sustainable production and consumption practices.

2.2.3 Data Sorting Rules

Based on the defined system boundaries and selected environmental impact indicators, this study draws on industry best practices to establish data selection rules aligned with actual production conditions. To streamline the data collection and evaluation process, factors deemed to have negligible influence on the Life Cycle Assessment (LCA) results are excluded.

2.2.4 Data Quality Assessment

The purpose of data quality assessment is to evaluate the reliability of Life Cycle Assessment (LCA) results and conclusions, and to identify key areas for improving data integrity. In this study, data quality will be managed and assessed across four dimensions: representativeness, completeness, reliability, and consistency.

1) Data Representativeness

Geographical Representation: Indicates the country or specific region that the data represents.

Temporal representativeness: Priority will be given to data from companies, literature, and background databases close to the base year of the study.

Technical Representativeness: Describes the actual representativeness of the production technology.

2) Data integrity

The objective of data quality assessment is to ensure the reliability of Life Cycle Assessment (LCA) results and conclusions, while identifying critical areas for enhancing data integrity. In this study, data quality will be systematically managed and evaluated across four key dimensions: representativeness, completeness, reliability, and consistency.

Integrity of the Background Database: The background database encompasses the mining, production, and transportation processes of key energy sources, basic raw materials, and chemicals within at least one country or region. This comprehensive coverage ensures the overall integrity and reliability of the database.

3) Reliability

- Reliability of Real Data: For key inputs such as raw material consumption, energy usage, and transportation, actual production records from the enterprise should be used wherever possible. Environmental emission data should prioritize values obtained from official environmental monitoring reports.

- Reliability of Background Data: Data on upstream production processes for critical materials and energy sources should be sourced from publicly available databases that represent the country of origin and utilize comparable production technologies. Preference should be given to recent annual data.

- Database Reliability: Background databases should be based on statistical records, surveys, and published literature from the relevant country or region. These sources must accurately reflect the local energy mix, production system characteristics, and average technological standards.

4) Consistency

All real-world data used in this study adheres to uniform statistical standards. This includes alignment in product output definitions, process boundaries, and the time of data collection, ensuring consistency across all datasets.

3 Data collection

3.1 Overview of the Production Process

3.1.1 Procurement of Raw Materials and Energy

The materials used in NMAA's aluminum alloy ingots production include:

Electrolytic Aluminum: obtained from the process of bauxite mining/alumina production/electrolysis, hereinafter collectively referred to as "primary aluminum.”

Aluminum Waste: Refers to aluminum materials recovered from external sources, primarily consisting of recycled scrap from previously manufactured products. These materials are collectively referred to as “recycled aluminum” throughout this report.

Silicon: Produced metallurgically from quartz and other raw materials, and hereinafter collectively referred to as “industrial silicon.” All primary materials mentioned above are transported to the factory via automobile delivery.

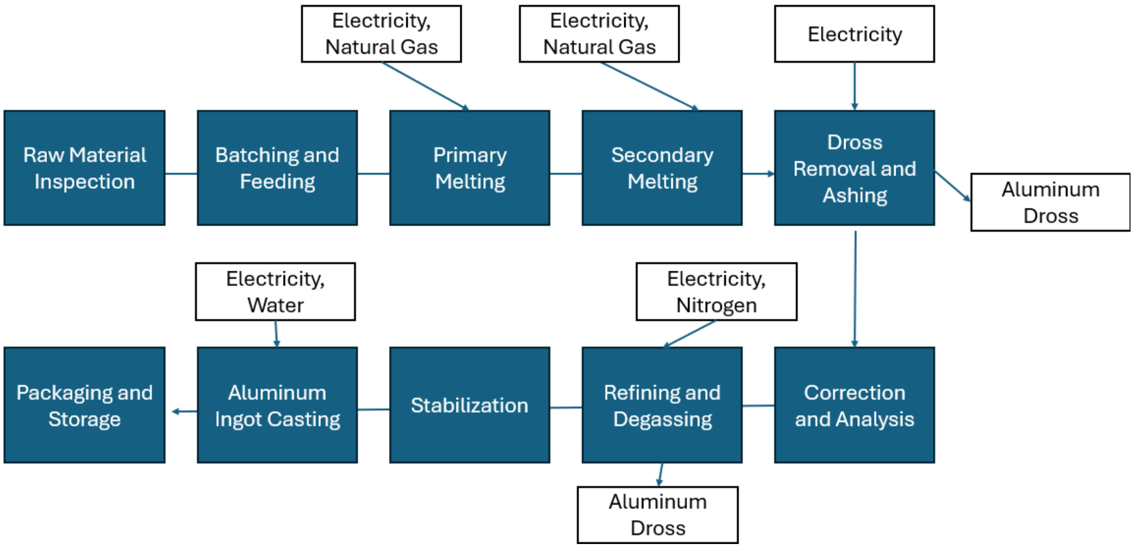
All energy, such as natural gas and electricity, is sent to the factory through dedicated lines.

3.1.2 Manufacturing Process

The manufacturing process of NMAA's aluminum alloy ingots is as follows-

Process	Detailed Description	Energy & Resource Input
Raw Material Inspection	Various raw materials such as aluminum ingots, silicon, and scrap aluminum are inspected for composition and weight.	Diesel
Batching and Feeding	According to the batching sheet, prepared raw materials are placed into the feeding area, and then proportionally charged into the furnace.	Diesel
Primary Melting	Using natural gas as fuel, various raw materials such as aluminum ingots, scrap, and copper sheets are melted into high-temperature molten aluminum.	Natural Gas, Electricity, Diesel
Secondary Melting	Some raw materials need to be batched separately and added into the furnace multiple times for melting.	Natural Gas, Electricity, Diesel
Dross Removal and Ashing	Slag is removed, and the molten aluminum is treated with flux to further separate aluminum from dross.	Electricity, Diesel
Correction and Analysis	According to product specification requirements, adjustments and corrections are carried out for each composition.	Natural Gas, Electricity, Diesel
Refining and Degassing	The molten aluminum is treated with refining agents and nitrogen to remove dissolved hydrogen and inclusions.	Electricity, Diesel
Stabilization	The high-temperature molten aluminum is held for more than half an hour to stabilize its composition and temperature.	Natural Gas
Aluminum Ingot Casting	The high-temperature molten aluminum is cast into solid aluminum ingots, including both primary and secondary cooling processes.	Electricity, Circulating Water, Diesel
Packaging and Storage	The cooled aluminum alloy ingots are labeled, packaged, and stored.	Diesel

NMAA Alloy Ingot Production Process Flow Chart



Note: Diesel is exclusively used for forklifts and aluminum scrap vehicles

3.1.3 Product Sales

NMAA transports aluminum alloy ingot products to customer factories or warehouses using automobile transportation.

3.2 Collection of Production Data

Through on-site investigation of the organization, production process data from NMAA was collected and compiled into a comprehensive Production Data List.

Table 1. Aluminum Alloy Casting Ingot Production Data List

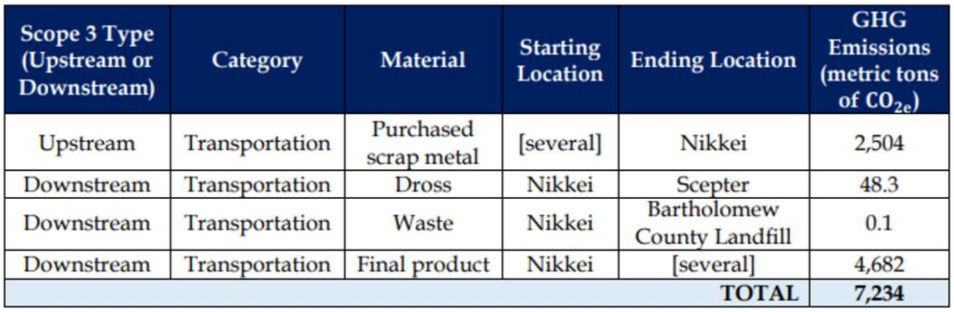
Item	Unit	Quantity
Natural Gas	scf	451,552,680
Diesel	gl	27,693
Electricity	kWh	6,257,837
Product	ton	58,847

3.3 Sources of background data

GHG Emissions from Purchased Goods

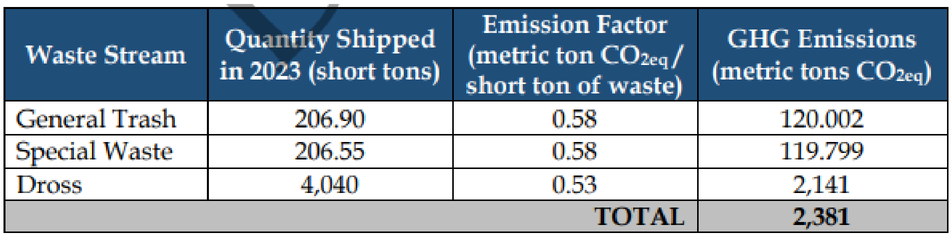
	Emission Fector (kg CO2e/kg product)	Emission Fector (kg CO2e/USD)	GHG Emissions (metric tons CO2e)		
Commodity Received			Al	Scrap	Additive
TyGem(85%)	–	1.018			113
Wheels(Dirty)	–	0.108		4444	
Wheels(Clean)	–	0.108		193	
356 Chips	–	0.108		867	
Chrome Wheels	–	0.108		110	
Wheels	–	0.108		10	
Sows	–	1.018		2205	
Chrome Wheel	–	0.108		0	
6000	–	0.108		482	
Wheel	–	0.108		4	
Cu	4.1	–			312
Mg	21.8	–			1281
Boron	21.8	–			59
P0506	–	1.018	5168		
P0610	–	1.018	15351		
P1020	–	1.018	7409		
Cu	4.1	–			15
Be	21.8	–			30
Sr	21.8	–			1029
Si	11.2	–			11953
Ni	21.8	–			1604
6061	–	1.018		12	
Wheel	–	0.108		40	
1350	–	0.108		6	
1350	–	0.108		6	
Wheel	–	0.108		5	
1350	–	0.108		144	
356	–	1.018		33	
Fe Scrap	–	0.108		0	
Wheel	–	0.108		0	
Silicon	11.2	–			3226
Mg scrap	–	0.108		96	
Mn	13.9	–			1078
Fe powder	21.8	–			91
			27,928	8,657	20,791
					57,376

GHG Emissions from Transportation



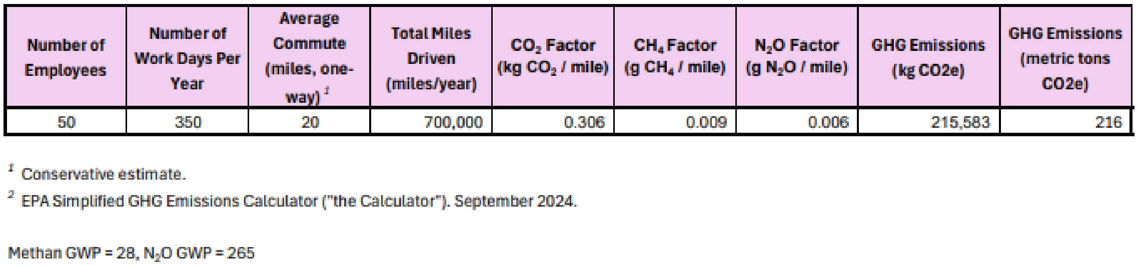
Scope 3 Type (Upstream or Downstream)	Category	Material	Starting Location	Ending Location	GHG Emissions (metric tons of CO_{2e})
Upstream	Transportation	Purchased scrap metal	[several]	Nikkei	2,504
Downstream	Transportation	Dross	Nikkei	Scepter	48.3
Downstream	Transportation	Waste	Nikkei	Bartholomew County Landfill	0.1
Downstream	Transportation	Final product	Nikkei	[several]	4,682
				TOTAL	**7,234**

GHG Emissions from Processing Sold Products



Waste Stream	Quantity Shipped in 2023 (short tons)	Emission Factor (metric ton CO_{2eq} / short ton of waste)	GHG Emissions (metric tons CO_{2eq})
General Trash	206.90	0.58	120.002
Special Waste	206.55	0.58	119.799
Dross	4,040	0.53	2,141
		TOTAL	**2,381**

GHG Emissions from Employee Commutes



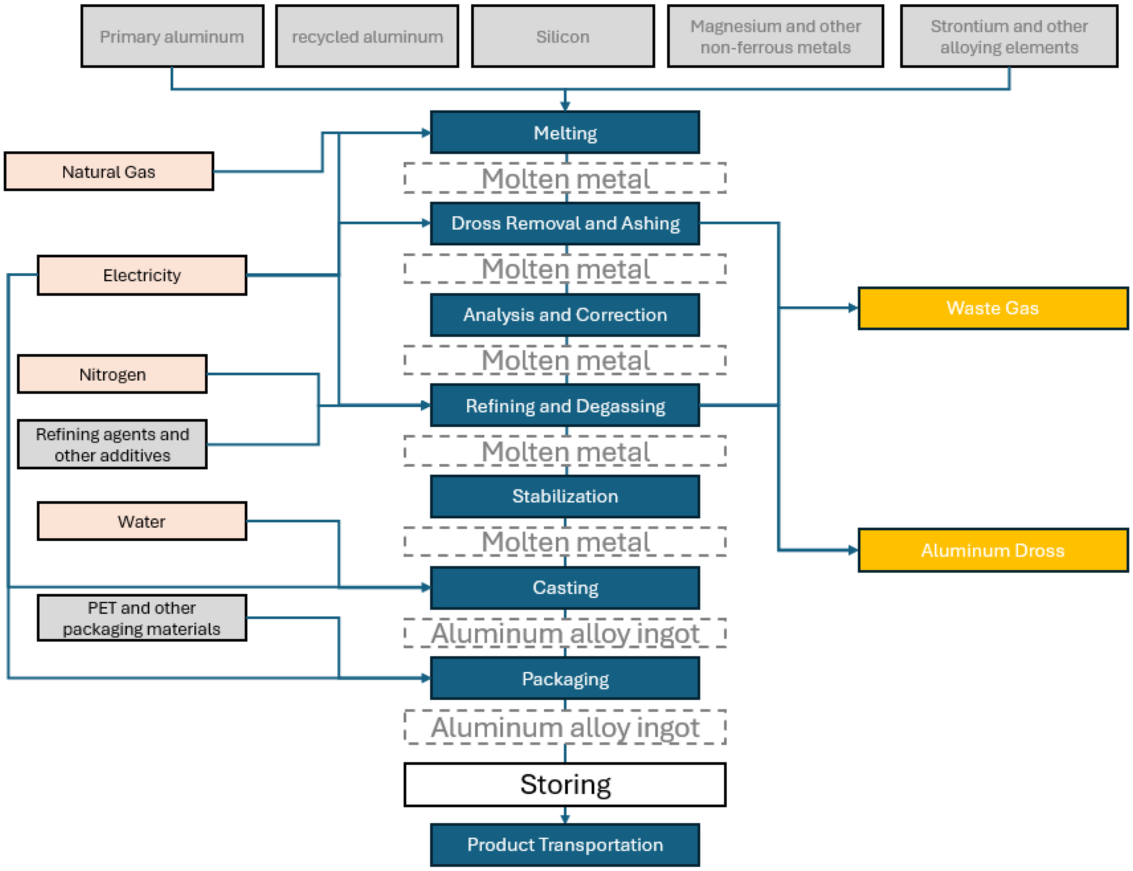
Number of Employees	Number of Work Days Per Year	Average Commute (miles, one-way) [1]	Total Miles Driven (miles/year)	CO_2 Factor (kg CO_2 / mile)	CH_4 Factor (g CH_4 / mile)	N_2O Factor (g N_2O / mile)	GHG Emissions (kg CO2e)	GHG Emissions (metric tons CO2e)
50	350	20	700,000	0.306	0.009	0.006	215,583	216

[1] Conservative estimate.

[2] EPA Simplified GHG Emissions Calculator ("the Calculator"). September 2024.

Methan GWP = 28, N_2O GWP = 265

4.1 Aluminum Alloy Ingot LCA Model



In alignment with the system boundaries established in this report—and taking into account actual production conditions and industry best practices—we have developed a life cycle model for aluminum alloy ingots produced by Nikkei MC Aluminum America, Inc.

4.2 Aluminum Alloy Ingot LCA Results

Based on the life cycle model of aluminum alloy ingots established in this report—and informed by the data collected during this study—we calculated the Life Cycle Assessment (LCA) results for one metric ton of aluminum alloy ingots using standard LCA methodologies. The results provide a quantitative evaluation of environmental impacts associated with each stage of the product's life cycle, offering insights into resource consumption, greenhouse gas emissions, and opportunities for sustainable improvement.

LCA results of one ton of aluminum alloy ingot

Environmental impact type	index	unit	result
climate change	GHG emissions	tCO2e / t	1.74

In accordance with the system boundaries defined in this report, the Life Cycle Assessment (LCA) results for aluminum alloy ingots are evaluated from "cradle to gate." This scope encompasses the entire process from raw material and energy acquisition, through production, to product transportation. The environmental impacts associated with each stage of the life cycle are quantified to provide a comprehensive understanding of the product's footprint. The LCA results for each process stage are summarized as follows:

Table 1. Life cycle of one ton aluminum alloy ingots GHG emissions results in each process.

				FY2023	
				tCO2	tCO2/(tAlloy)
Scope1		**Natural gas**		24,337	0.41
		Diesel			
Scope2		**Electric**		2,803	0.05
Scope3	1	**Purchased products and services**	**Primary Al**	27,928	0.47
			Scrap	8,657	0.15
			Additive	20,791	0.35
	4	**Upstream transportation and distribution**		7,234	0.12
	5	**Waste generated in operations**		2,381	0.04
	7	**Employee commuting**		216	0.004
	10	**Processing of sold products**		7,933	0.13
		Total		102,280	1.74

4.3 Conclusions and Recommendations

4.3.1 Conclusion

Production process data for aluminum alloy ingots at NMAA was collected through on-site investigation and compiled into detailed production data lists. These were integrated with background data to quantify the raw material and energy inputs across the life cycle stages—specifically from cradle to gate—for the production of one metric ton of aluminum alloy ingots.

Analysis of climate change impacts across the life cycle reveals that upstream raw material production contributes the most significantly. For each ton of aluminum alloy ingots produced, upstream raw materials account for approximately 0.97 tCO_2e, representing 56% of total greenhouse gas emissions. Notably, the production of primary aluminum alone contributes 0.47 tCO_2e per ton, which constitutes 49% of raw material emissions and 27% of total life cycle emissions.

When considering only the energy consumption during the production process, the carbon dioxide emissions associated with manufacturing aluminum alloy ingots amount to 0.46 tCO_2e per ton, representing 27% of the total life cycle emissions. Within this category, natural gas and diesel usage contribute the most significantly, accounting for 24% of total life cycle emissions.

Additionally, the transportation of raw materials and finished products required for the production of NMAA's aluminum alloy ingots generates 0.12 tCO_2e per ton, which corresponds to 7% of the total life cycle emissions.

4.3.2 Proposals

Based on the above LCA analysis, we will make the following suggestions:

In the life cycle of aluminum alloy ingots, the production of upstream raw materials—particularly primary aluminum—has the most significant impact on climate change. To mitigate this, priority is given to sourcing raw materials from suppliers that demonstrate lower energy consumption and environmentally responsible practices. Additionally, by implementing measures such as equipment upgrades and process optimization, the proportion of recycled aluminum used in production will be increased. This approach effectively reduces the environmental burden associated with the consumption of primary aluminum and supports the transition toward more sustainable manufacturing.

While energy consumption during the production of aluminum alloy ingots does not represent the largest share of total life cycle emissions, it remains a significant contributor—ranking third after primary aluminum and industrial silicon. To mitigate this impact, targeted strategies can be implemented to reduce energy consumption and enhance energy efficiency. These include strengthening energy management practices, upgrading equipment, and optimizing production processes. Such measures not only lower carbon dioxide emissions but also contribute to more sustainable and cost-effective manufacturing operations.

Although the carbon dioxide emissions generated during the transportation of raw materials and finished products represent a relatively small portion of the overall life cycle emissions of aluminum alloy ingots, this stage still offers meaningful opportunities for improvement within our operations. Emissions can be reduced by optimizing the lot size and frequency of raw material sourcing and product shipments, as well as by selecting low-carbon transportation methods and vehicles. These strategies contribute to a more efficient planning system and support broader goals for climate impact mitigation.

4.3.3 Research proposals

Due to time and cost constraints, this study begins with the manufacturing and processing stages of aluminum alloy ingots, applying a broad classification of life cycle processes. The focus is placed on defining system boundaries from a macro perspective, collecting relevant data, and conducting Life Cycle Assessment (LCA) calculations and analysis.

Provided that adequate resources and support are available, future research on the LCA of aluminum alloy ingots can be expanded in the following areas:

- End-of-Life Analysis: Incorporating recycling, disposal, and recovery processes to assess the full cradle-to-grave environmental impact.
- Use Phase Evaluation: Studying the performance and environmental implications of aluminum alloy ingots during their application in downstream products.
- Geographic Sensitivity Analysis: Comparing LCA results across different regions to account for variations in energy mix, transportation infrastructure, and production technologies.
- Supplier-Specific Data Integration: Enhancing accuracy by using primary data from specific suppliers rather than relying solely on generic background databases.
- Impact Category Expansion: Including additional environmental indicators such as water footprint, resource depletion, and human toxicity.
- Scenario Modeling: Exploring alternative production scenarios, such as increased use of renewable energy or higher recycled content, to identify pathways for emission reduction.
- Dynamic LCA Modeling: Applying time-dependent models to capture changes in technology, energy sources, and market conditions over time.

From the perspective of the industrial value chain, conducting in-depth research on both upstream and downstream enterprises enables the acquisition of real-world data from suppliers and customers. This approach offers two key advantages: first, it allows for the expansion of the system boundary—potentially extending the scope from "cradle to gate" to "cradle to grave"; second, it enhances the representativeness and reliability of the Life Cycle Assessment (LCA) by incorporating actual operational data. Integrating supplier and customer insights strengthens the accuracy of environmental impact evaluations and supports more informed decision-making across the entire value chain.

By further subdividing and analyzing the production and processing stages of aluminum alloy ingots, and refining the definition of the "reference flow," the Life Cycle Assessment (LCA) can be enhanced from a micro-level perspective. Conducting targeted data collection based on the availability of improved reference flow data allows for greater granularity and precision in evaluating environmental impacts. This approach supports a more detailed understanding of specific process contributions and facilitates the identification of opportunities for optimization and emissions reduction within individual production steps.